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Urban Deployment of IoT to Enhance Accessibility for People with Reduced Mobility: A Systematic Literature Review

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Abstract: Urban accessibility for people with reduced mobility (PRM) remains one of the most pressing challenges in contemporary urban planning. Despite the growing legislative framework, such as Algeria's Law 25-01, which mandates compliance with universal design standards, a significant gap persists between legal provisions and their effective implementation in the built environment. In the context of rapid digital transformation, emerging technologies offer promising tools to bridge this gap.

This paper addresses the following central research question: How can the Internet of Things (IoT) and assistive technologies be leveraged to address deficiencies in urban spaces and enhance the autonomy of people with reduced mobility? The study aims to explore and evaluate recent technological solutions adaptable to the urban context through a Systematic Literature Review (SLR) of scientific publications indexed in leading international databases. Methodologically, the paper adopts a critical analytical approach applied to a purposive sample of studies at the intersection of smart cities, inclusive design, and IoT.

The reviewed literature was classified into three thematic axes: first, the use of crowdsourcing for participatory accessibility mapping; second, embedded assistive technologies and smart mobility in public spaces; and third, inclusive planning based on urban modeling and Digital Twins.

Preliminary findings indicate that integrating IoT into urban space management contributes effectively to overcoming morphological barriers, transforming public spaces from static infrastructure into interactive and inclusive environments. The paper concludes by proposing an initial conceptual framework to guide decision-makers and urban managers toward mechanisms for adapting these technologies within urban upgrading projects, thereby promoting spatial equity and meeting sustainable development requirements.

Keywords: Internet of Things (IoT); Urban Accessibility; People with Reduced Mobility; Universal Design; Assistive Technologies; Urban Space Management.

Introduction:

Urban accessibility constitutes one of the foundational pillars of contemporary urban planning approaches. It is defined as the ease with which individuals, particularly people with reduced mobility, can reach and effectively use urban infrastructure and services (Nicoletti et al., 2023; Spadon et al., 2017). The significance of this issue lies in the fact that this population group can be directly affected by environmental obstacles and physical hazards within the city (Jampel, 2018). Such disparities in accessibility are directly reflected in the daily lived experience of urban space, limiting the active and independent participation of these individuals in society (Aini et al., 2019; Bromley et al., 2007).

Despite the growing academic and legislative interest in the principles of universal design, which aim to create built environments that accommodate individuals with diverse abilities (Imrie & Luck, 2014), a clear gap continues to exist between the laws and regulations addressing this group and their tangible implementation on the ground. While modern buildings and facilities may meet accessibility requirements, older structures and public spaces frequently lack such basic provisions (Andani et al., 2013; Froehlich-Grobe et al., 2008). Furthermore, studies have demonstrated that poor infrastructure quality, such as inadequately designed sidewalks, severely restricts the urban mobility of people with reduced mobility, generating feelings of isolation and frustration as a result of these persistent morphological barriers (Clarke et al., 2008; Velho, 2019).

Despite these clear and fundamental obstacles, which represent a genuine challenge to the ability of persons with disabilities to interact smoothly within the urban space, the rapid digital transition

and accelerated technological development emerge as a framework upon which this issue can be addressed. The smart cities paradigm and Internet of Things (IoT) technologies are considered promising tools for overcoming these obstacles and enhancing the autonomy of vulnerable groups within the urban realm, foremost among them people with reduced mobility (Paiva et al., 2021; Panta et al., 2019). The deployment of advanced digital technologies and data-driven solutions contributes to improving the efficiency of urban services and elevating quality of life (Dahmane et al., 2024). Moreover, integrating IoT and assistive technologies into the management of public spaces represents a significant opportunity to operationalize and reinforce spatial justice, transforming the built environment into a more inclusive and responsive setting for diverse human needs. This trajectory aligns closely with the requirements of sustainable development and the global objectives of smart mobility (Memić et al., 2025; Seyedrezaei et al., 2023).

Urban applications of IoT and smart technologies oriented toward serving people with reduced mobility undoubtedly contribute to formulating practical solutions to the challenges faced by this group. Smart navigation and routing systems, along with mobile applications, stand out as effective tools for providing customized and safe routes adapted to the specific needs of each user, such as generating barrier-free paths for wheelchair users, or relying on conversational voice interfaces to guide visually impaired persons through congested spaces (Matei et al., 2022; Paiva et al., 2021). On another front, crowdsourcing mechanisms have proven their effectiveness in collecting and analyzing user-generated assessment data on the quality of facilities and sidewalks, thereby contributing to participatory accessibility mapping that reflects the actual reality of urban barriers with greater accuracy than traditional surveying methods (Li et al., 2025; Duhair & Ghebghoub, 2022).

This technological evolution coincides with the emergence of contemporary planning models such as the 15-Minute City, which emphasizes spatial proximity and ease of access to essential services on foot or through flexible mobility means (Abdi & Vanoutrive, 2026; Nica et al., 2026). In this context, emerging technologies such as Digital Twins and Agent-Based Modeling play a strategic role in simulating pedestrian movement dynamics, improving crisis management, and guiding urban planning to be more responsive and inclusive (Divasson-J. et al., 2025; Kaynak et al., 2025). Likewise, Green IoT and autonomous systems, such as mobile robots, function as key enablers for environmentally sustainable smart mobility (Chand et al., 2025; Memić et al., 2025). Nevertheless, researchers emphasize that the pursuit of technological efficiency must not overlook the challenges associated with cybersecurity and the protection of user data, in order to ensure that social gaps are not deepened and that a secure digital and spatial environment is provided (Azadgar et al., 2026; Capaccioli et al., 2023).

Despite this academic and technological momentum, a clear gap remains in the scientific literature regarding how these scattered technologies can be systematically framed and integrated into urban space management policies, particularly in public spaces that exhibit deficiencies in achieving spatial equity and justice (Seyedrezaei et al., 2023). Building on this gap, the central research question of this paper is articulated as follows: How can the Internet of Things and assistive technologies be deployed to address deficiencies in urban spaces and enhance the autonomy of people with reduced mobility within the built environment?

To address this question, the present study aims to explore and evaluate recent technological solutions adaptable to the urban context through a Systematic Literature Review of studies and research at the intersection of smart cities, universal or inclusive design, and the Internet of Things.

In its outputs, this paper aspires to establish a preliminary conceptual framework that guides decision-makers and urban managers toward mechanisms for integrating these technologies within urban upgrading projects, thereby enabling such projects to respond to the requirements of sustainable development through enhancing the autonomy of the most vulnerable groups in society.

1. Methodology

To achieve the objectives of this study and to address the research question, an analytical-descriptive method was adopted through conducting a systematic literature review. The review sought to explore and analyze the most recent IoT-based technological applications oriented toward improving urban accessibility for people with reduced mobility. To ensure reliability and

transparency in the research process, the PRISMA protocol guidelines were followed across the stages described below.

1.1 Search Strategy and Databases

An initial comprehensive electronic search was conducted between February and May 2025, then updated and expanded in March 2026 to capture the most recent literature for the present study. The search was carried out across leading international academic databases, namely Scopus, Web of Science, and Google Scholar. To ensure precision, a search equation was constructed based on the intersection of three main groups of English-language keywords, as summarized in Table 1.

Table 1. Keywords and search term groups.

Axis	Keywords
Technological axis	"Internet of Things" OR "IoT" OR "Smart Cities" OR "Smart Mobility"
Urban axis	"Urban Accessibility" OR "Inclusive Urban Design" OR "Public Spaces"
Target population axis	"People with Reduced Mobility" OR "PRM" OR "Wheelchair Users" OR "Visual Impairment"

1.2 Inclusion and Exclusion Criteria

To refine the study sample and orient it toward the precise urban context, strict inclusion and exclusion criteria were applied. Inclusion criteria covered peer-reviewed scientific articles and papers published in international conferences during the period 2014 to 2026, in order to ensure the recency of the technologies under examination, as well as studies focusing exclusively on the application of technologies in public spaces and the outdoor built environment. Exclusion criteria covered clinical medical studies related to disability, research dealing exclusively with automation technologies within enclosed environments without linking them to the urban space, and articles for which the full text was not available, alongside published book chapters with restricted access (database access was provided through the SNDL account).

Table 2. Inclusion and exclusion criteria.

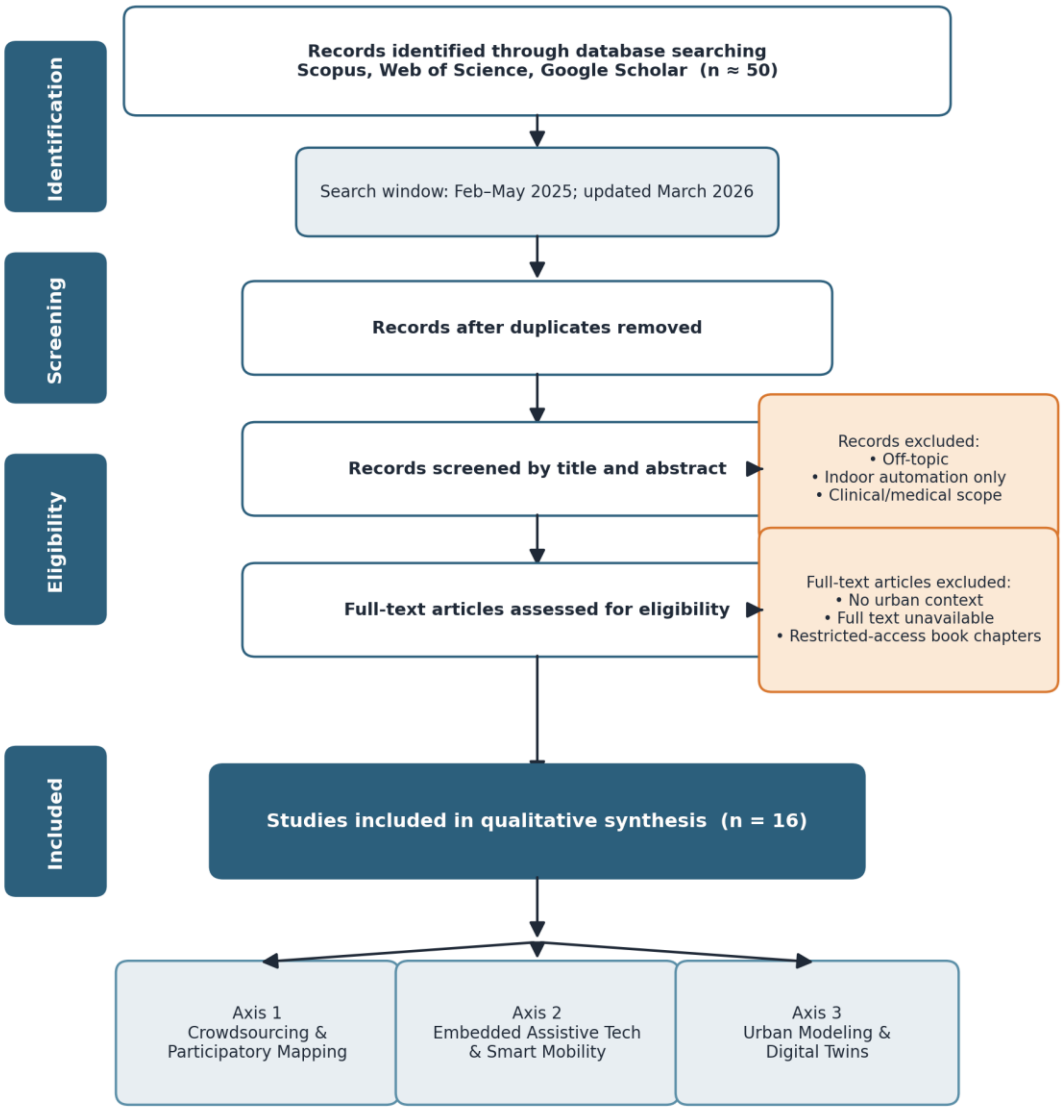
Type	Criterion
Inclusion	Peer-reviewed articles and international conferences (2014 to 2026)
Inclusion	Focus on public spaces and the outdoor built environment
Exclusion	Clinical medical studies related to disability
Exclusion	Research on automation within enclosed environments without urban linkage
Exclusion	Articles for which the full text was unavailable
Exclusion	Restricted-access books and book chapters with restricted access

1.3 Selection Process and Thematic Analysis

The initial search process yielded approximately 50 studies of preliminary relevance. After screening titles and abstracts and removing duplicates, the number was reduced to focus on the studies most closely related to the topic of urban management. In the final stage, a full reading and critical review were conducted on a purposive sample of 16 reference studies that constituted the

empirical core of the three thematic axes, while complementary studies were retained to support the theoretical framing of the introduction and discussion. To structure the findings and present a coherent analytical framework, the reviewed articles were classified, in accordance with the thematic analysis technique, into three main applied axes that constitute the core of this paper. The full selection pathway is summarized in Figure 1.

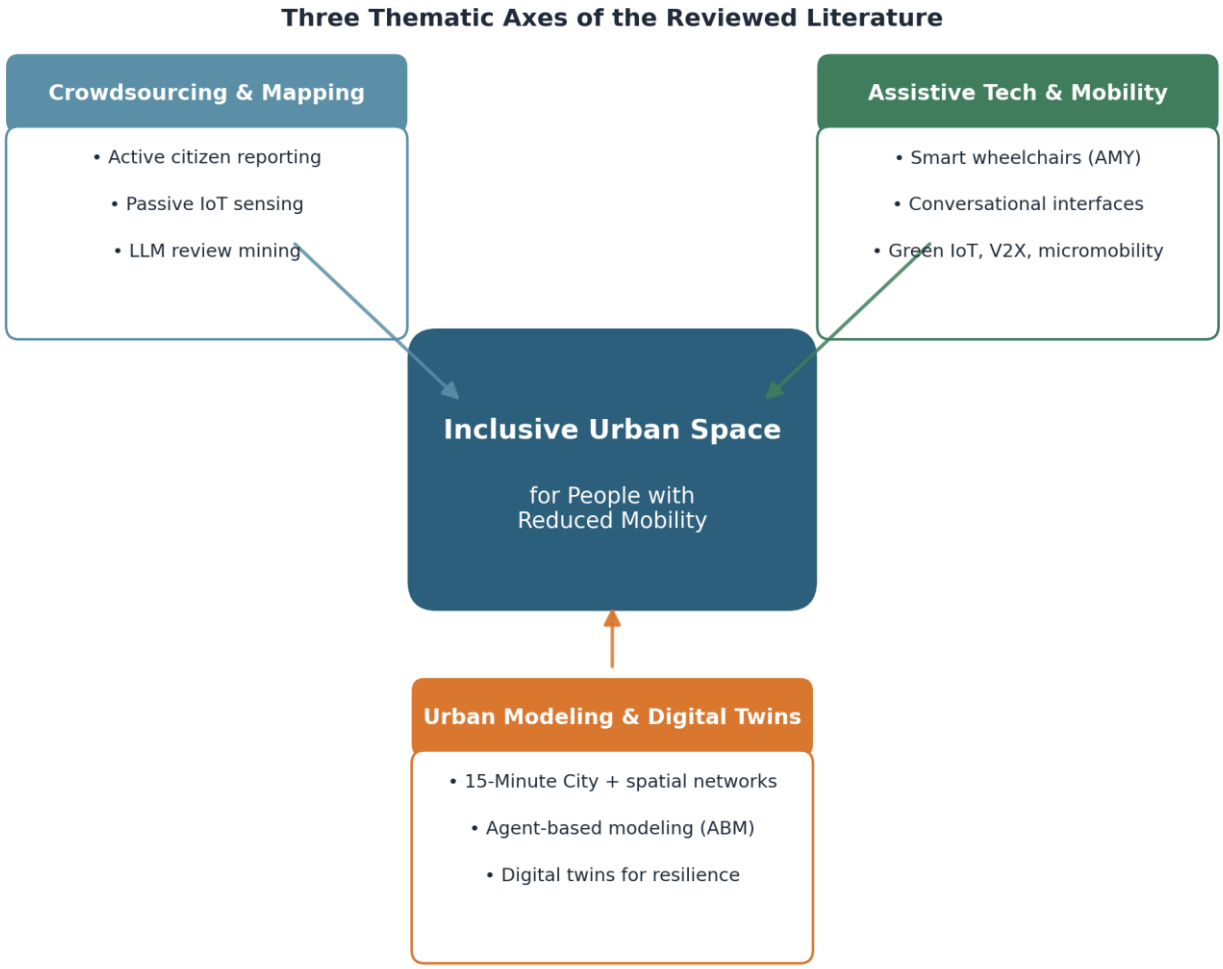
Figure 1. PRISMA-style flow diagram of the literature selection process.



2. Review Findings and Discussion

Building on the selection process described above, the reviewed literature was synthesized along the three thematic axes presented in Figure 2. Each axis is examined in turn in the subsections that follow.

Figure 2. The three thematic axes of the reviewed literature converging on inclusive urban space.



2.1 Crowdsourcing and Participatory Accessibility Mapping

Assessing urban accessibility represents a fundamental requirement in urban planning. However, reliance on traditional methodologies (such as field surveys and interviews) is often characterized by high cost and time consumption, in addition to limited geographic coverage and weak representation of target populations, particularly people with reduced mobility (Li et al., 2025). To address these limitations, crowdsourcing has been put forward as an effective decentralized approach for collecting and analyzing urban data (Certomà et al., 2015; Li et al., 2025; Velázquez et al., 2024). The literature indicates that planners and researchers rely on three main mechanisms for producing participatory accessibility maps.

2.1.1 Active Crowdsourcing

This approach refers to a participatory mode of accessibility assessment in which individuals deliberately contribute observations, ratings, or annotations regarding barriers encountered in the urban environment (Mobasheri et al., 2017). Its main value lies in capturing user-experienced obstacles that conventional audits may overlook, while generating fine-grained and context-sensitive evidence on the actual accessibility conditions of public spaces. One of the most representative examples is Project Sidewalk, which enables users to annotate street-level imagery, including Google Street View scenes, in order to identify sidewalk accessibility problems such as missing curb ramps, surface defects, or physical obstructions (Hara et al., 2013; Saha et al., 2019). Similarly, the EasyGo platform relies on user participation to report barriers and map urban facilities, thereby supporting the generation of customized routes for people with reduced mobility in smart-city contexts (Panta et al.,

2019). However, despite the analytical and practical value of these tools, their effectiveness remains constrained by uneven participation, reporting fatigue, and the spatial sparsity of contributed data, all of which may reduce the representativeness and continuity of accessibility mapping (Ding et al., 2014; Li et al., 2025).

2.1.2 Passive Crowdsourcing and the Internet of Things

To overcome the challenge of continuous human intervention, urban planning is moving toward passive crowdsourcing, which allows data to be extracted automatically and on a broader scale from users' daily activities, providing more representative data samples (Li et al., 2025; Loukis & Charalabidis, 2015). At this level, crowdsourcing intersects directly with IoT devices and assistive technologies. The SmartBFA system, for example, relies on IoT sensors mounted on wheelchairs to collect data on the obstacle-free condition of pathways (Kamaldin et al., 2019). In the same vein, smartphone sensors are passively employed in initiatives such as AccessMap to detect spatial features such as ramps and curbs, thereby improving map accuracy (Aly et al., 2021). Automated assessment systems, such as the mPASS system, also rely on accelerometer data to evaluate surface conditions and identify morphological barriers such as stairs and slopes (Prandi et al., 2014).

2.1.3 Crowdsourcing through Digital Reviews and Language Models

Alongside spatial sensing, crowdsourcing has evolved to encompass the analysis of digital reviews and ratings (such as comments on interactive maps) to measure accessibility levels at points of interest (POIs) at low cost. Recent studies have demonstrated the feasibility of employing Large Language Models (LLMs) and Text Mining techniques to decode unstructured comments, enabling urban managers to identify the fine-grained barriers that people with reduced mobility encounter on a daily basis (such as signage clarity or interior space organization), details that may exceed the capacity of traditional physical audits to capture (Li et al., 2025). This approach contributes to transforming public space into an interactive environment subject to continuous evaluation and development based on collective intelligence (Li et al., 2025; Saha et al., 2019).

2.2. Embedded Assistive Technologies and Smart Mobility in Public Spaces

The urban space is undergoing a major transformation through the integration of IoT technologies into personal devices, converting them from ordinary assistive tools into interactive nodes within the smart city network. In this context, wheelchairs have received significant research attention; cooperative control systems have been developed for smart wheelchairs, such as the AMY system, which employs laser sensors and 3D cameras to automatically correct the user's trajectory and avoid morphological obstacles in congested urban spaces (Chand et al., 2025). To overcome the high cost of these wheelchairs, engineering innovations have emerged that focus on the design of low-cost modular motor kits that can be quickly installed on conventional wheelchairs without compromising their basic structure, supported by wireless control systems based on Bluetooth technology and smartphone applications (Valladolid-Ballon et al., 2024). Improvements have also extended to individual conveyances, which have been equipped with active suspension systems to absorb shocks from sidewalks and uneven urban surfaces, thereby reducing the risk of overturning and enhancing safety (Chand et al., 2025).

At the level of smart navigation and routing, mobile applications and conversational interfaces play an essential role in safely guiding people with reduced mobility within cities. Experiments have demonstrated the effectiveness of developing applications that provide customized and optimized routes based on the nature of the impairment or disability (motor, visual, auditory) by relying on mathematical algorithms, such as Dijkstra's Algorithm, to map routes, avoid urban obstacles, and suggest suitable parking spaces and transit stops (Paiva et al., 2021). To meet the precise needs of blind and visually impaired users during navigation, Conversational User Interfaces (CUIs) have been developed that integrate with the IoT infrastructure. These applications connect automatically through nearby sensor networks to traffic signals equipped with broadcasting devices to inform the

user of the signal status and provide audio guidance to cross pedestrian intersections in full autonomy (Matei et al., 2022). This functions in a manner similar to certain smartphone systems that assist blind users in reading screen content audibly.

At the level of major infrastructure and critical facilities such as airports and transport stations, the logistical management of people with reduced mobility represents a significant challenge that requires direct and immediate response. To address the complexities of these environments, Semantic Web technologies and Ontologies are deployed to build smart digital models that manage passenger data, predict delays, and efficiently allocate human resources to ensure smooth mobility within facility corridors (Herrera-Martín et al., 2025). Moreover, Green IoT systems function as a key enabler of the smart electric mobility ecosystem; they enable direct communication between vehicles, signals, and infrastructure (V2X), thereby raising the efficiency of urban transport, reducing emissions, and supporting the integration of micromobility solutions to make cities more inclusive and sustainable (Memić et al., 2025).

2.3 Inclusive Planning Based on Urban Modeling and Digital Twins

Contemporary urban planning is witnessing an increasing orientation toward proximity-based planning models, most notably the 15-Minute City model, which aims to decentralize urban services and provide safe and sustainable access to daily needs on foot or through flexible mobility means (Abdi & Vanoutrive, 2026; Wang et al., 2024). However, a critical review of the literature indicates that exclusive reliance on temporal criteria and the limited area of the neighborhood or urban space may yield misleading results; such criteria often disregard the physical limitations of the elderly and people with reduced mobility, undermining the principle of spatial inclusivity (Azadgar et al., 2026). To overcome this shortcoming, the role of advanced urban modeling becomes prominent, moving beyond traditional measurements to rely on network-based spatial analysis. This analysis takes into account physical barriers in public space and slower walking speeds in order to realistically represent the capacities of people with reduced mobility, thereby helping to identify actual gaps in accessibility (Azadgar et al., 2026).

Alongside spatial network analysis, Agent-Based Modeling (ABM) plays a pivotal role in inclusive planning; it allows the simulation of urban mobility dynamics centered on humans rather than vehicles. These models help in evaluating the impact of infrastructure and spatial policies on populations with reduced mobility, providing decision-makers with a proactive tool to test and adapt transport policies in order to ensure equitable access for all (Divasson-J. et al., 2025).

To achieve comprehensive integration in the management of urban spaces, Digital Twin technology coupled with Big Data constitutes a new frontier and an unprecedented advance in the smart mobility ecosystem (Loia et al., 2026). Digital Twins function as platforms that integrate spatial data, IoT information, and individuals' movement to create an integrated and comprehensive virtual representation of the built environment. This technology allows the simulation of "what-if" scenarios related to accessibility under varying conditions. For example, through Digital Twins, it is possible to simulate the impact of crises or environmental disasters (such as floods) on infrastructure, in order to determine the extent to which spatially vulnerable groups can access vital facilities such as hospitals and transport stations, thereby ensuring the resilience and sustainability of mobility networks (Kaynak et al., 2025).

Recent studies converge on the view that integrating Digital Twins and urban modeling within urban planning and space management policies does not merely improve transport efficiency, but rather constitutes a key catalyst for achieving the Sustainable Development Goals, particularly Goal 11 (SDG 11) related to building sustainable cities and communities, provided that these technologies are coupled with participatory planning processes that take into account the precise needs of spatially vulnerable groups and avoid deepening spatial inequalities (Nica et al., 2026).

3. Limitations and Future Research Directions

While this systematic review provides a structured synthesis of recent advances in IoT-based urban accessibility, several limitations should be acknowledged in order to delineate the boundaries of the present work and to guide subsequent inquiry.

First, the search was confined to three databases (Scopus, Web of Science, and Google Scholar) and to English-language publications, which may have led to the omission of relevant studies indexed in regional repositories or published in other languages, particularly Arabic and French scholarship pertaining to North African and Mediterranean urban contexts. Second, the rapidly evolving nature of IoT technologies entails that the most recent industrial implementations and grey literature may not yet be reflected in the peer-reviewed academic record covered by the review window (2014 to 2026). Third, the heterogeneity of methodologies, evaluation metrics, and reporting standards across the reviewed studies precluded a quantitative meta-analysis, and the synthesis therefore remained qualitative and thematic in nature.

A further methodological challenge concerns the availability of empirical data. The validation of IoT-based accessibility systems often requires longitudinal sensor data drawn from diverse urban contexts, which remain scarce and are rarely shared due to privacy constraints affecting vulnerable populations (Capaccioli et al., 2023). To partially address this gap, recent initiatives have proposed physics-based synthetic data generation platforms that allow researchers to produce reproducible and peer-reviewable IoT datasets across smart-home, medical, and connected-vehicle domains while preserving statistical realism (Duhair, 2026). Such tools may support the early-stage validation of accessibility algorithms before real-world deployment, and they constitute a complementary research avenue worth deeper exploration in subsequent studies, particularly when coupled with Digital Twin platforms and agent-based simulations.

Building on these observations, future research is encouraged to extend the review scope to multilingual and grey literature in order to capture context-specific deployments in the Global South; to develop standardized evaluation frameworks for IoT accessibility solutions that combine real-world pilot data with synthetic benchmark datasets; and to examine the long-term socio-spatial impacts of IoT adoption on the daily mobility patterns of people with reduced mobility, with particular attention to questions of equity, governance, and digital inclusion.

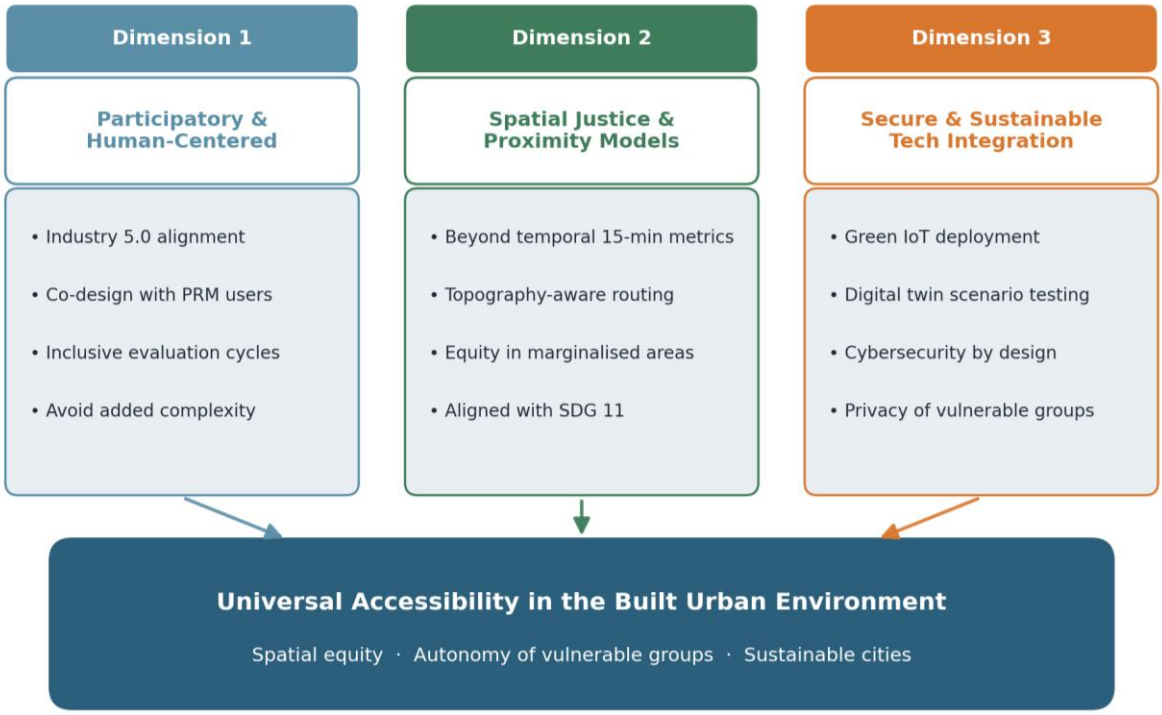
4. Conclusion and Recommendations

This systematic review demonstrates that integrating the Internet of Things and assistive technologies into urban planning does not represent a mere technological upgrade of the built environment, but rather constitutes a fundamental transformation toward more inclusive, resilient, and autonomy-supporting environments for people with reduced mobility. Through the axes that have been discussed, it becomes evident that crowdsourcing and IoT tools are capable of revealing the fine-grained spatial barriers that traditional physical audits fail to detect. Embedded assistive technologies, in turn, contribute to improving on-the-ground autonomy and wayfinding in complex environments. Likewise, Digital Twins and urban modeling provide proactive simulation environments that support the resilience of mobility networks in the face of morphological changes or crises (Kaynak et al., 2025; Li et al., 2025).

Studies emphasize that purely technical reliance, without social orientation and equity in distribution, may exacerbate the digital divide. Investments in smart infrastructure are often concentrated in well-equipped urban centers, which may deepen spatial and social segregation and exclude spatially vulnerable groups from benefiting from these transformations (Nica et al., 2026). Beyond technical deployment, however, the effectiveness of IoT-enabled accessibility solutions also depends on the capacity of cities to communicate, mediate, and socially embed these services among users and stakeholders. In this sense, accessibility technologies should be understood not only as engineering interventions but also as inclusive public urban services that require awareness-building, user engagement, institutional coordination, and trust-based adoption. This perspective introduces an urban service marketing logic into implementation, not in a commercial sense, but as a supportive mechanism for improving visibility, acceptance, and sustained use of smart inclusive solutions. To

address these intertwined challenges and to operationalize the legislative framework for universal accessibility on the ground, this paper proposes a conceptual framework directed toward decision-makers and urban managers, built upon three integrative dimensions illustrated in Figure 3.

Figure 3. Proposed conceptual framework with three integrative dimensions for IoT-enabled urban accessibility.



4.1 A Participatory and Human-Centered Approach

In line with the global shift toward Industry 5.0, the human being must remain at the center of urban planning, design, and service delivery. Achieving this requires the realization of spatial and social justice through participatory processes that directly involve people with reduced mobility in the design, testing, and evaluation of smart services. It also requires inclusive communication and awareness-building strategies that make these services visible, understandable, and responsive to actual user needs. In this way, technology can move beyond technical functionality to become a trusted and usable component of everyday urban life, rather than an additional layer of complexity imposed on vulnerable users (Anwar et al., 2025; Seyedrezaei et al., 2023).

4.2 Spatial Justice and Proximity Models

Urban managers must reformulate proximity planning models (such as the 15-Minute City) so that they extend beyond temporal criteria and area limitations. This requires integrating algorithms that take into account topographic obstacles, slower walking speeds, and routes equipped for wheelchairs when planning the location of services and facilities (Azadgar et al., 2026). Technological investments should also be directed toward marginalized neighborhoods to reduce spatial disparity, which contributes directly to achieving Sustainable Development Goal 11 (SDG 11) of building inclusive and safe cities (Nica et al., 2026; Tamim et al., 2025).

4.3 Secure and Sustainable Technological Integration

To ensure efficient and equitable management of public space, urban managers should adopt Green IoT solutions that support smart, low-impact, and environmentally sustainable mobility (Memić et al., 2025). These systems should be integrated with Digital Twin platforms capable of simulating how people with reduced mobility interact with the built environment under multiple scenarios, including disruptions caused by environmental hazards or urban crises. At the same time,

such technological integration must be accompanied by robust cybersecurity and data governance protocols to protect the personal privacy of spatially vulnerable groups. These safeguards are essential not only for preventing the misuse of sensitive data, but also for strengthening public trust and ensuring the long-term effectiveness and sustainability of inclusive smart mobility systems (Capaccioli et al., 2023).

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