

Neighborhood (Social) Sustainability Assessment Frameworks and Models: A Literature Review

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Abstract:

Neighbourhoods have garnered global attention in sustainability evaluation owing to their appropriate scale for demonstrating the interaction between the individual and the urban environment. Inspired by building sustainability assessment systems effectiveness in advancing sustainability principles and practices, over the past twenty years, a movement has advanced, and many systems and tools were developed to assess neighbourhood scale sustainability. Researchers have examined framework content, interactions, actors in the process, and institutions, as well as the efficacy of framework-based advancements in practical applications. Neighbourhood frameworks encompass environmental, social, and economic sustainability, offering a more complete approach than building frameworks. Nonetheless, there is minimal consensus over the practical implications of this, and concerns of economic and environmental prejudice have emerged. Also, the extensive geographical spread and regional disparities, along with contextual distinctions between developing and industrialised nations, pose challenges for the international implementation of any of these systems, which has resulted in consideration of different dimensions, items and scale and methods to assess neighbourhood sustainability. This paper aims to enhance comprehension of the existing tools, frameworks, and models proposed by researchers within the current body of knowledge, focusing on neighbourhood sustainable development and neighbourhood social sustainability.

Key Words: NSA Tools, frameworks, Models, Social Sustainability, EFA & CFA, Structure Equation Modeling

Introduction:

Sustainable neighbourhoods are regarded as essential elements of a sustainable city. (Sharifi & Murayama, 2013b; Shrivastava & Sinha, 2023). Jacobs asserts that “a sustainable mode of life should flow organically from the way our neighbourhoods are designed” (Jacobs, 1961). Consequently, comprehending the design of neighbourhood level developments is essential for advancing towards more appropriate urban environments. This can be partially achieved by employing sustainable construction assessment methodologies or frameworks. Neighbourhoods significantly contribute to the attainment of global sustainability. Over the last ten years, various assessment methodologies have been created globally to measure the efficacy of the growing number of neighbourhood planning and redevelopment plans. This shows that policymakers and the planning community are starting to see the importance of neighbourhoods in sustainable development. A neighbourhood represents the minimal scale for considering social features and challenges associated with economies of scale (Sharifi & Murayama, 2013c).

Neighbourhood sustainability assessment (NSA) is a recognised domain within sustainable development (Boyle et al., 2018). Assessment offers two advantages: evaluating sustainability and pinpointing areas for enhancement. Evaluation at the neighbourhood level presents a possibility for interventions at a significant yet feasible scale (Kamble & Bahadure, 2020). Local Agenda 21 initiatives for sustainable neighbourhoods implemented improvements in governmental policies (Yigitcanlar & Teriman, 2015). The evaluation systems offer insight, governance, methodology, and planning of a community for sustainability. Researchers in the fields of geography and urban planning have found significant contextual differences between advanced and developing countries. Conditions in developed and developing contexts are distinct with varying priorities (Libovich, 2005). The physical environment offers a significant framework for the thorough and cohesive execution of sustainable activities, particularly in tracking the swift transition to sustainability in urban areas. The approaches for promoting and evaluating sustainable development in the built environment are fundamentally categorised into two primary scales: building and urban (Berardi, 2015). Recent work highlights specific limitations in

A survey of current studies utilising these evaluation models and framework is discussed in this article. To direct future research, this study aims to identify research gaps. Even though neighbourhood sustainability assessments help make cities more sustainable, very few cities have used them to inform better sustainable development decisions. When it comes to increasing sustainability awareness, neighbourhood assessment methods are effective in addressing numerous issues. Evaluation and attainment of neighbourhood sustainability are approached from many angles. Over time, these tools should be refined and enhanced. Since the problems identified in one neighbourhood may not apply to another, the tool can be adjusted to fit the specifics of each location. According to a worldwide survey of urban sustainability assessment methods, out of 59 total, 24 are designed for newly developed neighbourhoods and only 2 for preexisting ones. Consequently, a sustainability framework tailored to the current neighbourhood's unique circumstances is required.

Social sustainability, an essential component of sustainability, received greater acknowledgement in recent years. It emphasises the attainment of human well-being and the improvement of life quality (Akcali & Ispalar Cahantimur, 2023; Wang & Ke, 2024). Communities, as essential physical and social entities within urban areas, provide a pragmatic framework for analysing social sustainability in the urban built environment, considered a fundamental element of sustainability, it is linked to 11 of the 17 Sustainable Development Goals (SDGs) set forth by the United Nations. The built environment is the central focus of social sustainability research (Razia et al., 2023; Wang et al., 2024). Social sustainability in neighbourhoods pertains to the capacity of a community to promote individual and communal well-being, encourage social inclusion and equity, and empower residents to fulfil their needs and prosper (Shrivastava & Singh, 2019). Social sustainability denotes a neighborhood's capacity to promote the welfare of all people while cultivating an inclusive, cohesive, and dynamic community. It includes fulfilling the fundamental needs of residents, advancing fairness and social justice, fostering social capital and community, and facilitating meaningful resident participation in choices impacting their neighbourhood. The fundamental concepts of social sustainability in communities include social fairness, variety, quality of life, interconnection, democracy, and effective governance.

Despite the increasing significance of social sustainability and the rising interest in investigating community social sustainability, enquiries such as "What constitutes a socially sustainable community?" remain unresolved. (Khamis et al., 2023) observed that substantial discrepancies in the descriptions and conceptualisations of neighborhood social sustainability impede the comparison of study findings and obstruct advancement. The lack of clarity in conceptualisation hinders the identification of measures to enhance community social sustainability. (Missimer & Mesquita, 2022) indicated that the existing academic framework concerning the actual application of social sustainability is very insufficient. After the Brundtland Report in 1987, which introduced the notion of sustainable development, there was a pronounced focus on economic and environmental sustainability (Colantonio, 2009), however social sustainability was overlooked, disregarded, and marginalised (Opp, 2017). The transdisciplinary, dynamic, and context-dependent characteristics of social sustainability render its definition and measurement complex (Weingaertner and Moberg, 2014). Evaluating social sustainability entails evaluating factors such as resident happiness, social capital, civic engagement, safety, diversity, affordability, and access to resources. Challenges encompass complexity, subjectivity, and a deficiency of consensus regarding measurement (Akcali & Cahantimur, 2022; Doğu & Aras, 2019; Hemani et al., 2011; Larimian & Sadeghi, 2021; Mirzakhani et al., 2023).

In conclusion, developing socially sustainable neighbourhoods necessitates a comprehensive planning strategy that advances equity, addresses the needs of different inhabitants, empowers people in the community, cultivates social connections, ensures access to opportunities, and facilitates resident participation in decision-making. It is a continuous process necessitating cooperation among citizens, community organisations, enterprises, and municipal authorities. Essential components encompass affordable housing, safety, inclusivity, community collaborations, walkability, and neighbourhood governance and engagement (Sinha et al., 2024). Assessing social sustainability is complex yet essential for recognising requirements and inadequacies. Through deliberate policies and inclusive design, neighbourhoods can transform into socially sustainable environments that facilitate the flourishing of all residents. So far, very little study has concentrated on neighbourhood sustainability assessments and how well they improve sustainable development decision-making, even though these assessments can make significant contributions to the attainment of sustainability (Sharifi et al., 2021). As existing literature suggests there is surge in social sustainability research from different perspectives, and development of various evaluation models and frameworks developed across the globe, in the subsequent section of the paper authors have explored the neighborhood social sustainability assessment with following objective

1. To understand and explain various neighbourhood sustainability assessment models, frameworks and systems.
2. To explore various method and frameworks developed to evaluate neighbourhood social sustainability.

Methods

The reference literature was sourced from two principal academic databases: "Scopus and Web of Science (WOS)". The authors have gathered information from approximately 127 sources, including research papers, books, and several scholarly publications. A subset of

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approximately 42 articles were subsequently analysed in greater detail for review process. The literature on NSA systems, and social sustainability assessment models and frameworks across developed as well as developing countries is reviewed. Following are the terminology used in different sustainability assessment frameworks and models.

Literature Review

Different authors employ distinct terms interchangeably in their research. The following terms are used and in this review of papers.

Framework

A framework is a tool that is intended to evaluate and direct the development of sustainable buildings, neighbourhoods, regions, or cities (Kamble & Bahadure, 2020). Alternatively, it is referred to as a "sustainability assessment tool" or an "environmental assessment method." The term "framework level" refers to the extent at which it is intended to be implemented, such as focusing on individual building only. In this paper, a framework will be applied to a neighbourhood-level unless otherwise specified.

Sustainability

Despite the absence of a globally recognised definition of sustainability or sustainable development (Berardi, 2013; Sharifi & Murayama, 2013b), it is often delineated in relation to the three pillars of sustainability: social, economic, and environmental dimensions. Consequently, sustainable development must strengthen, or at the very least, not undermine any of these pillars. Certain scholars additionally suggest a fourth "pillar" that includes the institutional or governance aspect (Hamedani & Huber, 2012; Sharifi & Murayama, 2013a). This includes the influence of institutions on development, along with factors such as governance, legal frameworks and mechanisms, and research and education to institutionalise sustainable development ((Sharifi & Murayama, 2013b).

Themes

Themes are defined by researchers as "broad topics of concern to sustainability," such as "energy and resource use". They are also known as "domains," "categories," and "issues" (Lee, 2013).

Criteria

"Criteria are scientific or technical notions defined as 'parameters utilised to assess the contribution of a project to accomplish the necessary objective'" (Sharifi & Murayama, 2013a), for example, cutting down on carbon emissions. They are also referred to as 'categories' and 'sectors' (Chandratilake & Dias, 2013; Lee, 2013).

Indicators

Indicators are specific credit-scoring factors that provide accurate measurements (Sharifi & Murayama, 2013a). These are objectives for which credits are awarded upon attainment. A directive to reduce carbon emissions by above 10% will be offset with x credits. These are occasionally referred to as 'criteria' or 'sub-criteria' (Lee, 2013).

Weighting

Weightings may be employed in numerous ways. They may be utilised for specific indicators, collections of indicators or criteria and themes. For example BREEAM Communities assigns varying weights for every theme, criterion, and indicator: "the theme 'land use and ecology (LE)' constitutes 12.6% of the total score, criterion 'LE02 – Land use' accounts for 2.1% (representing 16.7% of the LE theme), and each credit for achieving indicators within that criterion is valued at 0.7% of the total (equating to 33% of the LE02 criterion) (BRE 2012). DGNB-NSQ assigns equal weight to each criterion and indicator, with all themes valued at 22.5%, except for 'process quality,' which is assigned a weight of 10%" (Hamedani & Huber, 2012)

Sustainability Coverage

The breadth of coverage provided by a framework is dictated by the topics or criteria incorporated and the degree of information provided. Research aims to evaluate whether a framework's coverage is adequately comprehensive and similar to other frameworks and overarching principles of sustainability through comparison.

1. Themes and criteria
2. Mandatory Criteria
3. Local Issues

Neighborhood Sustainability Assessment (NSA)

Based on meeting certain requirements, the neighbourhood sustainability assessment (NSA) systems were put into operation. The requirements include (a) systems commonly referenced in literature; (b) completely established systems; (c) availability; and (d) systems that encompass all pillars of sustainability (social, environmental, and economic). The basic criteria, on the other hand, are relevant to the systems established in developed countries. The rationale is that they are extensively studied by numerous researchers, while systems in developing countries are rarely examined. Different systems developed with specific approach represent most of the geographical region (Fig. 01). Twelve indicator-based assessment systems have been identified for the project. The established methods from industrialised nations include "(1) BREEAM; (2) HQE2R; (3) LEED-ND; (4) STAR Communities; (5) NSF; and (6) CASBEE-UD. Systems from emerging

nations include (7) Green Star; (8) GRIHA-LD; (9) IGBC; (10) BCA Green Mark; (11) BEAM Plus; and (12) BERDE” (see Table 1).

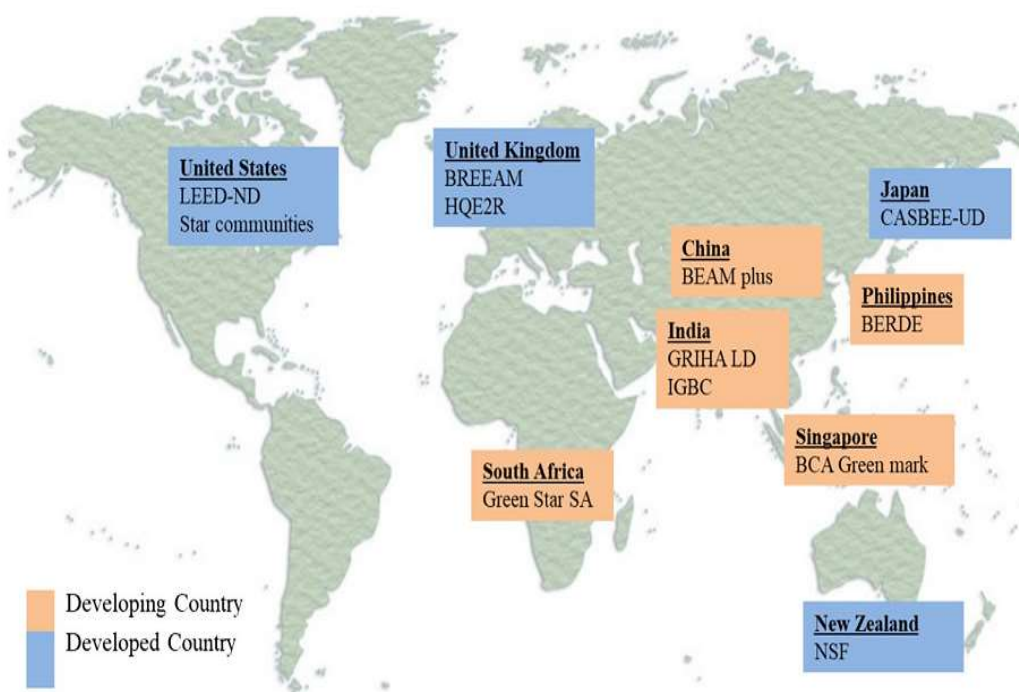


Fig. 1 The location of evaluation systems in relation to geography (Kamble & Bahadure, 2020)

Assessment Systems

Various criteria and indicators are employed to build the sustainability framework. While ensuring sustainability is the objective of these instruments, there are variations in the processes employed to attain this goal. They exhibit disparities in themes and indicators. A comparative analysis of six existing tools-(Table 2) “i) Indian Green Building Council (IGBC) Green Townships; ii) LEED for Neighborhood Development (ND); iii) Building Research Establishment Environmental Assessment Methodology (BREEAM) Communities; iv) Comprehensive Assessment System for Built Environment Efficiency for Urban Development (CASBEE- UD); v) Haute Qualité Environnementale et Economique Réhabilitation (HQE2R); and vi) Neighborhood Sustainability Framework (NSF)” articulated diverse methodologies. Among many key subjects “resources and environment” receives the highest attention, followed by “physical infrastructure and ‘transport” themes. The density of a neighbourhood significantly influences travel behavior. Additional influencing factors, like “building orientation, mixed-use development, and the presence of green spaces”, may mitigate environmental impacts. Apart from CASBEE-UD, mixed land-use is incorporated as an indicator in the other five tools. Sustainability challenges are interconnected, and mixed-use development influences other factors, including energy and transportation. The criteria for neighborhood selection in NSF include mixed use and density (high, medium, and low).

Table 01: Neighbourhood Sustainability Assessment Tools(Kamble & Bahadure, 2020).

	Country	NSA systems	Source	Name
Developed countries	United Kingdom	BREEAM	BRE (2011)	Building Research Establishment Environmental Assessment
		HQE2R	Charlot-Valdieu and Outrequin (2003)	Haute Quality Environmental Economic Rehabilitation
	The USA	LEED-ND	USGBC (2011)	Leadership in Environmental and Energy Designs-Neighborhood
		STAR communities	ICLEI (2010)	Sustainability tools for Assessing and Rating for communities
	New Zealand	NSF	Kay Saville-Smith (2005)	Neighborhood Sustainability Framework
	Japan	CASBEE-UD	IBEC (2014)	Comprehensive Assessment System for Built Environment Efficiency
Developing countries	South Africa	Green star	GBC (2013)	–
	India	GRIHA-LD	TERI and AdARSH (2014)	Green Rating for Integrated Habitat Assessment-Large Development
		IGBC	CII (2010)	Indian Green Building Council
	Singapore	BCA green mark	GMD (2012)	Building and Construction Authority
	China	BEAM plus	HKGBC (2016)	Building Environmental Assessment Method
	Philippines	BERDE	PHILGBC (2013)	Building for Ecologically Responsive Design Excellence

Table 02: Neighbourhood Evaluation System Criterion(Kamble & Bahadure, 2020)

	NSA systems	Input	Evaluation		Output		
Developed country	BREEAM	Project data	I -system	Pre-defined rating	E_B -system	Rating	R -system
	HQE2R	Project data/community opinion/ environmental aspects	I_P -system	Comparison with reference	E_B -system	Guidelines for improvement and environmental load	R_N -system
	LEED-ND	Project data	I -system	Pre-defined rating	E_B -system	Rating	R -system
	STAR communities	Community opinion	I_P -system	Prescriptive evaluation	E -system	Guidelines for improvement	R_N -system
	NSF	Project data and Community opinion	I -system	Prescriptive evaluation	E -system	Guidelines for improvement	R_N -system
	CASBEE-UD	Project data and environmental load	I_P -system	Comparison with reference	E_B -system	Environmental load	R_N -system
Developing country	Green star SA	Project data	I -system	Pre-defined rating	E_B -system	Rating	R -system
	GRIHA-LD	Project data and environmental load	I -system	Comparison with reference	E_N -system	Rating	R -system
	IGBC	Project data	I -system	Pre-defined rating	E_N -system	Rating	R -system
	BCA green mark	Project data	I -system	Pre-defined rating	E_B -system	Rating	R -system
	Beam plus	Project data	I -system	Pre-defined rating	E_B -system	Rating	R -system
	BERDE	Project data	I -system	Pre-defined rating	E_B -system	Rating	R -system

Indexing method for Model building

The indexing approach relies on composite indicators and encompasses the following processes.(Kamble & Bahadure, 2020)

- i) Selection of indicator
- ii) Different methods to collect data
- iii) Standardization of the indicator score (benchmarking);
- iv) Allocating weights to the indicators employing a survey of expert opinions; and
- v) Aggregation (linear).

$$\text{Composite Indicator} = \sum_{i=1}^n w_i I_i$$

Neighbourhood Sustainability (Social) Assessment

In this section authors examined neighbourhood sustainable development evaluation systems and the idea of urban social sustainability to investigate key themes and features through a thorough comparative analysis. The primary aim of this research is to elucidate the definitions, concepts, and frameworks of social sustainability by examining the available literature. Subsequently, it endeavors to identify the models and frameworks evaluating social sustainability within an urban context.

(Bahadure & Kotharkar, 2018) in their study of Nagpur city neighborhood they presented the neighborhood's sustainability rating by working out composite index, through different benchmark value (Table 3) of indicator and their respective assigned weights. The indicator domains are classified into three independent categories: "i) demography; ii) environmental; and iii) transport (including accessibility, road infrastructure, traffic speed, and safety)", expanded upon in twenty indicators presented in (Table 5). Every indicator is evaluated for its effect on sustainability. Each indicator has unique measuring units. The indicator scores are normalised on a five-point scale, from low to high sustainability levels. The benchmarking is established via a literature research and expert consultation. The selected indicators are assigned values based on how they perform (Table 6). The indicator scores are computed, and the results and observations are recorded for the neighbourhood.

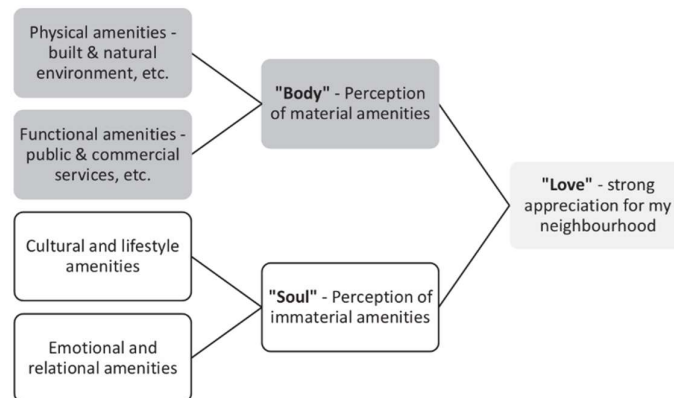


Fig 2. Conceptual framework and articulation of the notions of 'neighborhood love', 'body', and 'soul'.
(Hårsman Wahlström et al., 2020)

In another study (Hårsman Wahlström et al., 2020) examined the conflict between extensive urban agglomerations and human-scale urbanity, highlighting the necessity for novel analytical methods and efficient policy solutions within the framework of the 'urban century'. The notion of place quality is presented as a multidimensional metric that includes many measures of urban well-being, gaining significance in the realm of sustainable urban development. The conceptual paradigm

(Fig 2) differentiates between the city's 'body,' comprising its physical and functional attributes, and the city's 'soul,' which incorporates emotional and social factors. Two indices are established: the Human Habitat Index, which evaluates physical and functional characteristics, and the Feelgood Index, which measures emotional and relational dimensions of urban living. The methodology is structured to be methodical and relevant to urban studies across many contexts, emphasising the qualitative dimensions of urban life. The author developed the Neighbourhood Love Index (Fig. 3).

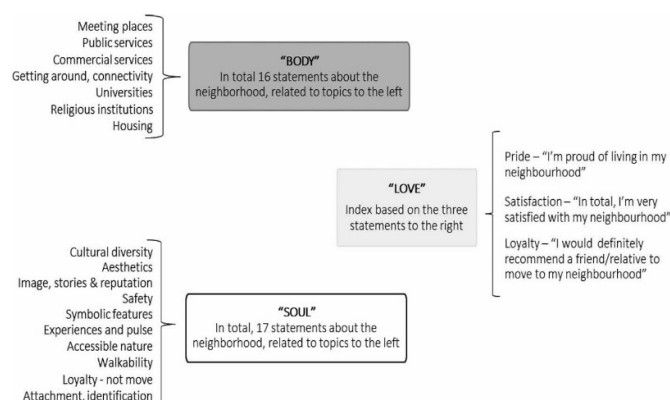


Fig 3. Conceptual model and operationalization of the concepts 'neighborhood love' (dependent), 'body', and 'soul' (independents)(Kourtiti et al., 2022)

(Seyed A. A. H., Ali A. T., 2018) in their study "A framework for the prosperity of neighborhoods" proposed framework (Fig 4) for neighbourhood prosperity presents a model that seeks to organise locations, individuals, activities, and the environment as fundamental components of neighbourhoods through an integrated concept. To propose a framework for the prosperity of neighborhoods, networks of relations between places, people, activities, and environment is proposed. Domains and indicators used are presented in table 4.

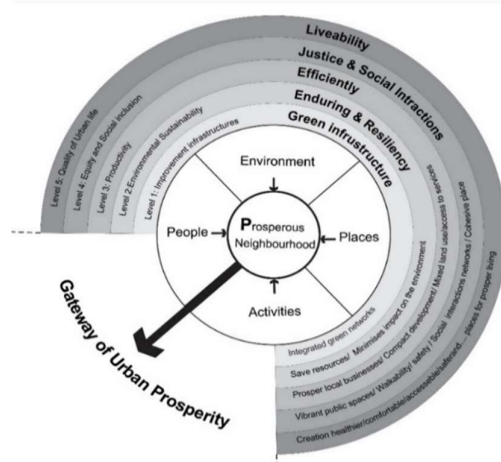


Fig 4. a framework for the prosperity of neighborhoods(Seyed A. A. H., Ali A. T., 2018)

Another study in Turkey by (Büyükağaçcı, S. B.; Arısoy, 2024) " suggested several important conclusions regarding social sustainability in urban parks. A research model (Fig 5) was proposed to test hypotheses related to social sustainability, considering geographical and cultural differences. The paper examined social sustainability in urban parks. Eight key dimensions (Accessibility, Safety, Place Attachment, Cohesion, Equity, Comfort, Facilities) of social sustainability are identified. Authors employed Exploratory Factor Analysis was performed for construct validity and Reliability Analysis was conducted to test scale reliability. Correlation analysis determined relationships between continuous variables. Authors also used T-test and ANOVA to assess differences between two groups (Akcali & Cahantimur, 2022) addressed urban social sustainability and socio-spatial issues in two neighborhoods in Izmir, Turkey. It emphasizes the relationship between urban space and social sustainability. It proposes a pentagon model for evaluating social sustainability through spatial analysis and questionnaire surveys. Authors employed independent t-tests to compare study areas and statistical analyses using SPSS version 24. Reliability and variance analysis was performed

on data. Authors explored “accessibility, social infrastructure, and open spaces, Sense of community and social relations, Security and safety perceptions and Participation levels in community activities”.



Figure 5. The pentagon model of social sustainability(Akcali & Cahantimur, 2022)

Another study by (Akcali & Ispalar Cahantimur, 2023) which focuses on social sustainability in urban environments. It examines socio-spatial aspects influencing social sustainability. Authors proposed social sustainability model (Fig 6) comparing social equity, Environmental equity and Sustainability of community as primary dimension with various subscales of these primary dimensions. Statistical analyses revealed significant differences in socio-demographic variables and their impact on social sustainability indicators between the two neighborhoods. Accessibility, daily operations, and open spaces were found to correlate positively with social sustainability, although the relationship between safety and accessibility was complex. The findings suggest that while open spaces enhance community sustainability, other factors like accessibility and social facilities also play critical roles. The study utilized a questionnaire with a 5-point Likert scale to assess socio-spatial indicators of social sustainability, piloted with a diverse group of participants. Data collection focuses on understanding the impact of various socio-spatial aspects on social sustainability in urban settings. The questionnaire's reliability was validated with Cronbach's alpha coefficient.

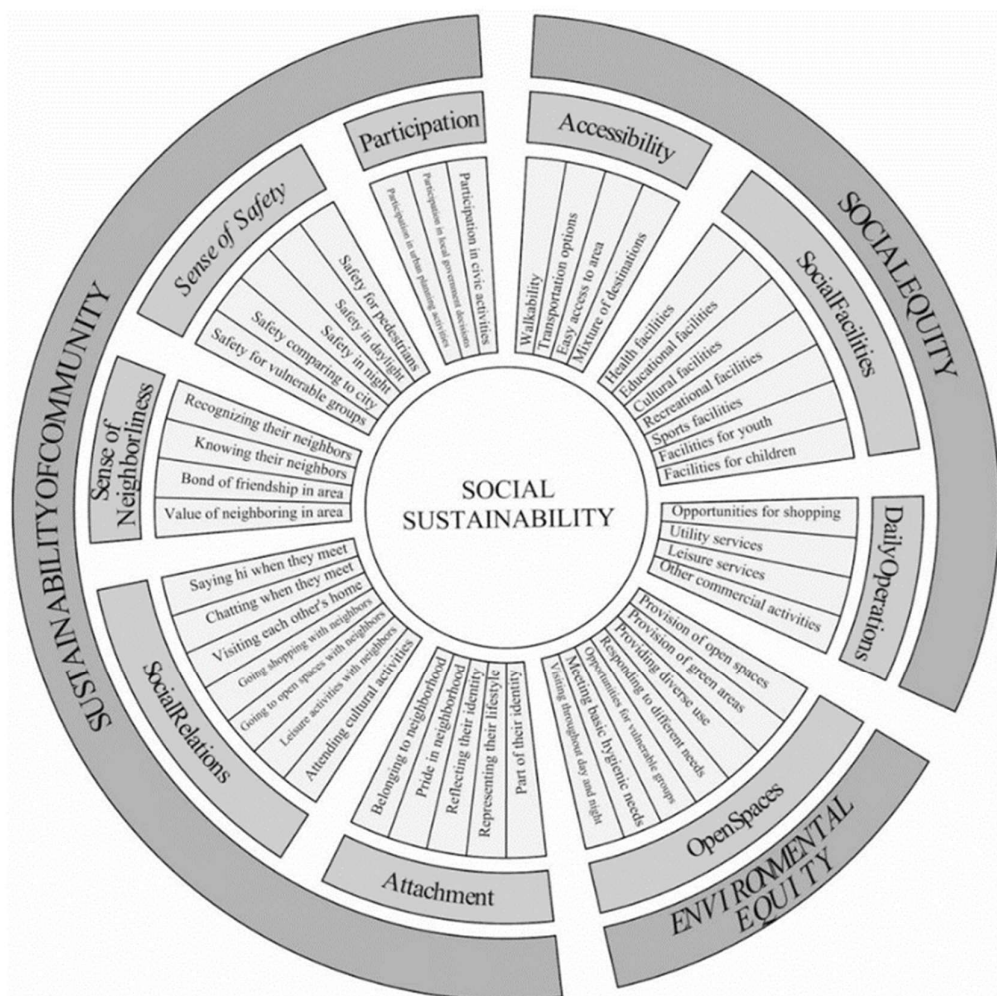


Fig. 6 Residential areas' socio-spatial sustainability indicators (Akcali & Ispalar Cahantimur, 2023).

A systematic literature review done by (Wang & Ke, 2024) reviews social sustainability in community contexts and it identifies frameworks, indicators, and improvement strategies. Researchers employed a qualitative systematic review approach. Content analysis method was the primary analysis technique and Meta-analysis method was used as a secondary technique. Positive correlations were established between spaces, infrastructure, and community satisfaction.

(Sugandha et al., 2022) in their study investigated the relationship between smart cities and social sustainability, questioning whether technology-driven urban development can meet social, environmental, and economic needs. It emphasizes the need for a critical analysis of how smart city initiatives can promote social sustainability, particularly in light of global frameworks like the UN's Sustainable Development Goals. The analysis reveals that while social capital and inclusion are emphasized in smart city definitions, social equity is often overlooked, indicating a gap in research. The research aims to establish a framework (Fig 7) that integrates social sustainability into smart city agendas, addressing key questions about definitions and improvements in urban development. The literature suggests that social sustainability indicators are less theory-driven and more based on practical understanding, emphasizing the importance of community engagement and participation. Authors used PRISMA Statement protocols and systematic qualitative literature review. Boolean search function was employed for literature selection. A mixed methods approach was suggested for social sustainability framework.

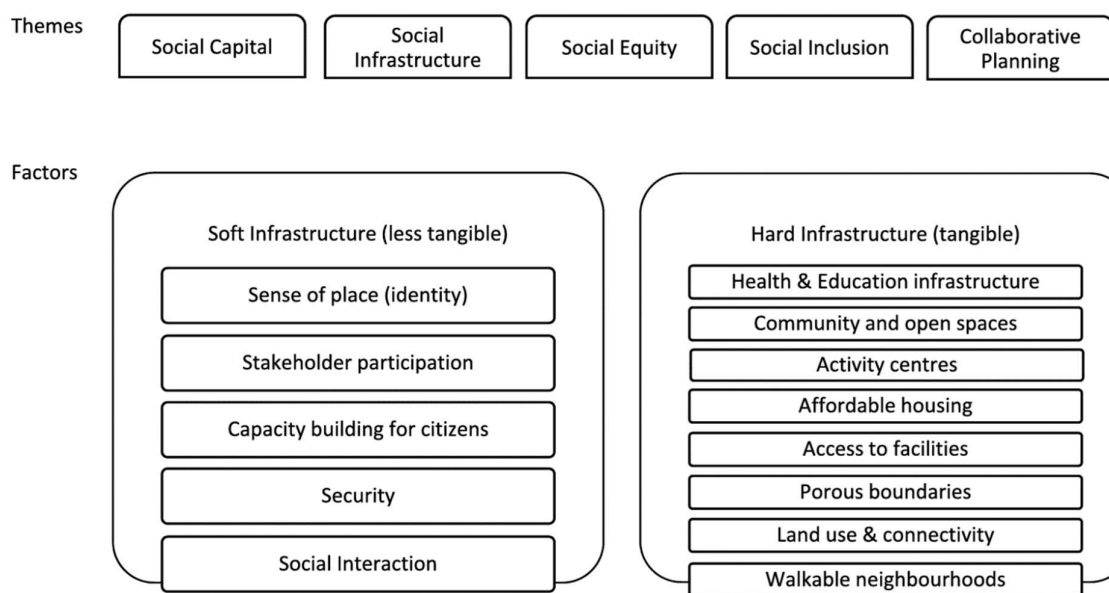


Fig. 7. Urban social sustainability in the smart City(Sugandha et al., 2022)

A research done by (Roosta et al., 2022), critiques the insufficient attention given to the social dimension of sustainable development, particularly in urban planning and design, despite its recognized importance. The study aims to explore the relationship between urban spatial configuration and social sustainability using the Space Syntax method, addressing gaps in existing research. Neighborhood units are identified as fundamental spatial units for assessing social sustainability, with indicators categorized into "social equality" and "sustainability of community." Key aspects of social sustainability include access to services, a sense of belonging, and community participation, with cultural context adding further dimensions.

The research methodology consists of three stages, beginning with mathematical modeling of the street network using the Space Syntax method. This stage involves analyzing the existing layout of neighborhoods to understand spatial configurations and their implications for social sustainability. Quantitative analyses of spatial configurations were conducted using UCL Depth Map software, converting street block data into axial and segment maps. The study focuses on three key parameters: Connectivity, Integration, and Intelligibility, which are essential for understanding the spatial dynamics of neighborhoods. Quantitative analyses of spatial configurations were conducted using UCL Depth Map software, converting street block data into axial and segment maps. Connectivity measures direct connections between spaces, while Integration assesses the accessibility of streets within the urban system. Intelligibility reflects the correlation between integration and connectivity, indicating how comprehensible the spatial environment is to users. Along with space syntax method, the author developed a questionnaire to assess social interactions, sense of security, and social justice, with validation from urban development experts. The study employed a stratified random sampling method to gather data from residents, achieving a high response rate and ensuring reliability through statistical analysis. Pearson correlation coefficients were calculated to explore the relationship between social sustainability indicators and Space Syntax parameters, revealing significant associations. Statistical analysis determined correlations between spatial configuration and social sustainability

(Larimian & Sadeghi, 2021), developed a social sustainability assessment model (Fig 8) by investigating how perceptions of neighborhood design quality influence perceived social sustainability, highlighting the importance of urban form in achieving social sustainability goals. A socially sustainable neighborhood is defined as one that provides equitable access to services and fosters community engagement and satisfaction. Each dimension is explained, emphasizing the role of social participation, safety, equity, and sense of place in contributing to overall social sustainability. The study emphasizes the importance of residents' subjective perceptions in assessing neighborhood quality, which cannot be fully captured by secondary data. A pilot study was conducted to refine the questionnaire, which was then distributed to 864 residents across five diverse neighborhoods in Dunedin, achieving a usable response rate of 29.1%. The study employs exploration and confirmatory factor analysis to develop and validate the USS scale, ensuring its reliability and dimensionality. Each dimension of social sustainability is operationalized through specific variables measured via a 7-point Likert scale in the household survey. The study utilizes previously validated survey questions to enhance the reliability of the measurements, ensuring a robust framework for analysis. Multiple regression analysis is used to explore the relationship between urban design quality and social sustainability, providing empirical evidence for the proposed hypotheses.

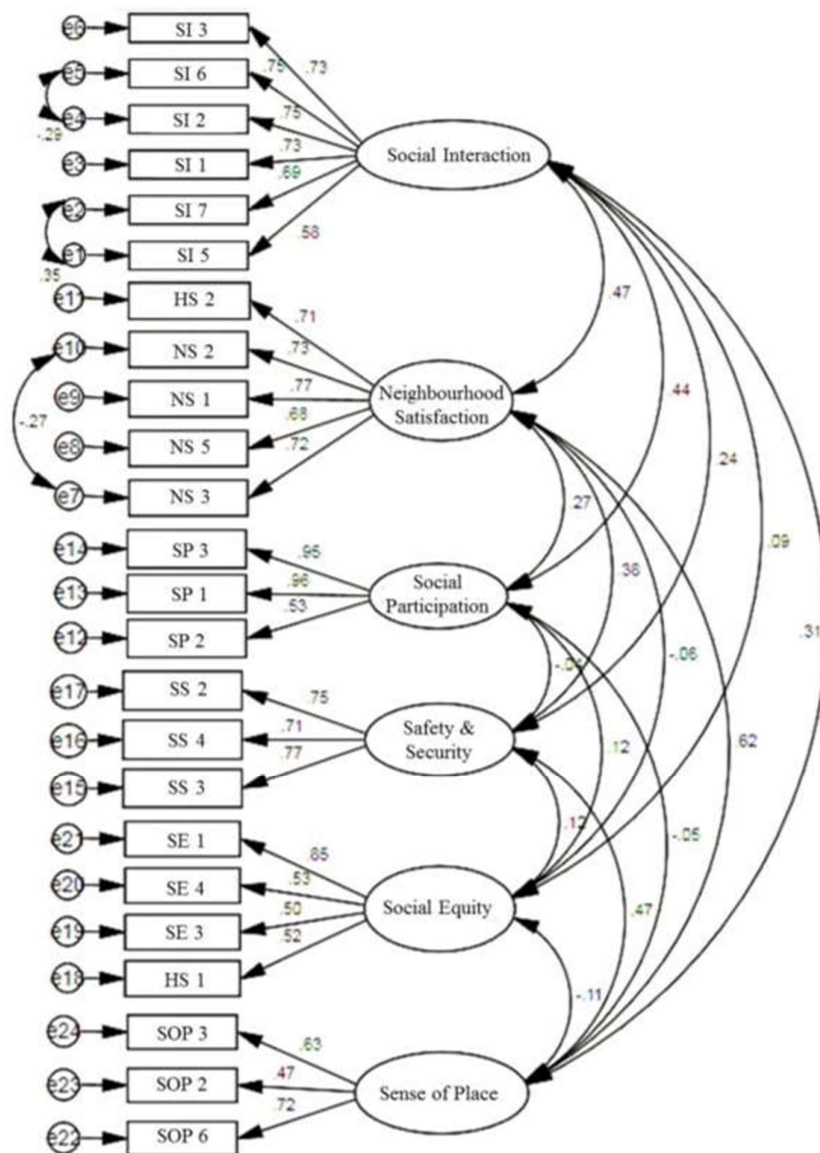


Figure 8. Analytic Structure of the USS measurement scale (Larimian & Sadeghi, 2021).

(Razia & Abu Bakar Ah, 2023) in their social suitability scale development in Dhaka, Bangladesh proposed a comprehensive model of social sustainability tailored to Dhaka's unique context, addressing the gaps in existing literature and providing a framework for urban management. It defines social sustainability as a critical component of urban development, ensuring quality of life and addressing the needs of marginalized populations, particularly in densely populated cities like Dhaka. Authors employed quantitative research approach using structured questionnaires. The study utilized a sample of 573 responses from Dhaka residents, employing a multistage sampling technique to ensure a representative sample of voters. A comprehensive survey was developed and validated through expert feedback, resulting in 62 items categorized under eleven themes of social sustainability. Eleven hypotheses were tested regarding social sustainability's influence. Indicators under 11 themes were identified for social sustainability (Fig 9).

The analysis involved exploratory and confirmatory factor analysis to establish the relationships between social sustainability indicators and their impact on urban development. The proposed model of social sustainability offers a structured approach for city authorities in Dhaka and other developing cities to enhance urban livability and address social challenges. The findings indicate that various factors, including healthcare access, gender equality, urban poverty, and transportation availability, significantly influence socially sustainable urban development in Dhaka. It also highlights the need for improved governance and urban planning to ensure that marginalized groups receive adequate support and resources.

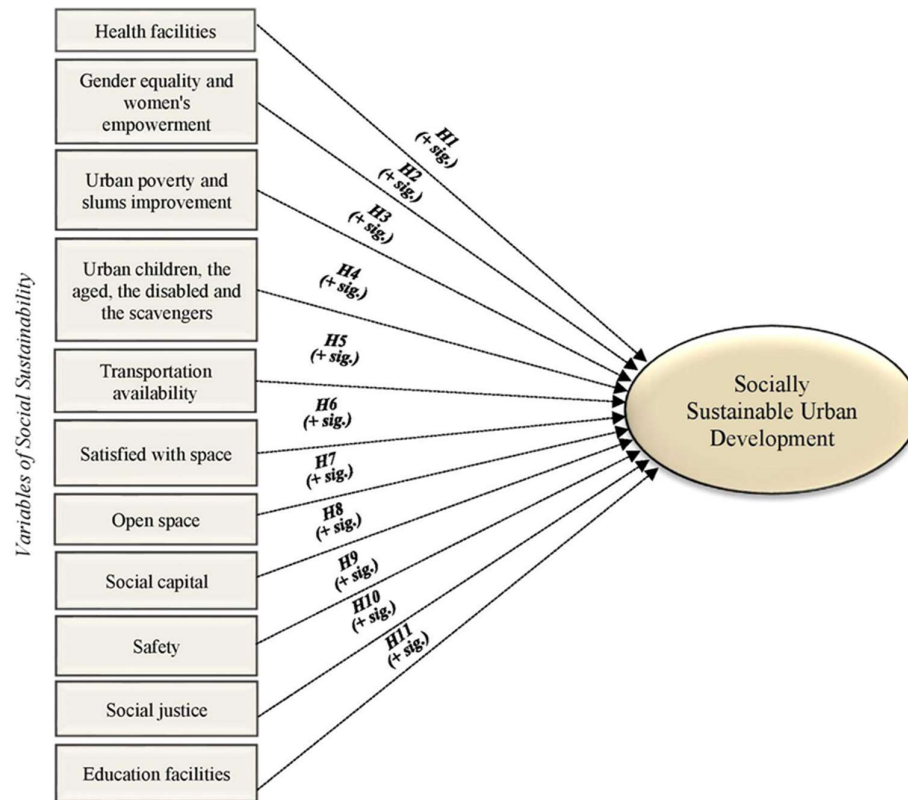


Fig. 9. Social sustainability model for socially sustainable urban development(Razia & Abu Bakar Ah, 2023).

An study done in the historical city centers of Iran by (Mirzakhani et al., 2023), explores the significance of sustainable development (SD) in urban planning, particularly in regenerating historical city centers that face social and structural challenges. The research seeks to ascertain the social determinants influencing the sustainability of the urban areas, emphasizing the need for resident participation in the regeneration process. Authors suggested that social sustainability focuses on creating equitable societies that ensure a quality of life that is great for everyone, emphasizing democracy, human rights, and social cohesion. Key factors identified include equity, participation, and social justice, which are crucial for fostering community engagement and improving living conditions.

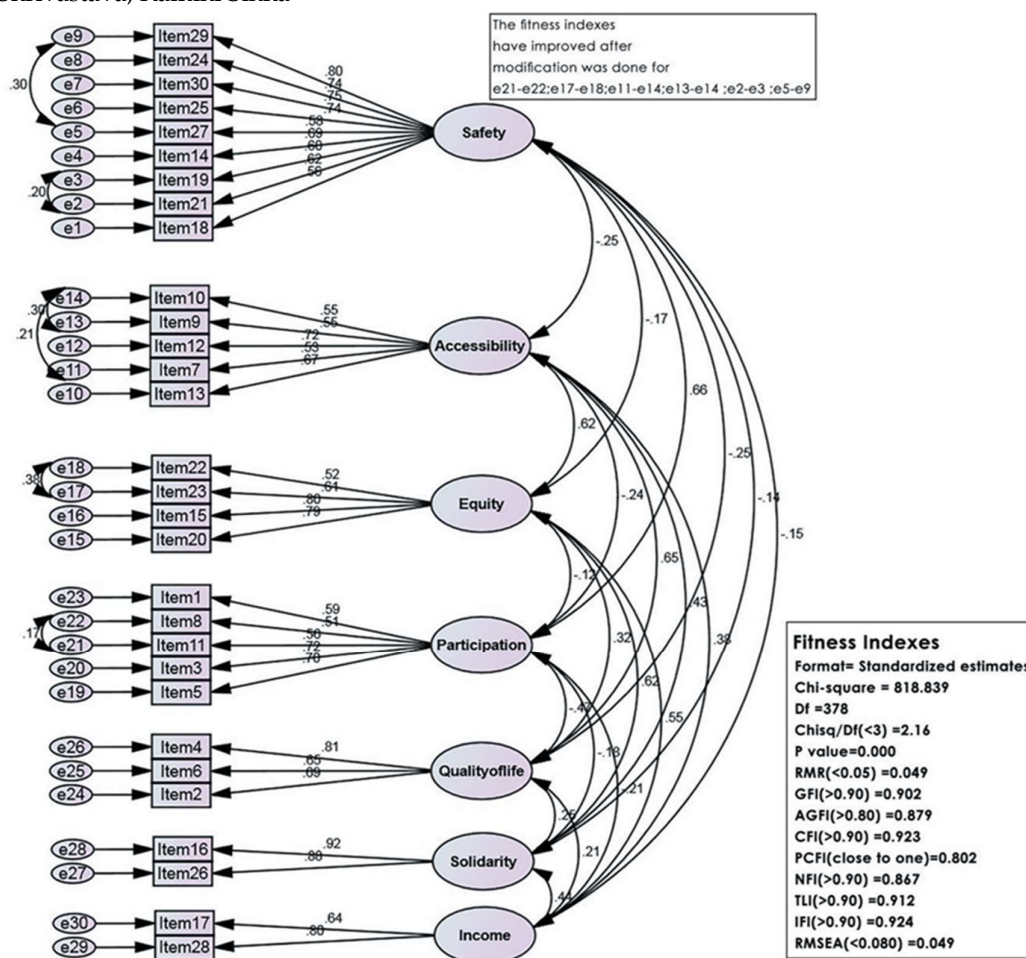


Figure 10. Path diagram, factor loadings and fitness indexes of the model (Mirzakhani et al., 2023).

EFA identified seven principal components (Fig 10) related to social sustainability, explaining 61.9% of the total variance in the data. The analysis involved factor rotation to simplify the interpretation of the components, which were named based on their relevance to social sustainability. This process helped clarify the relationships among various indicators and their significance in the context of historical urban areas. CFA was conducted to assess the validity and reliability of the model derived from EFA, focusing on construct validity, unidimensionality, and reliability. The analysis confirmed that the model fit the data well, with all fitness indexes meeting the required standards for validity. The results indicated that the identified factors were consistent with the researchers' expectations, reinforcing the model's robustness. The research identified seven key factors "security, accessibility, equity, participation, quality of life, solidarity, and income" influencing social sustainability in Iran's historical city centers, emphasizing the need for integrated regeneration strategies.

The research employed a multi-step methodology, starting with a literature review to identify social sustainability indicators relevant to historical urban areas. A Delphi method was used to refine these indicators through expert interviews, resulting in a questionnaire distributed to residents in four Iranian historical cities. The study utilized quantitative statistical methods, including Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), to analyze the data and validate the identified social factors.

(Doğu & Aras, 2019) discussed the evolution of sustainability, emphasizing the need for a balanced approach among its environmental, economic, and social dimensions, particularly highlighting the often-overlooked social aspect. It identifies a gap in the literature regarding the definitions, criteria, and measurement systems for social sustainability, leading to the development of a new scale (Fig 11) called Measurement of the City from Social Aspects (MCSA). The research involved a questionnaire survey with 400 locals, conducted over three years, focusing on interviews and observations to gather comprehensive data. The MCSA scale was developed through literature review and expert feedback, resulting in a refined 21-item Likert scale from an initial 36 items. Researchers used confirmatory factor analysis to test model fit. Construct and discriminant validity were assessed to check model fitness. The scale incorporates elements from existing studies, ensuring content validity and relevance to the context of Güzelyurt. Key factors measured include sense of belonging, social capital, perceived environment, and social interactions, which are critical for assessing social sustainability.

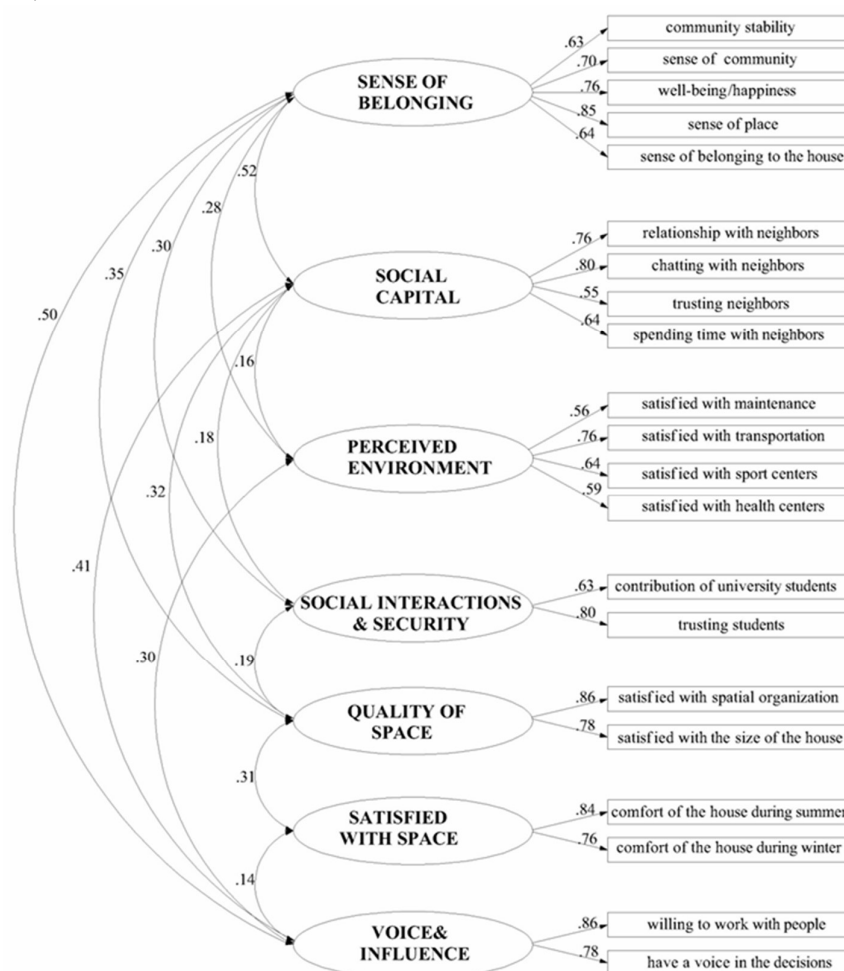


Figure 11. Analytic Structure of the MCSA Model (Doğu & Aras, 2019).

Results and Discussion

Literature reviews suggest that neighborhood sustainability assessment tools developed in different countries vary as per their context, approach, government policies and environmental goals. One of the major limitations of these tools is that they are not universal in nature, and they can be adopted directly, and it requires adjustment in criterion and items and their benchmarking and standardization. Social sustainability is a contextually dependent concept, and previous section have established that the literature on this topic is fragmented, multifaceted. This variation can be attributed to several factors identified in previous works: the intangibility of the concept, its constantly evolving nature (Dempsey et al., 2011),

interdisciplinary approaches (Colantonio, 2010), context dependence, multifaceted characteristics (Ghahramanpouri et al., 2015), diverse scales, scopes, and perspectives on the issue. Analysis of studies across various urban sizes indicated that earlier efforts on urban social sustainability focused predominantly on macro-scale urban challenges, such as those pertaining to cities. This research determined that there has been minimal discourse around micro-scale urban public spaces such as streets and public squares.

An examination of current interpretations of urban social sustainability in the literature indicates that scholars commonly identify qualities such as the fulfilment of human needs, a progressive viewpoint, social interaction, social mixing (cohesion and inclusion), and the enhancement of quality of life. An examination of urban strategies, including housing, urban renewal, urban form, urban rehabilitation, urban regeneration, and restoration within the literature on social sustainability, indicates that urban form and regeneration techniques are the most extensively researched topics, highlighting the context-dependent nature of discussions surrounding social sustainability. Common challenges impacting urban social sustainability include social equity, privacy, safety and security, legibility, social amenities, sense of place, identity, inclusiveness, diversity, public participation, and visual richness. Many researchers used different statistical methods to formulate assessment framework, which consists of regression analysis, exploration factor analysis, confirmatory factor analysis, structure equation modeling and space syntax. Owing to limitation to assess latent factors and corresponding errors in process, Structure equation modeling proved to be more common in use as this method facilitates assessment of many latent factors simultaneously.

Conclusion

The evaluation of neighbourhood sustainability (NSA) is an essential aspect of sustainable development. It facilitates the assessment of sustainability and offers guidance for development. A multitude of NSA systems are accessible worldwide. They were created after extensive research. These solutions were conceived with a broader sustainability framework in consideration. Academics and researchers necessitate tailored evaluation techniques for their specific enquiries. Consequently, the necessity for a novel NSA system tailored to a certain domain is evident. There are differences between the environments of industrialised and underdeveloped nations. In every case, the term "sustainability" and its interpretation vary significantly. It illustrates that, despite a shared objective of sustainability, the countries adopt varied methodologies. The article addresses relevant subjects in each situation. It possesses the capacity to understand them to identify their distinctions and focal points. Consequently, they act as a reference for developing nations in formulating rules. Furthermore, they exhibit differences in their methodologies about sustainability in each context. The categorisation of systems and the allocation of indicators distinctly illustrate the inequalities and inclinations between develop and developing nations.

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APPENDIX

Table 03: Categories, Indicators, Measures, Units of Neighborhood Sustainability Assessment Indicators(Bahadure & Kotharkar, 2018).

CATEGORIES	INDICATORS	CALCULATIONS	UNITS
Environmental	Land use mix	Total land use mix (LUM) value/Total parcel area Where total $LUM = \sum k(pk \ln pk)/\ln N$, k = Category of land use; p = proportion of land area devoted to specific land use; N = # of land categories	Index value
	Dwelling density	Dwelling units/Residential area Where: Residential area include internal street + half width adjoining access roads	Dwelling per Ha
	Impervious surfaces	[Total impervious area (TIA)/Total neighborhood area] $\times 100$ Where, TIA = roads, buildings, driveways, sidewalks, drainage, car parks	Percentage
	Internal connectivity	Total Intersections/ (Total Intersections + Cul-de-sac)	Index value
	External connectivity	Total perimeter length/# entry and exit points	Meter
	Open space provision	Total open space/ total residents	Square meter/person
	Non-motorized transport	[Total walkway + cycle length]/ total street length	Percentage
Social	Access to public transport	$(\sum Dna/\sum Da) \times 100$ Where Dna = # of dwellings located within a 600 m of a bus stop; Da = Total dwellings	Percentage
	Access to education	$(\sum Dna/\sum Da) \times 100$ Where Dna = # of dwellings located within a 600m of an educational facility; Da = Total dwellings	Percentage
	Access to local service	$(\sum Dna/\sum Da) \times 100$ Where: Dna = # of dwellings located within a 600 m of a local service center; Da = Total dwellings	Percentage
	Access to recreational space	$(\sum Dna/\sum Da) \times 100$ Where Dna = # of dwellings located within a 400 m of a park; Da = Total dwellings	Percentage
	Access to community centers	$(\sum Dna/\sum Da) \times 100$, Where Dna = # of dwellings located within a 600 m of a community center; Da = Total	Percentage
	Access to emergency services	Average response distance from 3 types of emergency services (i.e., police, ambulance, fire department)	Kilometers
	Crime prevention and safety	Total length of blind frontage/total frontage length	Percentage
	Traffic calming	Streets segments with traffic safety measures/total street segments	Percentage
Economic	Commercial establishment types	Number of diverse types of Commercial establishment types business activities	Number of types
	Affordable housing	Total affordable houses/Total residential in study area	Percentage
	Housing option diversity	$1 - \sum (n/N)^2$, where n = total dwelling is a category, N = total dwellings in all categories	Index Value

Table 04: Domains and Indicators Used(Seyed A. A. H., Ali A. T., 2018)

Basic elements of Neighbourhoods	Common Categories derived from the literature review	Design Principles
Place	- Infrastructure and transportation - Separation traffic mode - Physical form - Quality of architecture and construction - Suitable access to infrastructure - Livability - Resiliency	- Walkability - Appropriate density - Connectivity - Multimodal transportation - Architecture adapted to the local culture - Vibrant public spaces
Environment	- Environmental sustainability - Green urban design	- Healthy and safe environment - Green infrastructure - Clean transportation - Enduring and resiliency
People	- Social interactions - Justice - Quality of life - Social common sense - Equity	- Easy access to opportunities, - A sense of acceptance in the community - Life satisfaction
Activity	- Diversity - Mix used - Economic prosperity - Suitable access to services	- Allocate a range of activities in the neighborhood - Create local jobs

Table 05: Domains and Indicators Used (Bahadure & Kotharkar, 2018)

DOMAINS	INDICATOR SET	TWENTY INDICATORS
Demography	Density	- Population Density - Working Population per Hectare
Environmental	Noise Pollution	- Major Road Noise in decibel - Residential Road Noise in decibel
	Ecology (Trees Count)	- Tree Density per Hectare - Tree Density per Ten Persons
	Urban Habitat	- Open Areas per Hectare - Open Area Availability per Capita
Accessibility	Access to Land uses	Access to Various Amenities (Shop/Health /Services/Education/Green Spaces)
	Access to Transit (Bus)	- Average Distance to Bus Stops - Bus Frequency in Minutes
Road Infrastructure	Carrying Capacity	- Carrying Capacity of Major Road - Carrying Capacity of Residential Road
	Road Pattern and Network	Road Pattern and Complete Network
Traffic Speed	Two-Wheeler Speed	- Speed of Two-Wheelers on Major Road - Speed of Two-Wheelers' on Residential Roads
	Four-Wheeler Speed	- Speed of Four-Wheelers' on Major Road - Speed of Four-Wheelers' on Residential Roads
Safety	Safety Index	Fatalities per One Hundred Thousand Population
	Thefts	Thefts per Thousand Residents

Table 06: Benchmarking for Demography, Environmental and Transport domains' Indicators.

Indicators	Various Benchmark Values	Unit	Mode	Benchmark Value adopted in this study				
				Low (1)	Medium-Low (2)	Medium (3)	Medium-High (4)	High (5)
Population Density	80 pph [51]; 150 pph [8]; 50-100 pph [27]; 100 to 175 pph [23]	Persons per Hectare	Has two tail	0-49 350-More	50-74 300-349	75-99 250-299	100-149 200-249	150-199
Working Population	33% [23]	Percent	More is better	0-11	12-18	19-25	26-32	33-More
Major road Noise	Less than 75 dB [52]; 45-55 dB for residential and 55-65 dB for commercial [26]	Decibel	Less is better	75.00-More 65.00-More	70.00-74.99 60.00-64.99	65.00-69.99 55.00-59.99	60.00-64.99 50.00-54.99	59.99-Less 49.99- Less
Tree Density per Hectare	50 trees/ha [53]	Trees/Hectare	More is better	0.00-29.99	30.00-49.99	50.00-69.99	70.00-89.99	90.00-More
Tree Density per 10 Persons	a full grown tree produces oxygen, which ten people inhale in a year [30]	Trees/ 10 Persons	More is better	0.00-2.49	2.50-4.99	5.00-7.49	7.50-9.99	10.00-More
Open Space per Neighbourhood Area	18-30% [23]	Percent	More is better	0.00-4.99	5.00-9.99	10.00-14.99	15.00-19.99	20.00-More
Open Space per Capita	40 m ² /capita in developed nation and 20 m ² /capita in developing nations [33]; minimum 9 m ² /person [34]; 50 m ² /capita [27]	Square meter/ Capita	More is better	0.00-4.99	5.00-9.99	10.00-14.99	15.00-19.99	20.00-More
Access to Amenities	~ 400 m [54,55,56],	meters	Less is better	1000-More	800-999	600-799	400-599	0-399
Distance to Bus-Stops	150 to 300 m [42]; 200 m [28,56],	meters	Less is better	801-More	601-800	401-600	201-400	200-Less
Bus Frequency	10 min [43]	minutes	Less is better	20.01-More	15.01-20.00	10.01-15.00	5.01-10.00	5.00-Less
Carrying Capacity of Major Road	Six-point scale from Excellent (0.0-0.2) to Very-Very Poor (1.0-1.2) [46]	Ratio	Less is better	0.80-More	0.60-0.79	0.40-0.59	0.20-0.39	0.00-0.19
Carrying Capacity of Neighbourhood Road								
Road Pattern and Complete Network	Clear pattern (ring radial or gridiron) and complete network [46]	Points	-	Un-clear pattern and incomplete network	Unclear pattern and complete network	Somewhat clear pattern (ring radial or gridiron) but somewhat incomplete network	Clear pattern (ring radial or gridiron) somewhat incomplete network	Clear pattern (ring radial or gridiron) and complete network
Two-Wheelers' Speed on Major Road	30 km/h [47,37],	Km/h	Has two tail	11.99 less	12.00-16.99	17.00-21.99	22.00-26.99	27.00-34.99
Two-Wheelers' Speed on Neighbourhood Road								
Four-Wheelers' Speed on Major Road				50.00-more	45.00-49.99	40.00-44.99	35-39.99	
Four-Wheelers' Speed on Neighbourhood Road								
Fatal Accidents on Roads	Road safety index approaching 0.00 is un-safe and above 0.35 is safe [38]; 2 Fatality/Annum/Lakh Population [37]	Per lakh Population	Less is better	10.00-More	6.00-9.99	4.00-5.99	2.00-3.99	1.99-Less
Thefts	0 to 1 crime per 1000 persons for different crime types [50]	Per 1000 Population	Less is better	4.01-More	4.00-2.01	2.00-1.01	1.00-0.51	0.50-Less