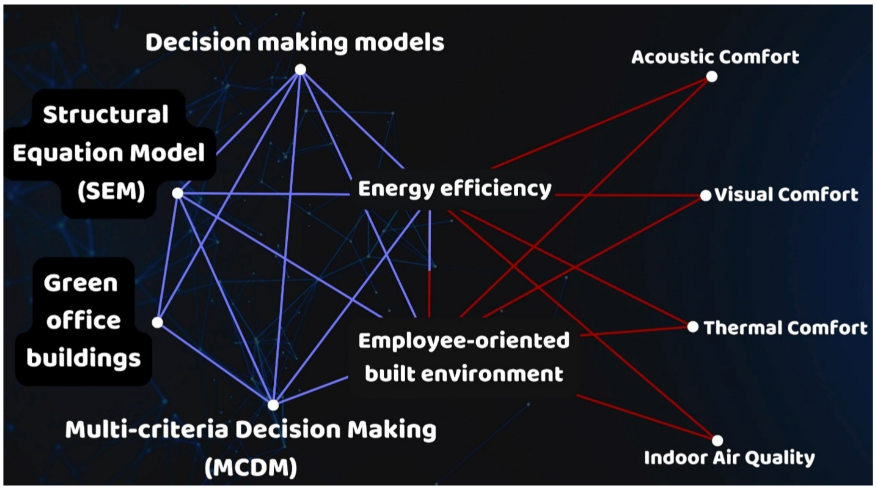
Open Peer Review on Qeios



[Review] Integrated decision-making model to enhance the employee-oriented built environment in urban green buildings

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

1 University of Moratuwa
2 Vilnius Gediminas Technical University
3 Kotelawala Defence University

Funding: No specific funding was received for this work.
Potential competing interests: No potential competing interests to declare.

Abstract

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 the workspaces. This paper thrives on aiming at the initiation of developing an employee-oriented built environment in urban office green 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 driven for 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 lesser complex hybrid decision-making model to create an improved employee-friendly built environment.

Wasudha Prabodhani Abeyrathna[1], **G.K.P. John**[2], **Rohantha Rukshan**[1], **R.I.S Ariyarathna**[1], **Manuja Promodya Hendawitharana**[1], **R.U Halwaturaa**[1], **Arturas Kaklauskas**[3], **F.R Arooz**[4], **A.S Perera**[5]

[1] *Departmet of Civil Engineering, University of Moratuwa, Katubedda Moratuwa, 10400*

[2] *Departmet of Civil Engineering Technology, Institute of Technology, University of Moratuwa, Bandaranayake Mawatha, Katubedda, Sri Lanka*

[3] *Department of Construction Management and Real Estate, Vilnius Gediminas Technical University, Vilnius, Lithuania*

[4] *Department of Architecture, General Sir John Kothelawala Defense University, Sri Lanka*

[5] *Department of Computer Science and Engineering, Faculty of Engineering, University of Moratuwa, Katubedda, Sri Lanka*

Keywords: Employee satisfaction; Green office buildings; MCDA; SEM; Urban built environment.

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 environment 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 a higher operational cost, 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 the 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 than 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 the 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 comes concepts like ‘Industry 4.0’, ‘smart manufacturing’, and ‘intelligent buildings’, which integrate the 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 updated with the technologies of the world. This integration of the green building construction and the intelligent building industry is essential in verifications and controls over the building management and the smooth process, which result in less maintenance due to the real-time monitoring of the building (B. Yang et al., 2022).

The literature availability is abundant on employee oriented decision makin models in buildings, the proper definition of the terminology is questionable as much of the early reports were critcriticized for focusing exclusively on the technological component but not the user and building interactions (Mofidi and Akbari, 2020, Wong and Wang, 2005). Conversely, recent approacheshess 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 decision-making tecnologies in developing countries (Krawczynski et al., 2016). Hence the theory ‘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 amongst the developed countries; thus, achieving sustainable goals in developing countries should consider alternative approaches.

In third-world developing countries, achieving decision-making technologies 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 ‘Employee oriented built-environment”, where the integration of green buildings and the clever grid concept has been well discussed in previous literature (Adalberth et al., 2001; Jadhav, 2016; Rameshwar et al., 2020).

Despite the number of prior research on the occupancy evaluation in green buildings and many decision-making models 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 to the 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 driven in systematic literature review and bibliographic analysis to perform three main approaches as (i) Identify main factors and existing decision-making models (ii) Bibliographic analysis and thematic mapping (2000-2022) (iii) 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 what decision models have been applied more in building-related applications and the topics related to occupant satisfaction and in which they have been used. 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 I describes the methodology of the study.

The importance of enhancing an employee-oriented built environment in green buildings

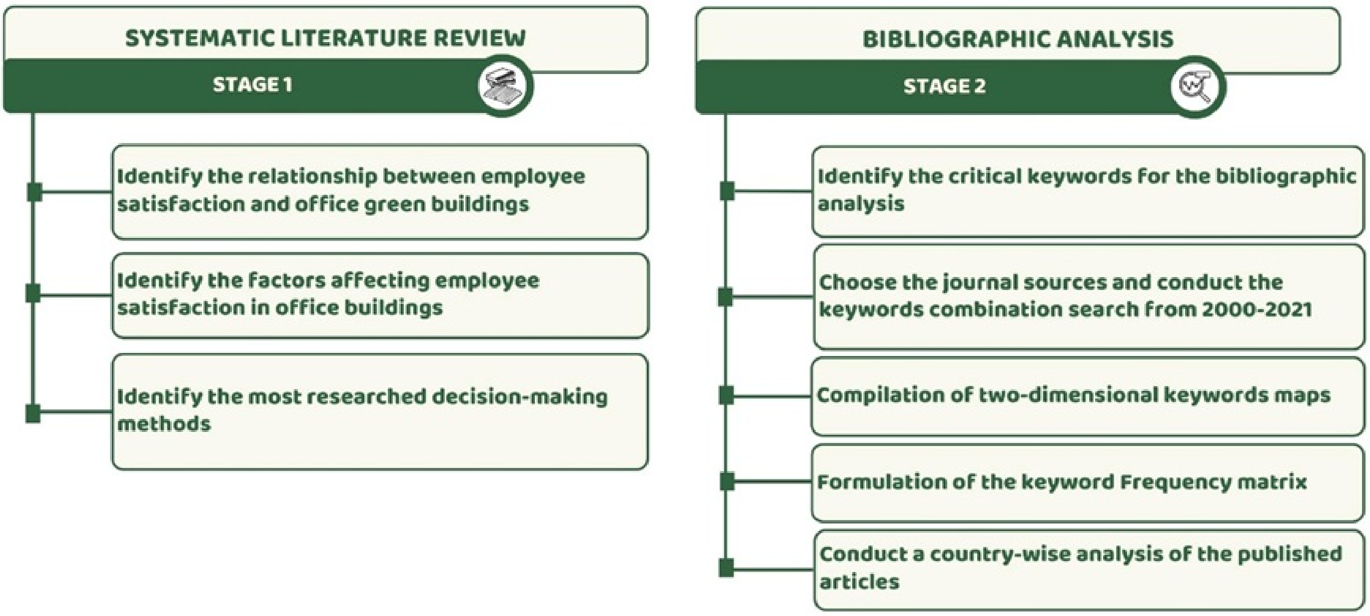


Figure I

Office buildings are one of the building commercial building sectors which need the most excellent attention in providing a well-managed work environment for the 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 the 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 improving 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' healthy, comfortable and efficient environment is paramount. These result in lower absenteeism, higher productivity, and improved mental and physical health of the employees (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 resources efficiently 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 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). 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). The review of global evidence depicts a contradictory body of knowledge regarding the impact of green buildings on occupant satisfaction.

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 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 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 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 were 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 a 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), 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 a lower perceived thermal comfort in green buildings.

According to Singh et al. (2010), the "honeymoon" effect,, a short period after occupancy can be impacted when rating the experience of the building. The occupant satisfaction studies considered in Table I have been conducted in various countries of different socio-economic backgrounds. In developed countries like 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 the building design and operation (He et al., 2014; Zhao et al., 2015).

As reflected in literature, Building Design and Facilities Management (BD&FM) of green buildings are perceived to be better than conventional buildings. Studies were 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 a 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 I.

The review of global evidence in Table I 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 which can help the decision-makers to evaluate employee satisfaction and implement the necessary adjustments.

	IAQ	Lighting	Acoustics	Thermal Comfort	Layout	Furnishings	Privacy	Cleanliness	Operation & Maintenance	Workspace	Colours and textures
(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 I. Review of Previous Research on Green Buildings and employee comfort

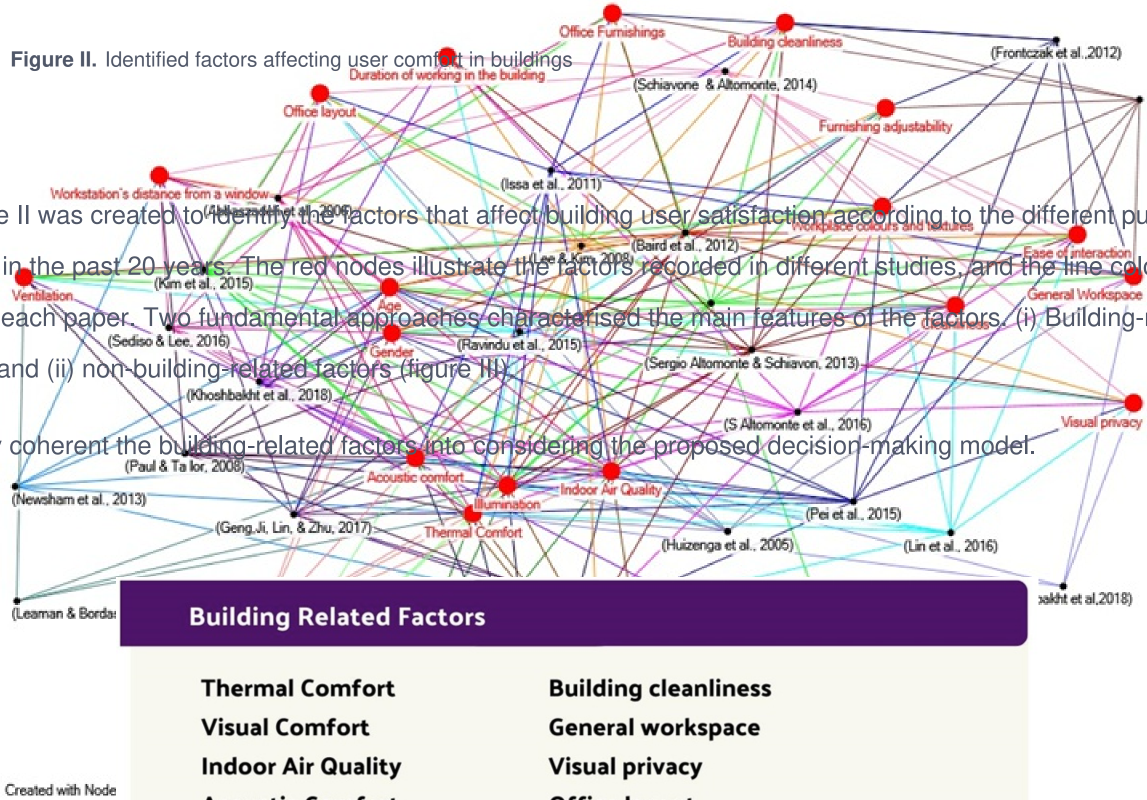


Figure II. Identified factors affecting user comfort in buildings

The Figure II was created to identify the factors that affect building user satisfaction according to the different publications published in the past 20 years. 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 III).

This study coherent the building-related factors into considering the proposed decision-making model.

Building Related Factors

Thermal Comfort	Building cleanliness
Visual Comfort	General workspace
Indoor Air Quality	Visual privacy
Acoustic Comfort	Office layout
Illumination	Ventilation
Furnishing adjustability	Workstation's distance from a window
Ease of interaction	Workspace colours and textures

Non-building Related Factors

Gender	Mood
Age	Office Furnishing
Job category	Duration of working in the building

Figure III. Identified factors affecting to 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 the 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 for 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).

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 exists 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 in, 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 technology 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

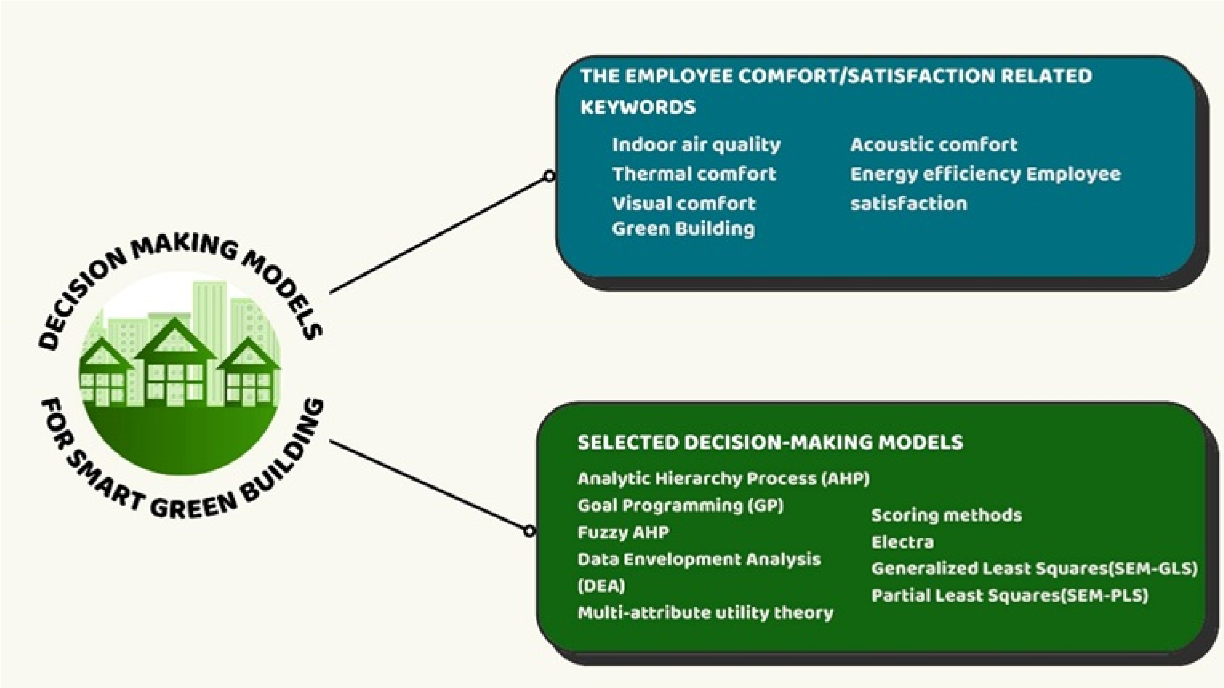


Figure IV. Selected Keywords for the Study

The keywords were chosen from green building-related employee comfort factors (figure IV), 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 distributed 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. The AHP and DEA have been practised prominently among the MCDA methods, and the PLS-SEM method was prominently used among SEM methods.

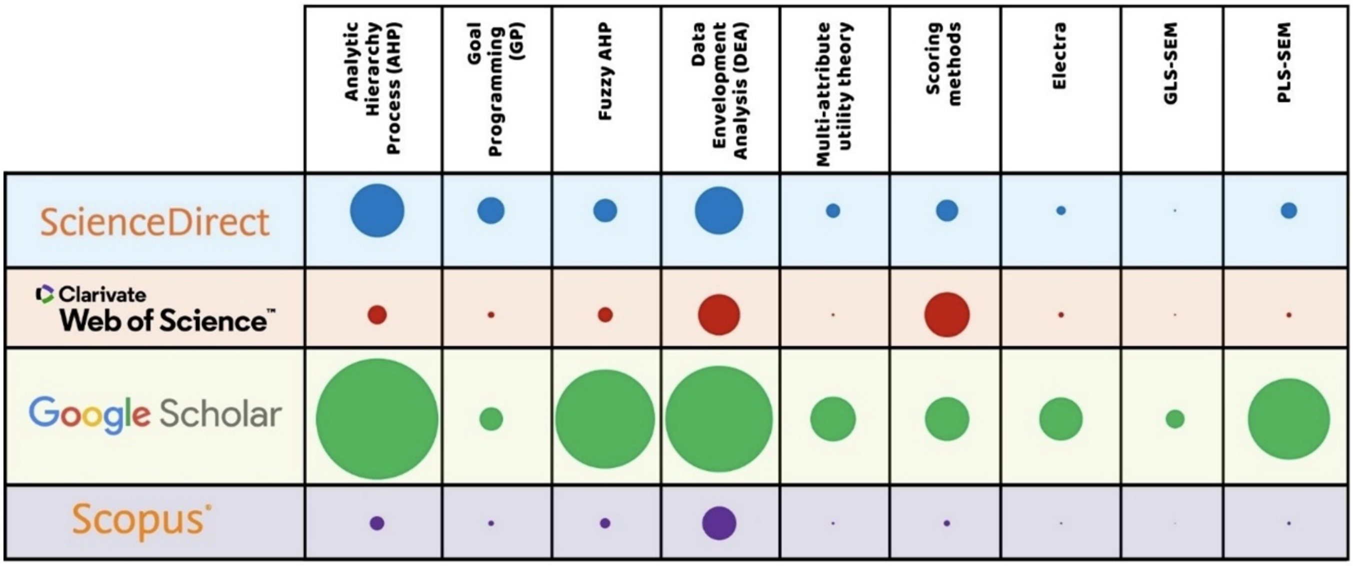


Figure V. 2-D map to illustrate the number of publications in journal sources from 2000-2021 for MCDA and SEM methods used in keywords related to building factors and study-focused keywords.

A two-dimensional keyword distributed 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 VI). 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 matrixes were prepared for the keywords to reflect the number of articles published in the past 21 years in Google Scholar.

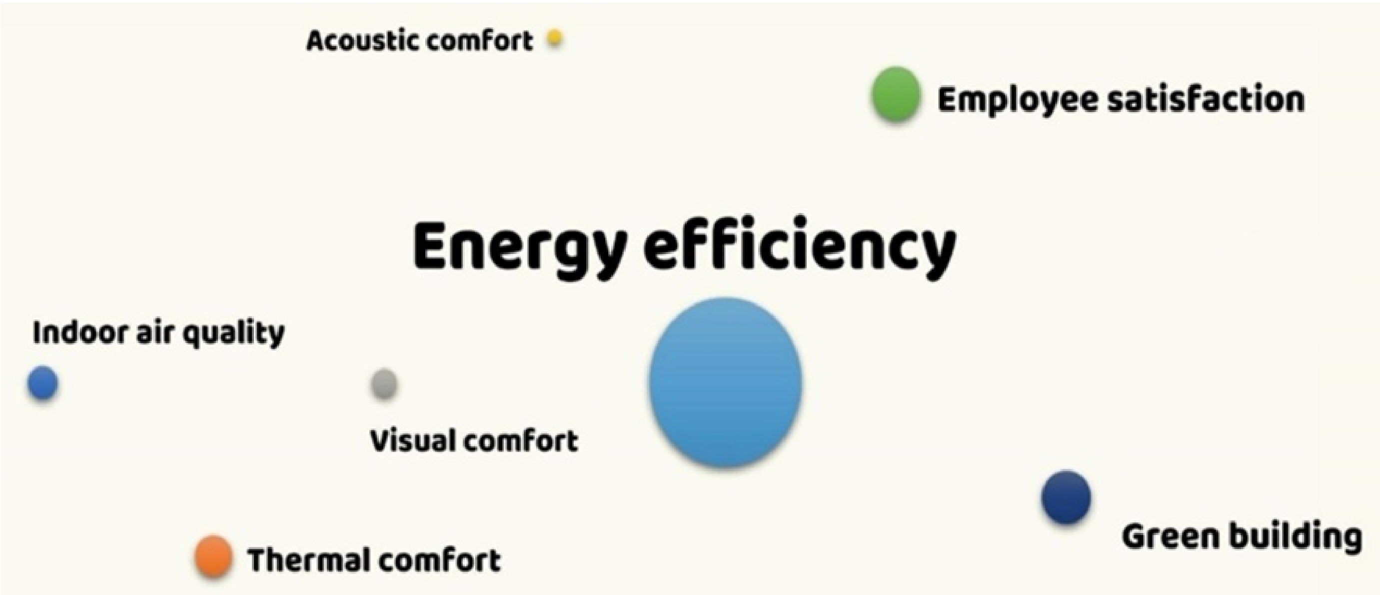


Figure VI. 2-D: number of papers published decision-making models for selected “Employee comfort-related keywords"

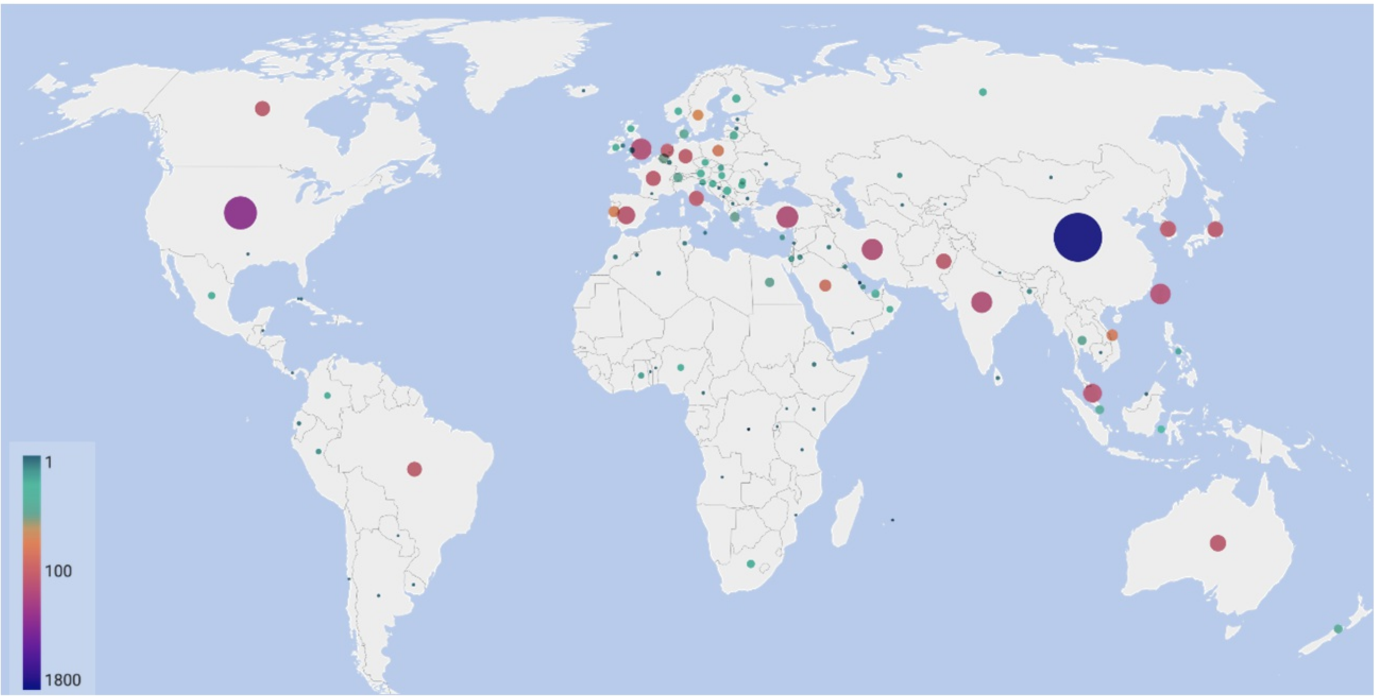


Figure VII. Number of publications according to the country

Country-wise keyword analysis has been conducted to understand the contribution to the study-related research keywords (see figure VII). The map depicts that developed countries like China, the USA, Japan, and South Korea contributed to the decision-making models and employee-related studies prominently than the other countries. Developing countries such as India, Taiwan, Turkey and Iran have paid a progressive contribution, and there are fewer publications in Asian Region. This proves that the decision-making models to enhance employee comfort is yet to be researched deeply in the 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 II depicts the total publications from 2000-2021 of selected decision-making models with the employee comfort-related keywords.

The table II explain the number of publications were done under selected keywords. AHP method records most of the publications under all the relevant keywords in all the journal sources besides 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.

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

ScienceDirect	IAQ	Thermal comfort	Visual comfort	Acoustic comfort	Energy efficiency	Employee satisfaction	Green building

		comfort	comfort	comfort	efficiency	satisfaction	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

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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

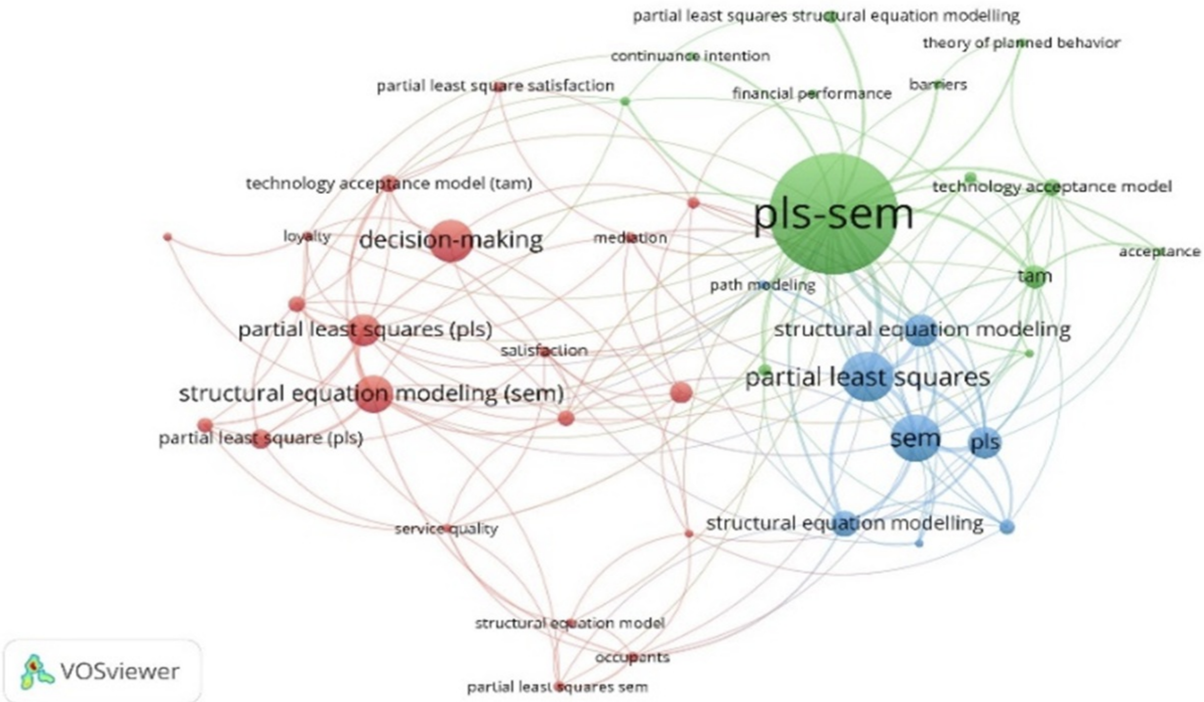


Figure VIII. Co-occurrence network map of PLS-SEM

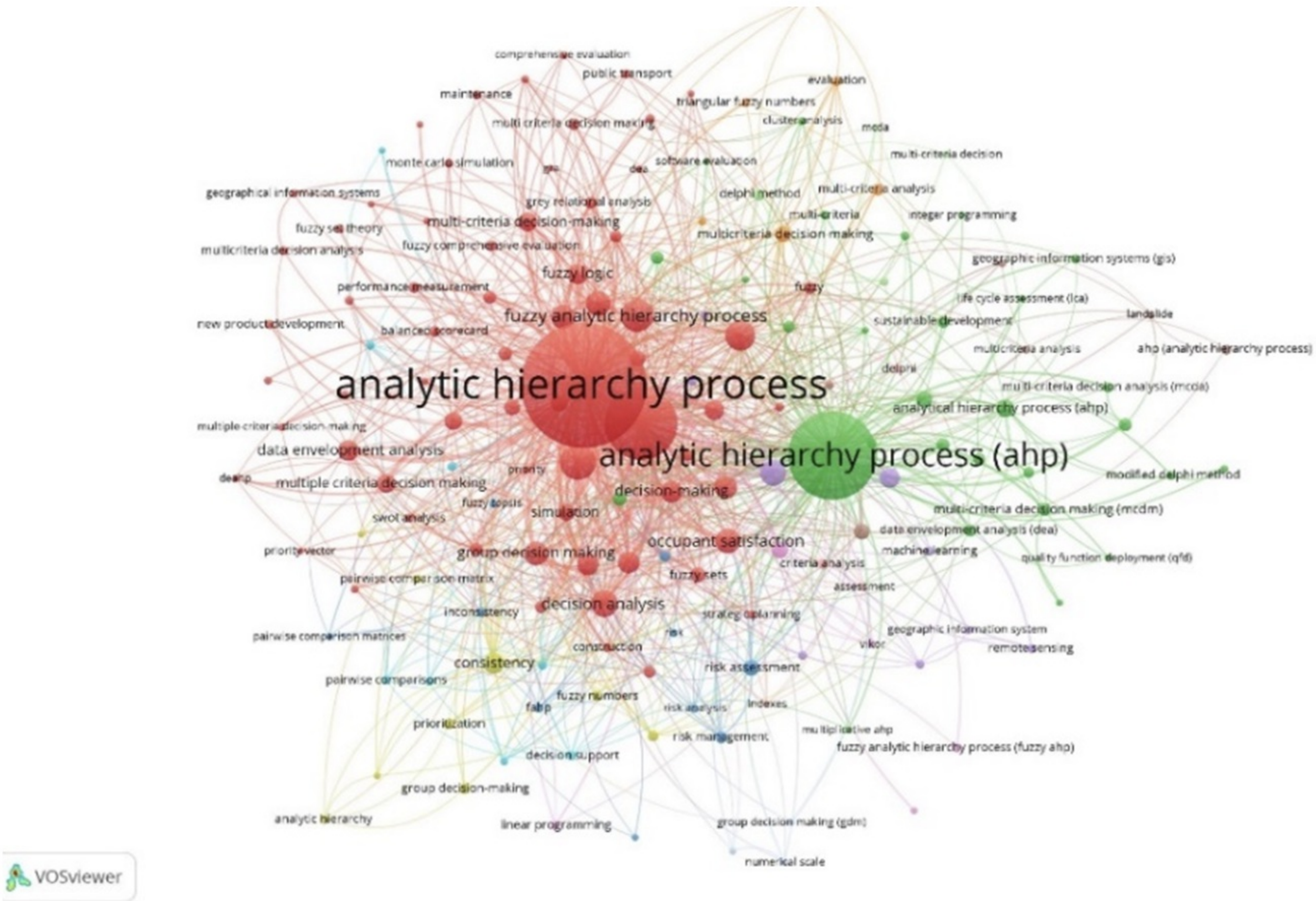


Figure IX. Co-occurrence network map of AHP

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 keyword with the AHP and PLS-SEM decision-making methods to create the hybrid model. Network maps (figure VIII,IX) were organised to illustrate the correlation between the cited keywords, AHP, and PLS-SEM.

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

Conclusion

A literature review into employee-oriented environment in green-certified buildings discloses a contrary body of research. As clearly depicted in Table 2, 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 conventional structures. Based on the findings, acoustic performance in green buildings was comparable with non-green facilities in most of the reported work. Regarding the design of the building and management of the facility parameters, most papers indicated a 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 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-sized 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 satisfaction of the employees in green buildings verifies that the building owners/employers should have a method to understand the implications to enhance the employees' satisfaction. The study proves that many models have been considered in the energy efficiency aspect but more secondary consideration in the visual comfort and acoustic comfort aspects. This paper demonstrates that the factors affecting 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 a integrated decision-making model. The AHP was chosen considering the frequency of publications under the all-selected keywords. But DEA method has also been prominently used for decision making specifically for energy efficiency aspects. It is recommended to do 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 the developing countries moving forward to modified green building approaches to achieve for the future of the sustainable buildings and creating fewer complex models as suggested can encourage the 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 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*, 103054.
- Abbaszadeh, S., Zagreus, L., Lehrer, D., & Huizenga, C. (2006). Occupant satisfaction with indoor environmental quality in green buildings. *Healthy Buildings Conference*.
- Adalberth, K., Almgren, A., & Petersen, E. H. (2001). Life cycle assessment of four multi-family buildings.*International Journal of Low Energy and Sustainable Buildings*, *2*.
- Agolla, J. E. (n.d.). We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists, for scientists TOP 1 %.
- 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*(pp. 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/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. (2021). *The Impact of Industry 4 . 0 on Employees — Insights from Australia*
- 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
- 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.
- 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 users are saying. *EcoLibrium(R)*.
- 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
- 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. *HEALTHINF*
- *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