RIVISTA ITALIANA DI ERGONOMIA
ORGANO UFFICIALE DELLA S.I.E. - SOCIETÀ ITALIANA DI ERGONOMIA E FATTORI UMANI

URBAN DESIGN ACROSS THE LIFE COURSE: TOWARDS LONGEVITY-ENABLING ENVIRONMENTS

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KEYWORDS: *Urban design for older adults, Urban design indicators, Urban green and blue infrastructure for AHA, Smart urban technologies for AHA, WHO Age-friendly Cities framework*

ABSTRACT

Since the early 2000s, global population ageing has significantly reshaped how urban design and planning address the human experience of city life. In this evolving context, age-friendly urban design has emerged as a transdisciplinary field aimed at configuring spatial systems that sustain autonomy, participation and wellbeing in later life. This study involves the theoretical and operational consolidation of the field by tracing its foundations in major UN and WHO frameworks and examining how these have been translated into technical standards, regulatory instruments and evaluative models, emphasising the ergonomic dimension of age-inclusive environments. The paper positions ergonomics and human factor as key interpretive lenses for understanding how the integration of accessibility and usability issues with environmental quality may shape inclusive urban settings across the ageing process in a life course perspective. The focus is on two critical application domains: technological innovation, encompassing smart-city infrastructures, participatory digital platforms and assistive systems, and urban green and blue infrastructures (UGBI), conceived as integrated strategies that support environmental resilience and multisensory restoration especially in later life. By combining theoretical perspectives with empirical evidence, the study synthesises current knowledge of age-friendly urbanism and identifies persistent conceptual and methodological fragmentation. It ultimately promotes a shift toward longevity-enabling environments, designed as adaptive, inclusive and evidence-based spatial systems that support human health through wellbeing, functional ability and human flourishing, not only during aging but across the entire lifespan.

INTRODUCTION: URBAN DESIGN FOR AN AGEING POPULATION

The accelerating demographic transformation associated with global population ageing constitutes one of the most profound challenges for twenty-first-century urbanism. This demographic shift compels a reconceptualization of how cities are designed, governed, and experienced, calling for environments capable of sustaining wellbeing, autonomy, and participation across the later phases of life. This perspective aligns with the dynamic concept of health as the ability to adapt and self-manage in the face of contemporary

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challenges (Huber et al., 2011). Within this context, the paradigm of active and healthy ageing reframes later life as a dynamic period of contribution, in which knowledge, skills, and civic engagement of older adults enrich collective urban life, reflecting the social-justice orientation of the age-friendly movement, which emphasises empowerment and co-production among older citizens (Buffel & Phillipson, 2018). A central corollary of this paradigm is the concept of ageing in place, formulated in the late 1970s to enable individuals to grow old within familiar physical and social environments, where emotional attachment, identity, and community belonging are deeply embedded (Woolrych & Li, 2024). Therefore, urban design constitutes an active catalyst of wellbeing in everyday settings, highlighting the need of specific environmental attributes in public-space evaluation, which structure liveability for senior users (Mehta, 2014). This perspective aligns with the broader objective of Ergonomics and Design for All, which emphasise human abilities, usability, and experiential quality as core determinants of inclusive and age-responsive environments. Within the evolving discourse on population ageing, the concept of urban ageing has emerged as a framework that analyses the interaction between socio-demographic transformations and urban dynamics associated with increasingly long-lived populations (Marston & van Hoof, 2019).Over the past two decades, this conceptual evolution has been accompanied by the progressive institutionalisation of age-friendly policy agendas. Notable initiatives include the Positive Ageing Indicators Report (New Zealand, 2007), which introduced national indicators for wellbeing in later life; Advancing an Age-Friendly NYC (2009), which emphasised community participation and adaptive urban design; and the South Australia Age-Friendly Guidelines (2012), establishing a regulatory framework for integrating ageing considerations into urban and regional planning. More recent strategies, such as the UK Age-Friendly Programme (2017–2020), Age-Friendly DC Strategic Plan (2018–2023), and Liverpool Ageing Strategy (2022–2026), have adopted a multisectoral, life-course approach that embeds digital inclusion, intergenerational solidarity, and equitable access to urban resources (Rashid et al., 2021). The design of public open spaces remains a significant cornerstone, particularly in relation to promoting physical activity and social interaction among older adults. Empirical evidence from Taichung, Taiwan, demonstrates that specific physical and environmental attributes of urban greenways, such as continuous paving, natural paths, resting areas, vegetation density, and proximity to water features, substantially influence older adults' participation in outdoor activities (Chang, 2020). Consistently, indicator-based studies of public open space demonstrate measurable associations between environmental qualities and community health outcomes, offering transferable metrics for age-supportive design (Villanueva et al., 2015). These findings underscore the importance of integrating interconnected dimensions into urban design as a foundational strategy for realising environments that are truly health-promoting and socially cohesive. Current research highlights that achieving such environments requires an operational culture of evidence-based and mindful design, where spatial, sensory, and emotional factors are explicitly considered to sustain wellbeing across the life course (Aslanoğlu et al., 2025).

THEORETICAL AND POLICY BACKGROUND: THE EVOLUTION OF GLOBAL FRAMEWORKS ON AGE-FRIENDLY URBAN DESIGN

The conceptual underpinnings of age-friendly urban design are deeply rooted in the policy frameworks advanced by the United Nations (UN) and the World Health Organization (WHO). In 2002, the Second World Assembly on Ageing in Madrid culminated in the adoption of the Madrid International Plan of Action

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on Ageing (MIPAA), which defined population ageing as both a challenge and an opportunity for the twenty-first century. The Assembly underscored the imperative of fostering an inclusive society for all ages, thereby establishing ageing as a global policy priority and linking demographic change to social, economic, and environmental dimensions (United Nations, 2002). Building upon this foundation, the WHO Active Ageing Framework (2003) introduced a multidimensional perspective centred on health, participation, and safety, laying the groundwork for more targeted approaches to urban environments. A pivotal milestone was the WHO Global Age-Friendly Cities Guide (2007), developed through the Vancouver Protocol, which defined the core attributes of an age-friendly city, acknowledging the diversity of older people, valuing their participation across community life, respecting individual choices, and responding flexibly to age-related needs. The Guide operationalised these principles into eight interrelated urban domains, thus providing the first comprehensive global framework for designing urban environments responsive to ageing populations. The evolution of the WHO Age-Friendly Cities agenda has strengthened participatory governance by integrating older citizens' voices into urban policy (van Hoof & Marston, 2021) and was further institutionalised with the establishment of the Global Network for Age-Friendly Cities and Communities (GNAFCC) in 2010. In parallel, the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) was launched in the same year, as a large-scale public–private partnership aimed at extending healthy life expectancy in the EU by two years by 2020. To achieve this goal, the initiative structured its work into thematic Action Groups, including domains such as medication adherence (A1), falls prevention (A2), frailty prevention and health promotion (A3), integrated care (B3), independent living solutions (C2), and age-friendly environments (D4) (European Commission, 2021). The Active Ageing Index has since provided a quantitative framework linking participation, independent and healthy living, and enabling environments, supporting cross-country monitoring and policy benchmarking (UNECE, 2018). More recently, the UN Decade of Healthy Ageing (2021–2030) has articulated a comprehensive framework for coordinated global action, reinforcing the principle that cities are essential to enabling people to live longer and healthier lives. Collectively, these initiatives have positioned age-friendly urban design as a core element of international policy discourses on ageing. Recent global assessments, such as the OECD report "Cities for All Ages" (2025), underscore the need to translate these frameworks into integrated strategies that align urban design, housing, transport, and healthcare infrastructures, ensuring inclusivity for diverse ageing trajectories.

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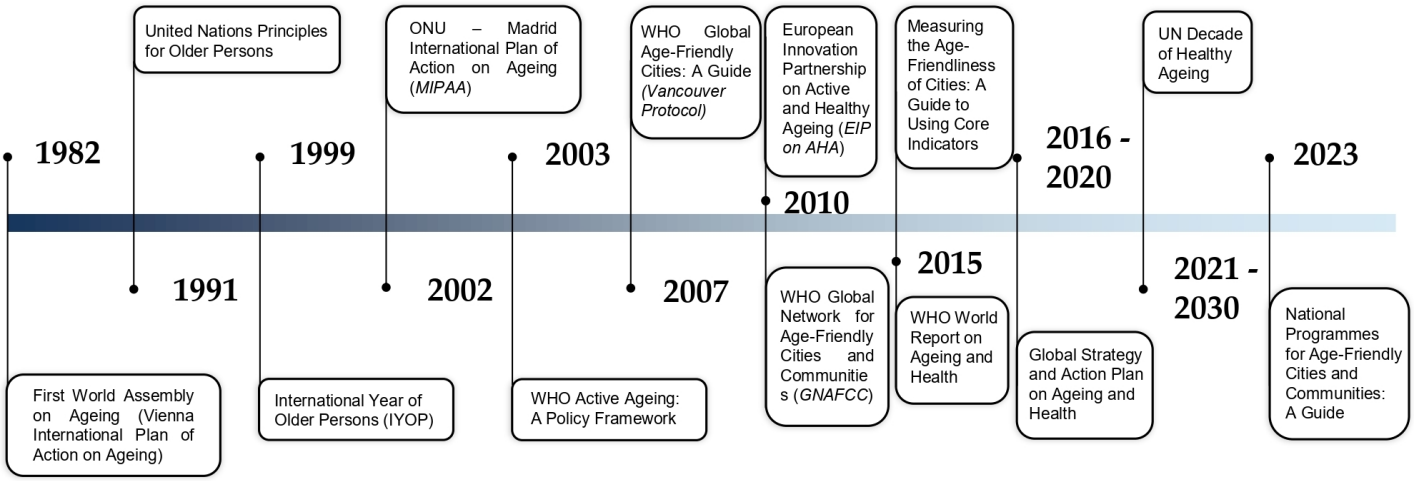

Figure 1. Timeline of major UN and WHO policy frameworks addressing ageing and urban design

METHODOLOGICAL AND ANALYTICAL FRAMEWORK: OPERATIONALISING AGE-FRIENDLY URBANISM

The translation of age-friendly principles from global policy frameworks into the operative domain of urban design has progressively relied on a diverse set of normative, methodological, and evaluative instruments. Over the past two decades, an articulated corpus of international standards, design guidelines, and assessment tools has emerged, defining how the built environment can respond to the evolving needs of ageing populations. At the international level, ISO and CEN standards, such as ISO 21542, ISO 21801, EN 17210, and EN 17161, provide the technical foundations for physical, sensory, and cognitive accessibility, embedding Universal Design and Design for All principles into both architectural and urban environments. Complementary regional and national frameworks, including the South Australia Age-Friendly Guidelines (2012), the WHO National Programmes for Age-Friendly Cities and Communities: A Guide (2023), and the Centre for Ageing Better toolkits (2025), translate these principles into actionable guidance for public authorities and practitioners. At the municipal scale, documents such as the City of Markham Age-Friendly Design Guidelines (2022) operationalise age-supportive criteria through context-sensitive approaches to neighbourhood planning and public-realm design. In parallel, indicator-based and evaluative frameworks have strengthened the measurement dimension of age-friendly urbanism. These include the Canadian and WHO age-friendly indicator sets, highlighting the evaluative backbone of municipal action (Kano et al., 2017), the Wijkscans voor Ouderen tool (2025) in the Netherlands, an integrated diagnostic instrument that combines spatial audits with participatory assessment of neighbourhood quality, enabling municipalities to prioritise interventions for safety, active mobility, and social interaction. Comparative studies have also broadened the indicator landscape across diverse socio-territorial contexts, revealing marked variability in the applicability of WHO domains along urban–rural gradients and differing stages of economic development (Rugel et al., 2022). Complementary

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approaches, such as the spatial-indicator framework proposed by Davern et al. (2020), operationalise the lived environment through measurable dimensions (accessibility, safety, and aesthetics), bridging subjective wellbeing with objective spatial data. Concurrently, a series of evaluative instruments has consolidated the analytical dimension of age-friendly urbanism, from the WHO Checklist of Essential Features of Age-Friendly Cities (2007) to the AARP Livability Index 2.0 (2023), that provide both diagnostic and participatory mechanisms for assessing quality of spaces for older adults. Related public-space evaluation approaches converge on a core set of attributes, accessibility, comfort, and perceived safety, as practical proxies for inclusive urban quality (Mehta, 2014). In 2021, the WHO also has strengthened the emphasis on environmental determinants of health through its consolidated reviews on green and blue spaces, which highlight their relevance for mental health, stress reduction and overall wellbeing (WHO, 2021). Collectively, these standards, guidelines, and evaluative instruments mark a shift from prescriptive accessibility norms toward more integrated frameworks that recognise the physical, cognitive, and environmental dimensions of urban experience. Yet they largely remain fragmented and seldom converge into a coherent design methodology. Contemporary scholarship underscores the need for integrative strategies that couple environmental performance with experiential wellbeing, moving beyond checklist-based approaches toward adaptive frameworks capable of aligning policy intentions with lived urban conditions (Aslanoğlu et al., 2025; Buffel et al., 2018). From an ergonomics and human factors perspective, these limitations reflect the lack of a systematic consideration of usability, perceptual and sensory experience, and human–environment interaction within existing urban age-friendly instruments. Accessibility norms primarily address essential functional requirements, yet they often do not encompass the cognitive, behavioural and experiential dimensions that ergonomics identifies as central to inclusive environmental quality. Such integration strengthens transdisciplinary collaboration across environmental design, public health, and social policy, positioning the built environment as an active mediator of functional ability and social participation in later life (Rugel et al., 2022). The following Table 1 summarises the main standards, guidelines, and evaluative tools that operationalise age-friendly frameworks across international, national, and municipal scales.

Source	Year	Content	Field of Application
Standards and Technical Codes			
BS 8300-1 Design of an Accessible and Inclusive Built Environment – Part 1: External Environment	2018	Defines human performance-based principles and technical criteria for accessibility and inclusive use in external built environments, including access routes, pedestrian circulation, streetscapes, open spaces, and approaches to buildings	Urban & Built Environment
EN 17161 Design for All – Accessibility Following a Design for All Approach in Products, Goods and Services	2019	Specifies an organisational framework for embedding Design for All principles in the design, development, provision and management of products and services	Governance & Services
ISO 21801-1 Cognitive Accessibility – General Guidelines	2020	Provides general guidelines for cognitive accessibility in systems, products, services and built environments, addressing perception, orientation and usability for people with cognitive disabilities	Cognitive & Built Environment Ergonomics
ISO 21542 Building Construction – Accessibility and Usability of the Built Environment	2021	Specifies international requirements for accessibility and usability in building access, internal circulation areas, and external routes directly connected to buildings	Urban & Built Environment
EN 17210 Accessibility and Usability of the Built Environment –	2021	Defines functional accessibility and usability requirements for indoor and outdoor built	Urban & Built Environment

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Functional Requirements		environments, grounded in Design for All and Universal Design principles	
Guidelines and Toolkits			
WHO – Global Age-Friendly Cities: A Guide	2007	Provides foundational guidance for designing age-friendly urban environments, outlining principles, priority domains, design implications and participatory processes for older adults	Urban Policy & Planning
South Australia Age-Friendly Guidelines	2012	Defines a policy and planning framework for integrating age-inclusive planning and design principles into urban and regional development	Urban & Regional Planning
Good Practices of Accessible Urban Development (UN-Habitat)	2016	Presents international good-practice case studies and policy lessons advancing accessible and inclusive urban planning and public space design	Urban Policy & Planning
The Inclusive Imperative: Towards Disability-Inclusive and Accessible Urban Development	2016	Outlines key strategic recommendations for embedding accessibility, inclusion and Universal Design principles into sustainable urban development processes	Urban Policy & Planning
Enabling Inclusive Cities: Tool Kit for Inclusive Urban Development (Asian Development Bank)	2017	Provides practical tools and methodologies for inclusive, barrier-free, and age-responsive city planning	Urban Policy & Planning
City of Markham Age-Friendly Design Guidelines (Canada)	2022	Provides municipal design guidance for neighbourhoods, geared toward supporting ageing in place and inclusive communities for people of all ages	Neighbourhood & Public Realm
AccessibleEU – Resource Centre for Accessibility (European Commission)	2023	EU-wide digital platform providing a knowledge base, standards repository, case studies and best practices to support accessibility in the built environment	Urban & Built Environment
WHO National Programmes for Age-Friendly Cities and Communities: A Guide	2023	Outlines procedures and strategic recommendations for establishing and sustaining national programmes on age-friendly cities and communities	Urban Policy & Governance
Centre for Ageing Better – Age-Friendly Communities: A handbook of principles to guide local policy and action	2025	Provides a comprehensive set of policy principles and design criteria for local authorities, covering walkability, accessibility, environmental quality, participation and service delivery across the eight domains of age-friendly communities	Public Realm & Local Policy
Evaluation and Assessment Instruments			
AARP Livable Communities: An Evaluation Guide	2005	Provides a participatory framework, including survey tools and checklists, for assessing community livability and accessibility from the perspective of older residents	Urban Assessment & Evaluation
WHO Checklist of Essential Features of Age-Friendly Cities	2007	Establishes qualitative indicators and observational criteria for assessing the eight domains of age-friendly cities, including outdoor spaces, mobility, social participation and community support	Urban Assessment & Evaluation
Atlanta Regional Commission – Lifelong Communities Initiative: Principles for Housing and Neighbourhoods	2009	Defines key planning and design principles for developing age-inclusive, walkable and socially connected neighbourhoods	Neighbourhood & Public Realm
UK Department for Communities and Local Government – Lifetime Neighbourhoods	2011	Defines principles and evaluative criteria for neighbourhoods that support ageing in place, walkability, social participation, accessibility and wellbeing across the life course	Neighbourhood & Public Realm
Measuring the Age-Friendliness of Cities: A Guide to Using Core Indicators	2015	Provides a structured indicator framework to measure age-friendly performance across the eight age-friendly WHO domains	Urban Assessment & Evaluation
AARP Livability Index 2.0 (USA)	2023	Offers a quantitative assessment framework that evaluates core dimensions of community livability and age-friendliness	Urban Assessment & Evaluation

Table 1. Key standards, guidelines and tools translating age-friendly frameworks into urban design practice

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RESULTS: EMERGING DOMAINS INTO AGE-FRIENDLY URBAN DESIGN

Evidence[1] reveals a gradual broadening of the age-friendly discourse toward more integrative and adaptive interpretations of the urban environment. Rather than a prescriptive focus on accessibility or risk mitigation, recent approaches conceive urban design as an active enabler of functional ability, participation, and wellbeing across the life course. Within this evolving framework, two complementary domains stand out for their transformative potential. The first concerns technological innovation, through which digital infrastructures, smart systems, and participatory platforms are reshaping the interaction between people, space, and data. The second pertains to urban green and blue infrastructure, which embeds ecological and restorative processes into the built environment, enhancing environmental quality and comfort, resilience, and social cohesion. Together, these domains converge toward a broader vision of longevity-enabling urban environments, intended as an adaptive spatial system that sustain health, inclusion, and quality of life throughout the different ageing processes.

[1]The literature search across PubMed, Web of Science, and Google Scholar addressed conceptual and operational dimensions of age-friendly urban design, spanning WHO frameworks, technical standards, and recent developments in digitally enabled spatial interventions and nature-based urban design practices. Studies published from 2000 onward and relevant to urban or environmental design were included. Of 67 records identified, 34 met the inclusion criteria.

TECHNOLOGICAL INNOVATION IN THE URBAN ENVIRONMENT

Technological innovation in age-friendly urban design represents an exemplary shift from tailored solutions toward adaptive, data-informed, and co-created urban settings (Perillo, 2025). Within this transformation, frameworks such as Smart Healthy Age-Friendly Environments (SHAFE) have redefined technology as an embedded capability of the urban fabric, mediating autonomy, safety, and social connection across the life course (Dantas et al., 2021). Rather than focusing solely on accessibility or risk prevention, emerging approaches aim to produce responsive, participatory, and ethically grounded environments that evolve with the changing needs of ageing citizens, aligning with broader conceptions of the built environment as a key determinant of liveability and age-friendliness (van Hoof et al., 2021). Within this perspective, public-space evaluation criteria offer a transferable benchmark for assessing whether smart deployments substantively enhance inclusive urban experience (Mehta, 2014). Across the reviewed literature and pilot initiatives, three complementary trajectories can be identified. First, monitoring and prevention systems, exemplified by City4Age and ACTIVAGE, use interoperable IoT infrastructures, together with wearable sensors and mobile interfaces, to detect early signs of frailty, monitor mobility and enable personalised care interventions (Medrano-Gil et al., 2018). Second, interactive and participatory public spaces, such as those tested in UrbanLife+ and MUSA, deploy smart urban objects (SUOs), such as adaptive lighting, interactive benches, and gamified navigation systems, to enhance safety, orientation, and social engagement (Fietkau & Stojko, 2020; Padrón-Nápoles et al., 2021). Third, predictive and planning-oriented models, those developed in the URBANAGE project, employ Local Digital Twins (LDTs) and city information models to integrate accessibility data, simulate scenarios, and co-create inclusive urban solutions with citizens (Villanueva-Merino et al., 2024). To these trajectories, large-scale integrative ecosystems, such as PHArA-ON and GATEKEEPER, add a broader governance and interoperability dimension. Both projects demonstrate how distributed IoT infrastructures, AI, and cloud-based systems can link domestic and urban scales, promoting continuous and person-centred ageing support (D'Onofrio et al., 2022). Although originally developed to enhance independent living and health monitoring, both initiatives increasingly operate at the interface between technological and spatial systems. Their pilot regions demonstrate how digital infrastructures, when scaled to the urban fabric, can function as territorial

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enablers, integrating data on mobility, accessibility, and environmental quality. Taken together, these innovations signal the role of technology as a catalyst for equity, resilience, and participatory urban intelligence. Yet significant challenges persist, ranging from usability and digital literacy to data privacy and governance (Ciobanu et al., 2024), but also to the lack of meaningful involvement of older citizens, a condition that risks reproducing new forms of exclusion (Marston & van Hoof, 2019). Current scholarship underscores the need for ethical inclusion, embedding participatory design, accessibility-by-default, and data accountability across the full innovation cycle (van Hoof et al., 2021). Evidence further indicates that citizen-generated data enhances contextual accuracy while empowering older adults as co-producers of urban knowledge, thereby reinforcing digital-age inclusivity (Wood et al., 2022). Therefore, emerging technologies may operate as enablers of adaptive, socially cohesive, and longevity-oriented urban environments, particularly as their impacts intersect with wider urban dynamics, such as densification-driven changes in mobility, environmental stressors, and social cohesion, whose cumulative effects on mental health and wellbeing are increasingly recognised as non-linear and mediated by feedback mechanisms (Beenackers et al., 2024). Advances in neuroadaptive architecture extend this trajectory by introducing responsive spatial systems that attune to users' cognitive and affective states, enhancing environmental comfort and psychological wellbeing across age-diverse populations (Makanadar, 2024). Table 2 synthesises representative international projects that translate the integration of smart technologies into actionable design and governance models for age-friendly cities. Together, they illustrate the gradual shift from technology as assistive infrastructure to technology as an urban enabler of inclusion, participation, and wellbeing.

Project	Period	Technologies	Main Outcomes	Relevance for Age-Friendly Urban Design
City4Age (The ultimate city for the elderly population)	2015–2018 (EU/non-EU multi-site pilots)	Smartphones, wearable sensors, Bluetooth beacons, ambient sensing, urban information systems, behaviour-monitoring analytics	Demonstrated the feasibility of unobtrusive, behaviour-based monitoring to detect early changes in mobility, social activity and cognitive patterns among older adults across multiple pilot cities	Enables proactive, context-aware interventions that support autonomy, safety and participation of older adults in everyday urban environments, informing smarter and more responsive age-friendly city services
ACTIVAGE (ACTivating InnoVative IoT smart living environments for AGEing well)	2017–2020 (EU)	IoT interoperable ecosystem, wearable devices, environmental sensors, smart-home and smart-city IoT nodes, mobility and health monitoring platforms	Validated the first large-scale IoT pilots for Active and Healthy Ageing across different sites in Europe, integrating mobility, social participation and health data through an interoperable architecture	Demonstrates how scalable, interoperable smart-city systems can enhance autonomy, social inclusion, safety and wellbeing of older adults in community and urban environments
UrbanLife+	2015–2020 (Germany)	Smart Urban Objects (SUOs), including adaptive	Tested smart urban interfaces in real urban	Shows how interactive, co-designed technological elements can enhance safety, comfort and participation in public spaces, supporting age-friendly

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		lighting systems, interactive benches, sensor-based interfaces and gamification tools for social engagement	settings, demonstrating improvements in perceived safety, orientation, social interaction and overall experiential quality of public spaces for older adults	environments through experiential and responsive urban design
URBANAGE (Enhanced URBAN planning for AGE-friendly cities through digital twins)	2021–2024 (EU)	Local Digital Twins (LDT), City Information Models (CIM), geospatial analytics, AI-based prediction models, accessibility and mobility data integration, citizen-input interfaces	Developed predictive planning tools that combine accessibility, mobility and environmental data with citizen input to model inclusive scenarios for ageing populations across three European pilot sites	Demonstrates how data-driven, simulation-based approaches can support participatory and evidence-informed planning, enhancing accessibility, mobility and service provision for older adults in urban environments
MUSA (Mobiliario Urbano Sostenible y Avanzado)	Pilot 2018–ongoing (Municipal Pilot Project, Madrid)	IoT-enabled bus stops, interactive smart traffic furniture, automatic passenger counters (APC), multi-modal travel interfaces	Implemented prototype inclusive transport infrastructures in Madrid combining sensorized buses and smart stops, interactive displays and data systems to improve real-time service planning and user experience	Enhances urban mobility experience, wayfinding and safety for all users via inclusive transport infrastructure and interactive public-realm hardware
GATEKEEPER (Smart Living Homes - Whole interventions demonstrator for people at health and social risks)	2019–2023 (EU)	Standard-based open platform, IoT devices and sensors, AI analytics, data federation architecture, interoperable multi-stakeholder ecosystem	Established a large-scale, open and ethical data architecture engaging 40k + older users across European regions, enabling personalised services through interoperable health, mobility and environmental data flows	Demonstrates cross-domain data governance and interoperability models applicable to urban systems, supporting integrated approaches to mobility, health, safety and community services for ageing populations
PHArA-ON (Pilots for Healthy & Active Ageing in Europe)	2019–2024 (EU)	IoT sensors & devices, wearables, AI analytics, cloud/edge computing, big data platforms,	Validated multi-site digital ecosystems across Europe linking domestic,	Connects digital infrastructures across scales to support inclusive governance, mobility, service provision and longevity-oriented urban policies for ageing populations

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		open interoperable ecosystems	community and urban services for active ageing, leveraging interoperable platforms and integrated data flows	
SHAPES (Smart and Health Ageing through People Engaging in Supportive Systems)	2019–2023 (EU)	IoT devices and sensors, wearables, ambient assisted living systems (AAL), AI analytics, robotics, cloud/edge computing, federated digital platforms for cross-domain service integration	Validated a multi-country ecosystem linking home, community and care services through interoperable digital platforms, enabling personalised support, remote monitoring and coordinated service delivery for older adults across 15 pilot sites	Demonstrates how cross-scale digital infrastructures can connect domestic, neighbourhood and urban services, supporting inclusive governance, integrated mobility and care pathways, and longevity-oriented policy frameworks

Table 2. Key projects integrating technological innovation into age-friendly urban design

Across these initiatives, interoperability, user co-creation, and ethical data governance emerge as the strongest predictors of sustained impact. Projects that combine technological intelligence with participatory design generate more inclusive, context-sensitive outcomes, while isolated device-based pilots often fail to scale (van Hoof et al., 2021; D'Onofrio et al., 2022). Local Digital Twins, when embedded in transparent governance frameworks, represent a bridge between individual-level sensing and neighbourhood-scale decision-making, offering new pathways toward evidence-based, longevity-enabling urbanism (Villanueva-Merino et al., 2024).

URBAN GREEN AND BLUE INFRASTRUCTURE

Urban green and blue infrastructure (UGBI) have emerged as a cornerstone of contemporary age-friendly urban design, reframing the relationship between environmental quality, health, and longevity, while also operating as an infrastructure of social health that supports intergenerational interaction and community belonging (Buffel & Phillipson, 2018). UGBI integrates ecological, social, and health-promoting dimensions into urban systems, providing restorative, inclusive, and preventive environments for ageing populations. Design-oriented frameworks such as the ECN Adaptive Circular Cities project demonstrate how green and blue infrastructures can be designed to co-deliver ecosystem services and health outcomes, translating parameters such as temperature regulation, air purification, and noise reduction into spatial strategies that promote healthy urban living (ECN, 2022). However, as highlighted in the OECD's Cities for All Ages (2025) report, the benefits of green and blue infrastructure are maximised only when urban policy and planning are coordinated across housing, mobility, public space, social infrastructure, and service accessibility. Empirical evidence further shows that compact-city strategies frequently lead to the loss and fragmentation of green areas,

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weakening the continuity and effectiveness of UGBI networks and intensifying exposure to heat, noise, and crowding, that undermine the restorative and climate-regulating functions natural environments provide, particularly for older adults (Berghauser Pont et al., 2021; Balikçi et al., 2022). Quantitative findings also indicate that proximity to green infrastructure alone is insufficient to generate truly health benefits for older populations unless coupled with adequate design and maintenance (Davern et al., 2020). At the same time, exposure to green–blue environments is consistently associated with improved mental health and stress recovery (Dennis et al., 2019; Andreucci et al., 2019; White et al., 2020), a conclusion reinforced by recent WHO evidence linking access to diverse and accessible natural spaces with mental resilience, cognitive benefits, and reductions in all-cause mortality in later life (WHO, 2021). Recent research and practice converge on the need for environments that combine spatial design with systemic governance. Frameworks such as the WHO Age-Friendly Indicators (Kano et al., 2017) and the Active Ageing Index (UNECE, 2018) underscore the interdependence of environmental quality, accessibility, and participation as intertwined aspects of urban wellbeing. These insights reinforce the importance of multi-scalar, evidence-based approaches capable of linking ecological performance with public-health outcomes, echoing calls for integrated assessment models of outdoor environments (Mehta, 2014; Davern et al., 2020). Such approaches operationalise environmental quality through transferable indicators—proximity, connectivity, microclimatic regulation, and perceived safety, closely associated with the wellbeing of ageing communities (Villanueva et al., 2015; Davern et al., 2020). Collectively, these initiatives show how UGBI is conceived as multifunctional infrastructure underpinning urban environments conducive to healthy longevity. This integrative perspective aligns with emerging paradigms of evidence-based and reflexive design, which prioritise experiential quality, affective resonance, and human–environment reciprocity in the built environment (van Hoof, 2025). It advances the conception of cities that not only accommodate but actively foster healthy ageing, converging with the age-friendly movement's emphasis on equity and co-production (Buffel & Phillipson, 2018) and with international policy frameworks that recognise ecological infrastructures as crucial enablers of wellbeing in ageing populations (UNECE, 2018; Kano et al., 2017). The initiatives summarised in Table 3 exemplify how Urban Green and Blue Infrastructure (UGBI) strategies integrate ecological, social, and health objectives within age-friendly urban design, linking environmental performance with wellbeing and inclusion across the life course.

Source	Period	Objective	Relevance for age-friendly urban design
NYC Greenstreets Programme	1996-ongoing	To convert underused traffic islands and paved residual spaces into micro-greenspaces that enhance walkability, stormwater management and local microclimates throughout New York City's neighbourhoods	Improves neighbourhood-level walkability through distributed micro-green "rest points", offering shade, seating opportunities and cooler microclimates that support older adults' comfort, mobility and outdoor independence in dense urban areas
Cheonggyecheon River Restoration (Seoul, South Korea)	2003–2005	To transform a dismantled elevated highway into a continuous blue–green urban corridor that enhances walkability, microclimatic cooling, ecological restoration and public-realm quality, creating an accessible linear landscape integrated into the dense city centre.	Demonstrates how a revitalised blue–green corridor can support safe walking, thermal comfort, social activity and intergenerational use of public space, making dense environments more age-friendly and health-supportive

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Tokyo Green Road Network (Japan)	2007-ongoing	To create a metropolitan-scale network of tree-lined pedestrian paths, ecological corridors, riverside promenades and pocket parks designed to increase walkability, reduce heat exposure and enhance green connectivity across Tokyo's dense neighbourhoods	Improves thermal comfort and reduces heat-related risks—which disproportionately affect older adults—while providing shaded walking routes, rest areas and accessible ecological corridors that facilitate safe everyday mobility and outdoor activity for ageing populations
NHS Forest Programme (United Kingdom)	2009–ongoing	To integrate trees, pocket woodlands and green infrastructure into healthcare facilities and surrounding communities through large-scale planting, restorative landscape design and participatory greening, with the goal of improving environmental quality, supporting physical and mental health, and strengthening community engagement	Shows how therapeutic and climate-responsive green infrastructure embedded in healthcare and neighbourhood environments can enhance recovery, environmental comfort, walkability and social connectedness for older adults, contributing to healthier and more inclusive urban settings
Melbourne Urban Forest Strategy (Australia)	2012–ongoing	To expand and diversify the city's urban forest through large-scale street tree planting, micro-forest patches, and integrated blue–green infrastructure, with the goal of reducing urban heat, improving air quality, increasing walkability, and enhancing the ecological and social performance of public spaces	Strengthens age-friendly environments by mitigating heat stress—one of the major environmental risks for older adults—while improving shade, thermal comfort, pedestrian safety and opportunities for low-intensity outdoor activity, thereby supporting healthier, more resilient ageing in dense urban areas
Pocket-Park Interventions in Copenhagen (Denmark)	2014–ongoing	To implement small-scale "lommepark" interventions—compact neighbourhood greenspaces integrated into streetscapes and residual plots—to provide shade, seating, and opportunities for informal social interaction	Demonstrates how distributed micro-greenspaces within dense urban districts can support restorative breaks, social contact, and safe outdoor mobility for older adults, enhancing wellbeing in high-density settings.
Singapore Therapeutic Gardens Network	2016–ongoing	To develop a network of accessible therapeutic and sensory gardens within neighbourhoods and urban parks to promote psychological restoration, stress reduction, and cognitive engagement—particularly supporting seniors, including those with mobility limitations or mild cognitive impairment	Demonstrates how restorative landscape infrastructures integrated into everyday public environments can enhance mental wellbeing, sensory stimulation, and emotional comfort in later life, contributing to age-friendly urban spaces that support cognitive health, relaxation and safe outdoor activity
Barcelona Superblocks Programme (Spain)	2016–ongoing	To reorganise the structure of urban blocks to prioritise pedestrians, reduce vehicular traffic, and increase green and social spaces for community interaction	Enhances active mobility and outdoor sociability, improving cardiovascular health, reducing environmental stressors and promoting community interaction among older residents

Table 3. Representative initiatives integrating Urban Green and Blue Infrastructure (UGBI) into age-friendly urban design

DISCUSSION: TOWARD INTEGRATIVE AND ADAPTIVE FRAMEWORKS FOR LONGEVITY-ENABLING URBAN DESIGN

Across contemporary debates on age-friendly urban design, a growing alignment across the literature recognises that prescriptive checklists, static indicators and technical standards are no longer adequate for guiding interventions in increasingly complex, dense and dynamic urban

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environments. Although international frameworks, from the WHO Age-Friendly Cities agenda to the UN Decade of Healthy Ageing, have consolidated important normative foundations, their operational translation into urban design practice remains fragmented. Persistent gaps concern the limited ability of existing instruments to link environmental performance, experiential qualities and health outcomes (Kano et al., 2017; UNECE, 2018; Buffel & Phillipson, 2018). A central limitation concerns the lack of integration of emerging digital and smart city technologies and urban green and blue infrastructure strategies, two domains that have become structurally decisive for later life wellbeing. Even though UGBI is widely recognised for its contributions to microclimatic regulation, restorative benefits and enhanced walkability, qualities of particular value for older adults who are sensitive to heat, noise and environmental stressors (Dennis et al., 2019; Davern et al., 2020; WHO, 2021), these insights remain marginal within mainstream age-friendly standards. Similarly, rapid advances in IoT ecosystems, Local Digital Twins and AI-supported monitoring present substantial opportunities for older adults, offering enhanced environmental sensing, early risk detection and more responsive urban services that can support autonomy and safety in daily mobility (Wood et al., 2022; D'Onofrio et al., 2022). Yet their integration into guidelines often overlooks issues of usability, trust, behavioural adaptability and data governance. These gaps reveal a structural mismatch in which contemporary urban environments are increasingly shaped by densification pressures, technological infrastructures and climatic instability. Consequently, current frameworks struggle to articulate how environmental, technological and experiential dimensions interact to shape autonomy, mobility and wellbeing across their life course. Therefore, these limitations underscore the need for a new generation of instruments through integrative and adaptive approaches that connect environmental performance (e.g. microclimate regulation, ecological connectivity, accessibility), experiential qualities (e.g. comfort, legibility, perceived safety), and health and wellbeing outcomes (e.g. stress recovery, functional ability, resilience). Adopting an ergonomics and human factors lens helps clarify that these challenges are partly rooted in a narrow operationalisation of accessibility that tends to overlook the interdependence between usability, sensory comfort, environmental performance and behavioural adaptability. Thus, an ergonomics-informed perspective provides a conceptual bridge for integrating emerging digital technologies and UGBI into holistic models of environmental support for ageing populations, as it explicitly positions human–environment interaction at the core of everyday functioning and of the adaptive and inclusive design strategies. Within this expanded operational and conceptual landscape, the paper advances the transition from age-friendly urban environments to longevity-enabling environments. This shift reframes the goal from providing universally "age-friendly" features to designing dynamic socio-environmental systems capable of sustaining functional ability, autonomy and wellbeing across the entire life course. The longevity-enabling approach to urban environments foregrounds the need to monitor and respond to the continuous interaction between changing individual capabilities of users and evolving environmental conditions. In this perspective, a proactive orientation provides a strong pathway for including digital technologies and UGBI into contemporary urban design practices, strengthening their potential to sustain functional ability and support more adaptive, future-ready environments.

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ACKNOWLEDGMENTS

This article is based upon work from the Italian Ministry of University and Research's Enlarged Partnership 8 "A novel public-private alliance to generate socioeconomic, biomedical and technological solutions for an inclusive Italian ageing society" (Project number: PE0000015), supported by the Italian National Recovery and Resilience Plan, financed by Next Generation Europe programme.

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