v1: 9 February 2023

Review Article

Exploring an Integrated Decision-Making Model to Enhance the Employee-Oriented Built Environment in Urban Green Buildings: A Review

Peer-approved: 9 February 2023

Qeios, Vol. 5 (2023)
ISSN: 2632-3834

Wasudha Abeyrathna[1], Gayanthi Krishani Perera John[2], Rohantha Jayasinghe[1], R.I.S. Ariyarathna[1], Manuja Promodya Hendawitharana[3,4], Rangika U. Halwaturaa[1], Arturas Kaklauskas[5], F. Rizna Arooz[6], A. Shehan Perera[3]

1. Departmet of Civil Engineering, University of Moratuwa, Sri Lanka; 2. Departmet of Civil Engineering Technology, University of Moratuwa, Sri Lanka; 3. University of Moratuwa, Sri Lanka; 4. National Aquatic Resources Research and Development Agency, Colombo, Sri Lanka; 5. Department of Construction Management and Real Estate, Vilnius Gediminas Technical University, Lithuania; 6. Department of Architecture, Kotelawala Defence University, Sri Lanka

Integrating building technology systems into urban green buildings is an emerging building movement in developed countries to create a paradigm of a human-oriented built environment inside workspaces. This paper aims at the conversion of green buildings to smart-green facilities, initiated to develop an employee-oriented built environment in urban green office buildings using decision-making models. The study identifies the factors affecting employee satisfaction as building-related factors, non-building-related factors, Multiple Criteria Decision Analysis (MCDA), and Structural Equation Model (SEM) through a comprehensive literature review. Extensive bibliographic research has been conducted over 21 years to understand the relationship between decision-making models and employee satisfaction in green office buildings. This paper provides an overall ideology of the impact of green office buildings and the conversion to buildings focusing on employee satisfaction. The study concludes by introducing an integrated MCDA and SEM method to create a less complex hybrid decision-making model to create an improved employee-friendly built environment.

Correspondence: papers@team.qeios.com — Qeios will forward to the authors

Introduction

There has been a drive for urban sustainability on various frontiers, with the human-oriented viewing platform receiving unprecedented attention and increasing emphasis on the expediency, performance, and efficacy of sustainable measures in recent years (Fu et al., 2021). In response to the global environmental protection movement, carbon neutrality and energy efficiency have become the core of the building industry's sustainability agenda. These targets have thus reinforced the importance of green building policy (Altomonte et al., 2016; Ravindu et al., 2015). In order to offer people a healthy, acceptable, and efficient use space that is also in harmony with nature, green buildings are described as those that save resources (energy, land, water, and materials) to the greatest extent possible (Ding et al., 2018). Concerning office buildings, one of the commercial building sectors contributing to higher operational costs, the need to build green offices is of more importance (Juan et al., 2010).

However, it is seen that green office building growth is at a considerably satisfactory level from a global perspective. Adapting intelligent technologies to buildings is one of the leading emerging trends in the developing world. Advanced technologies updated in the world daily have led to their incorporation into the management and operations of buildings. This move has led to more highlighted benefits for green buildings with real-time monitoring integrated intelligent systems (Chew et al., 2020).

The industrial revolutions in past centuries were technological transformations with economic and societal changes (Ejsmont, 2021). The fourth industrial revolution emerged in the past few decades, allowing better collaboration by connecting physical work with digital, contributing to establishing sustainable smart cities across the globe. Industrial 4.0 requires digital platforms and nurtured employee capital to achieve its improved objectives compared to the other industrial revolution stages (Agolla, 2018). Employee comfort in office buildings plays a vital role in an industry's work efficiency and helps maintain technological revolutions to tremendous success. Since green buildings specifically consider occupant satisfaction as an element in their certification criteria (Building Research Establishment Environmental Assessment Method—BREEAM, Leadership in Energy and Environmental Design - LEED, etc.), this review has been focused on introducing green buildings to the smart-green buildings system while increasing employee comfort to create an intelligent and sustainable work environment.

Generally, the concept of 'green buildings' can be elaborated as a collection of core principles such as resource conservation, energy efficiency, lifecycle effects, human health, and building performance (Howe, 2011; Zuo and Zhao, 2014). Yet, with the emerging technological advancement come concepts like 'Industry 4.0', 'smart manufacturing', and 'intelligent buildings', which integrate technology with key industrial components; machines, data, and people to achieve industrial automation. Industry 4.0 is a fusion of technologies that overlap in physical, digital, and biological circles (Terziyan et al., 2018).

An innovative sustainable design approach derived recently is the Intelligent Green Buildings (IGP). This concept has been widely accumulating interest among architects, building owners, and engineers (X. Yang et al., 2020). Green buildings in the current world require the assistance of scientific and technological support, which, in other words, explains the green buildings being smart with the updated technologies of the world. This integration of green building construction and the intelligent building industry is essential in verifications and controls over the building management and the smooth process, which results in less maintenance due to the real-time monitoring of the building (B. Yang et al., 2022).

Smart or intelligent buildings have been established to achieve this automation component. Even though the literature availability is abundant on intelligent buildings, the proper definition of the terminology is questionable, as much of the early reports were criticized for focusing exclusively on the technological component but not on the user and building interactions (Mofidi and Akbari, 2020, Wong and Wang, 2005). Conversely, recent approaches to establishing intelligent buildings have focused on enhancing consumer satisfaction and adding cognitive learning aspects ((Alanne, (2021; Rameshwar et al., 2020).

The immaturity in the prior industrial stages generally constitutes a barrier to adopting Industry 4.0 in developing countries (Krawczynski et al., 2016). Hence, the theory of 'diffusion of innovations' has been broadly discussed in the contemporary literature, emphasising its role in developing countries where proximity factors generally limit the transfer of knowledge; economic, cultural, and geographical (Gluszak et al., 2019). In conclusion, this implies that the spread of innovation is centred among the developed countries; thus, achieving Industry 4.0 goals in developing countries should consider alternative approaches.

In third-world developing countries, achieving Industry 4.0 appears to be more challenging given that the level of technology, capital investment, strategic planning, resource scarcity, and expert labour requirements are lacking (Bogoviz et at., 2019; Raj et al., 2020; Roodt, and Koen, 2020). Thus, as a more sustainable solution, we believe that adding automation components to green buildings serves more towards employee satisfaction than vice versa in developing countries. The concept of 'Green Smart Buildings', where the integration of green buildings and the smart grid concept has been well discussed in previous literature (Adalberth et al., 2001; Jadhav, 2016; Rameshwar et al., 2020).

The objective of this study is to provide an overall ideology of the impact of green office buildings and the conversion to buildings focusing on employee satisfaction. The paper tries to highlight the most used decision model structures and propose an integrated decision-making model framework to enhance the working environment of the employees. Despite the number of prior research on occupancy evaluation in green buildings and many decision-making models that have been experimented with in the past few decades for different aspects, a system to influence structures to enhance employee comfort has not yet been comprehensively explained. The literature review discusses the impact of working in a green building on employees in different aspects. This study investigates the most cited multi-criteria decision-making analysis (MCDA) and structural equation modelling (SEM) methods used related to employee comfort and green buildings to propose a hybrid decision-making model framework.

Methodology

The study is driven by a systematic literature review and bibliographic analysis to perform three main approaches: (i) to identify main factors and existing decision-making models, (ii) to conduct a bibliographic analysis and thematic mapping (2000-2022), and (iii) to present the most appropriate methods for a hybrid decision-making model framework. An extensive literature review was conducted to identify the factors related to employee comfort and SEM, MCDA models which have been demonstrated to have many theoretical and practical applications in decision-making in green buildings and employee satisfaction. A quantitative analysis based on two-dimensional maps was carried out to understand which decision models have been applied more in building-related applications and the topics related to occupant satisfaction. VOSviewer (version 1.6.16) was the tool selected to perform the bibliometric analysis in this study, ArcGIS (version 2.6) for the global publications map, and NodeXL for the correlation of satisfaction factors and publications. Figure 01 describes the methodology of the study.

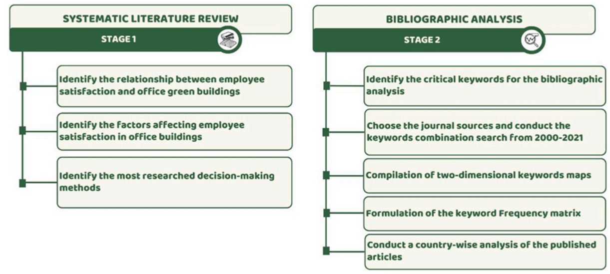

Figure 1. The research flow of the study

Identifying the factors for enhancing an employee-oriented built environment in green buildings

Office buildings are one of the commercial building sectors that need the most excellent attention in providing a well-managed work environment for employees; on the other hand, this sector consumes the highest number of resources during its operational period since employees spend 80% of their time inside these buildings. Office buildings are among the highest energy consumers compared to other building types. Moreover, the work pressure in this sector is critically increasing (Wu et al., 2021). Therefore, the need for a suitable office environment has arisen to improve work efficiency by enhancing occupant comfort with an optimised indoor climate. Research has concluded that work efficiency could be increased by 15% - 20% with an improved green office environment (Esfandiari et al., 2017). Apart from the specific benefits of a green office building, such as energy-saving, water-saving, etc., the employees' health and comfort, along with an energy-efficient environment, are paramount. These factors have been shown to result in lower absenteeism (Wu et al., 2021).

Green rating tools have been initiated to accelerate the transformation of the building sector towards a more environmentally friendly model (Roderick et al., 2009). All green building rating tools share the same concept to maximise energy and resource efficiency and improve occupant health and well-being (Gou & Xie, 2017). However, the role of green rating tools in improving indoor environmental quality and occupant experience in green buildings is uncertain (S Altomonte et al., 2016; Gou et al., 2014).

Employee satisfaction is of great importance for many organisations, particularly commercial organisations

doi.org/10.32388/70OGM8.5

and institutions, as it helps elevate employee work performance and productivity (Veitch et al., 2007). Employee satisfaction can also be correlated with turnover intentions and retaining a talented and skilled workforce (Van Dick et al., 2004). The review of global evidence depicts a contradictory body of knowledge regarding the impact of green buildings on occupant satisfaction. Therefore, the success of a sustainable building relies on its indoor environmental quality (IEQ), which directly affects the quality of the employee's life. It is, thus, essential to assess whether green-certified buildings are genuinely successful as sustainable buildings by evaluating the satisfaction of their employees.

Numerous post-occupancy studies have investigated the relationship between green certifications and occupant/employee satisfaction. Most green building occupant satisfaction studies come from the U.S. and the U.K., and recent studies are emerging from Asia (Liu et al., 2018; Ravindu et al., 2015).

As reflected in the majority of the literature, indoor air quality (IAQ) in LEED buildings is perceived to be higher when compared with non-green buildings (Abbaszadeh et al., 2006; Huizenga et al., 2005; Issa et al., 2011; Kim et al., 2015; Lee & Kim, 2008; Turner, 2006). Studies conducted on green buildings in China (Lin et al., 2016; Pei et al., 2015) and Taiwan (Liang et al., 2014) reported a higher perceived IAQ in green buildings.

However, post-occupant evaluations conducted on BREEAM buildings have reported lower satisfactory IAQ than their conventional counterparts (S Altomonte et al., 2016; Adrian Leaman & Bordass, 2007). Results reported from Australia (Paul & Taylor, 2008), South Korea (Sediso & Lee, 2016), and Sri Lanka (Ravindu et al., 2015) have indicated no significant difference in the IAQ of green buildings compared to non-green buildings. Furthermore, some studies on LEED buildings (Sergio Altomonte & Schiavon, 2013) have also indicated that the IAQ of green buildings is comparable with that of conventional buildings. Incidentally, Gou, Lau, & Zhang (2012) reported that green buildings perform better in summer but worse in winter. This study is supported by (Gou, Lau, & Shen, 2012), who reported that the summer performance of LEED buildings in Hong Kong concerning IAQ was much better than their winter performance.

Regarding lighting performance, most research has detected no significant difference in LEED buildings (Abbaszadeh et al., 2006; Sergio Altomonte & Schiavon, 2013; Huizenga et al., 2005). However, some studies have indicated a higher satisfaction score (Issa et al., 2011; Kim et al., 2015; Turner, 2006), whereas others have reported a lower satisfaction score in LEED buildings (Brown et al., 2010; Lee & Kim, 2008). Similarly, in BREEAM buildings, some studies have perceived a higher satisfaction score (Baird et al., 2012; Zhang & Altan, 2011), while others have reported no significant differences (S Altomonte et al., 2016; Adrian Leaman & Bordass, 2007) in satisfaction between green and non-green groups.

In the Chinese context, two studies (Gou, Lau, & Shen, 2012; Gou, Lau, & Zhang, 2012) have reported no significant differences in lighting performance, whereas another study (Pei et al., 2015) indicated higher perceived lighting scores in green buildings compared to their conventional counterparts. Post-occupancy evaluation surveys conducted on Green Star buildings in Australia (Khoshbakht et al., 2018; Paul & Taylor, 2008) have reported no significant differences in lighting performance between green and non-green facilities. However, studies conducted in South Korea (Sediso & Lee, 2016) on G-SEED buildings (Green Standard for Energy and Environmental Design) have reported higher perceived satisfaction in lighting performance in green buildings.

Concerning literature, green buildings are the least successful in terms of noise performance. The majority of papers have reported either no significant differences (Abbaszadeh et al., 2006; Sergio Altomonte & Schiavon, 2013; Huizenga et al., 2005) or lower satisfaction scores (Brown et al., 2010; Issa et al., 2011; Lee & Kim, 2008; Turner, 2006) in LEED buildings in comparison with non-LEED structures. A study on higher education buildings in Australia (Khoshbakht et al., 2018) has also reported lower satisfaction levels with noise in Green Star-certified buildings. Similarly, post-occupant evaluations conducted on BREEAM buildings (S Altomonte et al., 2016; Adrian Leaman & Bordass, 2007; Zhang & Altan, 2011), Green Star buildings (Paul & Taylor, 2008), G-SEED facilities in South Korea (Sediso & Lee, 2016), and LEED buildings in Sri Lanka (Ravindu et al., 2015) have reported no significant differences in the noise performance of green and non-green buildings. Contrarily, some studies (Liang et al., 2014; Newsham et al., 2013) have indicated a higher perceived satisfaction score in the noise performance of green buildings.

Regarding thermal comfort, most studies have detected higher performance in green buildings compared to conventional buildings. Post-occupant evaluations conducted on LEED buildings (Brown et al., 2010; Huizenga et al., 2005; Issa et al., 2011; Kim et al., 2015; Newsham et al., 2013; Zhang & Altan, 2011) have indicated greater thermal comfort compared to their conventional counterparts. In the Chinese context, most studies (Gou et al., 2014; Lin et al., 2016; Pei et al., 2015) have reported higher thermal satisfaction in green buildings. Similarly, studies conducted in Taiwan (Liang et al., 2014) and South Korea (Sediso & Lee, 2016) reported that green buildings significantly outperform non-green buildings concerning thermal comfort.

However, few studies have been conducted on LEED buildings (Sergio Altomonte & Schiavon, 2013), BREEAM buildings (S Altomonte et al., 2016), China Three Star buildings (Gou, Lau, & Zhang, 2012), and Green Star buildings (Menadue et al., 2014; Paul & Taylor, 2008). These studies have reported comparable thermal satisfaction in green and non-green buildings, with no significant differences.

Contradictory results on the perceived thermal performance of green buildings have also been reported. Baird et al. (2012) reported lower satisfaction scores in BREEAM buildings than in non-BREEAM buildings.

An Australian-based study (A Leaman et al., 2007) said Green Star buildings underperformed their conventional counterparts regarding thermal comfort satisfaction. Similarly, a survey conducted in Sri Lanka (Ravindu et al., 2015) reported lower perceived thermal comfort in green buildings.

According to Singh et al. (2010), the "honeymoon" effect, a short period after occupancy, can impact when rating the experience of the building. The occupant satisfaction studies considered have been conducted in various countries with different socio-economic backgrounds. In developed countries like the U.S. and U.K., where standards are very high and stringent, improvements brought by green building designs may be marginal (A. Darko et al., 2017; Amos Darko et al., 2017). Therefore, modifications to occupant satisfaction might be minimal. However, building design and service standards are relatively low in developing countries like China and Sri Lanka. In these countries, the improvements brought by green building concepts can significantly improve building design and operation (He et al., 2014; Zhao et al., 2015).

As reflected in the literature, Building Design and Facilities Management (BD&FM) of green buildings are perceived to be better than those of conventional buildings. Studies conducted on LEED buildings (Brown et al., 2010; Kim et al., 2015; Lee & Kim, 2008; Newsham et al., 2013) and BREEAM buildings (Baird et al., 2012) have recorded more satisfactory performance in green buildings. In the Chinese context, higher perceived satisfaction scores were achieved in green buildings in terms of operation and maintenance (Lin et al., 2016), health (Gou et al., 2014), and productivity (Gou et al., 2014). Furthermore, green buildings in Sri Lanka (Ravindu et al., 2015), South Korea (Sediso & Lee, 2016), and Green Star buildings in Australia (Khoshbakht et al., 2018) have shown satisfactory performance in terms of BD&FM parameters when compared with non-green facilities. Issa et al. (2011) also reported that student and staff absenteeism in green schools was 2-7.5% lower, and students' performance was 8-19% higher when compared with conventional schools. However, one study conducted in China (Gou, Lau, & Zhang, 2012) indicated that occupant satisfaction in green and non-green buildings was comparable. A summary of the literature findings detailed above is given in Table 1.

	IAQ	Lighting	Acoustics	Thermal Comfort	Layout	Furnishings	Privacy	Cleanliness	Operation & Maintenance	Workspace	Colours and textures
(Nkini et al., 2022)	✓	×	×	✓							
(Geng et al., 2019)	✓			✓							
(Abbaszadeh et al., 2006)	✓	∘	∘	✓		✓		✓	✓	✓	
(Issa et al., 2011)	✓	✓	×	✓							
(Kim et al., 2015)	✓	✓	✓	✓	✓						
(Lee & Kim, 2008)	✓	×	×	✓	×	✓		✓	✓		
(Lin et al., 2016)	✓	✓	✓	✓		✓	✓	∘	✓		
(Pei et al., 2015)	✓	✓	✓	✓							
(Turner, 2006)	✓	✓	×				×				
(Altomonte et al., 2016)	×	∘	∘	∘			∘	∘			
(Sediso & Lee, 2016)	∘	✓	∘	✓	✓	✓		✓	✓		
(Altomonte & Schiavon, 2013)	∘	∘	∘	∘		∘	∘	∘	∘		
(Huizenga et al., 2005)	✓	∘	∘	✓							
(Brown et al., 2010)		×	×	✓							
(Paul & Taylor, 2008)	∘	∘	∘	∘							
(Khoshbakht et al., 2018)	✓	∘	×	✓							
(Liang et al., 2014)	✓	✓	✓	✓							
(Leaman & Bordass, 2007)	×	∘	∘	×							
(Ravindu et al., 2015)	∘	✓	∘	×	✓	✓	✓	✓			
(Baird et al., 2012)	✓	✓	∘	×		✓		✓	✓		
(Zhang & Altan, 2011)		✓	∘	✓							
(Newsham et al., 2013)			✓	✓						✓	✓
(Liang et al., 2014)	✓	✓	✓	✓							

Table 1. Review of Previous Research on Green Buildings and Employee Comfort

The review of global evidence in Table 01 depicts a contradictory body of knowledge regarding the impact of green buildings on occupant/employee satisfaction. This proves that there should be a verified decision-making model that can help decision-makers evaluate employee satisfaction and implement the necessary adjustments.

Figure 2 depicts the factors that affect building user satisfaction according to the different publications published in the past 20 years.

doi.org/10.32388/70OGM8.5

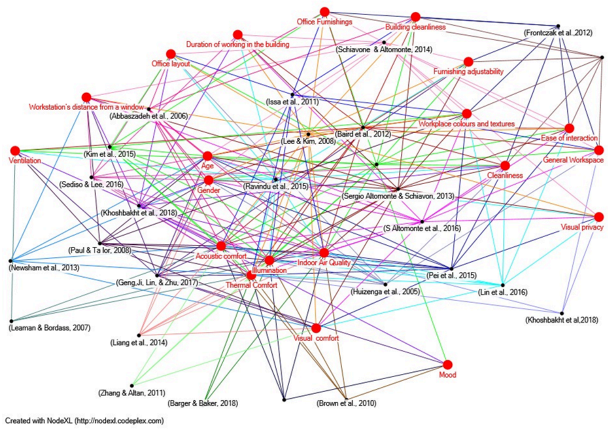

Figure 2. Identified factors affecting user comfort in buildings

The red nodes illustrate the factors recorded in different studies, and the line colours represent each paper. Two fundamental approaches characterised the main features of the factors: (i) Building-related elements and (ii) non-building-related factors (Figure 03).

This study identifies the building-related factors to consider when determining the decision-making model.

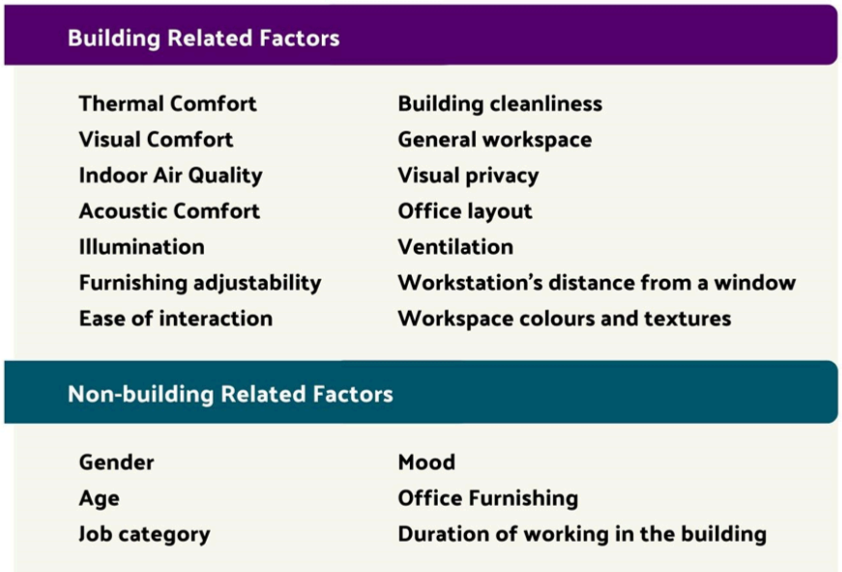

Figure 3. Identified factors affecting employee satisfaction in office buildings

Incorporation of Decision-making Models to Enhance Employee Satisfaction in Green Buildings

Decision-making models are considered pivotal in the process of automating green buildings. During the early 90s, Linear Programming models, a mathematical modelling technique in which a linear function is maximised or minimised when subjected to various constraints, were first used to make quantitative decisions in industrial processes (Färe et al., 1992). Yet, with the advancement of technologies, the use of single-criterion optimisation techniques was limited by the consideration of secondary consequences that require multiple criteria (Green et al., 2011). Thus, Multiple-Criteria Decision Analysis (MCDA) methods have evolved as a tool for analysing alternatives based on various dissimilar factors/criteria and collective evaluation of those criteria to rate or rank the other options (Greco et al., 2016; Huang et al., 2011). Depending on the problems' discrete or continuous nature, the MCDA can be classified into two categories: Multi-Objective Decision Making (MODM) and Multi-Attribute Decision Making (MADM).

MADM is more appropriate for analysing isolated problems using a cluster of criteria and thus evaluating or ranking a predetermined and yet limited number of alternatives. MADM models are of three types. The first category is the MADM models with explicit values, developed to support decision-making processes to evaluate, select, and improve. Secondly, MADM models with fuzzy values account for errors and uncertainties. The third category integrates MADM models with other methods. Recently, hybrid MADM methods combining different MADM methods have become popular. Conversely, in analysing ongoing problems associated with designing or planning to acquire desired goals within given constraints, MODM methods are used (Medić et al., 2019).

Thus, here we discuss Structural Equation Modeling (SEM) as a powerful tool to be integrated with the MADM. SEM is a statistical technique used to measure, analyse, and evaluate relationships amongst multiple variables, both latent and observable (Fan et al., 2016).

Various MCDA and SEM methods were initially chosen to investigate the most appropriate MCDA and SEM models to create the hybrid model. A bibliographic analysis was conducted to understand the research on decision-making models in the building sector. There are numerous MCDA methods such as the Analytic Hierarchy Process (AHP), Goal Programming (GP), Fuzzy AHP, Data Envelopment Analysis (DEA), Multi-attribute utility theory, Scoring methods, Electra, Technique for order of preference by similarity to ideal solution (TOPSIS), VIKOR: stepwise procedure, and many more (Mohamadali & Garibaldi, 2012).

doi.org/10.32388/70OGM8.5

Many SEM estimation methods exist, such as generalised least squares (GLS), weighted least squares, maximum likelihood (ML), and partial least squares (PLS) (Fan et al., 2016). Various statistical software exist for performing statistical analysis, including R-programming, Statistical Package for Social Sciences (SPSS), Minitab, STATA, SAS, SEM-AMOS, WarpPLS, and SEM-SmartPLS (Hanafi et al., 2010).

In recent years, hybrid decision-making models have become more prevalent, given their ability to evaluate and determine the most preferred alternative based on multiple criteria analysis (Kumar et al., 2021). Likewise, when the technology integration level and complexity are higher, the Industry 4.0 adoption requires more complex and combined decision-making approaches rather than framing one or two critical available models (Medić et al., 2010; Sansana et al., 2021). In addition, most conventional multi-criteria decision analysis approaches are not applicable when multi-layered interactions and competing criteria are available in the decision-making process.

Bibliographic analysis

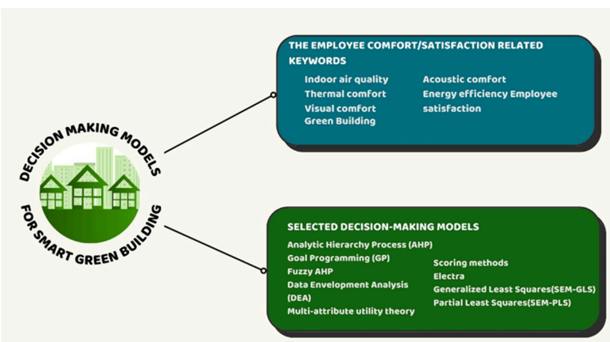

Figure 4. Selected Keywords for the Study

The keywords were chosen from green building-related employee comfort factors (Figure 4), MCDA methods (AHP, GP, Fuzzy AHP, DEA, Multi-attribute utility theory, Scoring methods, Electra), and SEM methods (SEM-PLS and SEM-GLS) only were considered in this study. The MCDA and the SEM software model methods were cross-analysed with the employee comfort factors. The analysis was conducted in Google Scholar, ScienceDirect, Web of Science, and Scopus journal sources. The publication's keywords for the past 21 years were analysed (2000-2021).

The two-dimensional keyword distribution map for MCDA and SEM methods was created for the total publications in the past 21 years to discuss the total number of published papers in the journal sources. The size of the circles in Figure 5 depicts the total number of publications done in the past 21 years for the keywords' combination of "Selected decision-making models" + "the employee comfort/satisfaction related keywords" and "selected decision-making models" + "study-focused keywords". According to Figure 5, the total publications were higher in Google Scholar. AHP and DEA have been practised prominently among the MCDA methods, and the PLS-SEM method was prominently used among SEM methods.

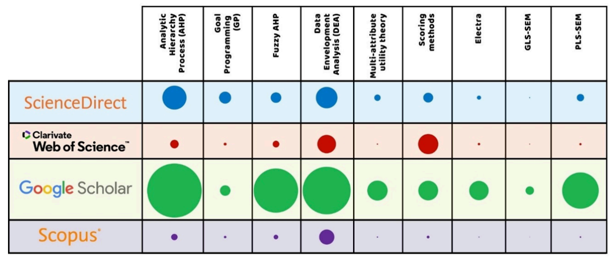

Figure 5. 2-D map to illustrate the number of publications in journal sources from 2000-2021 for MCDA and SEM methods used in keywords related to building factors and study-focused keywords

A two-dimensional keyword distribution map was organised for the employee comfort/satisfaction-related and study-focused keywords to reflect the number of papers from 2000-2021 published for decision-making methods used for certain factors (Figure 6). The "Energy efficiency" keyword was significant among the others, implying that many energy efficiency-related decision-making models have been developed in the past 21 years. Coloured document frequency matrices were prepared for the keywords to reflect the number of articles published in the past 21 years in Google Scholar.

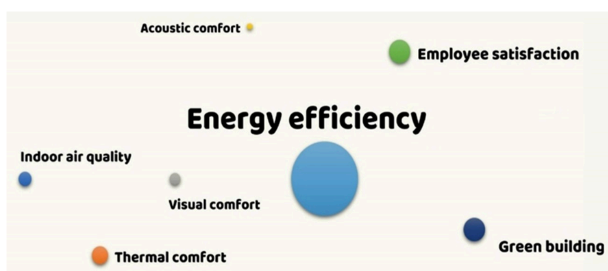

Figure 6. 2-D: number of papers published on decision-making models for selected "Employee comfort-related keywords"

 doi.org/10.32388/70OGM8.5

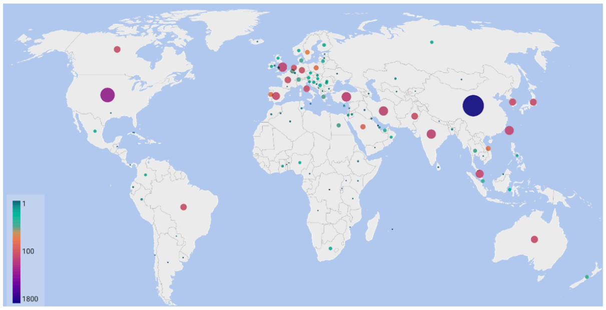

Figure 7. Number of publications according to the country

Country-wise keyword analysis has been conducted to understand the contribution to the study-related research keywords (see Figure 7). The map depicts that developed countries like China, the USA, Japan, and South Korea contributed to the decision-making models and employee-related studies more prominently than other countries. Developing countries such as India, Taiwan, Turkey, and Iran have made a progressive contribution, and there are fewer publications in the Asian region. This proves that decision-making models to enhance employee comfort are yet to be researched deeply worldwide, and many developed countries have already started to see the outcomes.

The study further narrowed down to identify the most published MCDA and SEM methods to construct a hybrid model. Table 03 depicts the total publications from 2000-2021 of selected decision-making models with the employee comfort-related keywords.

Table 3 explains the number of publications done under selected keywords. The AHP method records most of the publications under all the relevant keywords in all the journal sources except Web of Science. The Scoring method was used in most of the Web of Science, and the DEA method was used more frequently for decision-making in energy efficiency than AHP.

ScienceDirect	IAQ	Thermal comfort	Visual comfort	Acoustic comfort	Energy efficiency	Employee satisfaction	Green building
Analytic Hierarchy Process (AHP)	214	327	74	44	1656	125	329
Goal Programming (GP)	49	91	14	2	483	24	45
Fuzzy AHP	26	42	7	6	346	35	47
Data Envelopment Analysis (DEA)	52	99	23	6	1998	68	90
Multi-attribute utility theory	16	21	5	2	116	5	28
Scoring methods	40	64	9	6	232	26	87
Electra	12	6	3	0	58	1	3
GLS-SEM	0	1	0	0	1	3	0
PLS-SEM	4	11	2	3	116	51	29
Web of Science	IAQ	Thermal comfort	Visual comfort	Acoustic comfort	Energy efficiency	Employee satisfaction	Green building
Analytic Hierarchy Process (AHP)	10	27	5	5	201	17	64
Goal Programming (GP)	19	0	7	7	2	2	5
Fuzzy AHP	6	7	0	2	126	10	44
Data Envelopment Analysis (DEA)	3	2	0	0	1752	12	19
Multi-attribute utility theory	1	0	0	0	6	0	2
Scoring methods	81	111	593	32	727	352	187
Electra	0	0	1	0	28	0	0
GLS-SEM	0	0	0	0	0	3	1
PLS-SEM	2	3	2	2	15	220	41
Google Scholar	IAQ	Thermal comfort	Visual comfort	Acoustic comfort	Energy efficiency	Employee satisfaction	Green building
Analytic Hierarchy Process (AHP)	550	807	183	102	10065	902	1531
Goal Programming (GP)	12	16	1	0	425	47	19
Fuzzy AHP	158	326	46	46	6766	603	710
Data Envelopment Analysis (DEA)	93	147	16	5	10076	681	341
Multi-attribute utility theory	102	125	27	9	1360	111	195
Scoring methods	96	126	35	13	1294	188	203
Electra	63	73	17	8	1624	33	87
GLS-SEM	5	12	2	1	121	179	12
PLS-SEM	100	116	37	27	1402	3155	465
Scopus	IAQ	Thermal comfort	Visual comfort	Acoustic comfort	Energy efficiency	Employee satisfaction	Green building
Analytic Hierarchy Process (AHP)	10	8	1	0	142	8	25
Goal Programming (GP)	0	0	0	4	26	3	0
Fuzzy AHP	6	3	0	1	62	4	18
Data Envelopment Analysis (DEA)	1	1	0	0	1177	4	8
Multi-attribute utility theory	0	2	0	0	7	0	1
Scoring methods	4	1	10	0	14	2	5
Electra	0	0	0	0	4	0	0
GLS-SEM	0	0	0	0	0	0	1
PLS-SEM	0	0	0	0	0	0	0

Table 3. Total publications from 2000-2021 of selected decision-making models with the employee comfort-related keywords

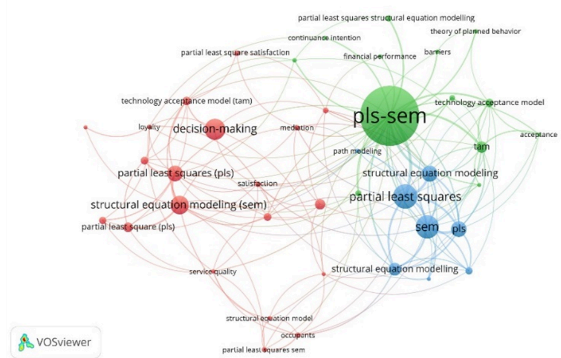

Figure 8. Co-occurrence network map of PLS-SEM

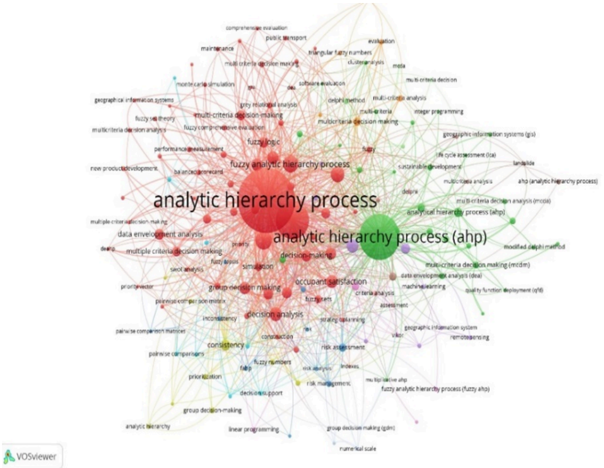

Figure 9. Co-occurrence network map of AHP

The bibliographic analysis concludes to select AHP as MCDA and PLS-SEM as SEM to create the hybrid decision-making model to enhance employee comfort in green buildings. The bibliographic analysis continued to profoundly investigate the cited keywords with the AHP and PLS-SEM decision-making methods to create the hybrid model. Network maps (Figures 8 and 9) were organised to illustrate the correlation between the cited keywords, AHP, and PLS-SEM.

The maps depict the co-occurrence network of AHP and PLS-SEM. The thematic map is clustered with the nodes to illustrate the connection of the main keywords. Both of the maps highlight the connectivity of occupant satisfaction and decision-making. Also, the model methods are further correlated with technology acceptance, sustainability, and human behaviour.

Conclusion

A literature review into employee-oriented environments in green-certified buildings discloses a contrary body of research. As described, there is no consistent global evidence to prove that green buildings are more satisfactory than non-green buildings. Based on most of the research, green buildings provide improved IAQ and thermal comfort compared to conventional buildings. Regarding lighting performance, a higher inconsistency was observed, with over 50% of the research indicating no difference or poorer performance in green buildings than in conventional structures. Based on the findings, acoustic performance in green buildings was comparable to non-green facilities in most of the reported work. Regarding the design of the building and management of the facility parameters, most papers indicated better performance in green buildings, particularly in furnishing, cleanliness, and operation and maintenance. The contradicting results in the literature review can be attributed to various reasons influencing employee evaluations.

1. The period of employment: If the survey was conducted on a newly constructed green building, or if the employee is newly recruited to the building, a short period after employment, it could manifest artificially higher satisfaction measures. Therefore, the period of employment can bias the evaluation and influence employee satisfaction measures.
2. Socio-economic background: Modifications to employee satisfaction in developed countries might be minimal. However, building design and service standards are relatively low in developing countries. This will lead to considerable improvements in their satisfaction. Therefore, the socio-economic background of the nations must also be considered when evaluating the parameters.
3. Green building features vary from building to building. This could be another contributing factor to the inconsistent results in satisfaction observed in the literature.
4. The sample size and characteristics will also affect the findings. If the number of respondents in green and non-green buildings is disproportionate, this asymmetry might lead to biases when comparing their responses. Therefore, the effect of sample size must be given due consideration.

The building owner or facility management can control the building-related factors and hence can be appropriately monitored and measured in a decision-making model. The literature review of employee satisfaction in green buildings verifies that building owners/employers should have a method to understand the implications to enhance employees' satisfaction. The study proves that many models have been considered in the energy efficiency aspect but receive more secondary consideration in the visual comfort and acoustic comfort aspects. This paper demonstrates that the factors affecting an employee-oriented environment are not unbiasedly evaluated, and there is a necessity emerging to draw researchers' attention to enhancing employee comfort in office green buildings. The two selected decision-making methods can be incorporated to create an integrated decision-making model. The AHP was chosen considering the frequency

doi.org/10.32388/70OGM8.5

of publications under all selected keywords. However, the DEA method has also been prominently used for decision making, specifically for energy efficiency aspects. It is recommended to conduct a proper demographic and social study of employees before creating a decision-making model to ensure fewer model errors are affected by non-building-related factors. It is well illustrated that developing countries moving forward to modified green building approaches to achieve the future of sustainable buildings and creating fewer complex models, as suggested, can encourage other developing countries, especially in the Asian region, to apply the measures to enhance the employee environment. This study opens up the reviewed path for future researchers to identify the most cited decision-making model methods in various green building aspects and provides an opportunity to apply them in the real world according to the chosen parameter. Also, it revealed the research gaps in essential factors related to employee satisfaction/comfort, which should be addressed immediately to achieve the user-industry-environment friendly concept.

Acknowledgement

The authors would like to acknowledge the support from the European Union Erasmus+ program for Capacity Building in the field of Higher Education for financing the project activities. The content of this research paper is related to the BECK Project and reflects only the author's view. The National Agency and the Commission are not responsible for any use that may be made of the information it contains.

References

- Alanne, K. (2021). A novel performance indicator for the assessment of the learning ability of smart buildings. Sustainable Cities and Society, 72, https://doi.org/103054
- Abbaszadeh, S., L. Zagreus, D. Lehrer, and C. Huizenga. 2006. Occupant satisfaction with indoor environmental quality in green buildings. Proceedings, Healthy Buildings 2006, 3, 365-370, Lisbon, Portugal. June. http://escholarship.org/uc/item/9rf7p4bs
- Adalberth, K., Almgren, A. and Petersen, E.H. (2001) Life Cycle Assessment of Four Multi-Family Buildings. International Journal of Low Energy and Sustainable Buildings, 2, 1-21.
- Agolla, J. E. (2018). Human Capital in the Smart Manufacturing and Industry 4.0 Revolution. Digital Transformation in Smart Manufacturing. https://doi.org/10.5772/intechopen.73575
- Altomonte, S., Saadouni, S. & Schiavon, S. (2016). Occupant satisfaction in LEED and BREEAM-certified office buildings. N Proceedings of the PLEA 2016-36th International Conference on Passive and Low Energy Architecture: Cities, Buildings, People: Towards Regenerative Environments.
- 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
- Angelopoulos, C. M., Filios, G., Nikoletseas, S., Patroumpa, D., Raptis, T. P., & Veroutis, K. (2013). A holistic IPv6 test-bed for smart,green buildings. IEEE International Conference on Communications, 6050–6054. https://doi.org/10.1109/ICC.2013.6655569
- 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
- Bogoviz, A. V., Osipov, V. S., Chistyakova, M. K., & Borisov, M. Y. (2019). Comparative analysis of formation of Industry 4.0 in developed and developing countries. In Industry 4.0: Industrial Revolution of the 21st Century, 155-164. Springer, Cham.
- Brans, J. P., & De Smet, Y. (2016). PROMETHEE methods. In Multiple criteria decision analysis (pp. 187-219). Springer, New York, NY.
- Brown, Z., Cole, R. J., Robinson, J., & Dowlatabadi, H. (2010). Evaluating user experience in green buildings in relation to workplace culture and context. Facilities, 28(3/4), 225–238. https://doi.org/10.1108/02632771011023168
- Chew, M. Y. L., Teo, E. A. L., Shah, K. W., Kumar, V., & Hussein, G. F. (2020). Evaluating the roadmap of 5g technology implementation for smart building and facilities management in singapore. Sustainability (Switzerland), 12(24), 1–26. https://doi.org/10.3390/su122410259
- Clements-Croome, D. (2011). Sustainable intelligent buildings for people: A review. Intelligent Buildings International, 3(2), 67–86. https://doi.org/10.1080/17508975.2011.582313

- Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. International Journal of production economics, 204, 383-394.
- 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
- Darko, A., Zhang, C., & Chan, A. P. C. (2017). Drivers for green building: A review of empirical studies. Habitat International, 60, 34–49. https://doi.org/10.1016/J.HABITATINT.2016.12.007
- Ejsmont K. The Impact of Industry 4.0 on Employees—Insights from Australia. Sustainability. 2021; 13(6):3095. https://doi.org/10.3390/su13063095
- Esfandiari, M., Zaid, S. M., Ismail, M. A., & Aflaki, A. (2017). Influence of indoor environmental quality on work productivity in green office buildings: A review. Chemical Engineering Transactions, 56, 385–390. https://doi.org/10.3303/CET1756065
- Fan, Y., Chen, J., Shirkey, G., John, R., Wu, S. R., Park, H., & Shao, C. (2016). Applications of structural equation modeling (SEM) in ecological studies: an updated review. Ecological Processes. https://doi.org/10.1186/s13717-016-0063-3
- Färe, R., Grosskopf, S., & Li, S. K. (1992). Linear programming models for firm and industry performance. The Scandinavian Journal of Economics, 94(4), 599-608.
- Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. International Journal of Production Economics, 210, 15-26.
- Fu, Y., Wang, H., Sun, W., & Zhang, X. (2021). New dimension to green buildings: Turning green into occupant well-being. Buildings, 11(11), 1–17. https://doi.org/10.3390/buildings11110534
- Geng, Y., Ji, W., Wang, Z., Lin, B., & Zhu, Y. (2019). A review of operating performance in green buildings: Energy use, indoor environmental quality and occupant satisfaction. Energy and Buildings, 183, 500–514. https://doi.org/10.1016/J.ENBUILD.2018.11.017
- Gluszak, M., Gawlik, R., & Zieba, M. (2019). Smart and green buildings features in the decision-making hierarchy of office space tenants: An analytic hierarchy process study. Administrative Sciences, 9(3), 52.
- Gou, Z., Lau, S. S.-Y., & Shen, J. (2012). Indoor Environmental Satisfaction in Two LEED Offices and its Implications in Green Interior Design. Indoor and Built Environment, 21(4), 503–514. https://doi.org/10.1177/1420326X11418700
- Gou, Z., Lau, S. S.-Y., & Zhang, Z. (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., & Lau, S. S.-Y. (2014). Impacts of green certifications, ventilation and office types on occupant satisfaction with indoor environmental quality. Architectural Science Review, 57(3), 196–206. https://doi.org/10.1080/00038628.2014.908113
- Gou, Z., & Xie, X. (2017). Evolving green building: triple bottom line or regenerative design? Journal of Cleaner Production, 153, 600–607. https://doi.org/10.1016/j.jclepro.2016.02.077
- Greco, S., Figueira, J., & Ehrgott, M. (2016). Multiple criteria decision analysis (Vol. 37). New York: springer.
- Greene, R., Devillers, R., Luther, J. E., & Eddy, B. G. (2011). GIS- based multiple- criteria decision analysis. Geography compass, 5(6), 412-432.
- Hanafi, M., Ong, A., & Mara, U. T. (2010). Quantitative Data Analysis: Choosing Between SPSS, PLS and AMOS in Social Science Research. International Interdisciplinary Journal of Scientific Research, 14–25.
- He, B. jie, Yang, L., Ye, M., Mou, B., & Zhou, Y. (2014). Overview of rural building energy efficiency in China. Energy Policy, 69, 385–396. https://doi.org/10.1016/J.ENPOL.2014.03.018
- Howe, J. C. (2011). Overview of green buildings. Envtl. L. Rep. News & Analysis, 41, 10043.
- Huang, I. B., Keisler, J., & Linkov, I. (2011). Multi-criteria decision analysis in environmental sciences: Ten years of applications and trends. Science of the total environment, 409(19), 3578-3594.
- Huizenga, C., Zagreus, L., Abbaszadeh, S., Lehrer, D., Goins, J., & Hoe, L. (2005). LEED post-occupancy evaluation: Taking responsibility for the occupants. Proceedings of GreenBuild.
- Issa, M. H., Rankin, J. H., Attalla, M., & Christian, A. J. (2011). Absenteeism, Performance and Occupant Satisfaction with the Indoor Environment of Green Toronto Schools. Indoor and Built Environment, 20(5), 511–523. https://doi.org/10.1177/1420326X11409114
- Jadhav, N. Y. (2016). Green and Smart Buildings: Advanced Technology Options. Springer Nature. https://doi.org/10.1007/978-981-10-1002-6_1
- Juan, Y. K., Gao, P., & Wang, J. (2010). A hybrid decision support system for sustainable office

building renovation and energy performance improvement. Energy and Buildings, 42(3), 290–297. https://doi.org/10.1016/j.enbuild.2009.09.006

- Khoshbakht, M., Gou, Z., Xie, X., He, B., & Darko, A. (2018). Green building occupant satisfaction: Evidence from the Australian higher education sector. Sustainability (Switzerland), 10(8), 1–21. https://doi.org/10.3390/su10082890
- Kim, S.-K., Hwang, Y., Lee, Y. S., & Corser, W. (2015). Occupant Comfort and Satisfaction in Green Healthcare Environments: A Survey Study Focusing on Healthcare Staff. Journal of Sustainable Development, 8(1). https://doi.org/10.5539/jsd.v8n1p156
- Kumar, V., Vrat, P., & Shankar, R. (2021). Prioritization of strategies to overcome the barriers in Industry 4.0: a hybrid MCDM approach. Opsearch, 58(3), 711-750.
- Krawczynski, M., Czyzewski, P., & Bocian, K. (2016). Reindustrialization: A challenge to the economy in the first quarter of the twentyfirst century. Foundations of Management, 8(1), 107.
- Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. Business & information systems engineering, 6(4), 239-242.
- 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
- Leaman, A., Thomas, L., & Vandenberg, M. (2007). Green Buildings: What Australian Building Users are saying. EcoLibrium., (January 2007).
- Lee, Y. S., & Kim, S.-K. (2008). Indoor Environmental Quality in LEED-Certified Buildings in the U.S. Journal of Asian Architecture and Building Engineering, 7(2), 293–300. https://doi.org/10.3130/jaabe.7.293
- Liang, H.-H., Chen, C.-P., Hwang, R.-L., Shih, W.-M., Lo, S.-C., & Liao, H.-Y. (2014). Satisfaction of occupants toward indoor environment quality of certified green office buildings in Taiwan. Building and Environment, 72, 232–242. https://doi.org/10.1016/j.buildenv.2013.11.007
- Lin, B., Liu, Y., Wang, Z., Pei, Z., & Davies, M. (2016). Measured energy use and indoor environment quality in green office buildings in China. Energy and Buildings, 129, 9–18. https://doi.org/10.1016/j.enbuild.2016.07.057
- 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
- Medić, N., Anišić, Z., Lalić, B., Marjanović, U., & Brezocnik, M. (2019). Hybrid fuzzy multi-attribute decision making model for evaluation of advanced digital technologies in manufacturing: Industry 4.0 perspective. Advances in Production Engineering & Management, 14(4), 483-493.
- Menadue, V., Soebarto, V., & Williamson, T. (2014). Perceived and 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
- Mofidi, F., & Akbari, H. (2020). Intelligent buildings: An overview. Energy and Buildings, 223, 110192.
- Newsham, G. R., Birt, B. J., Arsenault, C., Thompson, A. J. L., Veitch, J. A., Mancini, S., Galasiu, A. D., Gover, B. N., Macdonald, I. A., & Burns, G. J. (2013). Do ‘green’ buildings have better indoor environments? New evidence. Building Research & Information, 41(4), 415–434. https://doi.org/10.1080/09613218.2013.789951
- Nkini, S., Nuyts, E., Kassenga, G., Swai, O., & Verbeeck, G. (2022). Evaluation of occupants’ satisfaction in green and non-green office buildings in Dar es Salaam-Tanzania. Building and Environment, 219, 109169. https://doi.org/10.1016/J.BUILDENV.2022.109169
- 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
- Raj, A., Dwivedi, G., Sharma, A., de Sousa Jabbour, A. B. L., & Rajak, S. (2020). Barriers to the adoption of Industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. International Journal of Production Economics, 224, 107546.
- Rameshwar, R., Solanki, A., Nayyar, A., & Mahapatra, B. (2020). Green and smart buildings: A key to sustainable global solutions. In Green Building Management and Smart Automation (pp. 146-163). IGI Global.
- Ravindu, S., Rameezdeen, R., Zuo, J., Zhou, Z., & Chandratilake, R. (2015). Indoor environment quality of green buildings: Case study of an LEED platinum certified factory in a warm humid tropical climate.

Building and Environment, 84, 105–113. https://doi.org/10.1016/j.buildenv.2014.11.001
- Roderick, Y.., McEwan, D.., Wheatley, C.., & Alonso, C. (2009). Comparison of energy performance assessment between LEED, BREEAM and Green Star. In Proceedings of the Eleventh International IBPSA Conference, 27–30.
- Roodt, J. H., & Koen, H. (2020, July). A review of hurdles to adopting Industry 4.0 in developing countries. In INCOSE International Symposium (Vol. 30, No. 1, pp. 1079-1092).
- Rosin, F., Forget, P., Lamouri, S., & Pellerin, R. (2020, June). Industry 4.0 and Decision Making. In International Joint Conference on Mechanics, Design Engineering & Advanced Manufacturing (pp. 400-405). Springer, Cham.
- Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International journal of services sciences, 1(1), 83-98.
- Safiullin, A., Krasnyuk, L., & Kapelyuk, Z. (2019). Integration of Industry 4.0 technologies for "smart cities" development. IOP Conference Series: Materials Science and Engineering, 497(1), 0–8. https://doi.org/10.1088/1757-899X/497/1/012089
- Sansana, J., Joswiak, M. N., Castillo, I., Wang, Z., Rendall, R., Chiang, L. H., & Reis, M. S. (2021). Recent trends on hybrid modeling for Industry 4.0. Computers & Chemical Engineering, 151, 107365
- Salosin, A., Gamayunova, O., & Mottaeva, A. (2020). The effectiveness of the Smart Office system. Journal of Physics: Conference Series, 1614(1). https://doi.org/10.1088/1742-6596/1614/1/012028
- Sediso, B. G., & Lee, M. S. (2016). Indoor environmental quality in Korean green building certification criteria—certified office buildings—occupant satisfaction and performance. Science and Technology for the Built Environment, 22(5), 606–618. https://doi.org/10.1080/23744731.2016.1176849
- Singh, A., Syal, M., Grady, S. C., & Korkmaz, S. (2010). Effects of green buildings on employee health and productivity. American Journal of Public Health, 100(9), 1665–1668. https://doi.org/10.2105/AJPH.2009.180687
- S-Mohamadali, N. A. K., & Garibaldi, J. M. (2012). Including explicitly the question of "which" in evaluation studies. 2012 - Proceedings of the International Conference on Health Informatics, 341–344. https://doi.org/10.5220/0003706503410344
- Sousa, A. C., Bertachini, A. F., Cunha, C., Chaves, R., & Varela, M. L. R. (2021). Literature review and discussion on collaborative decision-making approaches in Industry 4.0. FME Transactions, 49(4), 817-826.
- Terziyan, V., Gryshko, S., & Golovianko, M. (2018). Patented intelligence: Cloning human decision models for Industry 4.0. Journal of manufacturing systems, 48, 204-217.
- Turner, C. (2006). LEED building performance in the Cascadia region: a post occupancy evaluation report.
- Tong, L. I., Chen, C. C., & Wang, C. H. (2007). Optimization of multi-response processes using the VIKOR method. The International Journal of Advanced Manufacturing Technology, 31(11), 1049-1057.
- Wong, J. K., Li, H., & Wang, S. W. (2005). Intelligent building research: a review. Automation in construction, 14(1), 143-159.
- Wu, P., Fang, Z., Luo, H., Zheng, Z., Zhu, K., Yang, Y., & Zhou, X. (2021). Comparative analysis of indoor air quality in green office buildings of varying star levels based on the grey method. Building and Environment, 195(November 2020), 107690. https://doi.org/10.1016/j.buildenv.2021.107690
- Yang, B., Lv, Z., & Wang, F. (2022). Digital Twins for Intelligent Green Buildings.
- Yang, J. B., & Peng, S. C. (2008). Development of a customer satisfaction evaluation model for construction project management. Building and Environment, 43(4), 458-468.
- Yang, X., Peng, L. L. H., Jiang, Z., Chen, Y., Yao, L., He, Y., & Xu, T. (2020). Impact of urban heat island on energy demand in buildings: Local climate zones in Nanjing. Applied Energy, 260(30), 114279.
- Van Dick, R., Christ, O., Stellmacher, J., Wagner, U., Ahlswede, O., Grubba, C., Hauptmeier, M., Hohfeld, C., Moltzen, K., & Tissington, P. A. (2004). Should I Stay or Should I Go? Explaining Turnover Intentions with Organizational Identification and Job Satisfaction. British Journal of Management, 15(4), 351–360. https://doi.org/10.1111/j.1467-8551.2004.00424.x
- Veitch, J. A., Charles, K. E., Farley, K. M. J., & Newsham, G. R. (2007). A model of satisfaction with open-plan office conditions: COPE field findings. Journal of Environmental Psychology, 27(3), 177–189. https://doi.org/10.1016/j.jenvp.2007.04.002
- Zhang, Y., & Altan, H. (2011). A comparison of the occupant comfort in a conventional high-rise office block and a contemporary environmentally-concerned building. Building and Environment, 46(2), 535–545. https://doi.org/10.1016/j.buildenv.2010.09.001
- Zhao, D. X., He, B. J., Johnson, C., & Mou, B. (2015). Social problems of green buildings: From the humanistic needs to social acceptance. Renewable and Sustainable Energy Reviews, 51, 1594–1609. https://doi.org/10.1016/J.RSER.2015.07.072

- Zuo, J., & Zhao, Z. Y. (2014). Green building research–current status and future agenda: A review. Renewable and sustainable energy reviews, 30, 271-281

Declarations

Funding: The authors would like to acknowledge the support from the European Union Erasmus+ program for Capacity Building in the field of Higher Education for financing the project activities. The content of this research paper is related to the BECK Project and reflects only the author's view. The National Agency and the Commission are not responsible for any use that may be made of the information it contains.

Potential competing interests: No potential competing interests to declare.