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Integrating Neurourbanism into Urban Planning: A Charta-Based Indicator Framework for Public Open Spaces to Foster Social Connectivity and Support Mental Health

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Abstract

Rapid urbanization has intensified concerns about how spatial, environmental, and social conditions influence stress, social isolation, social connectivity, and mental health. In response, Neurourbanism has emerged as an interdisciplinary field linking neuroscience, mental health, urban planning, and public health. However, its findings remain insufficiently translated into assessable planning conditions for public open spaces (POS). Accordingly, this study aims to develop a literature-derived, Charta-based indicator framework for POS that identifies planning conditions to foster social connectivity and support mental health. The study methodology applied a critical integrative review, supported by systematic procedures, to examine relevant literature and develop the proposed framework. The study reviewed evidence from Neurourbanism, urban planning, public health, social isolation, social connectivity, and public-space research and translated it into assessable POS conditions. The study consolidated these conditions into 23 indicators, mapped them to the nine Charta of Neurourbanism as Direct or Indirect conceptual relationships, and organized them into seven operational domains. The resulting framework includes 94 indicator–Charta mappings: 28 Direct and 66 Indirect relationships. The findings show that POS relevance depends on the interaction of accessibility, environmental quality, safety, inclusion, cultural relevance, governance, and opportunities for social activity rather than on physical provision alone. The framework provides a structured basis for expert review and empirical validation across different contexts. Mental health and social outcomes require empirical testing and are not assumed.

Keywords: *Neurourbanism; Public Open Spaces; Social Connectivity; Mental Health; Built Environment; Urban Planning; Charta of Neurourbanism*

1. INTRODUCTION

Rapid urbanization has been linked to a range of interconnected urban health challenges, including overcrowding, social disconnection, and adverse mental and population-health outcomes, increasing pressure on public-health systems (Gruebner et al., 2017; Turan & Beşirli, 2008). Within this broader context, social isolation and loneliness have emerged as particularly significant public-health concerns because of their well-documented associations with adverse psychological and physical health outcomes (Hoang & Conn, 2024; Kim et al., 2021; New Jersey Department of Human Services, Office of Research and Evaluation [NJDHS], 2023). Although the literature broadly agrees that urban conditions influence mental health, it differs in conceptual emphasis. Some studies primarily foreground social determinants, socioeconomic inequality, social isolation, and weakened social networks (Allen et al., 2014; Simon et al., 2024; Turan & Beşirli, 2008). Others concentrate more directly on environmental stressors, patterns of urban exposure, and their neurobiological consequences (Costa e Silva & Steffen, 2019; Lambert et al., 2015). Adli et al. (2017) and Gruebner et al. (2017) integrate these perspectives, indicating that mental-health risks may emerge through interactions between the physical characteristics of urban environments and social conditions such as density, isolation, poverty, migration, and socioeconomic disadvantage.

Yet policy responses often prioritize social care and health services while paying less attention to the urban conditions that shape mobility, social encounters, and participation (Goldman et al., 2024; Taylor et al., 2023). However, this evidence has rarely been translated into assessable spatial conditions for planning practice (Capolongo et al., 2018; Gruebner et al., 2017), and the problem is especially apparent in Neurourbanism. Existing studies examine urban stress and mental well-being (Adli et al., 2017; Bonifácio et al., 2023), as well as navigation, spatial cognition, embodied experience, and emotional responses to urban environments (Giray Küçük & Yüceer, 2022; Purwanto & Ayuningtyas, 2022). However, these insights have not yet translated into consistent planning guidance or systematic approaches for assessing public spaces (Bonifácio et al., 2023). This translation is further complicated by differences in study design,

exposure conditions, measurement tools, analytical methods, and outcome variables, which make findings difficult to compare and synthesize across studies (Ancora et al., 2022; Hedin et al., 2022).

This problem is especially important for public open spaces (POS), including parks, plazas, streets, waterfronts, pocket parks, cultural spaces, and green corridors. These settings can support everyday sociability, social interaction, and social cohesion (Addas & Rishbeth, 2018; Jennings & Bamkole, 2019; Salih & Ismail, 2017; Whyte, 1980), while green POS may also contribute to restoration and mental well-being through environmental, physical-activity, and social pathways (Chen et al., 2021). Yet these benefits cannot be assumed from the mere provision of space. Whether POS are used and able to support health and well-being depends on conditions such as accessibility, proximity, safety, maintenance, and the availability of suitable features and activities (Clarke et al., 2023; Gianfredi et al., 2021; Hamilton et al., 2017; Hussein et al., 2022). Their ability to foster inclusive and meaningful encounters also depends on cultural inclusion, management, publicness, and opportunities for diverse users to gather and participate (Clarke et al., 2023; Li et al., 2022).

Accordingly, this study develops a literature-derived, Charta-based indicator framework that translates Neurourbanism into POS planning. It synthesizes interdisciplinary evidence, identifies assessable POS conditions, interprets them through the nine Charta of Neurourbanism—Public, Aesthetic, Mobility, Relationship, Participation, Diversity, Density, Segregation, and Culture (Interdisciplinary Forum Neurourbanism e.V. [IFN], n.d.-h)—and organizes them into planning-oriented domains. The framework provides a traceable basis for translating interdisciplinary evidence into assessable POS indicators and for subsequent expert review, empirical validation, and context-sensitive application; it is not presented as a validated causal model.

2. LITERATURE REVIEW

2.1. Urban Mental Health as a Spatial and Social-Determinant Issue

Cities provide access to healthcare, services, and other essential resources, yet urban living can also expose residents to environmental and social stressors (Gruebner et al., 2017). Socioeconomic inequality, poverty, disadvantage, and poor living conditions are important social determinants of mental health (Allen et al., 2014), while population density, noise, pollution, and social isolation may create additional psychological pressures (Gruebner et al., 2017). Limited access to green and public spaces, together with weak social cohesion, may further reduce opportunities for restoration, social interaction, and support (Chen et al., 2021; Gianfredi et al., 2021; Jennings & Bamkole, 2019).

Urbanicity has also been associated with mood and anxiety disorders and other adverse psychiatric outcomes. However, these relationships arise from interactions among environmental, social, and individual factors instead of from urban residence alone (Costa e Silva & Steffen, 2019; Gruebner et al., 2017). At the neuroscientific level, current urban living and urban upbringing have been associated with differences in neural responses to social-evaluative stress, particularly in the amygdala and perigenual anterior cingulate cortex (Lederbogen et al., 2011). Broader reviews further suggest that physical and social urban exposures may shape mental health through interconnected neurobiological, emotional, and stress-related pathways (Lambert et al., 2015; Senkler et al., 2023). These findings have led planning and public health scholars to call for stronger integration of health knowledge, restorative environments, and opportunities for social connection. Yet it remains unclear how to translate these relationships into practical, assessable conditions for urban planning (Bonifácio et al., 2023; Buttazzoni et al., 2022; Jalilisadrabad et al., 2023; Yao, 2023).

2.2. Social Isolation, Loneliness, and Spatial Opportunity

Loneliness is the subjective perception that one's social relationships are inadequate, whereas social isolation is an objectively assessable condition marked by limited ties, infrequent contact, or restricted social participation (de Jong Gierveld et al., 2006; Hoang & Conn, 2024; NJDHS, 2023). Although related, they may occur independently; a person may be isolated without feeling lonely or feel lonely despite frequent contact. Treating them as interchangeable can therefore complicate measurement and intervention. Urban planning cannot create meaningful relationships, but it can shape places that enable social contact, participation, and repeated encounters (Carstensen et al., 2022; Mehta, 2009).

Both loneliness and social isolation are associated with adverse mental and physical health outcomes, including depression, anxiety, cognitive decline, cardiovascular disease, poor self-rated health, and increased mortality (Hoang & Conn, 2024; Kim et al., 2021; NJDHS, 2023). Spatial conditions also shape

participation opportunities across the life course. Limited access to youth-oriented social infrastructure has been associated with greater mental-health difficulties among children and adolescents, particularly in deprived areas (Stahlmann et al., 2022). Among older adults, transport barriers, low income, poor health, and limited access to community resources may increase isolation (Hand et al., 2017; NJDHS, 2023). The central planning issue is therefore not whether a place is urban, but whether it provides equitable access, safe mobility, inclusive public spaces, and meaningful opportunities for participation (Llopis Abella et al., 2020; Salih & Ismail, 2017; South Ayrshire Health and Social Care Partnership, 2019). These conditions should form part of broader policy responses to loneliness and social isolation (Goldman et al., 2024).

2.3. Neurourbanism and the Translation Gap

Neurourbanism is an interdisciplinary field that links neuroscience and mental health research with urban planning, public health, environmental psychology, and built environment studies (Adli et al., 2017; Bonifácio et al., 2023; Buttazzoni et al., 2022; Ndaguba et al., 2022). It examines how built and natural urban environments relate to neural and physiological processes, behavior, spatial cognition, emotion, and mental well-being (Ancora et al., 2022; Costa e Silva & Steffen, 2019; Purwanto & Ayuningtyas, 2022).

Research has identified navigation, contact with nature, multisensory experience, environmental stress, visual complexity, legibility, enclosure, and linkage as relevant to how people perceive and experience urban environments (Buttazzoni et al., 2022; Ellard, 2020; Giray Küçük & Yüceer, 2022). Reviews also associate green, blue, and biodiverse environments with potentially positive cognitive, emotional, and stress-related responses, although these relationships are neither uniform nor deterministic (Ancora et al., 2022; Buttazzoni et al., 2021).

Despite this growing evidence, Neurourbanism remains theoretically and methodologically emergent and offers limited practical guidance for planners and policymakers (Bonifácio et al., 2023; Ndaguba et al., 2022). Existing frameworks connect environmental exposure to psychosocial and neurobiological mechanisms, but they have not established a method for assessing public open spaces (Buttazzoni et al., 2022).

Health-oriented planning research has developed observable indicators related to environmental risks, green infrastructure, mobility, physical activity, and access to resources, while emerging methods including physiological monitoring, emotional mapping, and affective computing offer additional possibilities for urban evaluation (Prokofyeva & Lebedeva-Nesevrya, 2018; Purwanto & Ayuningtyas, 2022; Robu-Movilă et al., 2025).

2.4. Public Open Spaces, Publicness, and Mental-Health Relevance

Public open spaces function as social, sensory, ecological, cultural, and health-relevant infrastructure. Their value depends not only on their physical presence or size, but on whether parks, plazas, streets, pocket parks, community spaces, and cultural facilities are accessible, welcoming, usable, safe, well-maintained, and supportive of participation and social encounter (Kostrzewska, 2017; Salih & Ismail, 2017; Samavati et al., 2025). Although green and public spaces have been associated with health, well-being, and social cohesion, their benefits may remain limited when they are inaccessible, poorly maintained, underused, or deprioritized (Gianfredi et al., 2021; Moughtin & Shirley, 2005; Yin et al., 2023).

Features such as seating, visibility, human scale, usable edges, transparent frontages, reduced traffic speed, pedestrian-oriented design, activity, safety, and effective management can support staying, observation, and interaction (Mehta, 2009; Salih & Ismail, 2017; Whyte, 1980). However, the capacity of these spaces to support inclusive use also depends on publicness, including sustained access, inclusion, permissible activities, maintenance, representation, and enabling management rather than ownership or physical provision alone (Clarke et al., 2023; Gianfredi et al., 2021; Hamilton et al., 2017; Karimi et al., 2022; Li et al., 2022).

Restorative opportunities are not limited to large parks. Streets, pocket parks, community gardens, informal greenery, and other everyday spaces may provide repeated contact with nature when they are accessible, safe, maintained, and connected to neighborhood routes (Gianfredi et al., 2021; Moughtin & Shirley, 2005; Myers, 2020; Yin et al., 2023). POS should therefore be assessed as networks of formal and informal environments rather than as isolated sites. Provision, accessibility, publicness, internal quality,

and social usability are assessable planning conditions; restoration, belonging, mental well-being, and social connectivity require empirical validation.

2.5. The Nine Charta of Neurourbanism

The Charta of Neurourbanism comprises nine interconnected fields—Public, Aesthetic, Mobility, Relationship, Participation, Diversity, Density, Segregation, and Culture—that bring together interdisciplinary perspectives on urban resilience and mental health (IFN, n.d.-h). In this study, the Charta serve as analytical lenses rather than operational domains or substitutes for the seven framework domains. They guide the interpretation and mapping of literature-derived POS indicators related to social connectivity, isolation risk, and mental well-being.

2.5.1. Public Charta: Publicness and Socially Supportive POS

The Public Charta frames public space as a setting for encounter, lingering, participation, and social exchange, where people engage with both the physical environment and the wider community (IFN, n.d.-d). From this perspective, publicness is understood not only in legal terms, but through how spaces are accessed, managed, and experienced as inclusive in everyday life (Li et al., 2022). At the street and public-space scales, seating, active and usable edges, visible activity, pedestrian-oriented design, and supportive management may encourage people to stay and interact (Mehta, 2009; Whyte, 1980). Design may also shape how attractive and welcoming a space feels, although the relationship between social diversity, trust, interaction, and cohesion varies across groups and contexts (Llopis Abella et al., 2020).

2.5.2. Aesthetic Charta: Sensory Experience and Restorative Quality

The Aesthetic Charta extends beyond visual appearance to include the sensory, emotional, cognitive, and symbolic experience of urban environments. It highlights complexity, coherence, comprehensibility, mystery, prospect–refuge relationships, openness, navigation, and sensory diversity as relevant to aesthetic appraisal, orientation, identity, exploration, and social interaction (IFN, n.d.-e). Related literature also emphasizes navigation, contact with nature, embodied and multisensory experience, and reduced environmental stressors as important considerations for neuro-urban design (Giray Küçük & Yüceer, 2022). In planning terms, urban aesthetics includes experiential and functional qualities that affect cognition, emotion, identity, and meaning; it is not limited to visual appearance (Nia & Atun, 2016; Nia & Olugbenga, 2020; Purwanto & Ayuningtyas, 2022).

Evidence concerning specific environmental features is more varied. Trees, flowers, and water have been associated with aesthetic preference and perceived restoration (Wang et al., 2019), while park walking and artistic interventions have been linked to short-term improvements in mood, anxiety, stress, or physiological relaxation, although findings are not consistent across outcome measures (Mikuni et al., 2024; Pratiwi et al., 2020). By contrast, shade, seating, lighting, greenery, safety, and accessibility are better treated as assessable conditions that support comfort, usability, and environmental quality instead of as restorative outcomes (Thilakaratne, 2022). On the other hand, biodiversity adds an ecological and experiential dimension, although its relationship with mental health remains difficult to establish because theories, variables, and methods differ across studies (Hedin et al., 2022).

2.5.3. Mobility Charta: Access, Walkability, and Everyday Movement

The Mobility Charta frames movement not only as efficiency but also as a condition for access, participation, social connection, and well-being. Active mobility, mixed land use, public transport, and equitable access can expand opportunities, whereas unsafe routes, traffic, and physical barriers may restrict movement and participation (IFN, n.d.-b). Walkability, access to destinations and services, transport connectivity, greenery, and safety all shape how people move through and engage with their neighborhoods. Perceived walkability has been associated with greater social activity (Danquah et al., 2022), while access to destinations has been linked to happiness, health, neighborhood satisfaction, and reduced car dependence (Leyden et al., 2024). Neighborhood and transport conditions are also important for older adults' out-of-home activity and ability to age in place (König et al., 2019; Menec et al., 2019). Access to facilities and proximity to parks may further support mental health through pathways related to safety and social cohesion (Zhang et al., 2022). Vegetation, tree cover, and walkable access to parks may likewise encourage walking and broaden opportunities for physical activity, social interaction, and well-being (Lin et al., 2023; Yang et al., 2019).

2.5.4. Relationship Charta: Social Cohesion and Social Infrastructure

The Relationship Charta focuses on interpersonal connection, social inclusion, belonging, and the balance between proximity and distance, while recognizing loneliness and social isolation as forms of

urban stress. It highlights age- and culturally responsive public, green, recreational, and cultural spaces that may support participation and relationship-building (IFN, n.d.-f). Related research identifies parks, plazas, walkability, mixed land use, communal facilities, and greenery as conditions that may support social interaction, cohesion, and sense of community, although their influence varies across users and contexts (Cao & Kang, 2019; Cui et al., 2024; Jennings & Bamkole, 2019). Physical provision alone, however, does not ensure social connection. Language barriers, discrimination, cultural disconnection, limited resources, and insensitive urban renewal may restrict interaction or disrupt established social practices (He et al., 2021; Johnson et al., 2019). Walkability and social infrastructure are therefore most effective when spaces are accessible, connected, culturally responsive, and supported by activities that bring people together (Danquah et al., 2022; Kim & Kim, 2024).

2.5.5. Participation Charta: Civic Engagement and Inclusive Governance

The Participation Charta emphasizes co-production, representation, inclusive governance, and civic presence, positioning residents as active contributors to the planning, design, management, and programming of urban spaces (IFN, n.d.-g). Participation may strengthen trust, attachment, efficacy, and social connection, but it can be limited by cost, transport, accessibility, stigma, confidence, and other practical or social barriers (Baxter et al., 2022). Meaningful participation therefore depends on affordable, welcoming, inclusive, and low-pressure settings. Community involvement may also help improve underserved parks, align renewal with local needs, and support migrant recognition, integration, and cohesion (Baxter et al., 2022; He et al., 2021; Zhang et al., 2023).

2.5.6. Diversity Charta: Inclusive and Multicultural Public Space

The Diversity Charta considers whether people of different ages, abilities, genders, incomes, ethnicities, religions, cultures, and backgrounds are welcomed and able to use POS (IFN, n.d.-c). Patterns of use may vary according to age, culture, spatial layout, soundscape, and preferred interpersonal distance, requiring spaces that support interaction, parallel use, and culturally diverse behaviors (Cao & Kang, 2019; Han et al., 2022).

Diversity also depends on whether spaces feel welcoming in practice. Inclusive design, flexible use, events, and cultural recognition may encourage participation, whereas territoriality, surveillance, fencing, poor maintenance, and exclusionary governance may discourage it (Clarke et al., 2023; Li et al., 2022). However, diversity does not necessarily result in direct interaction; different groups may share the same space while maintaining distinct relationships with landscape, memory, nature, and home (Addas & Rishbeth, 2018).

2.5.7. Density Charta: Compactness, Capacity, and Crowding

The Density Charta treats density as a context-dependent urban condition rather than inherently beneficial or harmful. Compact, mixed-use neighborhoods may shorten travel distances, improve walkability and access to services, and create more opportunities for social interaction (Giles-Corti et al., 2022; Mouratidis, 2018). Density may become stressful, however, when experienced as involuntary crowding or combined with inadequate housing, limited privacy, noise, pollution, insufficient green or public space, and reduced control over the immediate environment (Adli et al., 2017; Costa e Silva & Steffen, 2019; Ghazali et al., 2020; Gruebner et al., 2017; IFN, n.d.-i). Comparisons remain difficult because studies define and measure urban density and exposure inconsistently (Senkler et al., 2023).

Evidence from Greater Cairo illustrates this complexity. Higher density was associated with better mental well-being in medium-socioeconomic-status neighborhoods, whereas lower density was associated with better well-being in higher-socioeconomic-status areas. Safety, noise, privacy, facilities, access to open space, aesthetics, and satisfaction with housing and neighborhood conditions also shaped these differences (Ouda et al., 2020). Density should therefore be assessed alongside POS capacity, greenery, services, walkability, mixed land use, privacy, environmental quality, and opportunities for interaction rather than in isolation (Giles-Corti et al., 2022; IFN, n.d.-i; Mouratidis, 2018; Ouda et al., 2020).

2.5.8. Segregation Charta: Spatial Justice and Unequal Access

The Segregation Charta addresses spatial justice, affordability, universal access, exclusion, unequal distribution, and displacement. Processes such as privatization, financialization, gentrification, and uneven investment may displace lower-income groups, weaken diversity, and increase insecurity or loss of place identity (IFN, n.d.-a).

Segregation also operates through unequal exposure and access. Poverty, discrimination, environmental burdens, limited access to nature, weak social cohesion, and the absence of culturally supportive neighborhood environments have been associated with greater vulnerability or mental-health risk (Gruebner et al., 2017; Karimi et al., 2022). Deprivation and uneven infrastructure may also constrain access to transport, services, public spaces, and social opportunities (Lynch et al., 2021). These inequalities may affect low-income residents, older adults, children, and adolescents through differences in safety, accessibility, park condition, suitable features, proximity, and social cohesion (Cui et al., 2024; Hussein et al., 2022; Stahlmann et al., 2022; Zhang et al., 2022). POS assessment should therefore examine not only whether spaces exist, but how they are distributed, reached, maintained, and experienced across social and socioeconomic groups.

2.5.9. Culture Charta: Identity, Memory, and Cultural Infrastructure

The Culture Charta focuses on memory, identity, heritage, art, cultural infrastructure, and the meanings people attach to place. Cultural facilities, heritage sites, public spaces, and everyday cultural settings may support recognition, encounter, belonging, and well-being (IFN, n.d.-j). Culturally responsive Neurourbanism therefore considers place attachment, collective memory, and sociocultural meaning alongside physical design (Giray Küçük & Yüceer, 2022). Evidence from six Global South cities suggests that access to cultural and green infrastructure may strengthen participation, trust, engagement, and belonging, although these relationships depend on connectivity and equitable distribution (Tuhkanen et al., 2022). Culture-led regeneration may likewise support identity, creativity, and local development, but its outcomes depend on authenticity, safety, stakeholder participation, governance, and adaptable programming (Montgomery, 2004). Cultural meaning becomes relevant to POS assessment when it is accessible, recognized, represented, and supported through everyday use.

2.5.10. Variation in Operational Evidence Across the Charta

In the literature reviewed for this study, the nine Charta differed in how readily they could be translated into observable and assessable POS conditions. Public, Aesthetic, Mobility, and Relationship were more frequently represented through spatial, environmental, design, and use-related characteristics, whereas Participation, Diversity, Culture, Density, and Segregation more often required governance, inclusion, cultural, population, or area-level measures. This pattern reflects the composition of the reviewed literature and should not be interpreted as a ranking of theoretical importance, evidence quality, or causal relevance; rather, it identifies dimensions requiring further operational definition, context-specific measurement, and empirical validation.

2.6. Cross-Domain Evidence Synthesis and Derivation of Preliminary POS Conditions

The literature indicates that the mental-health and social relevance of urban environments emerge from interactions among spatial, environmental, and social conditions rather than from any single feature. Deprivation, segregation, crowding, limited access to nature and public space, and weak social cohesion have been associated with poorer mental-health outcomes, whereas accessible greenery, restorative environments, safe mobility, and socially supportive settings may offer protective pathways (Allen et al., 2014; Ancora et al., 2022; Buttazzoni et al., 2021, 2022; Gruebner et al., 2017).

Neurourbanism helps explain the sensory, cognitive, behavioral, and stress-related processes through which urban environments may affect people, while POS research identifies observable conditions that planners can assess. These include accessibility, connectivity, greenery, seating, shade, maintenance, safety, publicness, cultural inclusion, activity, and opportunities for social encounter (Clarke et al., 2023; Giray Küçük & Yüceer, 2022; Li et al., 2022; Mehta, 2009; Purwanto & Ayuningtyas, 2022; Whyte, 1980).

The unresolved issue is how to translate this evidence into POS assessment. Although the literature does not establish a single validated causal pathway between POS characteristics and mental-health outcomes, findings across several fields provide a basis for identifying preliminary and assessable POS conditions (Bonifácio et al., 2023; Buttazzoni et al., 2022; Clarke et al., 2023). The indicators developed in this study therefore represent a researcher-led synthesis of observable planning conditions. Restoration, belonging, social connectivity, reduced stress, and reduced isolation are treated as potential outcomes associated with these conditions and require further empirical testing.

Table 1 brings together the main evidence discussed in the literature review and examines it in relation to the nine Charta of Neurourbanism. The first column groups the evidence according to the main themes identified in the review. Then, the second column describes the urban or POS conditions discussed within each theme, and the third presents the mental-health, well-being, or social outcomes associated with those

conditions. The fourth column interprets these findings from a planning perspective by specifying the spatial, environmental, or social conditions that POS planning may address. From these planning implications, the fifth column presents the POS indicators developed in this study as assessable representations of these conditions. The following column links each relationship to the relevant Charta, providing a conceptual basis for interpreting the evidence, while the final column lists the supporting literature to maintain traceability between the framework and its sources.

Table 1. Cross-Domain Evidence Synthesis and Derivation of POS Indicators

Literature	Urban/POS condition	Mental health outcome	POS planning	Researcher-Proposed POS Indicators	Relevant Charta	Supporting Sources
Urban mental health	Deprivation, segregation, weak cohesion	Anxiety, depression	Equity and socially supportive access	Equitable spatial distribution of POS; Accessibility for all users; Accessibility to POS; Functional suitability for user needs	Segregation; Public; Relationship	Allen et al., 2014; Gruebner et al., 2017
	Crowding, limited privacy and nature	Stress, lower well-being	Adequate capacity and restorative exposure	Capacity related to population density; Availability of greenery	Density; Aesthetic; Public	Buttazzoni et al., 2021; Ouda et al., 2020; Senkler et al., 2023
	Limited access to public and green spaces	Poorer mental health; reduced well-being	Reachable and usable everyday POS	Accessibility for all users; Proximity to POS; Availability of POS; Accessibility to POS	Public; Mobility; Segregation	Allen et al., 2014; Stahlmann et al., 2022
Isolation and loneliness	Inaccessible/ unsafe spaces	Higher isolation risk	Safe, equitable reach to destinations	Safe pedestrian connectivity to POS; Accessibility for all users; Equitable spatial distribution of POS; Internal walkability within POS	Mobility; Public; Segregation	Lynch et al., 2021; Stahlmann et al., 2022
Social connectivity	Limited participation and repeated encounters	Lower belonging and social connectivity	Support gathering, activity, and participation	Availability of activity spaces; Availability of social gathering spaces; Inclusive governance and management	Relationship; Participation; Public	Goldman et al., 2024; Llopis Abella et al., 2020; Taylor et al., 2023
Neurourbanism	Nature and green-space exposure	Restoration and improved mood	Provide accessible, usable natural elements	Availability of greenery; Quality landscape elements	Aesthetic; Public	Ancora et al., 2022; Buttazzoni et al., 2021
	Poor navigation, spatial coherence	Discomfort and reduced usability	Support wayfinding and spatial comprehension	Legibility and ease of orientation	Aesthetic; Mobility; Public	Giray Küçük & Yüceer, 2022; Purwanto & Ayuningtyas, 2022
POS evidence	Provision without access or distribution	Limited restorative and social relevance	Assess POS as a connected system	Availability of POS; Availability of diverse POS types; Equitable spatial distribution of POS; Proximity to POS	Public; Mobility; Segregation	Gianfredi et al., 2021; Moughtin & Shirley, 2005
	Ownership without management	Exclusion and limited contact	Assess lived publicness	Accessibility for all users; Accessibility to POS; Cleanliness and maintenance; Inclusive governance and management	Public; Diversity; Participation	Clarke et al., 2023; Li et al., 2022

Literature	Urban/POS condition	Mental health outcome	POS planning	Researcher-Proposed POS Indicators	Relevant Charta	Supporting Sources
	Insufficient seating, shade, and activity	Fewer opportunities for interaction	Support movement and staying	Availability of seating areas; Availability of shaded areas; Functional suitability for user needs; Availability of activity spaces	Public; Aesthetic; Relationship	Mehta, 2009; Whyte, 1980
	Poor visibility, lighting, and perceived safety	Restricted use and contact	Assess perceptual and spatial safety conditions	Perceived safety; Availability of lighting	Public; Aesthetic; Mobility	Clarke et al., 2023; Mehta, 2009
Culture and inclusion	Cultural disconnection, weak recognition	Lower belonging; isolation risk	Support culturally inclusive use	Cultural inclusiveness and relevance; Functional suitability for user needs	Culture; Diversity; Public	Addas & Rishbeth, 2018; Tuhkanen et al., 2022
Public, Mobility Charta	Access, walkability, and destination connection	Participation and contact opportunities	Evaluate external and internal movement	Accessibility to POS; Proximity to POS; Internal walkability within POS	Public; Mobility	Danquah et al., 2022; Zhang et al., 2022
Aesthetic Charta	Visual, ecological, and enclosure conditions	Reduced stress and improved experience	Assess internal experiential quality	Availability of greenery; Legibility and ease of orientation; Quality landscape elements; Spatial openness and enclosure balance; Availability of shaded areas	Aesthetic; Public	Purwanto & Ayuningtyas, 2022
Relationship, Participation	Limited spaces for encounter and involvement	Lower cohesion and belonging	Support social affordance and co-production	Availability of social gathering spaces; Availability of activity spaces; Inclusive governance and management; Availability of shaded areas	Relationship; Participation; Public	Baxter et al., 2022
Diversity, Segregation, Culture, Density	Unequal access and cultural exclusion	Unequal well-being; isolation risk	Assess equity, capacity, and distribution	Accessibility for all users; Capacity related to population density; Cultural inclusiveness and relevance; Equitable spatial distribution of POS	Diversity; Segregation; Culture; Density	Gruebner et al., 2017; Tuhkanen et al., 2022

(Source: Authors)

2.7. Interpretation of the Synthesis

The synthesis distinguishes three analytical levels: mental- and public-health research identifies urban exposures and associated outcomes; Neurourbanism helps interpret the possible sensory, cognitive, behavioral, and stress-related pathways through which urban conditions may be experienced; and POS research identifies spatial, environmental, social, and managerial conditions that can be assessed in planning practice. These levels are complementary, not interchangeable. The first establishes the health and social relevance of urban conditions, the second provides a conceptual basis for interpreting possible pathways, and the third translates that evidence into planning-relevant conditions. This distinction provides the rationale for the framework-development process described in the following methodology.

3. METHODOLOGY

3.1. Research Design and Approach

This study used a critical integrative review informed by systematic procedures and combined with a framework-development design. The approach enabled conceptual and methodologically diverse evidence from Neurourbanism, urban planning, public health, social-isolation and social-connectivity research, and public-space studies to be compared and translated into a planning-oriented analytical framework, without attempting exhaustive retrieval or quantitative aggregation.

The study pursued three principal objectives: (a) to interpret the planning-relevant dimensions represented by the nine Charta of Neurourbanism; (b) to derive and consolidate literature-based, assessable conditions of public open spaces into a set of planning indicators while distinguishing these conditions from social-connectivity and mental-health outcomes; and (c) to develop a Charta-based framework that systematically maps and organizes the resulting indicators and provides a structured basis for their future evaluation and empirical validation.

The study was not designed as a formal systematic or scoping review. Nevertheless, systematic procedures were documented to strengthen transparency and analytical traceability, including source types, eligibility criteria, evidence clusters, indicator-extraction and consolidation decisions, and the rules used to classify and map retained indicators to the nine Charta.

3.2. Literature Identification and Evidence Sources

Literature identification followed an iterative and purposive process consistent with a critical integrative review. Sources were identified through targeted academic searches, backward reference-list checking, citation-based follow-up, and consultation of the official Charta of Neurourbanism sources. Search terms were combined and refined based on the main evidence clusters. They included Neurourbanism, urban mental health, urban stress, social isolation, loneliness, social connectivity, public space, POS, accessibility, proximity, walkability, publicness, green space, perceived safety, participation, cultural inclusion, spatial distribution, and planning indicators. The aim was to identify interdisciplinary evidence relevant to framework development, not to claim exhaustive coverage.

3.3. Definition and Scope of POS

This study defines POS as outdoor or predominantly open urban settings that are publicly accessible in everyday practice and that support movement, staying, recreation, gathering, participation, or social encounters. These settings include parks, plazas, streets, sidewalks, waterfronts, playgrounds, green spaces, pedestrian routes, pocket parks, and publicly accessible residential open spaces. Markets, cultural facilities, community facilities, transport-linked settings, and other forms of social infrastructure were considered only when their publicly accessible outdoor components or their direct functional relationship with a POS network was relevant to the assessment.

3.4. Eligibility and Screening

Sources were included when they contributed directly to at least one of the following areas:

1. the relationship between urban spatial or environmental conditions and mental health or well-being;
2. social isolation, loneliness, social connectivity, participation, or repeated encounter in urban settings;
3. Neurourbanism, environmental stress, sensory experience, cognition, mobility, restoration, or urban exposure;
4. the accessibility, publicness, safety, quality, management, use, or social function of POS; or
5. the conceptual interpretation or operational assessment of the nine Charta of Neurourbanism.

Sources were excluded when they lacked a meaningful urban, spatial, environmental, or public-space dimension; focused exclusively on clinical diagnosis or treatment without a built-environment component; addressed outcomes that could not be translated into planning-relevant conditions; or did not contribute directly to indicator derivation, Charta interpretation, or framework development.

3.5. Framework-Development Stages

The framework was developed in four stages (Figure 1). First, evidence on urban mental health, environmental stress, social isolation, and social connectivity was synthesized to establish the relevance of POS. Second, Neurourbanism literature was examined to identify how evidence on stress, cognition, restoration, mobility, density, and natural environments could inform assessable planning variables. Third, eligible conditions were consolidated into 23 indicators and interpreted through the nine Charta

as Direct or Indirect conceptual relationships. Fourth, the indicators were grouped by primary assessment function into seven operational domains.

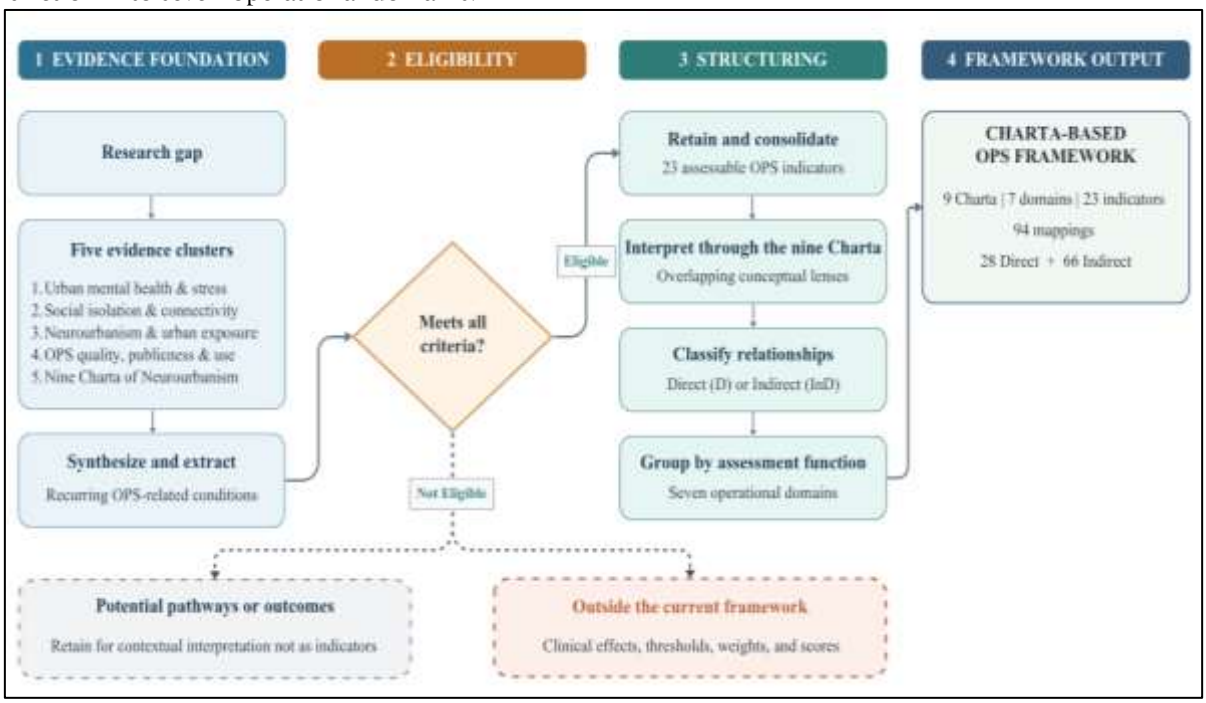

Figure 1. Framework-development process for the Charta-based POS indicator framework

3.6. Indicator Extraction and Charta Mapping

A Direct mapping was assigned when an indicator corresponded to a defining concept of a Charta field and represented a primary conceptual basis for interpreting that indicator. An Indirect mapping was assigned when the reviewed evidence supported a secondary, enabling, or contextual relationship with the Charta field, while the indicator's primary assessment function lay elsewhere. For example, proximity to POS was mapped Directly to Mobility because it concerns spatial reachability, while its relationship with Segregation was classified as Indirect because unequal proximity may reflect broader patterns of spatial inequity. These classifications reflect conceptual relationships rather than causal strength, evidence weighting, or relative importance.

3.7. Indicator Eligibility

Variables were retained when they (a) described spatial, design, environmental, accessibility, governance, management, or use-related POS conditions; (b) could be observed, documented, mapped, audited, or measured; (c) were supported by the reviewed literature; and (d) were applicable across different POS types. The study excluded mental well-being, social connectivity, belonging, restoration, reduced stress, and reduced isolation as indicators and treated them instead as potential pathways or outcomes. The study also excluded clinical effects, thresholds, weights, scores, and performance standards.

3.8. Domain Formation and Framework Structure

Indicators were grouped by their primary POS assessment function into seven domains: Accessibility and Connectivity; Capacity, Suitability, and Spatial Vitality; Inclusiveness, Equity, and Publicness; Internal Quality and Comfort; Safety and Visibility; Spatial Availability; and Use, Activity, and Social Interaction. This structure separates conceptual interpretation from operational assessment: the Charta explains why an indicator is relevant, while the domains define the POS aspect being assessed. The resulting framework integrates nine Charta, seven domains, and 23 indicators. Figure 2 summarizes the framework's analytical structure, showing how the reviewed evidence informed indicator extraction, Charta mapping, and organization into seven operational domains. It also distinguishes assessable POS conditions from social-connectivity and mental-health outcomes, which require separate empirical validation.

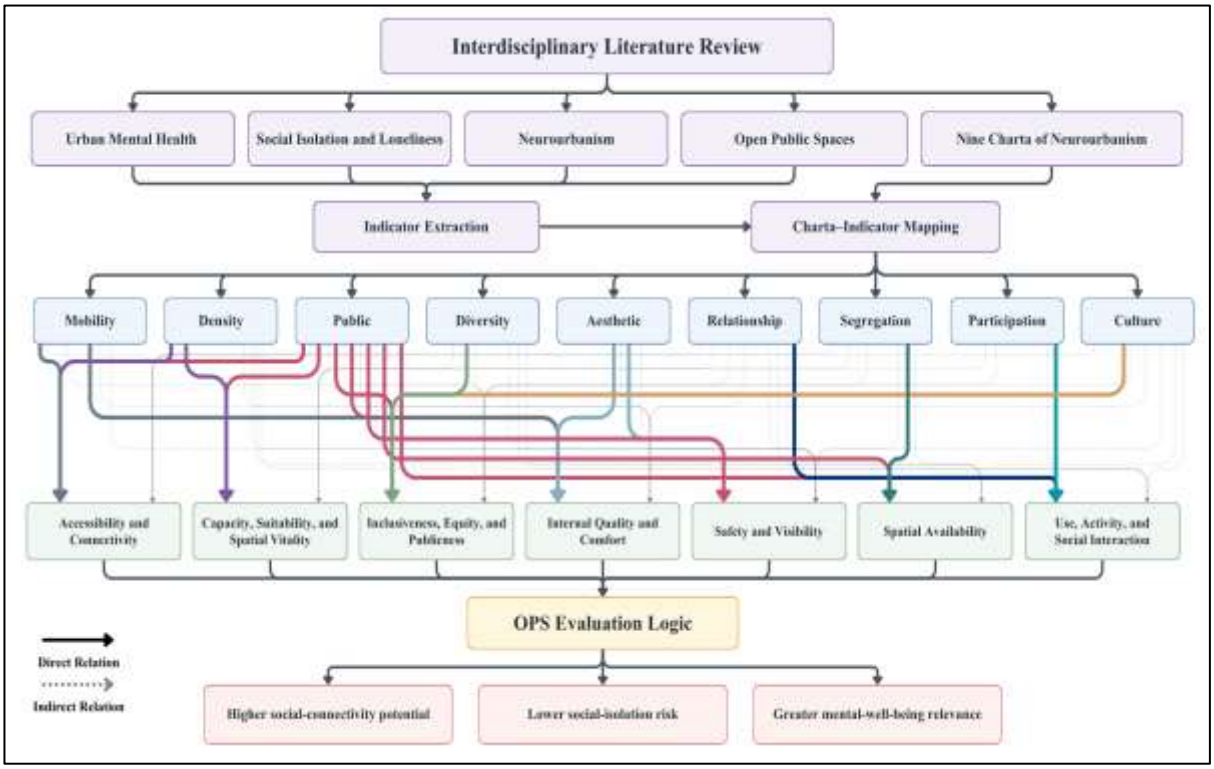

Figure 2. Analytical Charta-Based Framework

4. RESULTS: CHARTA-BASED POS INDICATOR FRAMEWORK

4.1. Framework Structure and Derivation

The final framework comprises 23 literature-derived POS indicators organized into seven planning-oriented domains. Across these indicators, 94 indicator–Charta assignments were identified: 28 Direct (29.8%) and 66 Indirect (70.2%) (Table 2). Direct (D) and Indirect (InD) mappings denote primary and supporting conceptual relationships, respectively, rather than causal strength or empirical importance.

Table 2. Charta-based indicator framework for assessing public open spaces

Domains	Indicators	Charta relation	Sources
Accessibility and Connectivity	Accessibility to POS	Public (D); Mobility, Relationship, Segregation, Culture (InD)	Addas & Rishbeth, 2018; Clarke et al., 2023; Gianfredi et al., 2021; Li et al., 2022; Llopis Abella et al., 2020; Salih & Ismail, 2017; Zhang et al., 2022
	Proximity to POS	Mobility (D); Public, Segregation, Culture (InD)	Lin et al., 2023; Menec et al., 2019; Zhang et al., 2022
	Safe pedestrian connectivity to POS	Mobility (D); Public, Relationship, Segregation, Density (InD)	Cui et al., 2024; Gianfredi et al., 2021; Giles-Corti et al., 2022; Llopis Abella et al., 2020; Mehta, 2009; Yang et al., 2019
Capacity, Suitability, and Spatial Vitality	Capacity related to population density	Density (D); Public, Segregation (InD)	Giles-Corti et al., 2022; Gruebner et al., 2017; Hussein et al., 2022; Mouratidis, 2018; Ouda et al., 2020; Senkler et al., 2023
	Functional suitability for user needs	Public (D); Relationship, Diversity, Participation (InD)	Cao & Kang, 2019; Clarke et al., 2023; Cui et al., 2024; Han et al., 2022; Li et al., 2022; Salih & Ismail, 2017; Whyte, 1980
Inclusiveness, Equity, and Publicness	Accessibility for all users	Public (D); Mobility, Diversity, Segregation, Relationship, Culture (InD)	Carstensen et al., 2022; König et al., 2019; Li et al., 2022; Menec et al., 2019; Zhang et al., 2022
	Cultural inclusiveness and relevance	Diversity, Culture (D); Public, Relationship, Participation (InD)	Addas & Rishbeth, 2018; Baxter et al., 2022; Giray Küçük & Yüceer, 2022; Han et al., 2022; Karimi et al., 2022; Montgomery, 2004; Tuhkanen et al., 2022; Zhang et al., 2023
Internal Quality and Comfort	Availability of greenery	Public, Aesthetic (D); Mobility, Relationship, Density, Culture (InD)	Cabanek et al., 2020; Gianfredi et al., 2021; Wang et al., 2019; Yin et al., 2023
	Availability of seating areas	Public (D); Aesthetic, Relationship (InD)	Mehta, 2009; Thilakaratne, 2022; Whyte, 1980
	Availability of shaded areas	Public (D); Aesthetic, Relationship (InD)	Addas & Rishbeth, 2018; Thilakaratne, 2022; Yin et al., 2023
	Cleanliness and maintenance	Public (D); Diversity (InD)	Clarke et al., 2023; Hamilton et al., 2017; Karimi et al., 2022
	Internal walkability within POS	Mobility (D); Public, Relationship (InD)	Danquah et al., 2022; Hamilton et al., 2017; Mehta, 2009; Yang et al., 2019
	Legibility and ease of orientation	Aesthetic (D); Mobility, Public (InD)	Giray Küçük & Yüceer, 2022; Purwanto & Ayuningtyas, 2022
	Quality landscape elements	Aesthetic (D); Public, Culture (InD)	Cabanek et al., 2020; Karimi et al., 2022; Wang et al., 2019; Yin et al., 2023
	Spatial openness and enclosure balance	Aesthetic (D); Public, Diversity (InD)	Cabanek et al., 2020; Purwanto & Ayuningtyas, 2022; Thilakaratne, 2022
Safety and Visibility	Perceived safety	Public (D); Mobility, Relationship, Diversity, Segregation, Aesthetic (InD)	Cao & Kang, 2019; Karimi et al., 2022; Li et al., 2022; Salih & Ismail, 2017
	Availability of lighting	Aesthetic (D); Public (InD)	Mehta, 2009; Thilakaratne, 2022
Spatial Availability	Availability of POS	Public (D); Relationship, Density, Segregation, Culture (InD)	Hussein et al., 2022; Jennings & Bamkole, 2019; Kim & Kim, 2024; Lynch et al., 2021; Ouda et al., 2020; Senkler et al., 2023

Domains	Indicators	Charta relation	Sources
	Availability of diverse POS types	Public (D); Relationship, Diversity, Culture (InD)	Addas & Rishbeth, 2018; Myers, 2020; Thilakaratne, 2022; Tuhkanen et al., 2022
	Equitable spatial distribution of POS	Public, Segregation (D); Diversity, Mobility (InD)	Giles-Corti et al., 2022; Li et al., 2022; Lynch et al., 2021
Use, Activity, and Social Interaction	Availability of activity spaces	Public (D); Relationship, Mobility, Participation, Culture, Diversity (InD)	Cui et al., 2024; Danquah et al., 2022; Han et al., 2022; Lin et al., 2023; Salih & Ismail, 2017; Whyte, 1980; Yang et al., 2019; Zhang et al., 2023
	Availability of social gathering spaces	Public, Relationship, Participation (D); Culture, Diversity, Density (InD)	Baxter et al., 2022; Cao & Kang, 2019; Carstensen et al., 2022; Giles-Corti et al., 2022; Jennings & Bamkole, 2019; Mehta, 2009; Mouratidis, 2018; Whyte, 1980
	Inclusive governance and management	Public (D); Participation, Diversity (InD)	Carstensen et al., 2022; Clarke et al., 2023; He et al., 2021; Li et al., 2022

(Source: Authors)

Note. Safe pedestrian connectivity to POS refers to the continuity and safety of pedestrian routes linking surrounding neighborhoods and destinations to POS entrances. Its future measurement may consider pedestrian-network continuity, the availability and quality of crossings, exposure to vehicular traffic, physical barriers, and perceived or observed route safety. These dimensions clarify the indicator's scope but do not yet constitute validated thresholds, weights, or scoring criteria. To maintain the readability of Table 2, the Source column presents a limited set of representative references selected for their clearest direct relevance to each indicator. The literature review documents the wider evidence base.

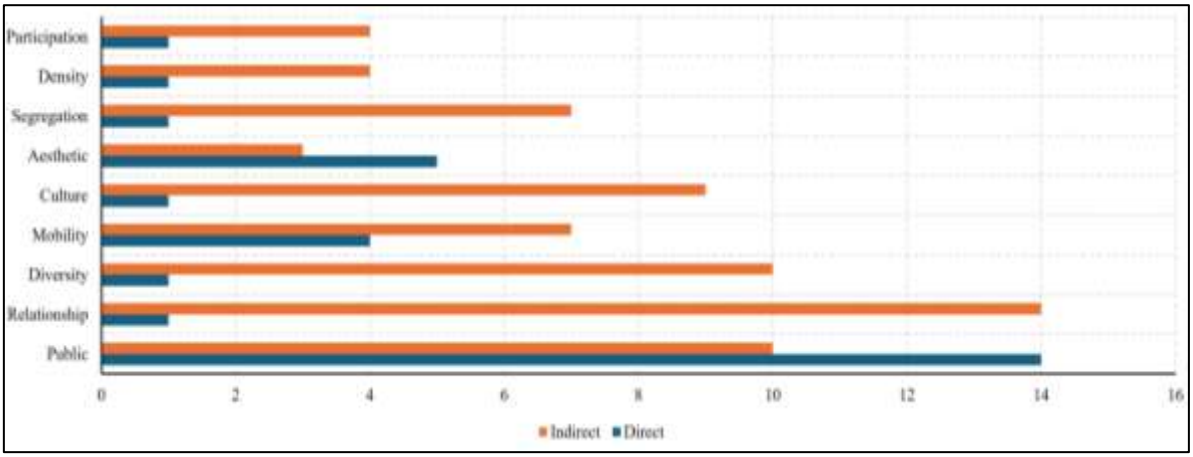

Figure 3. Distribution of Direct and Indirect indicator–Charta mappings across the 23 POS indicators

Figure 3 presents the distribution derived from the indicator–Charta relationships reported in Table 2. For each of the 23 indicators, every Charta relationship was recorded according to its classification as Direct or Indirect. Each occurrence was then counted once under the corresponding Charta and relationship type, and the counts were aggregated across all indicators. Because individual indicators could be related to more than one Charta, the number of indicator–Charta assignments exceeds the number of indicators. This aggregation produced 94 assignments in total, comprising 28 Direct and 66 Indirect relationships. As shown in Figure 3, Direct mappings were concentrated in Public (n = 14), Aesthetic (n = 5), and Mobility (n = 3), while Relationship, Participation, Diversity, Density, Segregation, and Culture each received one Direct assignment. Indirect mappings were more widely distributed, with Relationship appearing most frequently (n = 13), followed by Diversity (n = 10), Public and Culture (n = 9 each), Mobility and Segregation (n = 7 each), Participation and Density (n = 4 each), and Aesthetic (n = 3). This

distribution indicates that many indicators extend beyond their primary conceptual relationship and intersect with several Charta. These frequencies describe conceptual overlaps within the framework; they are not weights, measures of evidence strength, causal effects, or indicators of the relative importance of individual Charta.

4.2. The Seven Operational Domains

The domain-level analysis examines how the 23 POS indicators are conceptually distributed across the Charta fields within each of the seven operational domains. Direct relationships identify an indicator's primary Charta connection, whereas Indirect relationships represent supporting or contextual connections. The resulting profiles therefore show how each operational domain is conceptually structured and where different Charta fields overlap within the framework. They do not represent weights, performance scores, causal influence, or the relative importance of individual Charta fields.

For each domain, the frequency of Direct and Indirect relationships was calculated according to the number of indicators associated with each Charta field relative to the total number of indicators in that domain, as expressed below:

Relationship frequency (%) = (number of indicators within the domain associated with the specified Charta and relationship type / total number of indicators within the domain) × 100

The radar charts in Figures 4a–4g visualize these domain-specific profiles. A value of 100% indicates that the relevant Charta relationship occurs across all indicators within that domain, whereas lower percentages indicate that the relationship occurs in only part of the domain. Because the seven domains contain different numbers of indicators, interpret the percentages within each domain as distinct, not as a basis for ranking the domains against one another.

Taken together, the charts provide an additional analytical layer to the framework. Table 2 identifies the individual indicator–Charta mappings, whereas Figures 4a–4g reveal how these relationships are distributed at the domain level. This makes it possible to examine whether a domain is concentrated around particular Charta fields or depends on a broader combination of spatial, environmental, social, cultural, and governance dimensions. The resulting patterns also help clarify how assessable POS conditions may create or constrain opportunities relevant to social interaction, participation, restoration, and well-being. These remain potential pathways or outcomes rather than effects measured by the present study.

4.2.1. Accessibility and Connectivity

The Accessibility and Connectivity domain contains three indicators: accessibility to POS, proximity to POS, and safe pedestrian connectivity to POS. Direct relationships are concentrated in Mobility, which appears in two of the three indicators (66.7%), and Public, which appears in one indicator (33.3%). Indirectly, Segregation is associated with all three indicators (100%), while Public, Relationship, and Culture each occur in two indicators (66.7%); Mobility and Density each occur in one (33.3%). These relationships indicate that access is not only a movement issue but is also shaped by whether routes and destinations are equitably distributed, publicly reachable, socially meaningful, and responsive to population demand. Accordingly, reachability therefore functions as a prerequisite for the social and restorative opportunities that POS may provide, without implying that access alone produces social connectivity or mental-health outcomes.

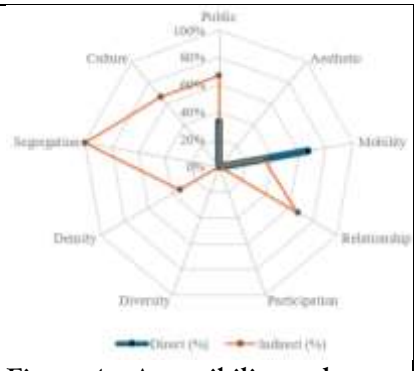

Figure 4a. Accessibility and Connectivity

4.2.2. Capacity, Suitability, and Spatial Vitality

The Capacity, Suitability, and Spatial Vitality domain contains two indicators: capacity related to population density and

functional suitability for user needs. Figure 4b shows an evenly divided Direct profile between Density and Public (50% each), reflecting whether POS provision is adequate relative to demand and whether the space is usable for everyday public purposes. Public, Relationship, Participation, Diversity, and Segregation each occur indirectly in one indicator (50%). This pattern shows that POS adequacy depends not only on the amount of provision but also on equitable provision, responsiveness to diverse users, and opportunities for social use. Within the framework, capacity and suitability therefore operate together, linking Density and Public with broader concerns of equity, participation, and social interaction. These conditions may support opportunities for use and encounter but do not directly indicate improved social connectivity or mental health.

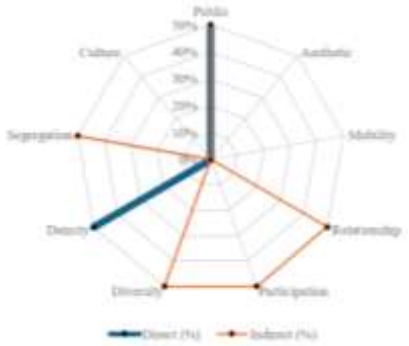

Figure 4b. Capacity, Suitability, and Spatial Vitality

4.2.3. Inclusiveness, Equity, and Publicness

The Inclusiveness, Equity, and Publicness domain comprises accessibility for all users and cultural inclusiveness and relevance. Figure 4c shows Direct relationships with Public, Diversity, and Culture (50% each), while Relationship is indirectly associated with both indicators (100%). Public, Mobility, Participation, Diversity, Segregation, and Culture each occur indirectly in one indicator (50%). The complete Relationship connection indicates that inclusive publicness is not limited to physical access but also concerns whether different users can meaningfully share and engage with POS. In operational terms, the overlap between Public, Diversity, and Culture shows that equitable publicness depends on both universal usability and cultural recognition. Inclusive POS may therefore broaden opportunities for participation, encounter, and belonging, while social connectivity and mental-health outcomes still require independent empirical validation.

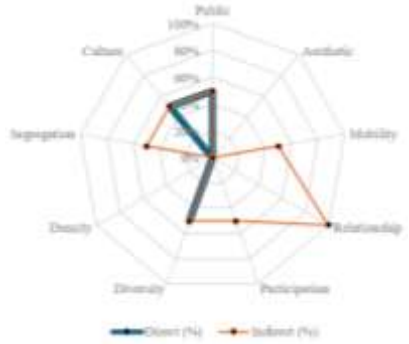

Figure 4c. Inclusiveness, Equity, and Publicness

4.2.4. Internal Quality and Comfort

The Internal Quality and Comfort domain contains eight indicators: greenery, seating, shade, cleanliness and maintenance, internal walkability, legibility, landscape quality, and openness-enclosure balance. Figure 4d shows Direct relationships in Public and Aesthetic (50% each) and Mobility (12.5%). Indirectly, Public and Relationship each occur in 50%; Aesthetic, Mobility, Diversity, and Culture in 25%; and Density in 12.5%. Concentration in Public and Aesthetic indicates that internal POS quality depends on the interaction between practical usability and sensory-spatial experience rather than on either dimension alone. The Relationship connection further extends these qualities to conditions that may encourage staying and social encounter. From a Neurourbanism perspective, these indicators are relevant to comfort and restorative experience but are environmental conditions, not direct measures of social connectivity or mental health.

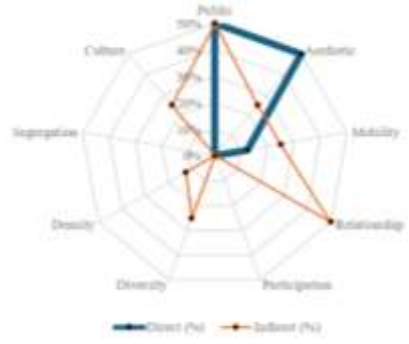

Figure 4d. Internal Quality and Comfort

4.2.5. Safety and Visibility

The Safety and Visibility domain includes perceived safety and availability of lighting. Figure 4e shows Direct relationships evenly

divided between Public and Aesthetic (50% each), while Public, Aesthetic, Mobility, Relationship, Diversity, and Segregation each occur indirectly in one indicator (50%). Safety therefore emerges as a cross-cutting POS condition linking public usability and environmental perception with movement, inclusion, and equitable access. In this domain, a space may be physically available yet functionally inaccessible if it is perceived as unsafe or poorly lit. Safety and visibility may therefore support continued use, social encounter, and environmental comfort, but they remain assessable conditions rather than direct measures of social connectivity or mental health.

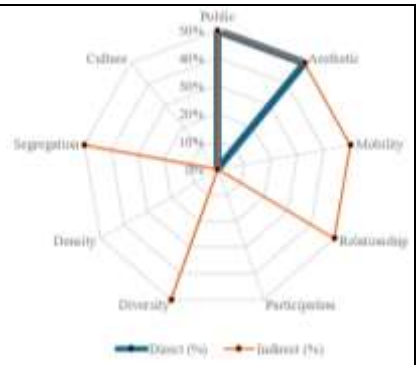

Figure 4e. Safety and Visibility

4.2.6. Spatial Availability

The Spatial Availability domain contains three indicators: availability of POS, availability of diverse POS types, and equitable spatial distribution of POS. Figure 4f shows a complete Direct relationship with Public (100%), while Segregation is directly associated with equitable distribution (33.3%). Indirectly, Relationship, Diversity, and Culture each appear in 66.7% of indicators, while Mobility, Density, and Segregation appear in 33.3%. The dominance of Public indicates that spatial availability is fundamentally about whether POS are provided as public resources, while the Direct Segregation relationship shows that provision cannot be separated from spatial equity. The recurring Relationship, Diversity, and Culture connections further indicate that availability is not only quantitative but also concerns whether the POS network offers varied and socially relevant opportunities across different users and contexts. Accordingly, this shifts assessment from counting individual spaces to evaluating the adequacy, diversity, and equity of the wider POS network. Such provision may broaden opportunities for repeated encounters, participation, and access to supportive environments, while social connectivity and mental health remain outcomes that require separate validation.

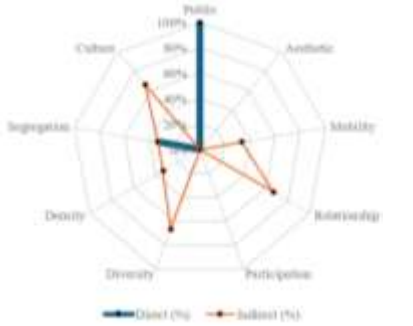

Figure 4f. Spatial Availability

4.2.7. Use, Activity, and Social Interaction

The Use, Activity, and Social Interaction domain includes activity spaces, social gathering spaces, and inclusive governance and management. Figure 4g shows a complete Direct relationship with Public (100%), while Relationship and Participation each occur directly in 33.3% of the indicators. Diversity is also present indirectly across all three indicators (100%), followed by Participation and Culture (66.7%) and Mobility, Relationship, and Density (33.3%). The dominance of Public shows that this domain is primarily concerned with how POS function as places of shared use, not simply the presence of physical facilities. The complete Indirect relationship with Diversity further indicates that interaction opportunities depend on whether activities, gathering spaces, and management practices accommodate different users. Within the framework, this domain therefore connects physical provision with participation, inclusion, and social use, making it the most direct operational expression of the framework's social-connectivity pathway. Its contribution lies in

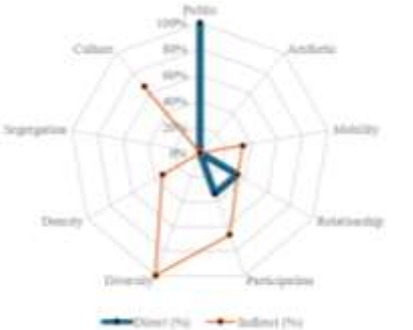

Figure 4g. Use, Activity, and Social Interaction

distinguishing the provision of opportunities for repeated encounter from social outcomes themselves: POS can enable interaction and participation, but friendship, belonging, reduced isolation, and improved mental health must still be measured independently.	

5. DISCUSSION

The framework contributes to Neurourbanism by translating interdisciplinary evidence on urban stress, cognition, sensory experience, environmental quality, and social conditions into assessable variables for POS planning (Adli et al., 2017; Ancora et al., 2022; Buttazzoni et al., 2021; Lederbogen et al., 2011). The distribution of mappings makes this contribution more explicit: of 94 indicator-Charta assignments, 28 were Direct, and 66 were Indirect, with Direct assignments concentrated in Public (n = 14), Aesthetic (n = 5), and Mobility (n = 3). This concentration should not be interpreted as a ranking of theoretical importance. Rather, it indicates that the POS conditions most readily translated into observable planning variables cluster around publicness, sensory-spatial quality, and movement, whereas participation, diversity, culture, density, segregation, and relationship more often operate as cross-cutting contextual dimensions. This interpretation aligns with Neurourbanism reviews that describe urban mental-health effects as emerging through multiple interacting environmental and psychosocial pathways rather than single built-environment determinants (Ancora et al., 2022; Buttazzoni et al., 2022). It also parallels healthy-city indicator approaches that combine access, mobility, environmental quality, and social conditions instead of treating them as isolated planning concerns (Capolongo et al., 2018; Giles-Corti et al., 2022).

A central finding is the distinction between assessable POS conditions and pathways or outcomes that must be measured independently. Accessibility, connectivity, greenery, seating, shade, lighting, maintenance, safety, cultural relevance, equitable distribution, governance, and opportunities for activity can be observed, documented, mapped, or audited. By contrast, restoration, belonging, trust, social connectivity, reduced stress, and reduced isolation require empirical investigation. This distinction matters because existing green-space and mental-health research shows that benefits are mediated by factors such as access, physical activity, social contact, environmental quality, and context, rather than produced by the presence of green space alone (Chen et al., 2021; Gianfredi et al., 2021). Similarly, studies of publicness and social cohesion show that provision does not necessarily translate into inclusive use when access, safety, maintenance, management, or social conditions are unfavorable (Clarke et al., 2023; Li et al., 2022). The framework therefore positions POS characteristics as potential planning supports and exposures, not as proxies for social or mental-health outcomes.

The indicators are also intended to be interpreted in combination instead of as independent benefits. This is supported by both the mapping results and prior public-space research. Whyte (1980) and Mehta (2009), for example, show that seating, active edges, visible activity, and pedestrian-oriented design can support staying and interaction, but these features depend on a wider setting that remains accessible and usable. Karimi et al. (2022) and Clarke et al. (2023) likewise emphasize the combined importance of environmental quality, safety, maintenance, and social conditions. The framework extends this logic by organizing such conditions across seven domains while retaining their overlapping Charta relationships. Consequently, greenery or activity spaces may have limited practical value when access is restricted, maintenance is poor, safety is low, or management is exclusionary. The analytical implication is that POS performance should be assessed relationally: individual indicators describe specific conditions, while their combined pattern provides the more meaningful basis for planning interpretation.

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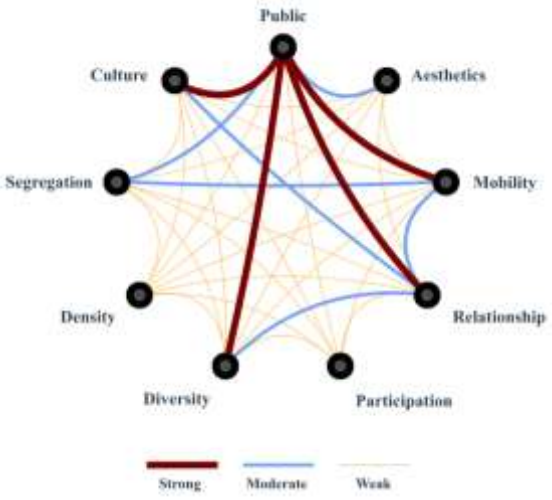
Figure 5. Pairwise co-occurrence of indicator mappings among the nine Charta fields

5.1. Integrated Operation of the Seven-Domain Framework

The distribution of mappings confirms that the Charta operate as overlapping analytical lenses. Across the 23 indicators, 66 of the 94 assignments (70.2%) were Indirect, showing that most POS conditions retain supporting relationships beyond their primary Charta. Pairwise co-occurrence is most frequent around the Public Charta, particularly with Relationship, Diversity, Mobility, and Culture (Figure 5). Here, pairwise co-occurrence refers to how often two Charta fields map to the same POS indicator. This pattern is consistent with publicness research, which treats access and use as inseparable from inclusion, permissible activity, and social experience (Li et al., 2022), and with evidence that urban green and public spaces support social cohesion only when they are accessible, welcoming, and responsive to different users (Clarke et al., 2023; Jennings & Bamkole, 2019). The resulting overlap indicates that Public functions as a cross-cutting conceptual field connecting access, inclusion, movement, cultural relevance, and social use, rather than operating as an isolated category. This reinforces the framework's relational interpretation of POS conditions.

The domain-level findings reveal different but interdependent ways through which POS conditions may become relevant to use and experience. Accessibility and Connectivity and Spatial Availability establish whether opportunities are spatially reachable and equitably distributed, consistent with evidence linking walkability and destination access with social activity and well being and identifying geographic barriers as contributors to social isolation (Danquah et al., 2022; Leyden et al., 2024; Lynch et al., 2021; Menec et al., 2019). Internal Quality and Comfort and Safety and Visibility then influence whether spatially available POS are comfortable, legible, well maintained, and perceived as safe enough to support continued use (Karimi et al., 2022; Thilakaratne, 2022; Wang et al., 2019). Inclusiveness, Equity, and Publicness, and Use, Activity, and Social Interaction extend this progression from access and usability toward meaningful participation by addressing cultural recognition, governance, gathering opportunities, and inclusive use (Addas & Rishbeth, 2018; Baxter et al., 2022; Carstensen et al., 2022; Tuhkanen et al., 2022). Read together, the domains therefore function as



complementary rather than independent conditions: spatial provision creates opportunity, internal quality influences usability, and inclusive social conditions shape whether that opportunity can support participation and encounter. Density further demonstrates why indicators should not be interpreted in isolation. Compact neighborhoods may support walkability and social interaction but may become stressful when accompanied by crowding, limited privacy, inadequate open space, or insufficient infrastructure (IFN, n.d.-i; Mouratidis, 2018; Ouda et al., 2020). Ouda et al. (2020) found that the association between density and mental well-being varied by socioeconomic context, reinforcing the need to interpret density alongside POS capacity, accessibility, greenery, environmental quality, and social infrastructure. This is consistent with the present framework, in which Density has relatively few Direct assignments but appears as a contextual relationship across several indicators. The result is not evidence that density is unimportant; rather, it indicates that its planning relevance depends strongly on the conditions with which it co-occurs.

The unequal distribution of Direct and Indirect mappings also clarifies why the Charta should not be treated as equivalent measurement categories. Direct mappings identify where a POS condition has a primary conceptual fit, whereas Indirect mappings capture the contextual dependencies through which that condition may become relevant in practice. The much larger Indirect set therefore supports a relational interpretation of the framework: access, comfort, safety, inclusion, and activity are analytically distinct conditions, but their planning relevance depends on how they combine within a POS. This interpretation aligns with studies showing that the social and health relevance of public and green spaces depends on interacting conditions rather than physical provision alone (Chen et al., 2021; Clarke et al., 2023; Gianfredi et al., 2021).

5.2. Contribution to Knowledge and Practical Implications

The principal contribution to knowledge lies not in claiming that each of the 23 indicators is novel in isolation. Many of these conditions are already established in public-space, healthy-city, and environmental-health research. The contribution is their structured operationalization within a Charta-based POS assessment framework. Neurourbanism studies have primarily linked urban exposures to cognitive, emotional, physiological, or psychosocial processes while identifying a persistent translation gap for planning practice (Bonifácio et al., 2023; Buttazzoni et al., 2022; Ndaguba et al., 2022). In parallel, planning and public-space studies provide assessable conditions related to access, environmental quality, publicness, safety, and social use (Capolongo et al., 2018; Clarke et al., 2023; Giles-Corti et al., 2022). This study brings these strands together by interpreting 23 literature-derived POS indicators through the nine Charta and organizing them into seven operational domains.

A further contribution is the explicit separation between conceptual interpretation and operational assessment. The Charta explains why a condition is relevant, while the seven domains specify what aspect of POS is being assessed. The majority of Indirect assignments (70.2%) support this distinction by showing that many observable conditions cross conceptual boundaries as distinct from belonging to a single Charta. This structure preserves conceptual overlap without turning it into a weight or causal claim. It also retains social connectivity, belonging, restoration, reduced stress, and mental health as outcomes requiring independent measurement, consistent with evidence that public- and green-space benefits depend on mediating conditions such as access, environmental quality, social contact, and management (Chen et al., 2021; Clarke et al., 2023; Gianfredi et al., 2021; Li et al., 2022).

The framework can serve as a structured diagnostic guide for POS planning and assessment. A staged application is most appropriate. First, planners can map conditions that can be assessed spatially, such as POS availability, proximity, pedestrian connectivity, capacity relative to population density, and equitable distribution. Second, field audits can assess internal conditions including greenery, seating, shade, maintenance, lighting, walkability, legibility, landscape quality, and openness-enclosure balance. Third, use perceptual and institutional evidence for conditions that spatial data alone cannot represent adequately, particularly perceived safety, cultural inclusiveness, publicness, governance, and patterns of social use. This staged approach is consistent with the framework's distinction between observable planning conditions and independently measured outcomes. It can help planners identify where barriers

to access, comfort, inclusion, or encounter occur, while avoiding the unsupported assumption that a favorable POS score would itself demonstrate improved mental health or social connectivity.

5.3. Limitations

The framework reflects interpretive judgment in evidence synthesis, indicator consolidation, domain formation, and Direct and Indirect Charta mapping. The purposive review did not use exhaustive literature retrieval, independent duplicate screening, or a formal study-quality appraisal; consequently, the evidence base cannot be considered as comprehensive as that of a formal systematic review. The indicators and mappings have not been independently coded, expert-validated, weighted, normalized, scored, or empirically tested, and their transferability across different POS types, population groups, urban settings, and sociocultural contexts remains to be established. The present study also does not directly measure social connectivity or mental-health outcomes and therefore cannot establish causal relationships between the proposed POS conditions and these outcomes.

The framework currently provides a conceptual and operational structure rather than a validated scoring or decision-support system. Measurable variables, data requirements, benchmarks, thresholds, weighting procedures, scoring rules, and performance standards remain to be developed and validated before the framework can be converted into a scored assessment tool. These limitations define the next stage of framework development and should be considered when interpreting its current planning and research applications.

6. CONCLUSIONS

This study developed a literature-derived, Charta-based indicator framework that translates Neurourbanism into assessable conditions for public open spaces (POS), distinguishes planning indicators from social-connectivity and mental-health outcomes, and provides a structured basis for future evaluation and empirical validation.

The analysis showed that the nine Charta—Public, Aesthetic, Mobility, Relationship, Participation, Diversity, Density, Segregation, and Culture—function as complementary, overlapping conceptual lenses instead of independent categories. Together, they provide a conceptual basis for interpreting the spatial, environmental, social, cultural, and governance characteristics of POS. These planning-relevant dimensions were translated into 23 assessable POS indicators organized across seven operational domains: Accessibility and Connectivity; Capacity, Suitability, and Spatial Vitality; Inclusiveness, Equity, and Publicness; Internal Quality and Comfort; Safety and Visibility; Spatial Availability; and Use, Activity, and Social Interaction.

The relationships between the 23 indicators and the nine Charta were systematically organized through 94 conceptual assignments, comprising 28 Direct and 66 Indirect relationships. The predominance of Indirect relationships demonstrates the cross-cutting nature of POS conditions and indicates that many indicators relate simultaneously to several dimensions of Neurourbanism. Public, Aesthetic, and Mobility have the most frequent Direct mappings, while Relationship, Diversity, Culture, Segregation, Participation, and Density contribute important contextual and supporting relationships. These mappings represent conceptual associations and should not be interpreted as weights, measures of evidence strength, indicators of relative importance, or causal effects.

The findings further indicate that the planning relevance of POS cannot be attributed to any single physical or spatial feature. Rather, it depends on interactions among accessibility, capacity, comfort, safety, publicness, inclusion, cultural relevance, spatial distribution, governance, activity, and opportunities for repeated encounter. In practical terms, the framework provides planners and researchers with a common structure for examining POS through spatial analysis, field audits, environmental assessment, user-based inquiry, and governance or institutional evaluation. It can therefore help organize the assessment of conditions that may support or constrain the social and health-related potential of public open spaces.

Importantly, the framework clearly distinguishes between assessable POS conditions and the social or mental-health outcomes potentially associated with them. The proposed indicators identify planning conditions that may foster social interaction, participation, and well-being, but they should not be treated

as proxies for belonging, social connectivity, restoration, reduced stress, or improved mental health. These outcomes require independent measurement and empirical testing.

The study is limited by the purposive and interpretive nature of the review, the absence of exhaustive literature retrieval and formal study-quality appraisal, and the lack of independent expert and empirical validation of the indicators and mappings. In addition, the framework does not yet include validated weights, thresholds, benchmarks, or scoring procedures. Future research should therefore focus on validating the framework across different POS types and sociocultural contexts, developing explicit measurement and scoring procedures, and examining relationships between selected planning indicators and independently validated social-connectivity and mental-health outcomes.

Overall, the principal contribution of this research is not the identification of each POS condition as novel in isolation; many of these conditions are established in public-space, healthy-city, and environmental-health research. This research contributes by establishing a transparent, structured bridge between the conceptual principles of Neurourbanism and the assessable conditions of public open spaces. By interpreting the planning relevance of the nine Charta, deriving a coherent set of POS indicators, and systematically organizing their Direct and Indirect relationships within seven operational domains, the study establishes a foundation for future evaluation, scoring, empirical validation, and context-sensitive application. The framework should therefore be understood as a structured planning foundation from which a validated assessment and decision-support approach can subsequently be developed, rather than as a validated index or causal model.

7. Recommendations

Future research should prioritize staged validation and operationalization of the framework across different spatial, social, and institutional contexts. The following recommendations address feasibility testing, spatial sensitivity, equity considerations, and integrating planning indicators with independently measured social and mental-health outcomes.

a. Pilot the framework across multiple POS types and contrasting urban contexts to assess feasibility, contextual sensitivity, equity implications, and data availability. Such testing should also support developing explicit measurement protocols, benchmarks, thresholds, weighting procedures, and scoring criteria before converting the framework into a scored decision-support tool.

b. Test alternative spatial units, pedestrian-network assumptions, and distance thresholds before interpreting indicators related to accessibility, proximity, availability, capacity, or spatial distribution. This will help determine how sensitive framework results are to different spatial definitions and analytical scales.

c. Pair spatial and planning indicators with independently validated measures of social connectivity, loneliness, stress, well-being, and mental health. Where appropriate, analyses should also examine differences by age, gender, disability, socioeconomic position, and cultural background to assess the framework's applicability across diverse population groups and strengthen its sensitivity to inclusion and spatial equity.

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