**Sustainability Concepts in Global High-rise Residential Buildings: A Scientometric and Systematic Review.**

**Abstract**

**Purpose** – Sustainability has been the subject of several scientific investigations. Many researchers in the construction industry have also examined a range of sustainability-related studies. However, little research has been conducted to thoroughly review studies regarding implementing sustainability principles in high-rise residential buildings (HRRBs).

**Design/methodology/approach** – By adopting scientometrics and systematic review (SR), this study seeks to map out recent sustainability trends and concepts in the design, development, and operation of HRRBs worldwide and in Hong Kong. With a focus on bibliographic records from the Web of Science (WoS) database, 1395 journal articles from 2013 to 2022 were analysed. Furthermore, thirteen studies were systematically reviewed.

**Findings** – The SR indicated that sustainable practices in developing Hong Kong's HRRBs emphasised zero-carbon buildings, reduced energy usage and energy-efficient retrofitting. Likewise, terms such as BIM, urban density, life cycle assessment and system dynamics are strongly connected with clusters that include "residential buildings", "high-rise buildings" and "high-rise residential buildings". The study identified significant themes in establishing HRRBs by combining sustainable practices, emphasising urban governance and policy management, building performance and thermal comfort, energy and design optimisation, occupant behaviour, and sensitivity analysis. Core sustainability ideas have improved resource management, air quality management, and knowledge of user behaviour in HRRBs.

**Originality/value** – The study provides researchers and practitioners with the opportunity to explore future research directions in the built environment per the application of sustainable concepts in the development of HRRBs from the design, construction and post-construction phases.

**Keywords:** Built environment; High-rise residential buildings; Hong Kong; Scientometrics; Sustainability.

**Article Type**: Literature review

# 1. Introduction

Sustainability encompasses several knowledge domains and has recently become an increasingly discussed subject. The 1987 World Commission on Environment and Development report indicated the need for research efforts on sustainability (Keeble, 1988). The report defined sustainable development as the ability to meet the demands of the present without endangering future generations' ability to meet their own needs. In order to be more productive and align with sustainable development goals, the global building industry also seeks to promote intelligent practices in executing its various operations (Olawumi *et al.*, 2018). Population growth increases the demand for land space in metropolitan areas, which has resulted in the construction of High-rise buildings (HRBs) (Maleki *et al.*, 2022).

Furthermore, there will be an increase in the construction of a compact model city with HRBs and accompanying city densification (Glaria *et al.*, 2018). Residential buildings in high-density cities are mostly high-rise developments (Wong and Baldwin, 2016). Thus, it is expedient to incorporate sustainability concepts while developing HRRBs. This study seeks to review recent sustainable practices in the development of HRRBs. The study focuses on two separate but interconnected scopes to accomplish this aim. First is a global perspective, which thoroughly examines HRRBs' global sustainability trends. The second scope looks at how these global trends and sustainability concepts play out in the local context of Hong Kong. Importantly, using thematic linkages, the study identifies key themes in global sustainability practices and highlights how these themes are reflected or applied in the Hong Kong context.

## 1.1 Sustainability Issues in HRRBs: An Overview

Over the years, many studies have examined ways to make HRRBs more environmentally friendly. For instance, Tereci *et al.* (2013) analysed the common building forms of urban residential buildings alongside their energy performance. Garcia-Montiel *et al.* (2014) explored sustainability in cities by identifying the relationship between consumption and waste disposal activities among building residents. Meanwhile, Hachem *et al.* (2014) focused on techniques to augment energy performance in HRRBs. The study revealed that investment in the advanced design of façades could significantly increase electricity production and ensure sustainability in HRRBs. Recently, focusing on promoting and implementing sustainable water use practices in HRBs, Katti *et al.* (2017) explored the influence of the interaction among social-structural, institutional, and cultural factors on individual water use behaviours and landscape decision-making. The study focused on educating property marketers on how luxury is perceived to satisfy buyers effectively.

Furthermore, Glaria *et al.* (2018) contributed health-related information to the study of residential design and end-users. Keynia (2018) established the potential of separating generation and co-generation systems to supply cooling, heating, and electrical loads in HRRBs. Furthermore, the study posited that energy efficiency in buildings entails the capacity of a building system to provide the essential energy quantity without reducing users' comfort.

## 1.2. Research gaps

Various studies have examined many reviews on the sustainable design, construction, and operation of high-rise (residential) structures. For instance, Chen *et al.* (2017)reviewed the application of sensitivity analysis in HRRBs that are passively designed in hot and humid climates. Barros *et al.* (2019) leveraged an SR to summarise the existing state of evidence on the influence of planning, urban design, and architectural features of HRRBs on occupants' social well-being and mental health. Similarly, Au-Yong *et al.* (2019) and Wang *et al.* (2020) extensively reviewed the application of preventive maintenance, routine maintenance, and low-carbon transition efforts in HRRBs.Nonetheless, studies have yet to explore both scientometric analysis and SR of studies relevant to sustainable concepts in HRRBs globally and in Hong Kong's context.

## 1.3. Research objectives

Some studies have explored the implementation of sustainability principles but there is no review study in this research theme. This study not only aims to identify global and local sustainability practices in the design and development of HRRBs but also seeks to demonstrate how these two scopes interact and inform one another. In this study, both VOSViewer and CiteSpace are employed to visualise literature related to sustainable concepts in HRRBs in the Web of Science (WoS) Core Collection database. In addition, to limit the research corpus to recent and emerging trends in the subject area, the search ranged from 2013 to 2022. The study's main objective is to understand, summarise, and investigate current research trends and cutting-edge concepts in sustainability and HRRBs.

# 2. Methodology

The current study used a multi-stage research approach to critically explore and assess the sustainability concepts and techniques in the existing literature concerning the design, construction, and management of HRRBs worldwide and in Hong Kong. The data retrieval step of the research approach is followed by science mapping and systematic analysis.

## 2.1 Data retrieval

Data collection is paramount to any bibliographic study (Olawumi *et al.*, 2022). While there are many databases for data collection, this study considered bibliographic data from the WoS core collection database. Some of the other prominent databases include Scopus, Google Scholar and Dimensions. Compared to other databases, WoS can retrieve more comprehensive literature with accompanied robustness (Olawumi and Chan, 2018)**.** Thus, WoS was selected for this study.The search was limited to the years 2013–2022 in order to focus on current and emerging trends in this field.

## 2.2 Science mapping

Science mapping has scientometrics, bibliometrics, and informatics as sub-fields (Hilal *et al.*, 2019). When there is a need to explore and evaluate research scientifically, scientometrics is a valuable instrument. Scientometrics is the study of the quantitative aspects of the process of science as a communication system (Mingers and Leydesdorff, 2015).

There are several science mapping tools. Each tool has strengths and peculiar capabilities (Darko *et al.*, 2020). VOSViewer is a software tool for creating maps based on network data and for visualising and exploring these maps. It offers three visualisation methods. The first is network visualisation. Here, items are represented by their label either with a circle (default) or with a rectangle. The overlay visualisation is similar to network visualisation but for different colourisation items.

On the other hand, density visualisation comprises item density visualisation and cluster density visualisation. A detailed description of the functionality can be found in the software manual. VOSViewer version 1.6.18 was used in this study. VOSViewer is easy to navigate and compatible with the WoS database (Hilal *et al.*, 2019).

CiteSpace is a research tool for investigating new ideas and comparing existing approaches (Chen, 2004). Its primary goal is to facilitate the analysis of emerging trends in a knowledge domain (Chen, 2006)**.** In this study, both VOSViewer and CiteSpace are employed to visualise literature related to sustainable concepts in (high-rise) residential buildings from the WoS Core Collection database.

## 2.3 Systematic review

Similarly, a systematic review (SR) was performed to identify and summarise specific sustainability themes integrated with the development of HRRBs in Hong Kong. SR is a thorough but time-consuming and resource-intensive process (Tsafnat *et al.*, 2014) that aids in providing an integrated report on previously published studies (Kachouie *et al.*, 2014). One of the many advantages of SRs is that it help to answer the research questions posed in studies satisfactorily (Li *et al.*, 2020).

This study utilised the five SR stages adopted by Gharbia *et al.* (2020): question formulation, study identification, studies screening, studies critical appraisal, and data extraction and synthesis of studies. This approach parallels the Preferred Reporting Items for Systematic Reviews (PRISMA) standards highlighted by Page *et al.* (2021) and was followed to achieve the study's aim. Meanwhile, the significant research questions covered in this study include: (1) What is the research focus on sustainable HRRBs in Hong Kong? (2) What are the key themes of sustainable practices in developing HRRBs? (3) At what stage of development are sustainability measures implemented in these buildings?Furthermore, the application phases mentioned per review question would be used to examine research focuses and the associated implications of sustainable practices in HRRBs. Figure 1 depicts the overall outline of this research.

**Figure 1**.

# 3. Research findings: scientometric analysis

The bibliographic data retrieved were visualised, analysed, and discussed in this section. Two significant aspects of scientometric analysis were conducted: co-authorship and co-occurring keywords.

## 3.1 Co-authorship analysis

The interactions of different authors within the research corpus were analysed and visualised using bibliographic information from the database with the aid of the selected tools for analysis. The study also visualised germane information about the authors' relationships regarding co-authorship, institutions, and countries. Figure 2 shows the number of published articles from 2013 to 2022 and the major academic publishers (with more than four publications) in the context of this study. The steep decrease in the number of publications in 2022 was because the data for this study were retrieved in the middle of the third quarter of 2022. Figure 2 also shows that Elsevier, MDPI, and Springer Nature are the top publishers, with 553, 320, and 91 articles published focusing on sustainability and HRRBs, respectively.

**Figure 2.**

### 3.1.1 Institutional analysis

This section discusses the interactions among various institutions. The VOSViewer and CiteSpace software tools were employed. Also, the threshold for the minimum number of documents from any institution was set to 1, while the minimum number of citations per institution was set to 0. With this threshold, there will be an equal representation of the organisations. Thus, the study recorded a total of 1,560 institutions in the analysis. It was observed that about 55% of these institutions have strong connections with each other. Figure 3 shows the cluster formation of the various institutions. Seven hundred and two (702) of these institutions formed an attractive, curved pattern around the significant cluster of institutions.

**Figure 3.**

### 3.1.1.1. Citation counts, bursts, and degree

The top-ranked institution by citation counts is Hong Kong Polytechnic University in Cluster #1, with a citation count of 40. The second is the University of Hong Kong in Cluster #1, with a citation count of 31. The third is the Chinese Academic of Science in Cluster #2, with a citation count of 21. The 4th is Tongji University in Cluster #0, with a citation count of 17. The 5th is the National University Singapore in Cluster #0, with a citation count of 15. The minimum duration is adjusted to 1 year, and gamma\* is set as 1. The top-ranked item by bursts is University Toronto in Cluster #0, with bursts of 3.39. The second one is Islamic Azad University in Cluster #7, with bursts of 3.18. The third is Jilin Jianzhu University in Cluster #4, with bursts of 3.14. As shown in Figure 4, the top-ranked item by degree is Hong Kong Polytechnic University in Cluster #1, with a degree of 13. The second one is the University of Hong Kong in Cluster #1, with a degree of 8. The third is the Chinese Academy of Science (2013) in Cluster #2, with a degree of 8. The 4th is Tongji University in Cluster #0, with a degree of 8. The 5th is the University Utrecht in Cluster #5, with a degree of 8.

**Figure 4.**

### 3.1.2 Countries analysis

For this analysis, the minimum number of documents and citations by country is set to 1 and 0, respectively, to ensure the maximum representation of each country. Over 90% of the countries have strong connections in research activities. Figure 5 shows the percentage representation of the countries regarding the number of documents to their name. In addition, Figure 6 displays the representation of countries within clusters and corresponding timelines. The timeline spans from 2013 to 2022. The following six clusters were formed: #0 steel building, #1 case study, #2 assessment methods, #3 sustainable cities, #4 building development, and #5 Baltic state. The connected countries are grouped into clusters. There are six clusters altogether. The first cluster is tagged #0, the second is tagged cluster #1, and the remaining clusters follow the same order.

**Figure 5.**

**Figure 6.**

### 3.1.2.1. Citation counts and bursts

The top-ranked item by citation counts is the Peoples' Republic of China in Cluster #0, with a citation count of 299. The second country is the USA in Cluster #1, with a citation count of 229. The third is Australia in Cluster #0, with a citation count of 96. The 4th is Canada in Cluster #3, with a citation count of 79. The 5th, South Korea in Cluster #1, with a citation count of 79. The top-ranked country by bursts is the USA in Cluster #1, with bursts of 10.22. The second one is Japan in Cluster #4, with bursts of 3.23. The third is Iran in Cluster #5, with bursts of 2.70. The 4th is England in Cluster #0, with bursts of 2.44. The 5th is Singapore in Cluster #0, with bursts of 2.35.

## 3.2. Co-word keywords analysis

In recent years, extensive research has been conducted on various topics and subject areas pertaining to HRRBs/HRBs and sustainability. The ubiquitous term "sustainability" has created many trends in the study of the planning, design, construction, and operation of HRRBs. This section explores evaluating and visualising the bibliographic data obtained from the WoS database.

### 3.2.1. Network of co-occurring keywords

This study relies on the significance of keywords to any research field. Keywords usually come in two categories. The authors give the first category, while the publishing journals assign the other. Usually, authors use keywords to define the scope of their study, which appear after the study's abstract. Keywords are crucial to understanding the concepts and contents of research articles (Olawumi and Chan, 2018). In VOSViewer, the co-occurrence analysis comes in three units viz-a-viz: all keywords, author keywords, and keywords plus. As displayed in Figure 7, the 'all keywords' unit was used to visualise the network of co-occurring keywords. The minimum co-occurrence number of a keyword was set as 10. Out of the extracted 6,967 keywords, 182 keywords met the threshold. These keywords were grouped into six major clusters. Cluster #1 (colour red) has one hundred and seventy-three items, cluster #2 (colour blue) has 43 items, cluster #3 (colour purple) has thirty-three items, cluster #4 (colour orange) has 27 items, cluster #5 (colour green) has four items. Cluster #6 (colour beige) has only two items. All six clusters generated a total of 4,939 links and 9,939 total link strength.

**Figure 7**

Figure 8 describes a close visualisation of the dataset, emphasising recent years. The keywords were linked with clusters: 'residential buildings', 'high-rise buildings' and 'high-rise residential buildings'. The keywords include 'BIM', 'system dynamics', 'life cycle assessment', 'CO2 emissions', 'sustainability', 'energy consumption', 'energy efficiency', 'system dynamics', 'HVAC', 'urban density', 'energy policy', and the like. The connections of these various keywords with 'residential buildings', 'HRRBs' and 'high-rise buildings' suggest the significant subjects of discussion and research in the built sector and its strong connection with critical sustainability concepts in recent years.

**Figure 8.**

Some of these keywords were described in recent studies. For example, Weng *et al.* (2022) utilised the ENVI-met simulations and Standard Effective Temperature (SET) evaluation to investigate the impact of several architectural design variables on thermal comfort in HRRBs within high-density cities. Also, Kim *et al.* (2022) explored the health and well-being of residents in high-density urban residential areas; with a closer look at the relationship between sky view factor (SVF) and land surface temperature (LST) during summer. In the same vein, David *et al.* (2021), Liu (2021), and Oh *et al.* (2020) discussed various approaches to ensure energy efficiency in HRBs. Authors such as Ahn *et al.* (2022) identified a significant challenge in the Korean construction sector's health and safety management cost (HSC) estimation. The study also sought to establish a cost assessment model for sustainable health and safety management of HRRBs. Lelévrier (2021) discussed the spatial and residential impact of housing policies in large residences in France, while Zhang *et al.* (2021) undertook a preliminary study on urban haze-fog dispersion in HRRBs. Meanwhile, Tan *et al.* (2021) designed a method that bridges the knowledge gaps in existing probabilistic risk analysis (PRA) methods for HRRBs.

## 3.3. Key research themes from the scientometric review

The co-word keyword analysis in this study finds significant topics highlighting trends in sustainability and HRRBs worldwide. This study identifies four main themes, namely: "urban governance and policy management", "building performance and thermal comfort", "energy and design optimisation", and "occupant behaviour and sensitivity analysis".

### 3.3.1. Urban governance and policy management

Hamman (2019) demonstrated how sustainable governance filters down to the level of user daily behaviour through local socio-technological energy systems. Similarly, Schenkel (2015) provided insightful information on neighbourhood-level measures for halting deterioration and decline. Also, Goggins *et al.* (2019) posited that integrating efforts across important sectors can boost the success of projects to achieve long-term sustainable transformations in home energy consumption.

Furthermore, Winston (2014) highlighted significant housing and community concerns in some urban areas that improve the quality of life for inhabitants and the sustainability of respective cities. However, Smedby (2016) assessed an urban, government-led sustainable building program in Malmö, Sweden, emphasising its energy components. Lee and Jeong (2021) incorporated many dimensions of home environmental satisfaction, such as accessibility, comfort, and safety. In addition, McManamay *et al.* (2019) provided a framework for creating acceptable spatially explicit alternative futures for city infrastructures. They examined tradeoffs across future paths for land, energy, carbon, and water resources.

### 3.3.2. Building performance and thermal comfort

Some topics focused on thermal performance, airtightness performance, and centralised greening, to mention a few. For instance, Alve*s et al*. (2021) focused on residential apartment buildings built in the 2000s to investigate their thermal efficiency and predicted comfort conditions while considering the urban present and future climate. Zheng *et al.* (2022) tested the airtightness of areas in freshly constructed and existing HRRBs. Similarly, Xiong *et al.* (2015) identified enhanced interior air quality (IAQ) as a vital component of green building design for green residential HRBs.

### 3.3.3. Energy and design optimisation

Zaraza *et al.* (2022) created a technique for reducing embodied emissions during the conceptual stage of HRRBs. Wang *et al.* (2018) created a conceptual framework to measure carbon emissions from building demolition waste throughout its life cycle.Also, López-Villarreal *et al.* (2014) provided a mathematical programming model for pollution trading among various pollution sources that consider the sustainability of the surrounding watershed.

In addition, Ghassemi *et al.* (2017) designed a closed-loop integrated water system with sources, water plants, end users, and wastewater systems. Campana *et al.* (2017) also developed an optimisation model for the planning of residential urban districts with special consideration of renewables and water harvesting integration. Meanwhile, Çavdar and Feryad (2021) designed and tested an efficient energy disaggregation (ED) model. In order to achieve optimisation goals, Bingham *et al.* (2019) considered the impacts of building envelope upgrades as well as a renewable energy system in the form of photovoltaic (PV) and battery electricity storage. Liu *et al.* (2020) investigated the techno-economic feasibility of renewable energy systems for power delivery to HRRBs.

### 3.3.4. Occupant behaviour and sensitivity analysis

The findings of Yu *et al.* (2022) aid the development of a comprehensive energy model that predicts occupant window and air conditioner behaviour and building height in HRRBs. Similarly, Brown (2016) investigated four Toronto HRRBs to provide input on how occupants feel and act in these structures. Du *et al.* (2020) studied several elements that influence energy consumption in HRRBs, including the effect of tenant behaviour. Brown and Gorgolewski (2015) suggested techniques that occupant satisfaction and behaviour can help or hinder energy efficiency in HRRBs.

# 4. Sustainability concepts in Hong Kong's HRRBs

In this section, studies concentrating on Hong Kong were selected. An in-depth content analysis of the study corpus was performed to identify publications that primarily discuss sustainability concepts in Hong Kong. These selection criteria were met by thirteen bibliographic records, which were included in the final research corpus for SR. The SR identified numerous application phases, including policy preparation, project development, design, building energy simulation, construction, and the like.

## 4.1. Policy and design development phase

The study by Pan and Pan (2018) investigated the difficulties of achieving zero carbon emissions in HRBs in heavily populated areas and the need for socioeconomic, regulatory, and political measures to accomplish this objective. The study's findings can be used to create zero-carbon building (ZCB) policies in high-density cities. Similarly, based on geographically referenced housing databases, Zhong et al. (2022) described the development of archetypes representative of Hong Kong residences, and simulations of unique combinations of archetype, occupation, and environment were run using EnergyPlus to estimate annual space-cooling energy consumption and annual average PM2.5 exposure concentrations under both non-retrofit and retrofit scenarios. According to the findings, modern village houses and top-floor flats in HRRBs used more space-cooling energy than other dwellings. Thus, rising housing demand may imply that high-rise apartments will become more prevalent, resulting in increased space-cooling demand in the residential sector.

Sustainable practices have also been incorporated into the building energy simulation and design phases. Yu et al. (2019) showed how to integrate occupant behaviour factors discovered through post-occupancy evaluation (POE) into energy use modelling using a real-life typical 40-story residential building in Hong Kong. Relatedly, Gan et al. (2018) created a comprehensive BIM framework for evaluating and finding more sustainable low-carbon HRB designs in Hong Kong. The proposed framework can measure and help reduce the embodied carbon of construction materials and the operational carbon from building lifetime energy use. Furthermore, the study by Xie et al. (2017) focused on balancing energy and daylighting efficiency in high-rise residential buildings in Hong Kong. The research suggested a new index, Energy Daylight Rate (EDR), to assist in determining the best envelope design scenario for daylighting and shading. The EDR method can be used as a simple multi-objective optimisation strategy to determine the optimal envelope design scenario for daylighting and shading.

Meanwhile, Liu and Lee (2020) explored how various transom window designs affect natural ventilation in HRBs. The goal was to assess the impact of transom window designs on natural ventilation in Hong Kong's HRRBs. Architects and engineers can improve natural ventilation in apartments by adding effective transom window designs, leading to better indoor air quality and lower energy usage for air conditioning. Also, Wong and Yang (2013) explored the feasibility of using remote-source solar lighting systems in the enclosed elevator lobbies of Hong Kong's HRRBs. The intention was to reduce energy consumption and promote sustainability by introducing natural lighting into areas typically illuminated by electric lighting.

## 4.2. Post-design phase

The study by Ai et al. (2015) focused on ventilation efficiency and indoor air quality (IAQ) in naturally ventilated HRRBs in Hong Kong. The study provided on-site measurements of four typical residential rooms within HRBs in various Hong Kong districts to determine the air changes per hour (ACH) concentrations of respirable suspended particulate matter (PM10 and PM2.5) and total volatile organic compounds (TVOC). Leveraging on the study, architects and engineers can design more effective ventilation systems that improve IAQ while reducing energy consumption via knowledge of the relationship between single-sided ventilation rate and various variables such as the direction of the approaching wind and building envelope features. Additionally, Chen et al. (2016) emphasised the significance of indoor environmental quality (IEQ) in green building assessment and how it can be improved through early design initiatives. Similarly, Liu et al. (2021) explored the ability of a naturally ventilated hybrid system to reduce cooling energy consumption while also providing thermal comfort.

The optimisation techniques introduced by Chiang et al. (2016) can be applied to other regions and building types to decrease lifecycle costs and carbon emissions. The study examined whether existing HRRBs in Hong Kong can be repaired and maintained using alternative material combinations to optimise social, economic, and environmental benefits. Also, Du and Pan (2022) investigated cooling-related energy uses and adaptive behaviours in HRRBs, specifically the vertical variation of energy uses and relevant variables. The study explained the cooling energy use of HRRBs in subtropical areas like Hong Kong and suggested ways to reduce it through in-situ monitoring and understanding occupants' behaviour. Whereas He et al. (2020) focused on developing a sustainable retrofit decision-making mechanism for HRBs in Hong Kong by uncovering the optimum set of retrofit solutions based on the local climatic conditions, building features and cost. By implementing the optimum retrofit solutions identified in this study, HRRBs can become more energy-efficient and sustainable, contributing to developing a greener and more sustainable built environment. Figure 9 indicates a synopsis of sustainable practices in developing Hong Kong's HRRBs.

**Figure 9**.

# 5. Conclusions

With several emerging trends in sustainability, the design and development of different types of buildings have also centred on sustainability in recent years. Be it planning, design, construction, and operation, much attention is given to how sustainability concepts can be ingrained into the various stages of building development.

The global sustainability themes identified in this study provide a framework for understanding the specific practices observed in Hong Kong's HRRBs. The emphasis on zero-carbon buildings, reduced energy usage, and energy-efficient retrofitting in Hong Kong reflect these broader themes and demonstrate the city's commitment to sustainable development. These practices align with the identified global themes, particularly those related to energy optimisation, building performance, and resource management. Figure 10 demonstrates how the global sustainability concepts inform the local practices in Hong Kong’s HRRB development.

**Figure 10**.

**Study synopsis and future directions.** On the one hand, the study's scientometric analysis has identified key themes in which sustainability practices have been implemented in the global development of HRRBs. The study identified four significant themes: urban governance and policy management, building performance and thermal comfort, energy and design optimisation, and occupant behaviour and sensitivity analysis. Among other applications, key sustainability concepts have enhanced energy and water management, air quality management, and understanding of users' behaviours in HRRBs. On the other hand, the study has, through a systematic review, highlighted different sustainability concepts employed in the pre-design, design and post-design stages of HRRBs development. Future studies on sustainability as it relates to the planning, design, construction, and operation of high-rise (residential) buildings can focus on themes which include but are not limited to circular economy, waste management, lean-led design and construction, end-user-oriented design, IOTs-centered facility management of HRRBs, modular integrated construction of HRRBs, to mention a few. Topics such as machine learning, building information modeling, numerical simulation, and the like can also be explored with greater attention to user behaviours.

# Competing interests

The authors' interpretation of data and presentation of information is not influenced by their personal or financial relationship with any organisation or persons.

# References

Ahn, H., Lee, J. and Hong, A. (2022), 'Urban form and air pollution: clustering patterns of urban form factors related to particulate matter in Seoul, Korea', *Sustainable Cities and Society*, Vol. 81, doi: 10.1016/j.scs.2022.103859.

Ai, Z.T., Mak, C.M. and Cui, D.J. (2015), 'On-site measurements of ventilation performance and indoor air quality in naturally ventilated high-rise residential buildings in Hong Kong', *Indoor and Built Environment*, Vol. 24 No. 2, pp. 214–224, doi: 10.1177/1420326X13508566.

Alves, C.A., Gonçalves, F.L.T. and Duarte, D.H.S. (2021), 'The recent residential apartment buildings' thermal performance under the combined effect of the global and the local warming', *Energy and Buildings*, Vol. 238, p. 110828, doi: 10.1016/j.enbuild.2021.110828.

Au-Yong, C.P., Ali, A.S. and Chua, S.J.L. (2019), 'A literature review of routine maintenance in high-rise residential buildings', *Journal of Facilities Management*, Vol. 17 No. 1, pp. 2–17, doi: 10.1108/JFM-10-2017-0051.

Barros, P., Ng Fat, L., Garcia, L.M.T., Slovic, A.D., Thomopoulos, N., de Sá, T.H., Morais, P., and Mindell, J.S. (2019), 'Social consequences and mental health outcomes of living in high-rise residential buildings and the influence of planning, urban design and architectural decisions: A systematic review', *Cities*, Vol. 93, pp. 263–272, doi: 10.1016/j.cities.2019.05.015.

Bingham, R.D., Agelin-Chaab, M. and Rosen, M.A. (2019), 'Whole building optimisation of a residential home with PV and battery storage in The Bahamas', *Renewable Energy*, Vol. 132, pp. 1088–1103, doi: 10.1016/j.renene.2018.08.034.

Brown, C. (2016), 'The power of qualitative data in post-occupancy evaluations of residential high-rise buildings', *Journal of Housing and the Built Environment*, Vol. 31 No. 4, pp. 605–620, doi: 10.1007/s10901-015-9481-2.

Brown, C. and Gorgolewski, M. (2015), 'Understanding the role of inhabitants in innovative mechanical ventilation strategies', *Building Research & Information*, Vol. 43 No. 2, pp. 210–221, doi: 10.1080/09613218.2015.963350.

Campana, P.E., Quan, S.J., Robbio, F.I., Lundblad, A., Zhang, Y., Ma, T., Karlsson, B., and Yan, J. (2017), 'Optimisation of a residential district with special consideration on energy and water reliability', *Applied Energy*, Vol. 194, pp. 751–764, doi: 10.1016/j.apenergy.2016.10.005.

Çavdar, İ.H. and Feryad, V. (2021), ‘Efficient Design of Energy Disaggregation Model with BERT-NILM Trained by AdaX Optimization Method for Smart Grid’, *Energies*, Vol. 14 No. 15, p. 4649, doi: 10.3390/en14154649.

Chen, C. (2004), 'Searching for intellectual turning points: Progressive knowledge domain visualisation', *Proceedings of the National Academy of Sciences*, Vol. 101 No. suppl\_1, pp. 5303–5310, doi: 10.1073/pnas.0307513100.

Chen, C. (2006), 'CiteSpace II: detecting and visualising emerging trends and transient patterns in the scientific literature', *Journal of the American Society for Information Science and Technology*, Vol. 57 No. 3, pp. 359–377, doi: 10.1002/asi.20317.

Chen, X., Yang, H. and Wang, Y. (2017), 'Parametric study of passive design strategies for high-rise residential buildings in hot and humid climates: miscellaneous impact factors', *Renewable and Sustainable Energy Reviews*, Vol. 69, pp. 442–460, doi: 10.1016/j.rser.2016.11.055.

Chen, X., Yang, H. and Sun, K. (2016), 'A holistic passive design approach to optimise indoor environmental quality of a typical residential building in Hong Kong', *Energy*, Vol. 113, pp. 267–281, doi: 10.1016/j.energy.2016.07.058.

Chiang, Y.H., Li, V.J., Zhou, L., Wong, F. and Lam, P. (2016), 'Evaluating Sustainable Building-Maintenance Projects: balancing Economic, Social, and Environmental Impacts in the Case of Hong Kong', *Journal of Construction Engineering and Management*, Vol. 142 No. 2, doi: 10.1061/(ASCE)co.1943-7862.0001065.

Darko, A., Chan, A.P.C., Adabre, M.A., Edwards, D.J., Hosseini, M.R. and Ameyaw, E.E. (2020), 'Artificial intelligence in the AEC industry: scientometric analysis and visualisation of research activities', *Automation in Construction*, Vol. 112 No. December 2019, p. 103081, doi: 10.1016/j.autcon.2020.103081.

David, T.M., Buccieri, G.P. and Silva Rocha Rizol, P.M. (2021), 'Photovoltaic systems in residences: a concept of efficiency energy consumption and sustainability in Brazilian culture', *Journal of Cleaner Production*, Vol. 298, p. 126836, doi: 10.1016/j.jclepro.2021.126836.

Du, J. and Pan, W. (2022), 'Cooling-related energy uses and adaptive behaviors in high-rise residential buildings in the subtropical climate: a case study in Hong Kong', *Building and Environment*, Vol. 223 No. April, p. 109456, doi: 10.1016/j.buildenv.2022.109456.

Du, J., Yu, C. and Pan, W. (2020), 'Multiple influencing factors analysis of household energy consumption in high-rise residential buildings: evidence from Hong Kong', *Building Simulation*, Vol. 13 No. 4, pp. 753–769, doi: 10.1007/s12273-020-0630-5.

Gan, V.J.L., Deng, M., Tse, K.T., Chan, C.M., Lo, I.M.C. and Cheng, J.C.P. (2018), 'Holistic BIM framework for sustainable low carbon design of high-rise buildings', *Journal of Cleaner Production*, Vol. 195, pp. 1091–1104, doi: 10.1016/j.jclepro.2018.05.272.

Garcia-Montiel, D.C., Verdejo-Ortiz, J.C., Santiago-Bartolomei, R., Vila-Ruiz, C.P., Santiago, L. and Melendez-Ackerman, E. (2014), 'Food Sources and Accessibility and Waste Disposal Patterns across an Urban Tropical Watershed: implications for the Flow of Materials and Energy', *Ecology and Society*, Vol. 19 No. 1, p. art37, doi: 10.5751/ES-06118-190137.

Gharbia, M., Chang-Richards, A., Lu, Y., Zhong, R.Y. and Li, H. (2020), 'Robotic technologies for on-site building construction: a systematic review', *Journal of Building Engineering*, Vol. 32 No. August, p. 101584, doi: 10.1016/j.jobe.2020.101584.

Ghassemi, A., Hu, M. and Zhou, Z. (2017), 'Robust Planning Decision Model for an Integrated Water System', *Journal of Water Resources Planning and Management*, Vol. 143 No. 5, doi: 10.1061/(ASCE)WR.1943-5452.0000757.

Glaria, F., Arnedo, I. and Sánchez-Ostiz, A. (2018), 'Advances in Residential Design Related to the Influence of Geomagnetism.', *International Journal of Environmental Research and Public Health*, Vol. 15 No. 2, p. 387, doi: 10.3390/ijerph15020387.

Goggins, G., Fahy, F. and Jensen, C.L. (2019), 'Sustainable transitions in residential energy use: characteristics and governance of urban-based initiatives across Europe', *Journal of Cleaner Production*, Vol. 237, doi: 10.1016/j.jclepro.2019.117776.

Hachem, C., Athienitis, A. and Fazio, P. (2014), 'Energy performance enhancement in multistory residential buildings', *Applied Energy*, Vol. 116, pp. 9–19, doi: 10.1016/j.apenergy.2013.11.018.

Hamman, P. (2019), 'Local governance of energy transition: sustainability, transactions and social ties. A case study in Northeast France', *International Journal of Sustainable Development & World Ecology*, Vol. 26 No. 1, pp. 1–10, doi: 10.1080/13504509.2018.1471012.

He, Q., Hossain, M.U., Ng, ST and Augenbroe, G. (2021), 'Sustainable building retrofit model for high-rise, high-density city: a case in Hong Kong', *Proceedings of the Institution of Civil Engineers - Engineering Sustainability*, Vol. 174 No. 2, pp. 69–82, doi: 10.1680/jensu.20.00026.

Hilal, M., Maqsood, T. and Abdekhodaee, A. (2019), 'A scientometric analysis of BIM studies in facilities management', *International Journal of Building Pathology and Adaptation*, Vol. 37 No. 2, pp. 122–139, doi: 10.1108/IJBPA-04-2018-0035.

Kachouie, R., Sedighadeli, S., Khosla, R. and Chu, M.-T. (2014), 'Socially Assistive Robots in Elderly Care: a Mixed-Method Systematic Literature Review', *International Journal of Human-Computer Interaction*, Vol. 30 No. 5, pp. 369–393, doi: 10.1080/10447318.2013.873278.

Katti, M., Jones, A., Özgöç Çağlar, D., Delcore, H. and Kar Gupta, K. (2017), 'The Influence of Structural Conditions and Cultural Inertia on Water Usage and Landscape Decision-Making in a California Metropolitan Area', *Sustainability*, Vol. 9 No. 10, p. 1746, doi: 10.3390/su9101746.

Keeble, B.R. (1988), 'The Brundtland report: "our common future"’, *Medicine and War*, Vol. 4 No. 1, pp. 17–25, doi: 10.1080/07488008808408783.

Keynia, F. (2018), ‘An optimal design to provide combined cooling, heating, and power of residential buildings’, *International Journal of Modelling and Simulation*, Vol. 38 No. 4, pp. 1–16, doi: 10.1080/02286203.2017.1422219.

Kim, J., Lee, D.-K., Brown, R.D., Kim, S., Kim, J.-H. and Sung, S. (2022), ‘The effect of extremely low sky view factor on land surface temperatures in urban residential areas’, *Sustainable Cities and Society*, Vol. 80, p. 103799, doi: 10.1016/j.scs.2022.103799.

Lee, K.-Y. and Jeong, M.-G. (2021), ‘Residential environmental satisfaction, social capital, and place attachment: the case of Seoul, Korea’, *Journal of Housing and the Built Environment*, Vol. 36 No. 2, pp. 559–575, doi: 10.1007/s10901-020-09780-2.

Lelévrier, C. (2023), 'Privatisation of large housing estates in France: towards spatial and residential fragmentation', *Journal of Housing and the Built Environment*, Vol. 38 No. 1, pp. 199–217, doi: 10.1007/s10901-021-09851-y.

Li, S., Fang, Y. and Wu, X. (2020), ‘A systematic review of lean construction in Mainland China’, *Journal of Cleaner Production*, Vol. 257, p. 120581, doi: 10.1016/j.jclepro.2020.120581.

Liu, J., Wang, M., Peng, J., Chen, X., Cao, S. and Yang, H. (2020), 'Techno-economic design optimisation of hybrid renewable energy applications for high-rise residential buildings', *Energy Conversion and Management*, Vol. 213, p. 112868, doi: 10.1016/j.enconman.2020.112868.

Liu, S. (2021), ‘Real-time monitoring of energy consumption of high-rise residential construction based on BIM building model’, *International Journal of Critical Infrastructures*, Vol. 17 No. 4, p. 317, doi: 10.1504/IJCIS.2021.120188.

Liu, T. and Lee, W.L. (2020), ‘Evaluating the influence of transom window designs on natural ventilation in high-rise residential buildings in Hong Kong’, *Sustainable Cities and Society*, Vol. 62, p. 102406, doi: 10.1016/j.scs.2020.102406.

Liu, T., Wang, X. and Lee, W.L. (2021), ‘Evaluating the effectiveness of transom window in reducing cooling energy use in high-rise residential buildings in Hong Kong’, *Journal of Building Engineering*, Vol. 35, p. 102007, doi: 10.1016/j.jobe.2020.102007.

López-Villarreal, F., Lira-Barragán, L.F., Rico-Ramirez, V., Ponce-Ortega, J.M. and El-Halwagi, M.M. (2014), 'An MFA optimisation approach for pollution trading considering the sustainability of the surrounded watersheds', *Computers & Chemical Engineering*, Vol. 63, pp. 140–151, doi: 10.1016/j.compchemeng.2014.01.005.

Maleki, B., Casanovas-Rubio, M. del M. and Fuente Antequera, A. de la. (2022), ‘Sustainability assessment in residential high-rise building design: state of the art’, *Architectural Engineering and Design Management*, Vol. 18 No. 6, pp. 927–940, doi: 10.1080/17452007.2022.2060931.

McManamay, R.A., DeRolph, C.R., Surendran-Nair, S. and Allen-Dumas, M. (2019), ‘Spatially explicit land-energy-water future scenarios for cities: guiding infrastructure transitions for urban sustainability’, *Renewable and Sustainable Energy Reviews*, Vol. 112, pp. 880–900, doi: 10.1016/j.rser.2019.06.011.

Mingers, J. and Leydesdorff, L. (2015), ‘A review of theory and practice in scientometrics’, *European Journal of Operational Research*, Vol. 246 No. 1, pp. 1–19, doi: 10.1016/j.ejor.2015.04.002.

Oh, S., Kim, C., Heo, J., Do, SL and Kim, K.H. (2020), 'Heating Performance Analysis for Short-Term Energy Monitoring and Prediction Using Multi-Family Residential Energy Consumption Data', *Energies*, Vol. 13 No. 12, p. 3189, doi: 10.3390/en13123189.

Olawumi, T.O. and Chan, D.W.M. (2018), ‘A scientometric review of global research on sustainability and sustainable development’, *Journal of Cleaner Production*, Vol. 183, pp. 231–250, doi: 10.1016/j.jclepro.2018.02.162.

Olawumi, T.O., Chan, D.W.M., Ojo, S. and Yam, M.C.H. (2022), ‘Automating the modular construction process: a review of digital technologies and future directions with blockchain technology’, *Journal of Building Engineering*, Vol. 46 No. April 2021, p. 103720, doi: 10.1016/j.jobe.2021.103720.

Olawumi, T.O., Chan, D.W.M., Wong, J.K.W. and Chan, A.P.C. (2018), ‘Barriers to the integration of BIM and sustainability practices in construction projects: a Delphi survey of international experts’, *Journal of Building Engineering*, Elsevier Ltd, Vol. 20 No. June, pp. 60–71, doi: 10.1016/j.jobe.2018.06.017.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A.,Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. and Moher, D. (2021), ‘The PRISMA 2020 statement: an updated guideline for reporting systematic reviews’, *International Journal of Surgery, Vol. 88 March, 105906*, doi: 10.1016/j.ijsu.2021.105906.

Pan, W. and Pan, M. (2018), ‘A dialectical system framework of zero carbon emission building policy for high-rise high-density cities: perspectives from Hong Kong’, *Journal of Cleaner Production*, Vol. 205, pp. 1–13, doi: 10.1016/j.jclepro.2018.09.025.

Schenkel, W. (2015), ‘Regeneration Strategies in Shrinking Urban Neighbourhoods—dimensions of Interventions in Theory and Practice’, *European Planning Studies*, Vol. 23 No. 1, pp. 69–86, doi: 10.1080/09654313.2013.820089.

Smedby, N. (2016), ‘Assessing local governance experiments for building energy efficiency – the case of Malmö, Sweden’, *Environment and Planning C: Government and Policy*, Vol. 34 No. 2, pp. 299–319, doi: 10.1177/0263774X15614176.

Tan, S., Weinert, D., Joseph, P. and Moinuddin, K. (2021), ‘Sensitivity and Uncertainty Analyses of Human and Organizational Risks in Fire Safety Systems for High-Rise Residential Buildings with Probabilistic T-H-O-Risk Methodology’, *Applied Sciences*, Vol. 11 No. 6, p. 2590, doi: 10.3390/app11062590.

Tereci, A., Ozkan, S.T.E. and Eicker, U. (2013), ‘Energy benchmarking for residential buildings’, *Energy and Buildings*, Vol. 60, pp. 92–99, doi: 10.1016/j.enbuild.2012.12.004.

Tsafnat, G., Glasziou, P., Choong, M.K., Dunn, A., Galgani, F. and Coiera, E. (2014), ‘Systematic review automation technologies.’, *Systematic Reviews*, Vol. 3 No. 1, p. 74, doi: 10.1186/2046-4053-3-74.

Wang, J., Wu, H., Duan, H., Zillante, G., Zuo, J. and Yuan, H. (2018), ‘Combining life cycle assessment and Building Information Modelling to account for carbon emission of building demolition waste: a case study’, *Journal of Cleaner Production*, Vol. 172, pp. 3154–3166, doi: 10.1016/j.jclepro.2017.11.087.

Wang, Y., Mauree, D., Sun, Q., Lin, H., Scartezzini, J.L. and Wennersten, R. (2020), ‘A review of approaches to low-carbon transition of high-rise residential buildings in China’, *Renewable and Sustainable Energy Reviews*, Vol. 131, p. 109990, doi: 10.1016/j.rser.2020.109990.

Weng, J., Luo, B., Xiang, H. and Gao, B. (2022), ‘Effects of Bottom-Overhead Design Variables on Pedestrian-Level Thermal Comfort during Summertime in Different High-Rise Residential Buildings: a Case Study in Chongqing, China’, *Buildings*, Vol. 12 No. 3, p. 265, doi: 10.3390/buildings12030265.

Winston, N. (2014), ‘Sustainable Communities? A Comparative Perspective on Urban Housing in the European Union’, *European Planning Studies*, Vol. 22 No. 7, pp. 1384–1406, doi: 10.1080/09654313.2013.788612.

Wong, I. and Baldwin, A.N. (2016), ‘Investigating the potential of applying vertical green walls to high-rise residential buildings for energy-saving in sub-tropical region’, *Building and Environment*, Vol. 97, pp. 34–39, doi: 10.1016/j.buildenv.2015.11.028.

Wong, I. and Yang, H.X. (2013), ‘Study on remote source solar lighting system application in high-rise residential buildings in Hong Kong’, *Energy and Buildings*, Vol. 60, pp. 225–231, doi: 10.1016/j.enbuild.2013.01.010.

Xie, J.C., Xue, P., Mak, C.M. and Liu, J.P. (2017), ‘Balancing energy and daylighting performances for envelope design: a new index and proposition of a case study in Hong Kong’, *Applied Energy*, Vol. 205, pp. 13–22, doi: 10.1016/j.apenergy.2017.07.115.

Xiong, Y., Krogmann, U., Mainelis, G., Rodenburg, L.A. and Andrews, C.J. (2015), ‘Indoor air quality in green buildings: a case-study in a residential high-rise building in the northeastern United States’, *Journal of Environmental Science and Health, Part A*, Vol. 50 No. 3, pp. 225–242, doi: 10.1080/10934529.2015.981101.

Yu, C., Du, J. and Pan, W. (2019), ‘Improving accuracy in building energy simulation via evaluating occupant behaviors: a case study in Hong Kong’, *Energy and Buildings*, Vol. 202, p. 109373, doi: 10.1016/j.enbuild.2019.109373.

Yu, C., Du, J. and Pan, W. (2022), ‘Impact of window and air-conditioner operation behaviour on cooling load in high-rise residential buildings’, *Building Simulation*, Vol. 15 No. 11, pp. 1955–1975, doi: 10.1007/s12273-022-0907-y.

Zaraza, J., McCabe, B., Duhamel, M. and Posen, D. (2022), ‘Generative design to reduce embodied GHG emissions of high-rise buildings’, *Automation in Construction*, Vol. 139, p. 104274, doi: 10.1016/j.autcon.2022.104274.

Zhang, Y., Yu, Y., Kwok, K.C.S. and Yan, F. (2021), ‘CFD-based analysis of urban haze-fog dispersion—a preliminary study’, *Building Simulation*, Vol. 14 No. 2, pp. 365–375, doi: 10.1007/s12273-020-0641-2.

Zheng, H., Long, E., Cheng, Z., Yang, Z. and Jia, Y. (2022), ‘Experimental exploration on airtightness performance of residential buildings in the hot summer and cold winter zone in China’, *Building and Environment*, Vol. 214, p. 108848, doi: 10.1016/j.buildenv.2022.108848.

Zhong, X., Zhang, Z., Wu, W. and Zhang, R. (2022), ‘Estimating Space-Cooling Energy Consumption and Indoor PM2.5 Exposure across Hong Kong Using a City-Representative Housing Stock Model’, *Buildings*, Vol. 12 No. 9, p. 1414, doi: 10.3390/buildings12091414.