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Livability in mixed-use vertical urbanism: A review and multi-dimensional framework for Indian cities

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Systematic Review

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Livability in mixed-use vertical urbanism: A review and multi-dimensional framework for Indian cities.

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Abstract

Vertical, mixed-use developments are increasingly used to support the urban growth of Indian cities, yet the tools used to evaluate the cities either rate the buildings on their environmental performance or measure livability at the neighbourhood scale. This review paper examines how livability has been conceptualised and assessed in vertical and mixed-use developments. Out of 50 targeted studies, 37 directly examine livability in high-density or vertical mixed-use settings. Through these studies, 24 indicators across functional, spatial, environmental, and social dimensions were coded by depth of treatment. The coverage of the indicators is uneven. Open space and density dominate, whereas management and maintenance, waste, affordability, universal accessibility, micro-climate, and vertical circulation are addressed by fewer than one in five studies, and indicators specific to vertical living receive less attention than general ones. The functional and environmental qualities are least covered, in contrast to the environmental focus of green building certification, in which Haryana can grant developers additional floor area without any assessment of livability qualities examined. The paper proposes a multi-dimensional framework that assesses all four dimensions together at the building level, street level, and neighbourhood scale. It specifies a measure for each indicator and it outlines a validation pathway for Indian cities such as Gurugram.

Keywords: Vertical urbanism; mixed-use development; livability indicators; urban livability; critical review; high-rise; neighbourhood scale

1. Introduction

Cities are growing rapidly on limited source of land. The United Nations has estimated that the World's urban population is projected to grow about 2.5 billion by 2050 (Al-Kodmany 2022). In response to this, the architects and planners have turned to growing buildings vertically rather horizontally, and high-rise buildings have become the principal response to the rapid urbanisation (Al-Kodmany 2018a). Mixed-use vertical developments which incorporates housing, retail, work, and recreation within a single

building or cluster is promoted as a solution to curb the urban sprawl, use land efficiently, and shorten trips (Al-Kodmany 2018b; Al-Kodmany et al. 2022).

Indian cities have now become a part of this shift, but at a very early stage. The density is regulated mainly through regulated limits on Floor Area Ratio and Floor Space Index (Kamble and Bahadure 2025), and these limits have been historically low by International standards. In a 2019 working paper, Somanathan and Natarajan reported that Mumbai then permitted a floor space index of up to 1.3, against up to 15 in New York and 25 in Singapore. In Haryana, on the other hand, the state building code permits a floor area ratio of 1.75 for group housing, maximum Ground Coverage of 35%, and no height limits, which later on rose to 3.5 for group housing in the high-density zones of Transit-Oriented-Development (Government of Haryana 2024, Code 6.3 and Annexure D). Density is also unevenly distributed: Avtar et al. (2025) describe Delhi as an "inverted compact" city, with higher densities at the periphery than in the core. Cities in the National Capital Region (NCR) such as Gurugram, the setting of the first author's doctoral research, offer a context in which to test how vertical urbanism performs in India.

Vertical growth, however, doesn’t automatically generate livable spaces. The reviews of tall-building research reports social isolation, , "vertical gated communities", poor integration with the street and high energy demand (Al-Kodmany 2018a), and design studies and resident surveys point to limited social interaction in high-rise housing (Moon and Miranda 2020; Nguyen et al. 2020). Higgs et al. (2019) warn that high-density development without amenities can amount to "high rise sprawl". The question here is not whether the cities should grow vertically or not, but how vertical mixed-use developments can become livable.

The tools that are mostly used to assess the quality of new buildings do not fully answer the above question. Green building certification systems such as BREEAM, LEED, etc were designed mainly around the environmental performance of the buildings and its surroundings. A comparison of these schemes against the WELL health standard found that they "mostly pay attention to indoor air quality, light and thermal comfort" (Potrč Obrecht et al. 2019, p. 1), leaving the other aspects of of well-being and health less covered. Thus, a development can earn a green rating and still lack active streets, affordable housing, shared social spaces, or easy access to transit systems. The gap between being livable and green is the starting point of this review.

Answering the above question requires differentiating five bodies of work that are often treated together. Research on high-rise building performance examines the space efficiency, structure, and environmental performance of individual towers (Moon and Miranda 2020; Al-Kodmany 2022; Ilgın 2023).). Research on vertical urbanism treats height as a way of organising the city in three dimensions, linking towers to infrastructure, public space and the street (Hou 2012; Lin 2016; Webb and White 2022). Research on mixed-use development examines how combinations of uses within buildings and neighbourhoods perform (Xie et al. 2022; Mishra and Roy 2024). Neighbourhood livability research measures the conditions around people's homes that support health and well-being (Badland et al. 2014; Higgs et al. 2019; Kamble and Bahadure 2025), and city-level livability rankings compare whole

cities (Kashef 2016). The mixed-use vertical development sits where these bodies of work meet, but each body covers only a part of it.

General livability indicators cannot be applied to the vertical developments without adaptation. The Urban Livability Index, for example, is calculated for residential addresses from indicators of the surrounding neighbourhood such as housing affordability, walkability, and access to public open spaces, and public transport (Higgs et al. 2019). Such indicators implicitly assume that the resident's front door opens onto the street. In a tower, the route from home to the street passes through lobbies, lifts, and shared spaces, and the resident's experience also depends upon evacuation routes, building management, daylight, and the relation between street and podium, conditions that neighbourhood indicators do not measure. Green building certification, conversely, assesses the building itself but concentrates on indoor environmental quality (Potrč Obrecht et al. 2019).

Existing reviews address parts of this problem. Badland et al. (2014) synthesised livability indicators linked to the social determinants of health and identified eleven domains at the neighbourhood and city scales. Kashef (2016) compared definitions of livability across disciplines and global city rankings. Al-Kodmany (2018a) consolidated critiques of tall buildings around the social, economic and environmental pillars of sustainability, and Potrč Obrecht et al. (2019) compared the health and well-being content of building certification schemes. Pradhan et al. (2025) reviewed indicators of urban sprawl, and Bibri et al. (2020) reviewed compact city strategies. This review differs from each of them. Unlike Badland et al. (2014), Kashef (2016) and Pradhan et al. (2025), it focuses on vertical and mixed-use development rather than on neighbourhoods, cities or sprawl. Unlike Al-Kodmany (2018a), it codes livability indicators study by study rather than consolidating critiques, and unlike Potrč Obrecht et al. (2019), it covers the street and the neighbourhood as well as the building. It also records, for every indicator, whether a study merely mentions, discusses or measures it, and it examines the evidence from Indian cities separately.

The central argument of the paper is that the livability in a mixed-use vertical environment should be assessed at three linked scales at the same point in time. At the building scale, the resident's daily experience depends upon corridors, lifts, daylight, shared spaces, and management:: Moon and Miranda (2020) show how the repetition of floors of limited area removes the horizontal circulation through which neighbours meet, and Nguyen et al. (2020) find that circulation areas such as corridors and lift lobbies are among the spaces residents use most for interaction. At the street and ground level, the podium and its frontage determine whether a tower contributes to street life or turns away from it (Al-Kodmany et al. 2022). At the neighbourhood scale, access to transit, services and green space shapes livability as it does for any housing (Higgs et al. 2019), and Webb and White (2022) argue that the high-rise neighbourhood, not the single tower, should be the unit of study. A deficit at one scale is not offset by quality at another; a well-equipped tower with a blank podium and no transit access remains poorly integrated with its city, and a well-located tower with unreliable lifts remains hard to live in.

The Indian evidence on these questions is limited. Of the 37 studies analysed in this review, three examine Indian cities, and none study residents of high-rise or mixed-use developments (Section 5.6).

This paper responds to these gaps through a critical analysis and review of 50 studies on mixed-use development, vertical urbanism, and urban livability. It addresses four research questions:

1. Why is vertical urbanism important, and what are the problems that it creates for urban livability?
2. Which livability indicators appear in the literature study, and how are they distributed across various dimensions?
3. Which methodologies are used by studies to examine livability in high-density and vertical settings?
4. Which indicators are understudied, and what does this imply for evaluating mixed-use vertical developments in Indian cities such as Gurugram?

The review paper has four contributions.

A map of how deeply each of the 24 livability indicators have occurred in the literature.

A multi-dimensional framework with indicator – to – scale matrix.

A comparison of the existing livability and building assessment frameworks through the literature.

A research agenda for Indian cities.

Section 2 provides a review methodology, Section 3 gives a conceptual background, Section 4 provides the findings, and Section 5 gives the discussion, and is concluded by Section 6.

2. Review method

This study is a critical review. It has been conducted through a documented process of identification, eligibility, quality screening, verbatim extraction, and indicator coding. It compares and evaluates the evidence rather than just cataloguing it. It is not a systematic review; the data were not drawn from a single database search, and the review doesn't claim complete coverage of the subject. Section 6.1 discusses this limitation.

2.1 Identification of studies

The studies were identified and selected through searches of academic databases and search engines, including Google scholar, ScienceDirect (Elsevier), and few other publishing databases during the first author's doctoral research. The searches had combined data from the terms related to vertical urbanism, high-rise buildings, tall buildings, urban livability, mixed-use development. From the results, 50 studies were selected on two grounds; first was their relevance to livability in vertical urban development and mixed-use development, second, their recency, priority was given to the recent publications. The search was targeted for open-access journal papers based on high-rise residential satisfaction, livability indicators, health and wellbeing in green certification systems, and density and wellbeing in Indian cities.

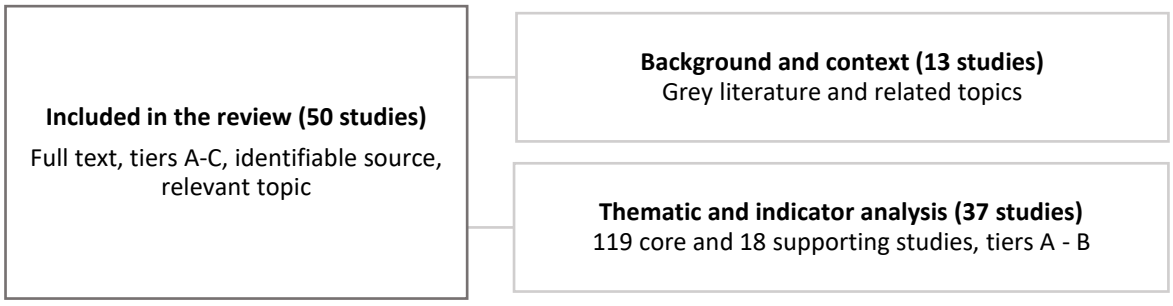
The exact dates of individual searches. Search strings, number of records retrieved and screened were not recorded. A full selection procedure however, cannot be presented and reported, and the exact search cannot be reproduced again; this is an acknowledged limitation in Section 6.1. To keep the selection transparent, the full list of the studies that are included (Section 2.2 Seupplementary Table S1).

2.2 Screening and quality assessment

All 50 studies were read completely and checked for their authors, year, venue, and content. Every study was assigned a quality tier based on its publication venue article (A) are in a Scopus-indexed journal, article (B) are in a peer-reviewed journal which are not indexed in Scopus, recognised conference proceedings, academic book chapter, or professional journals, and article (C) are grey literature which are working papers and theses. The Scopus coverage was checked in October 2026 using current source coverage, which might differ from a journal's coverage in the year the study was published. The studies such as conference reports published in professional journals were assigned in the lower tier. The tier are assigned by the first author. The studies selected in the review met tthree criteria (Figure 1):

1. The authors and publishers could be identified.
2. The full text is available.
3. The study addressed high-rise or mixed-use developments, vertical urbanism, urban density or urban forms, or urban livability.

Out of 50 studies reviewed, 37 of them formed the base of the indicator analysis.



`Fig 1. Studies in the review. 50 reviewed, out of which 37 were analysed and 13 were used for background study.

50 studies were then grouped by how directly they address the research questions. 37 studies met two further criteria and formed the basis of the thematic and indicator analysis (Section 4). These criterias are:

1. The study examines livability and its functional, spatial, environmental, or social qualities in mixed-use or high—density vertical settings; or develops ways to define and measure livability.
2. The study is a peer reviewed article, recognised conference paper, professional journal article, or an academic book chapter (tier A or B).

The target of the review is vertically integrated mixed-use development, high-rise clusters or buildings that combine with other uses, together with the public-realm environments and residences directly associated with them. The core 19 studies examine this phenomenon, or high-rise living directly. The other 118 supporting studies examine density, livability measurement, compact cities or the performance of tall buildings. They don't provide direct evidence about mixed-use vertical developments and are used only for two purposes: first, to define the indicators and identify the ways to measure these indicators, and second, to place core evidence in the context. The results are reported for both groups together and, where they differ, separately in Section 4.5.

Book chapters, conference papers, and professional journal articles were retained in the analysed data because the practitioner literature and design-led literature on tall buildings , including the proceedings and journal of the Council on Tall Buildings and Urban Habitat, appears in these venues; excluding them would remove most of the design studies. Their influence on results is tested (Section 4.5) by repeating the analyses for 26 studies in Scopus-indexed journals.

The remaining 13 studies include the related topics such as urban mobility, planning history, and urban expansion, and are grey literature. They provide the background and discussion but are not included in the indicator analysis because the studies that do not examine livability would understate how often livability indicators appear in the studies that do include them. The composition of the 37 studies analysed and summarised in Table 1.

The review collection of 50 studies was screened, extracted in full content, and quality was assessed (Supplementary Tables S1 and S2). The analytical data of 37 studies is the basis of each and every count, table, figure, and percentage in Section 4. The 13 background studies are not counted and one of them is cited for context (Somanathan and Natarajan 2019).

Table 1. Composition of 37 studies analysed

Characteristic	**Category**	**Core (n = 19)**	**Supporting (n = 18)**	**Total (n = 37)**
Quality tier	A: Scopus-indexed journal article	12	14	26
	B: other peer-reviewed or academic publication	7	4	11
Document type	Journal article	13	17	30

	Conference paper or report	3	1	4
	Book chapter	2	0	2
	Professional journal article	1	0	1
Publication period	2012–2019	7	5	12
	2020–2025	12	13	25
Study region	Global or conceptual	5	8	13
	East and Southeast Asia	8	3	11
	North America	4	0	4
	Australia	1	2	3
	India	0	3	3
	Europe	0	1	1
	Multiple regions	1	1	2

2.3 Data extraction

For every study five themes were extracted:

- The attributes or indicators
- Need of vertical urbanism
- Issues associated with vertical urbanism
- Methodology used in that particular study
- Solutions proposed.

To avoid paraphrasing, the themes were recorded as exact sentences from the study with reference page numbers so that every detail could be traced back to the sources. The extracted sentences and the above data is recorded for all 50 studies in Supplementary Table S2.

2.4 Indicator coding

Twenty-four livability indicators were extracted across four dimensions that are functional, spatial, environmental, and social before coding. These dimensions combine the domains of established livability frameworks (Badland et al. 2014; Higgs et al. 2019), the three pillars of sustainability used to critique tall buildings (Al-Kodmany 2018a) and the indoor-environment categories of building certification (Potrč Obrecht et al. 2019).

- The functional dimension covers how a developed setting meets the daily needs of an individual and what it costs him to use the space.

- The spatial dimension covers the built form and the relationship between the street and neighbourhood.
- The environmental dimension covers the physical conditions experienced by an individual in and around the building or clusters, and the resources that they use.
- The social dimension covers the relationship of the residents with the city.

The economic factor is not a separate dimension; the household aspects such as maintenance cost, management, and affordability are placed in the functional dimension as they determine whether or not the individual can use the development and stay in it.

Levels of treatment :

As the frequency of mentions is not an evidence that the indicator is examined. Every indicator studied was coded at one of four level mentioned:

- 0, not addressed;
- 1, mentioned: it means that the indicator appears only in passing, in background or in citation.
- 2, discussed: it means it has been explained in the study, it discusses about its effect on livability or quality of high-rise development.
- 3, measured: it means the study defines the indicator and collects or analyses data on it through spatial metrics, survey, building data or quantifies it in some way.

An indicator is counted addressed at level 2 or level 3.

Borderline cases:

The decision rules were applied to borderline cases as follows; further examples are given in Supplementary Table S3. An indicator named only in a list of general principles was coded as mentioned (land-use mix in Lin 2016). A study that measures a related building property without assessing the indicator itself was coded as discussing it: Ilgın (2023) measures the floor area taken by building cores but not lift provision for occupants. A target stated for a proposed scheme was coded as discussed (density in Shroff 2022), whereas a comparison of quantified design options was coded as measured (density in Tickle and Palmer 2016).

Procedure:

All 37 studies were read and coded by the first author. Keyword searches of the PDF texts were used to help locate relevant passages, but level was assigned from what the study does with the indicator, not from how often its keywords occur: a search for "density", for example, also returns passing mentions, and searches for abbreviations such as FAR return false matches that had to be discarded. Uncertain cases were re-read and resolved using the decision rules above. A generative AI tool was used to help extract text from the PDFs, locate candidate passages, and prepare a preliminary coding; the coding was then reviewed by the first author against the source studies (see Statements and Declarations). The resulting study-by-indicator coding is given in Supplementary Table S4.

Indicator frequencies are reported as the number of the 37 studies that address or measure each indicator. They describe the attention each indicator has received in this literature; they are not a ranking of the indicators' importance. Because, all coding was done by one reviewer and no inter-coder agreement could be calculated, the frequencies should be read as estimates of relative attention rather than precise measures.

2.5 Appraisal of methodological quality

The tier quality mentioned in Section 2.2 describes where a study was published not how well it was conducted. The methodological quality was therefore appraised separately for 17 empirical studies (the spatial or building-data analyses, resident or user surveys, and qualitative fieldwork or case studies in Table 3), using five criteria appropriate for empirical work of different designs: whether the data is adequate and clearly described; whether the indicators are clearly defined; whether the analysis is adequate to the data; whether the conclusions are supported by the results; and whether limitations are acknowledged. Each criterion was rated as met, partly met or not met, and each study was rated high (all criteria met, or three met and one partly), moderate or low (Supplementary Table S5). Conceptual essays, reviews and design studies were not appraised with these criteria because they do not report empirical data; they contribute concepts and propositions rather than evidence about how indicators perform. The appraisal was carried out by only one reviewer. It is used to interpret the measured evidence in Section 4.3: the number of studies that address an indicator shows how much attention the indicator has received, and not how strong the evidence about it is.

3. Conceptual background

3.1 Vertical urbanism and mixed – use vertical development

Vertical urbanism is more than building tall. Lin (2016, p. 5) concludes from a series of design studios that "vertical urbanism is not just a high-density urban form or an image of skyscraper city", but a way of organising space, infrastructure, and ecology in three dimensions. In the same spirit, Hou (2012) argues that the vitality of East Asian cities comes from their horizontal complexity at street level rather than from their skylines.

Recent scholarship also questions how vertical development is related to the city life. Demidov (2022) argues that skyscrapers will contribute to vertical urbanism only if they open their interiors to urban spaces. Ebbensgaard et al. (2024) observe that research on verticality often remains locked into binary critiques of success and failure, and call for context-specific understandings. Webb and White (2022) add that the unit of study should be the high-rise neighbourhood, not the single tower.

Mixed-use vertical development is the form most often proposed to make a vertical growth livable. It combines residential, commercial, and recreational uses within one building or a cluster of buildings. Al-Kodmany et al. (2022) propose tall buildings clustered around transit stations as a model that uses expensive land efficiently, raises ridership, and supports placemaking. In this review, mixed-use vertical urbanism refers to high-rise developments, or clusters, that integrate vvarious urban functions and are evaluated at the scale of the building and its surrounding neighbourhood

3.2 Urban livability

Urban livability has no single definition. Badland et al. (2014, p. 7) adopt the Australian Major Cities Unit definition: "Liveable cities are socially inclusive, affordable, accessible, healthy, safe and resilient to the impacts of climate change". Higgs et al. (2019, p. 2) operationalise livability through six domains: "transport, social infrastructure, walkability, housing, employment, and green infrastructure". Kashef (2016) shows that planning, design, and city-ranking traditions emphasise different aspects, and proposes an interdisciplinary view linking environmental, economic, and social domains.

Two features of the above definitions matter for vertical urbanism.

First, livability combines objective conditions such as open space, and access to transit with resident's experience, such as satisfaction and safety. Second, it is measured at the neighbourhood scale, where people live their day-to-day life. A livability framework for vertical development must look beyond the building envelope and up to the street, the cluster, and the services around it.

3.3 Green buildings versus livable places

Green building certification systems have been the main tool for raising the quality of new developments. They are focussed on energy, water, materials and indoor environmental quality. Potrč Obrecht et al. (2019, p. 1) compared LEED, BREEAM and DGNB with the health-focused WELL standard and found that these schemes "mostly pay attention to indoor air quality, light and thermal comfort". Other aspects of well-being covered by WELL received less attention as comapred.

Al-Kodmany (2022) reaches a related conclusion from a review of twelve sustainability-certified skyscrapers. He cites the warning that most of the discussions of sustainability focuses on "gizmo green", the idea that sustainability can be achieved "simply by using better equipment and better materials" (Al-Kodmany 2022, p. 12). For livability, the implication is that a building can perform well on environmental credits while still failing its residents as well as its neighbourhood. This review therefore treats environmental performance as one of four dimensions of livability, alongside functional, spatial and social dimensions

4. Findings

4.1 Why vertical urbanism is considered as a necessity

The studies give us four reasons for vertical growth, as mentioned in Table 2. The most common of them is the combination of population growth and limited land. The second one is the wish to contain the sprawl through a compact transit-oriented form. A third group mentions points to political-economic forces and market, and a fourth one questions whether vertical growth delivers the benefits that it claims for.

Table 2. Reasons for vertical urbanism in the reviewed studies

Reason	Studies	Illustrative statement
Population growth and land scarcity	Hou (2012); Tickle and Palmer (2016); Du et al. (2017); Moon and Miranda (2020); Nguyen et al. (2020); Hu et al. (2020); Novikov and Gimazutdinova (2021); Al-Kodmany (2022); Soltani et al. (2025)	"As urban populations continue to grow and space is limited, vertical buildings play an important role in the city development" (Nguyen et al. 2020, p. 1)
Containing sprawl through compact, transit-oriented form	Lin (2016); Al-Kodmany (2018b); Bibri et al. (2020); Al-Kodmany et al. (2022); Zhang and Yan (2023)	Tall buildings around transit are justified by "high land prices around mass-transit nodes … curbing horizontal expansion (sprawl), and fostering a sense of place" (Al-Kodmany et al. 2022, p. 4)
Market and political-economic forces	Hou (2012); Nethercote (2022); Webb and White (2022); Al-Kodmany et al. (2022)	Cities build skyscrapers due to "soaring land prices, a dire need for land preservation, greed, and vanity" (Al-Kodmany et al. 2022, p. 2)
Questioning the case for vertical growth	Higgs et al. (2019); Nethercote (2022); Soltani et al. (2025)	Urban compaction "is lauded as a fix-all: a panacea for sprawl" (Nethercote 2022, p. 11)

The Indian studies explains the need differently. Kamble and Bahadure (2025, p. 1) note that "Indian cities have been following high-density living", and Avtar et al. (2025) show that in Delhi density is already high but poorly distributed. In this context, the question is whether to densify or how to make existing and new density livable.

Several studies also caution that vertical growth can repeat the problems of urban sprawl. Soltani et al. (2025, p. 3) define "vertical sprawl" as "the unplanned, dispersed proliferation of high-rise developments" driven by population growth and land scarcity. Higgs et al. (2019) make the same point about high density without amenities. Vertical form alone, therefore, is not evidence of a livable development.

4.2 Issues associated with vertical urbanism

Functional

The strain on infrastructure and services, parking problems and overcrowding are reported for suburban tower clusters in the United States, for Delhi's mixed-use neighbourhoods and for the dense wards of Delhi (Al-Kodmany 2018b; Mishra and Roy 2024; Avtar et al. 2025). Tall buildings also raise functional risks: longer egress times and complex evacuation (Al-Kodmany 2018a; Moon and Miranda 2020); dependence on lifts, which, when inadequate or unreliable, discourage residents from using amenities on the ground floor (Al-Kodmany 2018a); and failures of maintenance and construction (Al-Kodmany 2018a; Nethercote 2022).

Spatial:

Studies mention a loss of human scale and connection with the street. The high-rise towers overshadow streets and public spaces and create windy plazas (Hou 2012), they dwarf the pedestrian and deprive streets of natural light (Al-Kodmany 2018a). Al-Kodmany et al. (2022) find that megastructure developments around Hong Kong stations produce large blocks, broad roads and poorly accessible public spaces, and the retail and social activity of many towers is internalised and disconnected from the street. Tickle and Palmer (2016) observe that engineering has largely overcome the limits to build at a higher density, but that providing open space and social infrastructure for the added population is much harder.

Environmental

The environmental issues include wind and overshadowing around towers (Hou 2012; Al-Kodmany 2018a), the loss of daylight for neighbouring residents (Ebbensgaard et al. 2024), poorly lit, single-aspect units without cross-ventilation (Nethercote 2022), energy demand (Novikov and Gimazutdinova 2021; Rinkinen et al. 2021) and noise in high-density communities (Zhang and Yan 2023). In Delhi, Avtar et al. (2025) warn that the unequal distribution of green space may intensify urban heat islands in densely populated wards

Social:

Social isolation is the most raised issue. Al-Kodmany (2018a) links isolation and depression in high-rise housing to poor neighbourhood relations and poor design, and Moon and Miranda (2020) attribute it to the repetition of floors of limited area, which removes the horizontal circulation through which the neighbours normally meet. Exclusivity is another concern. The towers are described as "vertical gated communities" for elite groups (Al-Kodmany 2018a; Demidov 2022) and as a means of internalising and protecting privately owned amenities (Lehrer and March 2019), while Hou (2012) links high-rise redevelopment to the displacement of long-time residents. Nethercote (2022) shows that condominium governance shapes residents' security, and Webb and White (2022) note the ageing of older high-rise neighbourhoods.

Collectively, these issues show that the problems of vertical urbanism are not only technical; most of them concern how the towers relate to the people, street, and to the neighbourhood, and what aspects are least covered by the green rating systems.

4.3 Methods used in literature

Most of the literature on vertical urbanism is design-led or conceptual (Table 3). Out of the 37 studies, 20 are essays, editorials, reviews or design proposals. Only 15 of them measure any one or more of the 24 livability indicators, mostly through resident surveys or spatial analysis. 7 studies collect primary data from residents or other users, and 4 of these study people living in high-rise housing: Du et al. (2017) in Chicago, Nguyen et al. (2020) in Hanoi, Zhang and Yan (2023) in three Chinese cities, and Yue et al. (2024) in China.

Table 3. Methodology used by the 37 analysed studies

Method	Studies (n)	Studies
Conceptual essay, editorial or conference summary	9	Hou (2012); CTBUH (2014); Lehrer and March (2019); Novikov and Gimazutdinova (2021); Demidov (2022); Webb and White (2022); Bertolini (2023); D'Acci et al. (2024); Ebbensgaard et al. (2024)
Spatial or building-data analysis	7	Al-Kodmany (2018b); Higgs et al. (2019); Al-Kodmany et al. (2022); Xie et al. (2022); Ilgın (2023); Avtar et al. (2025); Soltani et al. (2025)
Resident or user survey and interviews	7	Du et al. (2017); Nguyen et al. (2020); Rinkinen et al. (2021); Zhang and Yan (2023); Mishra and Roy (2024); Yue et al. (2024); Kamble and Bahadure (2025)
Literature or document review	6	Badland et al. (2014); Kashef (2016); Al-Kodmany (2018a); Potrč Obrecht et al. (2019); Al-Kodmany (2022); Pradhan et al. (2025)
Design study or proposal	5	Lin (2016); Tickle and Palmer (2016); Hu et al. (2020); Moon

		and Miranda (2020); Shroff (2022)
Qualitative fieldwork or policy case study	3	Bibri et al. (2020); Nethercote (2022); Roast (2024)

Each study is assigned to one category by a principal method provided in Supplementary Table S1. The various methods aused are editorial or conference summary, conceptual essay, arguments without any background data, quantitative analysis of maps, imagery, census or building records, user survey, interviews, manuals of policies and rating systems, structured analysis of published studies, design proposals, studio works, or proposal schemes.

Out of the 17 empirical studies 9 were rated high quality, 6 were moderate, 2 were low, mentioned in supplementary Table S5). The measured evidences are strongest for walkability, open spaces, public transport, open spaces, health and well-being, community interaction, and density, each of the element is measured in 3 high-rated studies atleast. The weakest ones are human scale, social, mix, and land-use mix.

The empirical studies use a wide range of tools. Spatial studies use GIS, remote sensing and composite indices (Higgs et al. 2019; Avtar et al. 2025; Soltani et al. 2025). Resident studies use satisfaction questionnaires with regression (Du et al. 2017; Zhang and Yan 2023), interaction diaries and interviews (Nguyen et al. 2020), factor analysis to build a validated scale (Yue et al. 2024), and the Analytic Hierarchy Process to select indicators (Kamble and Bahadure 2025).

There are two gaps that stand out. First, none of the studies combines objective indicators of the built environment with resident's own assessment of livability in mixed-use vertical developments. Second, none of the resident studies are set in Indian high-rise or mixed-use developments. The two Indian studies with primary data examine high-density neighbourhoods (Kamble and Bahadure 2025) and commercial streets (Mishra and Roy 2024), not vertical developments.

4.4 Solutions proposed

Table 4. Solutions proposed in the studies reviewed

Scale	Solution	Studies
Building	Shared social spaces distributed vertically through the building	Tickle and Palmer (2016); Lehrer and March (2019); Nguyen et al. (2020)
Building	Sky lobbies and bridges linking towers for interaction and evacuation	Hu et al. (2020); Moon and Miranda (2020)
Building	Units and spaces designed for different households and ages	Al-Kodmany (2018a); Zhang and Yan (2023)

Building	Biophilic design and greenery at building interfaces	Yue et al. (2024)
Street and ground	Active ground floors and seamless links between street and plaza	Novikov and Gimazutdinova (2021); Demidov (2022); Al-Kodmany et al. (2022)
Neighbourhood	Tall, mixed-use buildings clustered around transit stations	Al-Kodmany (2018b); Al-Kodmany et al. (2022); Shroff (2022)
Neighbourhood	Mixed residential-commercial zoning and integrated land use and transport	Mishra and Roy (2024); Avtar et al. (2025); Pradhan et al. (2025)
Policy	Three-dimensional (volumetric) planning and density limits where infrastructure is overloaded	Soltani et al. (2025); Avtar et al. (2025)
Policy	Design guidelines, planning controls and governance reform	Nethercote (2022); Webb and White (2022); Hu et al. (2020)
Measurement	Policy-linked livability indices and indicators	Badland et al. (2014); Higgs et al. (2019); Kamble and Bahadure (2025)

At building scale, Nguyen et al. (2020) recommends distributing shared spaces vertically through the building while protecting the resident's privacy and safety. At the street scale, Al-Kodmany et al. (2022, p. 19) proposes that developers dedicate "a minimum of 50% of the ground floor area to retail use". At the policy scale, Avtar et al. (2025) recommends vertical zoning regulations that restrict additional residential floor area in overcrowded wards of Delhi while encouraging commercial use of ground floors.

Most of these solutions are design proposals or policy recommendations rather than tested solutions or interventions. Only few of them address affordability, maintenance and management, or the governance of shared spaces, although Nethercote (2022) shows that governance shapes everyday life in high-rise housing. Measurement is also treated as a solution in its own right: Badland et al. (2014, p. 28) argue that "there is a need to create livable indices that are evidence-driven, and are linked to urban planning policies".

4.5 Livability indicators across four dimensions

Attention to the livability indicators is very uneven (Figure 2). Open and public spaces are discussed or measured in 27 of the 37 studies (73%), density in 23 (62%) and land-use mix in 18 (49%). On the other end, six indicators are addressed by fewer than one in five of the 37 studies: microclimate (7 studies), vertical circulation, housing affordability and universal accessibility (6 each), and maintenance and management and waste management (3 each). Measurement is still rarer. Only density is measured in

more than five studies (9), and five indicators (street interface, participation and governance, waste management, energy, and universal accessibility) are not measured in any.

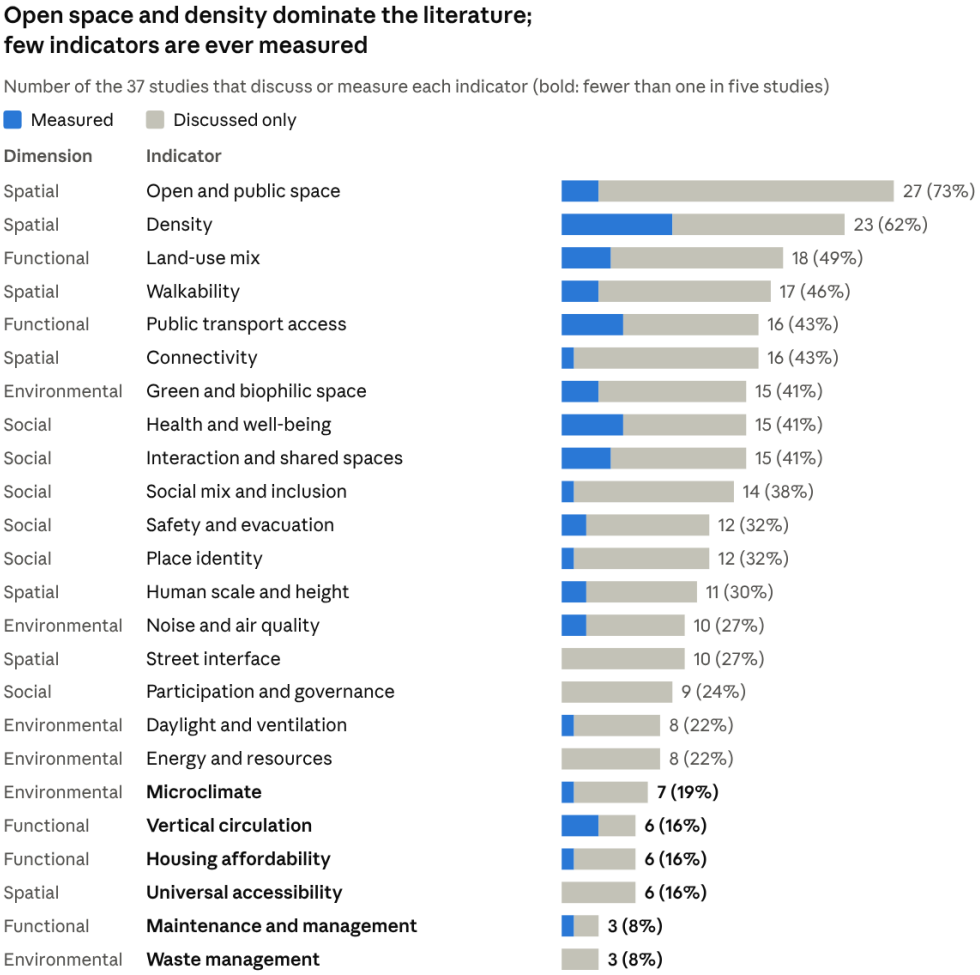


Fig 2. Indicators covered in 37 studies analysed deeply (Section 2.4 and Supplementary Table S4)

Table 5 summarises the dimensions covered. For each dimension, the number of the 37 studies addressing each indicator was divided by 37, and these shares were averaged with equal weight for every indicator. For the environmental dimension, for example, the six indicators are addressed by 8, 8, 7, 15, 3 and 10 studies, which gives an average of 51 ÷ (6 × 37) = 23%. Equal weighting is used because the framework does not yet assign weights to its indicators (Section 5.3), and any other weighting would need empirical justification. Within the selected analytical corpus, environmental indicators had the lowest average coverage under the study's coding framework (23%), against 26% for functional, 35% for social and 42% for spatial indicators. This should be read as a gap in this evidence base, and not as a general statement about the environmental performance receives in other literatures.

Table 5. Indicator coverage as per dimension

Dimension	Indicators (n)	All 37 studies	Core studies (n = 19)	Supporting studies (n = 18)	Least-addressed indicator (share of 37 studies)
Spatial	7	42%	48%	37%	Universal accessibility (16%)
Social	6	35%	39%	30%	Participation and governance (24%)
Functional	5	26%	24%	29%	Maintenance, management and running costs (8%)
Environmental	6	23%	18%	28%	Waste management (8%)

There are two qualifications that apply. The first one is that the functional indicators are poorly covered just like the environmental ones because vertical circulation, maintenance, and affordability are rarely addressed; the safer conclusion is that environmental and functional qualities are both under-studied. Second, the environmental dimension is not uniform. Energy and waste are addressed the least, the conditions residents experience directly such as microclimate, daylight, air quality, noise, and green space are adressed most often. In the core studies of vertical and mixed-use development, environmental coverage falls to 18%.

There are two patterns that stand out the most within the dimensions. First are the indicators that are most specific to the vertical living and receive less attention than those adapted from general urban livability. The 9 indicators identified are specific to vertical living (Section 5.2) and are addressed on an average, by 26% of the 37 studies, against 36% for the other 15. Vertical circulation is addressed in 6 studies and maintenance and management in 3 studies, although residents of tall buildings depend on both every day. Second, among environmental indicators, the conditions that residents experience directly in and around towers, such as microclimate, daylight and ventilation, are addressed less often than green space.

Sensitivity check: Repeating the analysis for the 26 articles in Scopus-indexed journals and for the 19 core studies gives the same pattern: environmental indicators have the lowest and spatial indicators have the highest average coverage, and maintenance and management, waste management and housing affordability remain among the least-addressed indicators. The main conclusions however do not depend upon the inclusion of conference papers, book chapters and professional articles

5. Discussion

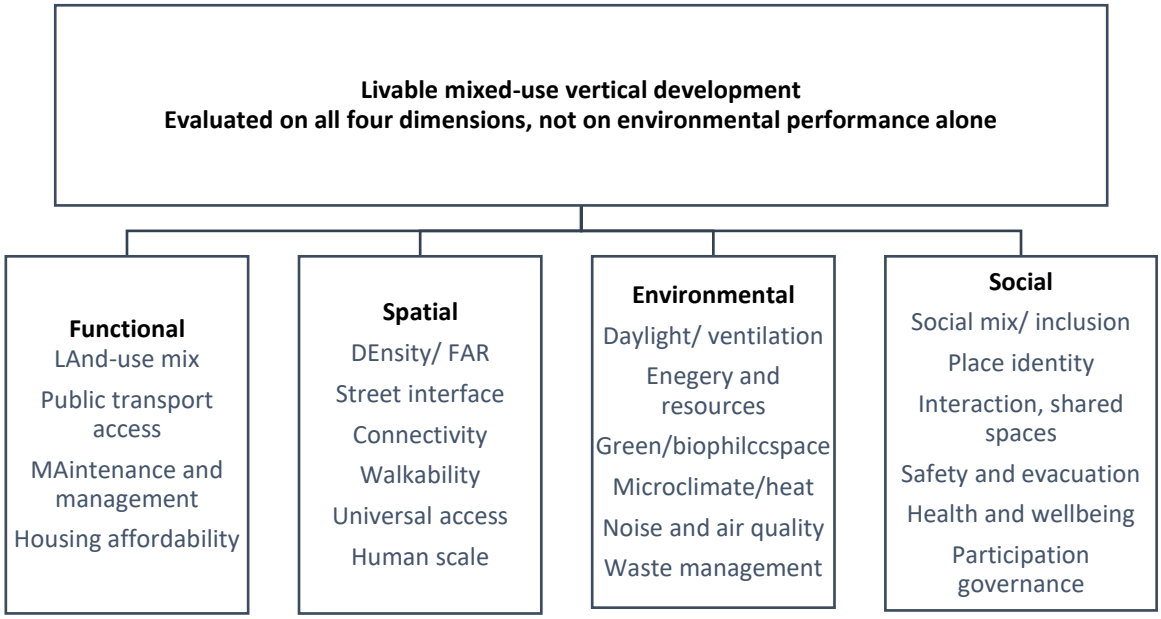
5.1 Green doesn’t mean it is not livable

The findings point out 2 aspects that cover different grounds. The Green Building Certification concentrates on the environmental performance and indoor conditions (Potrč Obrecht et al. 2019), whreas the studies on vertical urbanism reviewed here concentrate on social and spatial qualities and give very little attention to the environmental indicators particularly waste and energy (Table 5). Both of them are not directly comparable as the certification content is not coded with this review's framework,

the contrast between them is one of the emphasis. Neither one of them describes what makes a mixed-use vertical development livable.

The gap matters the most to the issues identified in Section 4.2. Social isolation,, loss of human scale, exclusivity, difficult evacuation, and poor access to open space are not measured by energy or water credits. A development can score well on certification while rreflecting the problems that critics of tall buildings describe (Al-Kodmany 2018a; Demidov 2022). Conversely, the environmental qualities residents experience every day, such as ventilation, daylight, and microclimate around towers, are very rarely examined in the studies that are reviewed. But an evaluation framework for vertical urbanism needs to combine both equally.

Four dimension of livability, each one assessed from building scale to neighbourhood scale



Assessed at 3 scales: Building scale, street and ground level, neighbourhood scale

Fig 3. Proposed multi-dimensional livability framework for mixed-use vertical urbanism

Table 6. Proposed framework compared with existing frameworls and closest assessment approaches in the reviewed literature.

Framework or approach	Unit of assessment	Vertical circulation	Social interaction	Governance and management	Environmental conditions
Liveability domains	Neighbourhood and city	No	Social cohesion	Local democracy	Natural environment

(Badland et al. 2014)					
Urban Liveability Index (Higgs et al. 2019)	Neighbourhood	No	No	No	Air quality
Green building certification (Potrč Obrecht et al. 2019)	Building	No	Limited (WELL only)	Management (some schemes)	Air, water, light, thermal and acoustic comfort
Critique of tall buildings (Al-Kodmany 2018a)	Building and city	Yes	Yes	Partly	Wind, shadow, heat, energy
Residential factors in high-density communities (Zhang and Yan 2023)	Building and neighbourhood	Yes	No	Yes	Lighting, noise, green space
Social interaction in high-rise buildings (Nguyen et al. 2020)	Building and neighbourhood	Partly	Yes	No	No
Framework proposed here	Building, street and neighbourhood	Yes	Yes	Yes	Yes

The comparison shows a considerable overlap. Most of the proposed indicators are already appearing somewhere: neighbourhood access and density in the Urban Liveability Index, lifts, maintenance, daylight and noise among Zhang and Yan's (2023) residential factors, social interaction in Nguyen et al. (2020), and indoor environmental quality in certification schemes. What is missing is their combination. The general livability frameworks do not generally look inside buildings, the building-scale approaches do not look at the street or the neighbourhood, and the studies closest to vertical living examine only a few dimensions. 9 of the 24 indicators are classified as specific to vertical living because they describe conditions that arise from stacking dwellings and uses vertically: vertical circulation;

maintenance and management of a shared building; street interface; connectivity between towers and to the ground; human scale; daylight in stacked units; microclimate around towers; shared spaces within buildings; and evacuation (Supplementary Table S3).

Several indicators serve in more than one dimension. Open space, for example, shapes the spatial structure of a development, moderates its microclimate and provides settings for social interaction to the prople. To avoid counting an indicator twice, each is assigned one primary dimension according to the quality it describes for residents, and its secondary dimensions are recorded in Supplementary Table S3. The framework also separates an indicator's conceptual relevance from how it is measured: the measures in Table 7 are examples drawn, where possible, from the reviewed studies, and other measures may suit other contexts.

Table 7. Indicators of proposed framework with each scale assessed

Indicator	Dimension	Scale	Example measure
Land-use mix	Functional	B, N	Variety of uses in the building and within walking distance
Public transport access	Functional	N	Walking distance to the nearest station
Vertical circulation	Functional	B	Lifts per dwelling; reliability of lift service
Housing affordability	Functional	B, N	Housing cost relative to household income
Maintenance, management and running costs	Functional	B	Maintenance charges; quality of upkeep
Density	Spatial	B, N	Dwellings per hectare; floor area ratio
Open and public space	Spatial	S, N	Open space per resident; distance to a park
Street interface	Spatial	S	Share of active ground-floor frontage
Walkability	Spatial	S, N	Walkability index
Connectivity	Spatial	B, S, N	Links between towers, to the street and to transit
Human scale and building height	Spatial	S	Podium height; setbacks

Universal accessibility	Spatial	B, S	Step-free access to dwellings and facilities
Energy and resources	Environmental	B	Energy and water use per unit of floor area
Daylight and natural ventilation	Environmental	B	Hours of natural light; cross-ventilated units
Microclimate (heat, wind, shadow)	Environmental	S, N	Surface temperature; wind and shadow at ground level
Green and biophilic space	Environmental	B, N	Green space per capita; sky gardens
Waste management	Environmental	B, N	Provision for segregated waste collection
Noise and air quality	Environmental	B, N	Noise level; air pollution
Community interaction and shared spaces	Social	B	Frequency of neighbour interaction; shared spaces per building
Social mix and inclusion	Social	B, N	Mix of unit sizes and tenures; gated access
Safety, security and evacuation	Social	B, N	Perceived safety; evacuation routes
Place identity and culture	Social	S, N	Residents' sense of place
Participation and governance	Social	B, N	Residents' role in building management
Health, well-being and quality of life	Social	B, N	Residential and life satisfaction

Scale: B = building; S = street and ground level; N = neighbourhood. The full specification of each indicator is given in Supplementary Table S6.

5.3 Distinctive contribution to the proposed framework

The framework is best described as an evidence-derived multi-dimensional framework for vertical mixed-use environments. It is a proposed framework and not a validated index or a completed measurement tool and its advance over existing approaches is incremental and lies in 3 features:

- Integration across scales: None of the frameworks in Table 6 assesses the building, street, and ground level, and the neighbourhood level together. The proposed framework does it so that

for a single development the reliability of its lifts, the use of its shared spaces, the podium activities, frontage, and access to transit can be assessed side by side.

- Vertical – specific indicators in one structure: The framework brings together the conditions that existing instruments treat separately or doesn't treat them at all: vertical circulation and lift provision (Xie et al. 2022; Zhang and Yan 2023), shared spaces within buildings (Nguyen et al. 2020), connections between towers and to the street (Moon and Miranda 2020; Al-Kodmany et al. 2022) and evacuation (Al-Kodmany 2018a; Moon and Miranda 2020). Each is documented in the reviewed literature; the contribution is to assess them together with neighbourhood livability, and not to identify them for the first time.
- Attention to evidence: Each indicator is reported with the number of studies that discuss it and measure it, the quality of the measuring studies, and its readiness for assessment (Figure 2; Supplementary Tables S5 and S6). This separates the indicators supported by measurement from those that rest on argument.
- What frameworks does not yet do: It doesn't provide common measurement protocols, reference thresholds or scoring procedures. Supplementary Table S6 specifies an operational definition, a unit of measurement, a data source, the spatial boundary and assessment scale, a collection or calculation procedure, whether the measure is objective, resident-reported or both, how missing data are handled, and whether higher or lower values indicate better performance. Most of these metrics, formulas and data sources are taken or adapted from the measurement framework developed in the first author's doctoral research; the remainder were defined for this review. Three general rules that apply are: boundaries are the approved site (building), the site frontage and abutting street (street and ground level) and an 800 m walking catchment (neighbourhood); values that cannot be obtained are recorded as not assessed rather than as zero and are not imputed; and estimates from substitute sources are flagged. It classifies ten indicators as ready to assess with measures used in the reviewed studies, nine as adaptable from existing measures, and five (maintenance and management, street interface, universal accessibility, waste management, and participation and governance) as needing new measures. Objective measures and residents' perceptions should be reported separately, not combined into a single score, until the relationship between them has been tested.
- Validation pathway: Validation would proceed in four steps:
  (1) Content validation, in which a panel of architects, planners, developers, building managers and resident's representatives reviews the indicators and their definitions for eg through a Delphi process;
  (2) Pilot application to a small number of mixed-use vertical developments in Gurugram, to test whether the required data can be obtained or not;
  (3) Reliability testing, through agreement between the two assessors on audit-based indicators and the internal consistency of survey scales; and
  (4) Validity testing, by examining whether indicator scores are associated with the resident's satisfaction and well-being. Weights and thresholds should be set only after these steps (Section 6.2).

5.4 Under – studied indicators

Four groups of indicators deserve more attention.

Costs and management of living in towers: Maintenance and management are addressed in only 3 studies, and housing affordability in 6 studies. Nethercote (2022) shows that the governance and running costs of shared buildings shape residents' security and sense of home, and Zhang and Yan (2023) find that property maintenance is associated with residential satisfaction in Chinese high-density communities.

Vertical circulation and access: Lifts are addressed in 6 studies and universal accessibility in 6, although older and disabled residents depend on lifts to reach everything outside their homes (Al-Kodmany 2018a; Ebbensgaard et al. 2024).

Microclimate and daylight: Few studies examine heat, wind, shade and daylight in and around towers, although these are among the first criticisms of tall buildings (Hou 2012; Al-Kodmany 2018a), and density can intensify heat islands where green space is unevenly distributed (Avtar et al. 2025).

Waste and services: Waste management is addressed in only 3 studies, although strain on infrastructure is a recurring issue in dense Indian cities (Avtar et al. 2025). The street interface, addressed in 10 studies, is discussed more often but never measured.

5.5 How the gaps interact

The under-studied indicators are not independent, and their effects on livability are likely to compound. Some of the links below are documented in the reviewed studies; others are proposed here as hypotheses for future research, and are identified as such.

- *Vertical circulation, access and inclusion.* Al-Kodmany (2018a) argues that when vertical transport is inadequate or unreliable, residents are discouraged from using amenities on the ground floor, and Ebbensgaard et al. (2024) report that lifts often stop working during air raids in Ukraine, leaving older and less mobile residents reluctant to descend to shelters. Lift reliability therefore links vertical circulation to universal accessibility, to the use of shared facilities and to social interaction. None of the reviewed studies measures these links; that lift performance shapes residents' access to shared spaces and neighbourhood services is a hypothesis for testing.
- *Maintenance, charges and affordability.* Nethercote (2022) shows that responsibility for upkeep, management and long-term maintenance rests with owners' corporations, and that investor-owners seek low maintenance fees, while Zhang and Yan (2023) find that property maintenance is associated with residential satisfaction. Together these suggest that the quality and cost of maintenance connect the functional and social dimensions: high charges may reduce affordability, while low charges may erode the shared amenities on which vertical living depends. This trade-off is proposed here rather than established by the reviewed studies.

- *The podium and the street.* Al-Kodmany et al. (2022) argue for a human-scaled base with active ground-floor uses and public spaces that admit natural light. Podium design thus links the street interface, human scale, accessibility and social interaction. Its effect on shade and microclimate at ground level is a further hypothesis that none of the reviewed studies tests.
- *Density as benefit and burden.* Density supports transit ridership and local businesses (Al-Kodmany et al. 2022) and, in Bhopal and Nagpur, is associated with more favourable perceptions of neighbourhood quality (Kamble and Bahadure 2025). It also increases pressure on open space, social infrastructure and services (Tickle and Palmer 2016; Avtar et al. 2025). Whether density improves or harms livability therefore depends on the other indicators that accompany it, which is why density alone is a weak proxy for livability.

These relationships suggest that the under-studied indicators should be examined together rather than one at a time.

5.6 Implications for Indian cities

Evidence from Indian studies. Only 3 of the 37 studies examine Indian cities, and none of the studies residents of high-rise or mixed-use buildings. Kamble and Bahadure (2025) find that residents of high-density neighbourhoods in Bhopal and Nagpur perceive neighbourhood quality, community well-being and social equity more favourably than residents of low-density neighbourhoods. Avtar et al. (2025) show that in Delhi the distribution of density, green space and services matters for well-being as much as density itself, and that densely populated wards with little green space may face stronger heat islands. Mishra and Roy (2024) show that in Delhi's mixed-use neighbourhoods commercial uses increase within residential plots, often informally before being regularised, raising the resident's concerns about parking and security. Together, these studies suggest that the density in Indian cities is not the problem; but its distribution, and the services that accompany it, are the problems.

Implications inferred from international evidence. The rest of the evidence comes from cities outside of India, and its relevance to Indian cities should be tested rather than to be assumed. Several conditions are likely to affect how it applies, although none of the reviewed studies examines them in Indian vertical developments: the low floor area ratios that have historically limited vertical growth (Somanathan and Natarajan 2019); heat, which gives microclimate, daylight and natural ventilation particular weight for comfort and energy use (Avtar et al. 2025); reliance on the lifts and on private building management where towers are privately developed and are managed; the informal growth of mixed uses described by Mishra and Roy (2024). Regulations are also linked to green certification and directly to density. The Haryana Building Code grants up to 15% additional floor area ratio to projects rated under GRIHA, IGBC or LEED, and further additional floor area for solar photovoltaic and solid waste management installations (Government of Haryana 2024, Code 6.5). An environmental rating can however, increase the permitted density of a development without any assessment of functional, spatial or social qualities examined in the review, which strengthens the case for evaluating green-rated vertical developments on all four dimensions. The framework's dimensions, indicator, and scale definitions are intended to transfer; the measures, weights and thresholds for each indicator, and residents' own priorities, require local empirical testing.

For Gurugram and similar cities, the review suggests three priorities for evaluating mixed-use vertical developments. First, assess them at the neighbourhood scale, including their links to transit and to the street, not only within the site boundary. Second, combine objective indicators with residents' and users' own assessments, which the literature rarely does. Third, include the under-studied indicators of Section 5.4, particularly maintenance and management, vertical circulation, affordability and microclimate.

6. Conclusion

This review analysed 50 studies, out of which 37 of them were studied in depth, to understand how livability has been conceptualised and assessed in vertical and mixed-use urban development. The vertical growth is justified mainly by population growth, land scarcity and the wish to control the urban sprawl, but the literature also warns us that it can lead to exclusivity, isolation, loss of human scale and "vertical sprawl" as a result. The evidence is largely very conceptual, and only 15 studies measure livability indicators, only 4 collect data from residents of high-rise housing, and none do so in India.

Attention to all the indicators is uneven. Open space and density are addressed in most of the studies, while maintenance and management, universal accessibility, affordability, microclimate waste management, and vertical circulation are each addressed by fewer than one in five, and the indicators most specific to vertical living receive very little attention than those adapted from general livability frameworks. Within the reviewed studies, environmental and functional qualities are the least covered aspects, and environmental indicators, especially energy and waste, have the lowest coverage, whereas green certification schemes concentrate primarily on environmental performance. These findings support the multi-dimensional framework proposed in Section 5.2, which combines functional, spatial, environmental and social qualities at building, street and neighbourhood scales. The framework is a proposal derived from the review and remains validated; Section 5.3 sets out the validation path.

6.1 Limitations

The review has 6 main limitations.
First, the data was assembled through the author’s doctoral research and targeted searches rather than a single exhaustive database search and the number of records at each stage was not recorded, so relevant studies might be missed and a full selection flow cannot be reported at the stage.
Second, the indicator coding iis carried out by only one coder with the help of a generative AI tool, and no inter-coder agreement is calculated.
Third, only English language studies are searched, studied, and included.
Fourth, the evidence from India is very limited to only 3 studies, so the implications for Indian cities are offered only as directions for research rather than tested conclusions.
Fifth, the framework derived has not been validated or weighted yet.
Sixth, methodological quality was assessed by one reviewer using a short checklist, and only for the 17 empirical studies.

6.2 Future research

Five directions follow from the review:

1. A full systematic review using Scopus and Web of Science, with an independent screening by two reviewers to test the patterns that are reported here.
2. Empirical studies of mixed-use vertical developments in Indian cities, such as Gurugram, that combine objective indicators with resident's and user's assessments.
3. Weighting of the framework's dimensions and indicators through a structured expert methodology to turn the framework into an evaluation index.
4. Methods to measure the under-studied indicators, particularly maintenance and management, vertical circulation, affordability, microclimate, and daylight in and around towers.
5. Comparison of green-rated and conventional vertical developments on the four dimensions, to test whether the certification is associated with livability.

Vertical urbanism will continue to shape the Indian cities. Making the cities livable requires looking beyond the building level and beyond environmental assessments, to how towers serve the people who live, work and socialise around them.

Statements and Declarations

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Author contributions. Divya Khatri: conceptualisation, literature collection, data curation, formal analysis and writing (original draft). Pranav Gupta: supervision, methodology, and writing (review and editing). Both authors have read and approved the final manuscript.

Ethics approval. Not applicable. This study is a review of published literature and involved no human participants or animals.

Consent to participate and consent to publish. Not applicable.

Data availability. All data generated or analysed during this study are included in this article and its supplementary information files.

Use of generative AI.

During the preparation of this paper, the authors used Claude (Anthropic) to help extract text from the source PDFs, locate passages relevant to the indicators, prepare a preliminary coding of the indicators, check references against the source documents, and edit the language. The authors reviewed and edited the outputs and take full responsibility for the content of the publication.

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