Are green buildings more liveable than conventional buildings? An examination from the perspective of occupants

Xu, Ying; Luo, Dan; Qian, Queena K.; Chan, Edwin Hon Wan

DOI
10.1007/s10901-022-09983-9

Publication date
2022

Document Version
Final published version

Published in
Journal of Housing and the Built Environment

Citation (APA)
Xu, Y., Luo, D., Qian, Q. K., & Chan, E. H. W. (2022). Are green buildings more liveable than conventional buildings? An examination from the perspective of occupants. *Journal of Housing and the Built Environment*, *38 (2023)*(2), 1047-1066. https://doi.org/10.1007/s10901-022-09983-9

Journal of Housing and the Built Environment
https://doi.org/10.1007/s10901-022-09983-9

ARTICLE

Are green buildings more liveable than conventional buildings? An examination from the perspective of occupants

Ying Xu[1] · **Dan Luo**[2,3] · **Queena K. Qian**[3] · **Edwin H. W. Chan**[4,1]

Received: 27 July 2021 / Accepted: 22 September 2022

Abstract

In response to excessive energy consumption and severe pollution, green building has gained increasing attention around the world. Governments' top-down incentive schemes and consumers' bottom-up choice preferences are two major channels of residential green building promotion. Regarding the bottom-up route, high liveability performance is critical to ensuring that occupants are willing to make secondary purchases or provide recommendations. Therefore, this paper, using post-occupancy evaluation, aims to evaluate and compare the liveability performance of green and conventional buildings from the perspectives of occupants. The results verified that the eco-label effect (i.e., subjective differences for building types) influenced the occupants' evaluations of building performance. When controlling for eco-label bias, we found that green buildings were not superior to conventional buildings in terms of liveability. This is highly relevant to evaluations of the orientation of green building certifications that concentrate on the consumption of energy and material resources but neglect the living experience of occupants. In addition, indicators related to thermal comfort (e.g., indoor temperature or frequency of air conditioner use) played an important role in the occupants' liveability evaluations. These findings provide concrete guidance regarding how the evaluation systems of green building certifications in various countries should be upgraded in the near future.

Keywords Green building · Liveability performance · Eco-label effect · Post-occupancy evaluation

1 Introduction

In response to excessive resource consumption and severe air pollution, the development of energy-efficient buildings has gained universal attention across the world (Deuble & de Dear, 2012; Gou et al., 2013; Varma & Palaniappan, 2019; Zhang et al., 2017). Many countries have established evaluation systems to certify green buildings, such as LEED in the US, BREEAM in the UK, and Green Star in Australia. In addition, various incentives

✉ Dan Luo
controlandbalance@163.com

Extended author information available on the last page of the article

have been formulated to promote the development of green buildings, including financial subsidies, tax deductions, and compulsory construction requirements for public buildings (He & Chen, 2021; Liberalesso et al., 2020; Shen & Faure, 2021).

For residential buildings, it is essential to promote green building development from the bottom-up perspective, in addition to governments' top-down incentive schemes. Consumer choice preference is a meaningful bottom-up channel for supporting green building development (Hu et al., 2016; Li et al., 2021; Wimala et al., 2016). In particular, the perceived liveability of occupants of green buildings greatly affects their willingness to make secondary purchases or give recommendations (Li & Pak, 2010; Olubunmi et al., 2016).

Green building should be a holistic concept that is not only concerned with environmental sustainability but also seeks to improve occupants' living experience (Khoshbakht et al., 2018; USGBC, 2014). Extensive research has demonstrated that green buildings are superior to conventional buildings in terms of energy saving and carbon emission reduction (Darko et al., 2017; Dwaikat & Ali, 2018; He, 2019; Vyas & Jha, 2018; Zhang et al., 2019); however, the liveability of green buildings remains under-researched (Gou et al., 2013). Therefore, this study aimed to answer the following research questions: (1) From occupants' perspective, are green buildings more liveable than conventional buildings? (2) What are the most significant physical and environmental factors that affect the occupants' liveability perceptions?

Unlike the precise measurement of energy consumption with scientific instruments, the comparative analysis of liveability performance between green and conventional buildings is usually conducted using post-occupancy evaluation (POE) (Bonde & Ramirez, 2015; Khoshbakht et al., 2018). However, because of the eco-label effect, this type of evaluation can be easily affected by occupants' subjective perceptions of their building types (Deuble & de Dear, 2012), which has not been taken into consideration in previous studies. This paper addressed this shortcoming to provide more precise comparative results.

In this paper, the green building is generally defined as the buildings with green certifications, like LEED, BREEAM, Green Star equivalent, etc. Specifying the case in this study, the green building is identified as the buildings with ESGB certification (the certification of green building in mainland China). The reason to address the certification in green building identification is that, this research aims to examine whether the eco-label effect exists or not, and compare the liveability evaluation between conventional buildings and green buildings after controlling the eco-label effect. Moreover, the "eco-label" means the certificate of green building. It hopes to shed light on the buildings that use these ratings as design and construction guidelines but do not seek actual certification.

The next section reviews the literature regarding occupants' evaluation and comparison of green and conventional buildings. The case study and data collection are described in Sect. 3. Section 4 evaluates the liveability performance and comparison of green and conventional buildings and identifies the factors affecting liveability. Section 5 presents a discussion of the results and policy implications. The final section concludes the paper.

2 Literature review

Extensive research has demonstrated that green buildings have superior environmental sustainability to conventional buildings in terms of energy saving and carbon emission reduction (Darko et al., 2017; Dwaikat & Ali, 2018; He, 2019; Vyas & Jha, 2018; Zhang et al., 2019). In contrast, little research has compared occupants' living experiences in green and conventional buildings, and the results of prior analyses have been inconsistent, fragmented, or contradictory (Khoshbakht et al., 2018; Pastore & Andersen, 2019; Thatcher & Milner, 2016).

Some studies have shown that green buildings provide better living experiences than conventional buildings (Bonde & Ramirez, 2015; Fuerst & McAllister, 2009; Pei et al., 2015), whereas others have found no significant differences (Leaman & Bordass, 2007; Menadue et al., 2014; Paul & Taylor, 2008; Zalejska-Jonsson, 2014). For example, an investigation in New Zealand showed that green buildings did not provide a better living experience from the perspective of occupants (Azizi et al., 2015). Furthermore, some scholars have demonstrated that the occupants of green buildings provided comparatively lower evaluation scores for indoor air quality, overall satisfaction, or comfort (Altomonte & Schiavon, 2013; Gou et al., 2013).

Environmental and physical variables such as the age of the building (Liu et al., 2018), the ability to control environmental factors (Zalejska-Jonsson, 2014), the evaluation system, and the sample size (Khoshbakht et al., 2018) have all been cited as reasons for the inconsistencies in the literature. The confirmation biases of occupants have also been acknowledged as an important factor affecting evaluations (Deuble & de Dear, 2012; Gou et al., 2013; Schiavon & Altomonte, 2014).

The eco-label effect is one such manifestation of confirmation bias, and it occurs when people idealize eco-label products and thus provide a more positive evaluation than their conventional alternatives (Sörqvist, 2018; Sörqvist et al., 2015a, 2015b). This effect causes consumers to forgive or ignore certain shortcomings of eco-label products (Holmgren et al., 2017; Sörqvist, 2018) while overestimating positive aspects (Deuble & de Dear, 2012; Holmgren et al., 2017), which can result in more positive appraisals (Holmgren et al., 2017; Sörqvist et al., 2015a, 2015b). Thus, green building certifications should be expected to affect occupants' evaluations.

Post-occupancy evaluation (POE) is typically used to measure building performance from the occupants' perspectives (Deuble & de Dear, 2014; Kim et al., 2013). This method focuses on the occupants of buildings and their needs, thus providing insight into the consequences of past design decisions and forming a sound basis for the future improvement of buildings (Preiser et al., 2015). Many studies that have utilized the POE method formulated evaluation metrics and collected questionnaires from the occupants (Baird et al., 2012). The widely accepted POE was designed by Preiser et al. (2015) and consists of three main dimensions: technological, functional, and behavioural performance, with some additional secondary variables in each dimension (Table 1).

3 Research methodology

3.1 The case study

China leads the global construction market, and the Chinese government has proposed ambitious top-down incentive schemes to promote energy-efficient building (Zhang et al., 2017). Changsha, located in central China (28.22°N, 112.94°E), is a typical temperate city with four distinct seasons. The hottest month is July, with an average temperature of 33.9 °C, and the coldest month is January, with an average of 2.0 °C (CCMS, 2019). Changsha has implemented a series of incentive schemes to promote green building development (CNR, 2018). By the end of 2018, more than half of newly built buildings in

Table 1 POE metrics adopted in relevant prior research

Primary variables	Secondary variables	Literatures
1. Technological performance	1.1 thermal comfort	(Sanni-Anibire & Hassanain, 2016); (Ning & Chen, 2016); (Mustafa, 2017)
	1.2 indoor air quality	(Sanni-Anibire & Hassanain, 2016);(Ning & Chen, 2016); (Mustafa, 2017)
	1.3 visual comfort	(Sanni-Anibire & Hassanain, 2016);(Ning & Chen, 2016); (Mustafa, 2017); (Adewunmi et al., 2011)
	1.4 acoustic comfort	(Sanni-Anibire & Hassanain, 2016); (Ning & Chen, 2016); (Mustafa, 2017)
	1.5 security and fire safety	(Sanni-Anibire & Hassanain, 2016); (Mustafa, 2017); (Adewunmi et al., 2011)
	1.6 management and maintenance	(Sanni-Anibire & Hassanain, 2016); (Adewunmi et al., 2011)
2. Functional performance	2.1 spatial comfort, layout and furniture	(Sanni-Anibire & Hassanain, 2016); (Ning & Chen, 2016); (Mustafa, 2017); (Ilesanmi, 2010)
	2.2 housing support service	(Sanni-Anibire & Hassanain, 2016); (Ning & Chen, 2016); (Hassanain et al., 2010) (Ilesanmi, 2010)
3. Behavioural performance	3.1 location	(Sanni-Anibire & Hassanain, 2016); (Ilesanmi, 2010); (Hassanain et al., 2010)
	3.2 appearance	(Sanni-Anibire & Hassanain, 2016); (Ilesanmi, 2010); (Hassanain et al., 2010)

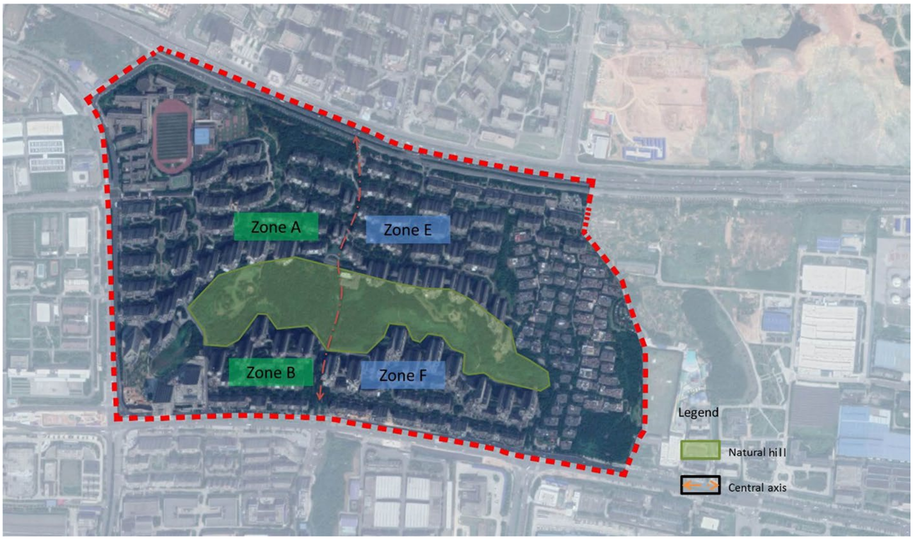

Fig. 1 Locations of the four selected zones (**A**, **B**, **E**, and **F**) in Lugu Linyu

Table 2 Information about the buildings in the selected zones

Zone	Building age	Number of buildings	Main construction features
Zone A & B (Green Building)	9–10 years	34	Lightweight and self-insulating brick; permeable road surface; rainwater recycling system; solar and wind complementary street light; natural lighting and ventilation in the basement; insulating glass window
Zone E & F (Conventional Building)	8–9 years	47	Electric street lighting system, watering system for public green areas, electrical lighting system in the basement, non-insulating glass window

Changsha were certificated as green buildings. With a typical temperate climate and massive green building development, Changsha is generally representative of other Chinese cities, allowing our findings to be generalised to many other Chinese cities.

The residential district named Lugu Linyu was selected as the study case within Changsha because it is a large residential community with more than 100 buildings (Fig. 1). The buildings in Zone A and B were built in accordance with China’s Evaluation Standard for Green Building (GB/T 50,378–2006) (ESGB) and obtained One-Star Green Building certificates in 2011. The residential buildings in Zone E and F were conventional buildings. More detailed information about the buildings in these zones is presented in Table 2.

Unlike prior studies with cases scattered across one or more cities, this research utilized only a residential district that contained both green and conventional buildings. The occupants of both types of buildings shared similar natural conditions, surrounding environments, public facilities, and amenities. Thus, the physical and environmental factors that likely affect the outcomes of post-occupancy evaluations were largely eliminated from occupants' evaluations of building liveability performance. In terms of subjective variables, the gender and age distributions of respondents from green and conventional buildings are quite similar (see Appendix). Apart from the demographic parameters, the socio-economic variables of respondents were also considered in the questionnaire. Unfortunately, the valid rate of these questions is not very high. However, these respondents all resided in the same housing district with different zones. To large extent, it can be assumed that they have similar income levels, consumption preferences, etc., which may affect their subjective evaluation of residential buildings.

3.2 Data collection

Liveability is a concept that is difficult to define (Mohit & Iyanda, 2016). Someone believes that liveability mainly refers to the subjective evaluation of the quality of the housing conditions (Heylen, 2006). Others assume liveability is part of the overall quality of life as experienced and perceived by residents (Mccrea & Walters, 2012). Besides, liveabilty could be measured in different dimensions, such as functional, physical and social environments (Leby & Hashim, 2010). In this manuscript, liveability refers to the overall living experience from the subjective point of view of the occupants. The independent variables used to measure building performance from occupants' perspective include satisfaction (Altomonte & Schiavon, 2013; Kim et al., 2013), comfort (Gou et al., 2013; Hedge et al., 2014), health (Gou et al., 2012), productivity (Geng et al., 2017), well-being (Al horr et al., 2016; Thatcher & Milner, 2016), long-term financial savings (Olubunmi et al., 2016), and living convenience (Kim et al., 2013). The liveability performance of residential buildings can thus be grouped into five major categories: comfort, health, convenience, economy, and satisfaction.

The questionnaire consisted of three parts. The first part covered general information, including age, gender, salary, previous living places, cognition of their building types (green or conventional building), and perception of environmental sustainability.

The second part contained 5 questions to rate the five major aspects, i.e., comfort, health, convenience, economy, and satisfaction, of liveability performance (Table 3).

The third part has 25 questions about perceivable variables of liveability derived from the ESGB. These perceivable liveability indicators are grouped into several categories, including thermal comfort, indoor air quality, visual comfort, acoustic comfort, security and fire safety, management and maintenance, spatial comfort, layout and furniture, housing support service, location, and appearance (Table 4).

Table 3 Five major aspects of liveability

No	Questions	Abbr
1	Please evaluate the overall comfort	O1
2	Please evaluate the overall health	O2
3	Please evaluate the overall convenience	O3
4	Please evaluate the overall economy	O4
5	Please evaluate the overall satisfaction	O5

Table 4 Perceivable variables affecting liveability

No	Categories	Questions	Abbr
1	Thermal comfort	Please evaluate the indoor temperature in summer and winter without air conditioner	TC1
2		Please evaluate the frequency of air conditioner use during summer and winter	TC2
3		Please evaluate the indoor humidity without using humidity conditioning equipment	TC3
4		Please evaluate the frequency of humidity conditioning equipment use	TC4
5	Indoor air quality	Please evaluate the indoor and outdoor air ventilation	IAQ1
6	Visual comfort	Please evaluate the natural lighting	VC1
7		Please evaluate the overall vision	VC2
8		Please evaluate the glare influence	VC3
9	Acoustic comfort	Please evaluate the outdoor noise	AC1
10		Please evaluate the sound insulation and vibration control	AC2
11	Security and fire safety	Please evaluate the security and fire safety	SFS1
12	Management and maintenance	Please evaluate the property management and equipment maintenance	PMEM1
13	Spatial comfort, layout and furniture	Please evaluate the overall space planning	SCLF1
14		Please evaluate the greening and landscape design	SCLF2
15		Please evaluate the parking lot	SCLF3
16		Please evaluate the motor vehicle lanes	SCLF4
17		Please evaluate the non-motor vehicle lanes and sidewalk	SCLF5
18		Please evaluate the material's durability, safety and eco-friendly in semi-public space	SCLF6
19		Please evaluate the energy saving in public equipment	SCLF7
20	Housing support service	Please evaluate the barrier-free structure and equipment	HSS1
21		Please evaluate the open space and activity facilities	HSS2
22	Location	Please evaluate the public transportation accessibility	L1
23		Please evaluate the educational accessibility	L2
24		Please evaluate the commercial accessibility	L3
35	Appearance	Please evaluate the appearance	A1

The questionnaire adopted a 5-point Likert scale to measure the items, where a score of 1 indicated the most negative evaluation (i.e., very unsatisfied) and a score of 5 indicated the most positive evaluation (i.e., very satisfied).

The occupants in Zones A and B and Zones E and F were accidentally chosen for in-person interviews in June and July of 2018. In total, 606 valid questionnaires were collected, of which 304 were from Zones A and B (green buildings) and 302 were from Zones E and F (conventional buildings).

4 Research analysis

4.1 The comparison of liveability performance between green and conventional buildings

As opposed to a direct comparison between occupants from green and conventional buildings, the respondents were divided into several groups based on their subjective perceptions of the building types. According to the answers to the question, 'As far as you know, is your current dwelling a green building?', the respondents were divided into three groups (Table 5). Group 1 included occupants who actually and cognitively lived in green buildings. The respondents from Groups 2 and 3 were unsure about their building types and lived in green and conventional buildings, respectively. The degree to which the 'eco-label' bias affected the subjective evaluation of building performance was examined by comparing Groups 1 and 2.

Occupants from Group 1 generally gave more positive ratings than those from Group 2, as it had higher mean values for 28 of the 30 indicators, which only excluded the indicators of convenience, open space, and activity facilities (Fig. 2). Moreover, the occupants from Group 1 typically gave moderate or higher evaluations for the indicators, excluding the frequency of air conditioner use, parking lots, and motor vehicles. In contrast, the occupants from Group 2 provided negative evaluations for nearly one-third of the variables. The comparison between group 1 and group 3 are irrelevant to the research objective. Therefore, we did not conduct this analysis.

An independent-samples t-test was conducted to further explore the differences between Groups 1 and 2 (Table 6). Although Groups 1 and 2 both resided in green buildings and shared similar physical environments, the respondents from Group 1, who realized that they lived in green buildings, gave significantly more positive liveability evaluations for more than half of the variables. This result demonstrated that the subjective differences in

Table 5 Information regarding each group

Perception Reality	In green building	Not sure	In conventional building	No response
Zone A and B (green buildings)	Group 1 (N = 109)	Group 2 (N = 171)	N.A. (N = 20)	N.A. (N = 4)
Zone E and F (conventional buildings)	N.A. (N = 74)	Group 3 (N = 204)	N.A. (N = 22)	N.A. (N = 2)

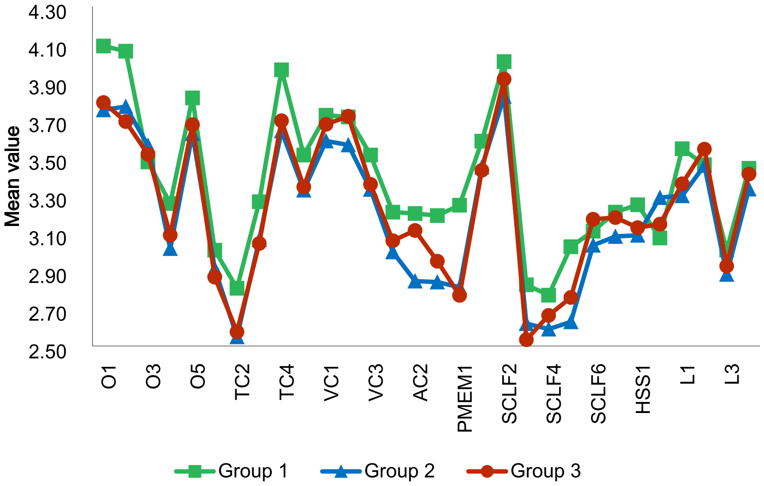

Fig. 2 Mean scores of the 30 evaluation indicators from the three groups

perceived building type affected the occupants' evaluation of building performance, providing persuasive evidence for the existence of the eco-label effect.

The eco-label effect must be controlled to obtain accurate and comparative post-occupancy evaluations between green and conventional buildings. The respondents from Groups 2 and 3 respectively resided in green and conventional buildings, and both groups were unsure about their building types. It can thus be assumed that the respondents from Groups 2 and 3 had no obvious subjective biases and that the eco-label effect was controlled for the comparison of these two groups. An independent-samples t-test between Groups 2 and 3 only revealed a significant difference in liveability evaluation in the three variables of vision, sound insulation and vibration control, and suitable materials for semi-public spaces (Table 7). This result indicated that when we controlled for the eco-label effect, the liveability performance of green buildings was not superior to that of conventional buildings from the perspective of the occupants. In other words, the technical advantages of green buildings may reduce energy consumption, but they do not improve the living experiences of the occupants.

4.2 The significant factors affecting the liveability evaluation of occupants

The overall liveability was decomposed into the five major dimensions of comfort, health, convenience, economy, and satisfaction. The mean values of buildings' liveability performance were 3.74 for Group 1, 3.55 for Group 2, and 3.56 for Group 3. A multiple regression analysis was then conducted using overall liveability as the dependent variable and the other 25 perceivable physical and environmental indicators from the ESGB and previous studies as independent variables. The analysis aimed to identify the physical and environmental variables that affected the liveability evaluations of occupants from different groups.

Table 6 Independent-samples t-test between Group 1 and Group 2

Variables	Group 1		Group 2		t-test for Equality means		
	Mean	S.D	Mean	S.D	t	df	Sig. (2-tailed)
Comfort	4.09	0.50	3.75	0.67	4.82	270.35	0.00*
Health	4.06	0.51	3.77	0.63	4.27	260.32	0.00*
Convenience	3.48	0.87	3.56	0.74	−0.87	205.07	0.39
Economy	3.26	0.90	3.02	0.90	2.17	276.00	0.03*
Satisfaction	3.82	0.72	3.63	0.75	2.08	276.00	0.04*
Indoor temperature	3.01	0.91	2.91	0.83	0.92	276.00	0.36
Frequency of air conditioner use	2.81	0.94	2.55	0.83	2.40	278.00	0.02*
Ventilation	3.51	0.70	3.33	0.75	2.08	278.00	0.04*
Indoor humidity	3.27	0.86	3.06	0.67	2.08	190.98	0.04*
Frequency of humidity control equipment use	3.97	0.96	3.64	1.00	2.43	230.00	0.02*
Natural lighting	3.72	0.69	3.59	0.61	1.73	277.00	0.09
Vision	3.72	0.56	3.57	0.60	2.09	241.95	0.04*
Glare	3.51	0.57	3.33	0.64	2.41	276.00	0.02*
Outdoor noise	3.21	0.85	3.00	0.86	2.00	277.00	0.05*
Sound insulation and vibration control	3.20	0.92	2.85	0.82	3.37	274.00	0.00*
Security and fire safety	3.19	0.86	2.84	0.96	3.12	276.00	0.00*
Property management and equipment maintenance	3.25	0.87	2.81	0.91	3.97	278.00	0.00*
Overall space planning	3.59	0.83	3.45	0.83	1.34	278.00	0.18
Greening and landscape design	4.01	0.57	3.82	0.74	2.35	268.06	0.02*
Parking lot	2.83	1.06	2.62	0.82	1.72	188.46	0.09
Motor vehicle lanes	2.77	0.99	2.59	0.87	1.61	278.00	0.11
Non-motor vehicle lanes and sidewalk	3.03	1.00	2.63	0.89	3.47	277.00	0.00*
Suitable materials for semi-public space	3.11	0.70	3.04	0.68	0.89	277.00	0.38
Energy saving in public equipment	3.21	0.64	3.08	0.70	1.56	278.00	0.12
Barrier-free structure and equipment	3.25	0.67	3.09	0.74	1.83	276.00	0.07
Open space and activity facilities	3.07	0.95	3.29	0.80	−2.01	276.00	0.05*
Public transportation accessibility	3.55	0.72	3.30	0.74	2.75	272.00	0.01*
Educational accessibility	3.46	0.56	3.46	0.58	0.06	272.00	0.96
Commercial accessibility	3.01	0.75	2.88	0.81	1.34	236.17	0.18
Appearance	3.44	0.70	3.33	0.60	1.33	196.05	0.18

*Significant $p < 0.05$

The regression results of Group 1 indicated that Model 1 explained 71.7% of the variance and was a significant predictor of overall liveability (F (25.58) = 5.886, $p < 0.001$). Specifically, indoor temperature (B = 0.171, $p = 0.003$), frequency of air conditioner use (B = -0.137, $p = 0.045$), motor vehicle lanes (B = -0.225, $p = 0.024$), open space and activity facilities (B = 0.120, $p = 0.045$), and public transportation accessibility (B = 0.252, $p = 0.007$) contributed significantly to the overall liveability evaluation.

Table 7 Independent-samples t-test between Group 2 and Group 3

Variables	Group 2		Group 3		t-test for Equality of Means		
	Mean	S.D	Mean	S.D	t	df	Sig. (2-tailed)
Comfort	3.75	0.67	3.79	0.65	−0.57	370.00	0.57
Health	3.77	0.63	3.69	0.71	1.15	370.69	0.25
Convenience	3.56	0.74	3.52	0.86	0.57	370.50	0.57
Economy	3.02	0.90	3.09	0.93	−0.75	369.00	0.45
Satisfaction	3.63	0.75	3.68	0.73	−0.62	367.00	0.54
Indoor temperature	2.91	0.83	2.87	0.83	0.53	370.00	0.60
Frequency of air conditioner use	2.55	0.83	2.58	0.84	−0.31	372.00	0.76
Ventilation	3.33	0.75	3.34	0.72	−0.23	372.00	0.82
Indoor humidity	3.06	0.67	3.04	0.67	0.29	369.00	0.77
Frequency of humidity control equipment use	3.64	1.00	3.70	1.02	−0.45	281.00	0.65
Natural lighting	3.59	0.61	3.68	0.58	−1.43	372.00	0.15
Vision	3.57	0.60	3.72	0.55	−2.53	347.58	0.01*
Glare	3.33	0.64	3.36	0.61	−0.41	368.00	0.68
Outdoor noise	3.00	0.86	3.06	0.88	−0.65	370.00	0.51
Sound insulation and vibration control	2.85	0.82	3.11	0.81	−3.16	368.00	0.00*
Security and fire safety	2.84	0.96	2.95	0.92	−1.13	370.00	0.26
Property management and equipment maintenance	2.81	0.91	2.77	0.89	0.46	373.00	0.64
Overall space planning	3.45	0.83	3.43	0.69	0.22	330.46	0.83
Greening and landscape design	3.82	0.74	3.92	0.64	−1.28	372.00	0.20
Parking lot	2.62	0.82	2.53	0.90	0.95	371.00	0.34
Motor vehicle lanes	2.59	0.87	2.66	0.93	−0.78	371.00	0.44
Non-motor vehicle lanes and sidewalk	2.63	0.89	2.76	0.90	−1.39	371.00	0.17
Suitable materials for semi-public space	3.04	0.68	3.17	0.65	−2.00	370.00	0.05*
Energy saving in public equipment	3.08	0.70	3.18	0.68	−1.41	372.00	0.16
Barrier-free structure and equipment	3.09	0.74	3.13	0.69	−0.55	370.00	0.59
Open space and activity facilities	3.29	0.80	3.15	0.82	1.68	372.00	0.09
Public transportation accessibility	3.30	0.74	3.36	0.63	−0.88	330.87	0.38
Educational accessibility	3.46	0.58	3.55	0.67	−1.31	366.00	0.19
Commercial accessibility	2.88	0.81	2.93	0.82	−0.52	367.00	0.60
Appearance	3.33	0.60	3.41	0.61	−1.26	367.00	0.21

*Significant at $p < 0.05$

Model 1:

$$\begin{aligned} \mathit{Overall\ liveability}_{Group\ 1} = {} & 1.699 + (0.171 * \mathit{indoor\ temperature}) \\ & - (0.137 * \mathit{frequency\ of\ air\ conditioner\ use}) \\ & - (0.225 * \mathit{motorvehiclelanes}) \\ & + (0.120 * \mathit{open\ space\ and\ activity\ facilities}) \\ & + (0.252 * \mathit{public\ transportation\ accessibility}) \end{aligned}$$

The regression results for Group 2 indicated that Model 2 explained 46.0% of the variance and was a significant predictor of overall liveability (F (25, 107) = 3.644, $p < 0.001$). Specifically, indoor temperature (B = 0.167, $p = 0.001$), ventilation (B = 0.154, $p = 0.011$), glare (B = -0.161, $p = 0.006$), and parking lot availability (B = 0.131, $p = 0.026$) contributed significantly to the overall liveability evaluation.

Model 2:

$$\begin{aligned} \mathit{Overall\ liveability}_{Group2} = & 2.161 + (0.167 * \mathit{indoor\ temperature}) \\ & + (0.154 * \mathit{ventilation}) - (0.161 * \mathit{glare}) \\ & + (0.131 * \mathit{parking\ lot}) \end{aligned}$$

The results of the regression analysis of Group 3 indicated that Model 3 explained 37.0% of the variance and that the model was a significant predictor of overall liveability (F (25.98) = 2.301, $p = 0.002$). Specifically, the frequency of air conditioner use (B = 0.143, $p = 0.040$) and natural lighting (B = 0.257, $p = 0.020$) contributed significantly to the overall liveability evaluation.

Model 3:

$$\begin{aligned} \mathit{Overall\ liveability}_{Group\,3} = & 1.665 + (0.143 * \mathit{frequency\ of\ air\ conditioner\ use}) \\ & + (0.257 * \mathit{natural\ lighting}) \end{aligned}$$

Of the above three models, Model 1 had the best general model fit, as the respondents in Group 1 had a clear understanding of their building types and thus also the expectations of building performance. These results indicated that the variables relating to thermal comfort (i.e., indoor temperature and frequency of air conditioner use) were significant and thus played a vital role in the liveability evaluation of the occupants from all three groups.

5 Discussion and policy implication

In the past few decades, green building has been widely accepted for its environmental sustainability. Many countries have formulated various incentive schemes, such as tax reduction and government subsidies, to promote the development of green buildings. However, these top-down motivation mechanisms present great challenges for the finances of local governments and have thus gradually become less common since the 2008 global economic crisis. Promotion policies should instead focus on the long-neglected 'bottom-up' choice preference. Individual willingness is key to the success of this bottom-up route, as occupants' liveability evaluations play a critical role in secondary purchasing decisions or the recommendation of living in green buildings.

Controlling for the eco-label effect, this study demonstrated that green buildings were not superior to conventional buildings according to the liveability evaluations of occupants in Changsha, China. In 2006, China's ESGB for the certification of the case study area included six major aspects: preservation of land and the outdoor environment, energy savings and utilization, water savings and utilization, material savings and utilization, indoor environment quality, and operational management. By concentrating on the material consumption levels of buildings, this evaluation standard improves environmental performance, but without regard for the living experience of occupants. In this study, the

Table 8 Liveability-related indicators in BREEAM, ESGB, LEED, and Green Star certifications*

Evaluation system	Early version	Intermediate version	Current version
BREEAM from Britain	EcoHomes (2006)	Code for sustainable homes (2010)	Home quality mark (2018)
	Energy (drying space, internal lighting, external lighting); *Transport* (public transport, local amenities, home office); *Pollution* (flood risk); *Water* (internal potable water use); *Health and wellbeing* (daylighting, sound insulation, private space); *Management* (home user guide, security)	*Energy and carbon dioxide emissions* (drying space, external lighting, home office); *Water* (indoor water use); *Surface water run-off* (flood risk); *Health & well-being* (daylighting, sound insulation, private space, lifetime homes); *Management* (home user guide, security)	*Transport and movement* (public transport availability, sustainable transport options, local amenities); *Outdoors* (recreational space); *Safety and resilience* (flood risk, managing rainfall impact, security); *Comfort* (indoor pollutants, daylight, noise sources, sound insulation, temperature, ventilation); *Energy* (energy and cost); *Materials* (life cycle costing, durability); *Space* (drying space, access, and space); *Water* (water efficiency)
ESGB from China	The 2006 version	The 2014 version (2014)	The 2019 version
	Land saving and outdoor environment (greening; outdoor noise, public transportation accessibility, amenities, motor lanes, sidewalks, parking lot, overall planning); *Energy saving and utilization* (natural lighting, high energy efficiency elevator and public equipment, thermal and humidity adjustment equipment); *Water saving and water resource utilization* (water saving); *Material saving and materials resources utilization* (material durability); *Indoor environment quality* (barrier-free facilities, natural lighting, sound insulation, and vibration control, ventilation, vision, glare); *Operation management* (safety, maintenance)	*Land saving and outdoor environment* (outdoor environment, traffic facilities of public service); *Energy saving and energy utilization* (heating ventilation and air conditioning, lighting and electricity); *Water saving and water resource utilization* (water saving system, water saving apparatus and equipment); *Indoor environment quality* (indoor acoustic environment, indoor light environment, and vision, indoor thermal and humidity environment, indoor air quality)	*Safety & durability* (safety, durability); *Health & comfort* (indoor air quality, water quality, sound & daylighting, indoor thermal environment); *Occupancy convenience* (transit & accessibility, service facility, intelligent operation, property management); *Environmental livability* (outdoor physical environment)

liveability evaluation comparison between green and conventional buildings verified this shortcoming.

The early and intermediate versions of the Chinese ESGB both focused on the consumption of land, water, energy and materials, and indoor air quality. However, in the latest version issued in 2019, four of the six major categories were directly related to occupants' living experience, and the proportion of liveability-related indicators, including comfort, health, customer experience, and occupant convenience, comprised a larger proportion of the evaluation system (Table 7). These recent changes to green building certification completely align with the conclusions of our research.

The other three widely used green building certifications, BREEAM, LEED, and Green Star, are manifested with completely divergent development orientations for liveability performance (Table 8). BREEAM has increasingly emphasized occupants' living experiences. The updated green building certification in 2006 formulated an EcoHomes version that specially addressed occupants' daily life experiences and introduced numerous liveability-related indicators (Suzer, 2019). In contrast, LEED and Green Star have remained focused on energy and resource consumption and lack metrics for convenience, health, and economics, despite several updates over the past decade (Awadh, 2017).

Therefore, apart from focusing on the energy efficiency performance of buildings, the green building certifications in every country should emphasize the living experiences of occupants and include more liveability-related indicators in their evaluation systems. This is particularly needed for the LEED and Green Star certifications. Our research also showed that the thermal comfort indicators were the most significant for occupants' overall liveability evaluation. Therefore, studies on the incorporation of liveability into the evaluation standards of green buildings should pay particular attention to factors related to thermal comfort (e.g., indoor temperature and frequency of air conditioner use), especially in countries with tropical and subtropical climates.

6 Conclusion

Building, industrial development, and transport are the three largest global consumers of energy. Energy-efficiency buildings are thus widely regarded as an effective way to achieve environmental sustainability. Many countries have subsequently formulated green building certifications, such as LEED in the US, BREEAM in the UK, and Green Star in Australia. A variety of incentive schemes have also been used by city governments to promote the development of green buildings. In addition to governments' top-down motivation, occupants' bottom-up choice preference is also significant for the promotion of green buildings. Liveability evaluations from the perspective of occupants are essential to encourage occupants to actively choose or recommend green buildings. However, the liveability performance of green buildings remains under-researched. Therefore, this study evaluated and compared the liveability performance between green and conventional buildings with a case study in Changsha, China.

We found that for occupants residing in green buildings, the respondents who knew that they lived in green buildings tended to provide more positive liveability evaluations than those who were unsure about their building type. The subjective perceptions of building types led to divergent liveability evaluation results, which verified the impacts of the eco-label effect on evaluations of building performance. We controlled for the eco-label effect, and the comparative results indicated that green buildings were not superior to

Table 8 (continued)

Evaluation system	Early version	Intermediate version	Current version
LEED from U.S	Building design + construction: Retail V1 (LEED 1.0 pilot 1998)	New construction (LEED V3.0 2009)	Building design + construction: Core and shell (LEED V4.1 2019)
	Sustainable sites (alternative transportation, development density & community connectivity, Heat-island effect, light pollution reduction); *Water efficiency* (water use reduction); *Indoor environmental quality* (environmental tobacco smoke control, minimum IAQ performance, controllability of systems, Daylight & view, increased ventilation, indoor chemical & pollutant source control, outdoor air delivery monitoring, thermal comfort)	*Sustainable sites* (development density & community connectivity, alternative transportation, stormwater design, heat-island effect, light pollution reduction); *Water efficiency* (water use reduction); *Indoor environmental quality* (minimum indoor air quality performance, environmental tobacco smoke control, outdoor air delivery monitoring, increased ventilation, low-emitting materials, indoor chemical, and pollutant source control, controllability of systems, thermal comfort, daylight, and views)	*Location and transportation* (surrounding density and diverse uses, access to quality transit, bicycle facilities, reduced parking footprint, electric vehicles); *Sustainable sites* (open space, rainwater management, heat-island reduction, light pollution reduction); *Water efficiency* (outdoor water use reduction, indoor water use reduction); *Indoor environmental quality* (minimum indoor air quality performance, environmental tobacco smoke control, enhanced indoor air quality strategies, low-emitting materials, daylight, quality views)
Green Star from Australia	Multi-unit residential pilot version (2008)	Design & as built V1.0 (2014)	Design & as built V1.3 (2020)
	Management (building user's guide, smart-metering); *Indoor environment quality* (ventilation rates, air change effectiveness, daylight, thermal comfort, hazardous materials, internal noise levels, volatile organic compounds, formaldehyde minimization, mold prevention); *Energy* (energy sub-metering, lighting zoning, car park ventilation, unoccupied spaces, energy efficient appliances); *Transport* (provision of car parking, fuel efficient transport, cyclist facilities, commuting mass transport, trip reduction); *Water* (occupant amenity water, water efficient appliances); *Land use & ecology* (communal garden facilities); *Emissions* (light pollution)	*Management* (building information); *Indoor environment quality* (indoor air quality, acoustic comfort, lighting comfort, visual comfort, indoor pollutants, thermal comfort); *Transport* (sustainable transport); *Emissions* (stormwater, light pollution)	*Management* (building information); *Indoor environment quality* (indoor air quality, acoustic comfort, lighting comfort, visual comfort, indoor pollutants, thermal comfort); *Transport* (sustainable transport); *Emissions* (stormwater, light pollution)

*The indicators outside the brackets are the primary indicators of the evaluation system. The indicators inside the brackets are the secondary indicators of the corresponding primary indicators conventional buildings in terms of liveability performance from the perspectives of occupants. In addition, thermal comfort variables (e.g., indoor temperature and frequency of air conditioner use) played the largest role in occupants' liveability performance evaluation.

Such findings are highly related to the evaluation of green building certifications, which emphasize energy and resource consumption but neglect occupants' living experience. Although such systems improve energy efficiency, they may do so at the cost of positive evaluations from occupants. This may hinder people from actively choosing green buildings. We, therefore, suggest that for this bottom-up route to successfully promote green buildings, more liveability-related indicators must be included in the evaluation systems of green building certifications, with special attention paid to indicators related to thermal comfort.

Appendix

Table of respondents' gender distribution.

Building Type	Gender	Valid Percent
Green buildings	Male	48.0
	Female	52.0
Conventional buildings	Male	45.3
	Female	54.7

Table of respondents' age distribution.

	Green buildings	Conventional buildings
younger than 20	5.0%	5.7%
21–30	27.4%	29.2%
31–40	48.5%	40.9%
41–50	15.7%	12.8%
51–60	2.0%	9.7%
older than 61	1.3%	1.7%

Funding This work is supported by the China Scholarship Council (Grant Number: 201806130145) and Faculty of Architecture and the Built Environment, Delft University of Technology. The Third author is grateful for the Delft Technology Fellowship (2014–2020) and for its generous funding support.

References

Adewunmi, Y., Omirin, M., Famuyiwa, F., & Farinloye, O. (2011). Post-occupancy evaluation of postgraduate hostel facilities. *Facilities, 29*(3/4), 149–168. https://doi.org/10.1108/02632771111109270

Al Horr, Y., Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A., & Elsarrag, E. (2016). Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature. *International Journal of Sustainable Built Environment, 5*(1), 1–11. https://doi.org/10.1016/j.ijsbe.2016.03.006

Altomonte, S., & Schiavon, S. (2013). Occupant satisfaction in LEED and non-LEED certified buildings. *Building and Environment, 68*, 66–76. https://doi.org/10.1016/j.buildenv.2013.06.008

Awadh, O. (2017). Sustainability and green building rating systems: LEED, BREEAM, GSAS and Estidama critical analysis. *Journal of Building engineering, 11*, 25–29. https://doi.org/10.1016/j.jobe.2017.03.010

Azizi, N. S. M., Wilkinson, S., & Fassman, E. (2015). An analysis of occupants response to thermal discomfort in green and conventional buildings in New Zealand. *Energy and Buildings, 104*, 191–198. https://doi.org/10.1016/j.enbuild.2015.07.012

Baird, G., Leaman, A., & Thompson, J. (2012). A comparison of the performance of sustainable buildings with conventional buildings from the point of view of the users. *Architectural Science Review, 55*(2), 135–144. https://doi.org/10.1080/00038628.2012.670699

Bonde, M., & Ramirez, J. (2015). A post-occupancy evaluation of a green rated and conventional on-campus residence hall. *International Journal of Sustainable Built Environment, 4*(2), 400–408. https://doi.org/10.1016/j.ijsbe.2015.07.004

CCMS, C. C. M. S. (2019). *Climate of Changsha*. Retrieved December 30 from http://www.nmc.cn/publish/forecast/AHN/changsha.html.

CNR, C. N. R. (2018). *Six departments in hunan province have issued guidelines on promoting green buildings*. Retrieved December 30 from https://baijiahao.baidu.com/s?id=1617816702598960850&wfr=spider&for=pc.

Darko, A., Chan, A. P. C., Ameyaw, E. E., He, B.-J., & Olanipekun, A. O. (2017). Examining issues influencing green building technologies adoption: The United States green building experts' perspectives. *Energy and Buildings, 144*, 320–332. https://doi.org/10.1016/j.enbuild.2017.03.060

Deuble, M. P., & de Dear, R. J. (2012). Green occupants for green buildings: The missing link? *Building and Environment, 56*, 21–27. https://doi.org/10.1016/j.buildenv.2012.02.029

Deuble, M. P., & de Dear, R. J. (2014). Is it hot in here or is it just me? Validating the post-occupancy evaluation. *Intelligent Buildings International, 6*(2), 112–134. https://doi.org/10.1080/17508975.2014.883299

Dwaikat, L. N., & Ali, K. N. (2018). The economic benefits of a green building–Evidence from Malaysia. *Journal of Building Engineering, 18*, 448–453. https://doi.org/10.1016/j.jobe.2018.04.017

Fuerst, F., & McAllister, P. (2009). An investigation of the effect of eco-labeling on office occupancy rates. *Journal of Sustainable Real Estate, 1*(1), 49–64. https://doi.org/10.2139/ssrn.1431575

Geng, Y., Ji, W., Lin, B., & Zhu, Y. (2017). The impact of thermal environment on occupant IEQ perception and productivity. *Building and Environment, 121*, 158–167. https://doi.org/10.1016/j.buildenv.2017.05.022

Gou, Z., Lau, S.S.-Y., & Zhang, Z. J. J. O. G. B. (2012). A comparison of indoor environmental satisfaction between two green buildings and a conventional building in China. *Journal of Green Building, 7*(2), 89–104. https://doi.org/10.3992/jgb.7.2.89

Gou, Z., Prasad, D., & Siu-Yu Lau, S. (2013). Are green buildings more satisfactory and comfortable? *Habitat International, 39*, 156–161. https://doi.org/10.1016/j.habitatint.2012.12.007

Hassanain, M. A., Sedky, A., Adamu, Z. A., & Saif, A.-W. (2010). A framework for quality evaluation of university housing facilities. *Journal of Building Appraisal, 5*(3), 213–221. https://doi.org/10.1057/jba.2009.15

He, B.-J. (2019). Towards the next generation of green building for urban heat island mitigation: Zero UHI impact building. *Sustainable Cities and Society, 50*, 101647. https://doi.org/10.1016/j.scs.2019.101647

He, L., & Chen, L. (2021). The incentive effects of different government subsidy policies on green buildings. *Renewable and Sustainable Energy Reviews, 135*, 110123. https://doi.org/10.1016/j.rser.2020.110123

Hedge, A., Miller, L., & Dorsey, J. A. (2014). Occupant comfort and health in green and conventional university buildings. *Work, 49*(3), 363–372. https://doi.org/10.3233/WOR-141870

Heylen, K. (2006). Liveability in social housing: Three case studies in Flanders. ENHR Conference'Housing in an Expanding Europe: Theory, Policy, Implementation and Participation', Date: 2006/07/02–2006/07/05, Location: Ljubljana (Slovenia).

Holmgren, M., Kabanshi, A., & Sörqvist, P. (2017). Occupant perception of "green" buildings: Distinguishing physical and psychological factors. *Building and Environment, 114*, 140–147. https://doi.org/10.1016/j.buildenv.2016.12.017

Hu, H., Geertman, S., & Hooimeijer, P. (2016). Personal values that drive the choice for green apartments in Nanjing China: The limited role of environmental values. *Journal of Housing and the Built Environment, 31*(4), 659–675. https://doi.org/10.1007/s10901-016-9494-5

Ilesanmi, A. O. (2010). Post-occupancy evaluation and residents' satisfaction with public housing in Lagos, Nigeria. *Journal of Building Appraisal, 6*(2), 153–169. https://doi.org/10.1057/jba.2010.20

Khoshbakht, M., Gou, Z., Lu, Y., Xie, X., & Zhang, J. (2018). Are green buildings more satisfactory? A review of global evidence. *Habitat International, 74*, 57–65. https://doi.org/10.1016/j.habitatint.2018.02.005

Kim, M. J., Oh, M. W., & Kim, J. T. (2013). A method for evaluating the performance of green buildings with a focus on user experience. *Energy and Buildings, 66*, 203–210. https://doi.org/10.1016/j.enbuild.2013.07.049

Leaman, A., & Bordass, B. (2007). Are users more tolerant of 'green' buildings? *Building Research & Information, 35*(6), 662–673. https://doi.org/10.1080/09613210701529518

Leby, J. L., & Hashim, A. H. (2010). Liveability dimensions and attributes: Their relative importance in the eyes of neighbourhood residents. *Journal of Construction in Developing Countries, 15*(1), 67–91.

Li, R. Y. M., Li, Y. L., Crabbe, M. J. C., Manta, O., & Shoaib, M. (2021). The impact of sustainability awareness and moral values on environmental laws. *Sustainability, 13*(11), 5882. https://doi.org/10.3390/su13115882

Li, R. Y. M., & Pak, D. H. A. (2010). Resistance and motivation to share sustainable development knowledge by Web 2.0. *Journal of Information & Knowledge Management, 9*(03), 251–262. https://doi.org/10.1142/S0219649210002656

Liberalesso, T., Cruz, C. O., Silva, C. M., & Manso, M. (2020). Green infrastructure and public policies: An international review of green roofs and green walls incentives. *Land Use Policy, 96*, 104693. https://doi.org/10.1016/j.landusepol.2020.104693

Liu, Y., Wang, Z., Lin, B., Hong, J., & Zhu, Y. (2018). Occupant satisfaction in Three-Star-certified office buildings based on comparative study using LEED and BREEAM. *Building and Environment, 132*, 1–10. https://doi.org/10.1016/j.buildenv.2018.01.011

Mccrea, R., & Walters, P. (2012). Impacts of urban consolidation on urban liveability: Comparing an inner and outer suburb in Brisbane, Australia. *Housing, Theory and Society, 29*(2), 190–206. https://doi.org/10.1080/14036096.2011.641261

Menadue, V., Soebarto, V., & Williamson, T. (2014). Perceivedand actual thermal conditions: Case studies of green-rated and conventional office buildings in the City of Adelaide. *Architectural Science Review, 57*(4), 303–319. https://doi.org/10.1080/00038628.2014.986433

Mohit, M. A., & Iyanda, S. A. (2016). Liveability and low-income housing in Nigeria. *Procedia - Social and Behavioral Sciences, 222*, 863–871. https://doi.org/10.1016/j.sbspro.2016.05.198

Mustafa, F. A. (2017). Performance assessment of buildings via post-occupancy evaluation: A case study of the building of the architecture and software engineering departments in Salahaddin University-Erbil, Iraq. *Frontiers of Architectural Research, 6*(3), 412–429. https://doi.org/10.1016/j.foar.2017.06.004

Ning, Y., & Chen, J. J. S. (2016). Improving residential satisfaction of university dormitories through post-occupancy evaluation in China: A socio-technical system approach. *Sustainability, 8*(10), 1050. https://doi.org/10.3390/su8101050

Olubunmi, O. A., Xia, P. B., & Skitmore, M. (2016). Green building incentives: A review. *Renewable and Sustainable Energy Reviews, 59*, 1611–1621. https://doi.org/10.1016/j.rser.2016.01.028

Pastore, L., & Andersen, M. (2019). Building energy certification versus user satisfaction with the indoor environment: Findings from a multi-site post-occupancy evaluation (POE) in Switzerland. *Building and Environment, 150*, 60–74. https://doi.org/10.1016/j.buildenv.2019.01.001

Paul, W. L., & Taylor, P. A. (2008). A comparison of occupant comfort and satisfaction between a green building and a conventional building. *Building and Environment, 43*(11), 1858–1870. https://doi.org/10.1016/j.buildenv.2007.11.006

Pei, Z., Lin, B., Liu, Y., & Zhu, Y. (2015). Comparative study on the indoor environment quality of green office buildings in China with a long-term field measurement and investigation. *Building and Environment, 84*, 80–88. https://doi.org/10.1016/j.buildenv.2014.10.015

Preiser, W. F., White, E., & Rabinowitz, H. (2015). *Post-occupancy evaluation (Routledge Revivals)*. Routledge.

Sanni-Anibire, M. O., & Hassanain, M. A. (2016). Quality assessment of student housing facilities through post-occupancy evaluation. *Architectural Engineering and Design Management, 12*(5), 367–380. https://doi.org/10.1080/17452007.2016.1176553

Schiavon, S., & Altomonte, S. (2014). Influence of factors unrelated to environmental quality on occupant satisfaction in LEED and non-LEED certified buildings. *Building and Environment, 77*, 148–159. https://doi.org/10.1016/j.buildenv.2014.03.028

Shen, Y., & Faure, M. (2021). Green building in China. *International Environmental Agreements: Politics, Law and Economics, 21*(2), 183–199. https://doi.org/10.1007/s10784-020-09495-3

Sörqvist, M. H. A. P. (2018). Are mental biases responsible for the perceived comfort advantage in "green" buildings? *Buildings, 8*(2), 20. https://doi.org/10.3390/buildings8020020

Sörqvist, P., Haga, A., Holmgren, M., & Hansla, A. (2015a). An eco-label effect in the built environment: Performance and comfort effects of labeling a light source environmentally friendly. *Journal of Environmental Psychology, 42*, 123–127. https://doi.org/10.1016/j.jenvp.2015.03.004

Sörqvist, P., Haga, A., Langeborg, L., Holmgren, M., Wallinder, M., Nöstl, A., Seager, P. B., & Marsh, J. E. (2015b). The green halo: Mechanisms and limits of the eco-label effect. *Food Quality and Preference, 43*, 1–9. https://doi.org/10.1016/j.foodqual.2015.02.001

Suzer, O. (2019). Analyzing the compliance and correlation of LEED and BREEAM by conducting a criteria-based comparative analysis and evaluating dual-certified projects. *Building and Environment, 147*, 158–170. https://doi.org/10.1016/j.buildenv.2018.09.001

Thatcher, A., & Milner, K. (2016). Is a green building really better for building occupants? A longitudinal evaluation. *Building and Environment, 108*, 194–206. https://doi.org/10.1016/j.buildenv.2016.08.036

USGBC. (2014). *The definition of green building*. Retrieved 24122019 from https://www.usgbc.org/articles/what-green-building.

Varma, C. S., & Palaniappan, S. (2019). Comparision of green building rating schemes used in North America, Europe and Asia. *Habitat International, 89*, 101989. https://doi.org/10.1016/j.habitatint.2019.05.008

Vyas, G. S., & Jha, K. N. (2018). What does it cost to convert a non-rated building into a green building? *Sustainable Cities and Society, 36*, 107–115. https://doi.org/10.1016/j.scs.2017.09.023

Wimala, M., Akmalah, E., & Sururi, M. R. (2016). Breaking through the barriers to green building movement in Indonesia: Insights from building occupants. *Energy Procedia, 100*, 469–474.

Zalejska-Jonsson, A. (2014). Parameters contributing to occupants' satisfaction. *Facilities, 32*(7/8), 411–437. https://doi.org/10.1108/f-03-2013-0021

Zhang, Y., Wang, H., Gao, W., Wang, F., Zhou, N., Kammen, D. M., & Ying, X. (2019). A survey of the status and challenges of green building development in various countries. *Sustainability, 11*(19), 5385. https://doi.org/10.3390/su11195385

Zhang, Y., Wang, J., Hu, F., & Wang, Y. (2017). Comparison of evaluation standards for green building in China, Britain, United States. *Renewable and Sustainable Energy Reviews, 68*, 262–271. https://doi.org/10.1016/j.rser.2016.09.139

Authors and Affiliations

Ying Xu[1] · Dan Luo[2,3] · Queena K. Qian[3] · Edwin H. W. Chan[4,1]

Ying Xu
xuyingefface@gmail.com

Queena K. Qian
k.qian@tudelft.nl

Edwin H. W. Chan
gmedchan@gmail.com

[1] School of Public Administration, Hunan University, Changsha, China

[2] School of Law, Hunan University, Changsha, China

[3] Management in the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Delft, The Netherlands

[4] School of Public Administration, Hunan University, Changsha, China