

A MEASUREMENT MODEL OF OCCUPANT WELL-BEING FOR  
MALAYSIAN OFFICE BUILDING

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A MEASUREMENT MODEL OF OCCUPANT WELL-BEING FOR  
MALAYSIAN OFFICE BUILDING

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## **DEDICATION**

For my beloved father and mother

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## ABSTRACT

There has been a shift in the direction of scientific research related to the energy and environmental performance of buildings towards a focus on occupant well-being, as a majority of the population spend most of their time indoors. The Indoor environment within a building has been identified as a major factor influencing occupant well-being because inadequate indoor conditions in buildings could create risks such as adverse health effects, productivity loss and higher rates of absenteeism. Assessing occupant well-being in office buildings has become a growing concern in facilities management practice as occupants represent the highest percentage of operational costs. However, the effects of indoor environment in office buildings can be difficult to quantify due to the wide range of influencing parameters. Globally, multiple tools have been developed to assess the performance of buildings but the existing assessment tools have not comprehensively assessed occupant well-being as a whole by capturing all essential criteria and parameters that are highly related to occupant well-being particularly in the context of office buildings. Therefore, to overcome this issue, this research was aimed to develop a measurement model to assess the performance of indoor environment in the office building on occupant well-being. The three objectives of this research are firstly, to identify the criteria of occupant well-being and associated indoor environment parameters in office buildings. Secondly, to verify the criteria of occupant well-being and associated indoor environment parameters for Malaysian office buildings; and thirdly, to develop a measurement model of occupant well-being for Malaysian office buildings. The first objective was achieved through the synthesis of theories, models and concepts in the literature review. The second was achieved through a semi-structured interview with experts; while the third was achieved using a questionnaire survey involving sixty-five experts in Malaysia through purposive sampling technique. Data were analysed for the second and third objectives using thematic analysis and Analytic Hierarchy Process (AHP) analysis. A measurement model of occupant well-being for Malaysian office buildings was developed in this research. A total of fifteen parameters were identified which were classified into four criteria; occupant comfort, occupant health, occupant adaptation and occupant safety. AHP analysis found that occupants' health scored the highest priority in computing the measurement model of occupant well-being for Malaysian office building. This study has made a methodological contribution by developing a novel approach to assess occupants' well-being in Malaysian office buildings, which is useful to help facility managers in prioritising resources and making decisions to improve occupants' well-being in office buildings.

## ABSTRAK

Terdapat anjakan ke arah penyelidikan saintifik yang berkaitan dengan prestasi tenaga dan persekitaran bangunan ke arah tumpuan terhadap kesejahteraan penghuni bangunan kerana sebahagian besar populasi meluahkan lebih banyak masa mereka di dalam bangunan. Persekitaran dalaman bangunan telah dikenal pasti sebagai faktor utama yang mempengaruhi kesejahteraan penghuni bangunan kerana keadaan persekitaran dalaman bangunan yang kurang baik boleh mewujudkan risiko seperti kesan buruk terhadap kesihatan, kehilangan produktiviti dan kadar ketidakhadiran yang lebih tinggi. Menilai kesejahteraan penghuni di bangunan pejabat telah menjadi kebimbangan yang semakin meningkat dalam amalan pengurusan fasiliti kerana penghuni bangunan mewakili peratusan kos operasi yang tinggi. Walau bagaimanapun, kesan persekitaran dalaman bangunan pejabat mungkin sukar untuk diukur disebabkan oleh terdapat pelbagai parameter yang mempengaruhi. Di peringkat antarabangsa, pelbagai instrumen telah dibangunkan untuk menilai prestasi bangunan tetapi instrumen penilaian sedia ada belum menilai secara komprehensif kesejahteraan penghuni bangunan secara keseluruhan dengan mempertimbangkan semua kriteria dan parameter yang penting dan amat berkaitan dengan kesejahteraan penghuni bangunan terutamanya dalam konteks bangunan pejabat. Oleh itu, bagi mengatasi masalah ini, kajian ini bertujuan untuk membangunkan model pengukuran untuk menilai prestasi persekitaran dalaman bangunan di pejabat terhadap kesejahteraan penghuni bangunan. Tiga objektif kajian ini adalah pertama, untuk mengenal pasti kriteria kesejahteraan penghuni bangunan dan parameter persekitaran dalaman yang berkaitan dalam bangunan pejabat. Kedua, untuk mengesahkan kriteria kesejahteraan penghuni bangunan dan parameter persekitaran dalaman yang berkaitan untuk bangunan pejabat di Malaysia; dan ketiga, untuk membangunkan satu model penilaian kesejahteraan penghuni bangunan pejabat di Malaysia. Objektif pertama dicapai melalui sintesis teori, model dan konsep dalam tinjauan kajian penyelidikan. Objektif kedua dicapai melalui temu bual separa berstruktur dengan pakar manakala objektif ketiga dicapai melalui tinjauan soal selidik yang melibatkan enam puluh lima pakar dalam Malaysia melalui teknik persampelan bertujuan. Data dianalisis untuk objektif kedua dan objektif ketiga menggunakan analisis tematik dan analisis proses hierarki (AHP). Model penilaian kesejahteraan penghuni untuk bangunan pejabat di Malaysia telah dibangunkan dalam kajian ini. Sejumlah lima belas parameter telah dikenal pasti dan dikategorikan dalam empat kriteria iaitu keselesaan penghuni bangunan, kesihatan penghuni bangunan, adaptasi penghuni bangunan dan keselamatan penghuni bangunan. Analisis AHP mendapati kesihatan penghuni bangunan mempunyai skor kepentingan yang tinggi dalam membangunkan model penilaian kesejahteraan penghuni bangunan pejabat di Malaysia. Kajian ini telah memberi sumbangan metodologi dengan membangunkan satu pendekatan baru untuk menilai prestasi kesejahteraan penghuni bangunan pejabat di Malaysia yang berguna untuk membantu pengurus fasiliti dalam mengutamakan sumber dan membuat keputusan dengan tujuan untuk meningkatkan kesejahteraan penghuni di bangunan pejabat.

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## LIST OF ABBREVIATIONS

WHO	-	World Health Organization
OECD	-	Organisation for Economic Cooperation and Development
GBI	-	Green Building Index
CASBEE	-	Comprehensive Assessment System for Built Environment Efficiency
BREAM	-	Beaufort Region Environmental Assessment and Monitoring
LEED	-	Leadership in Energy and Environmental Design
POE	-	Post-Occupancy Evaluation
LBC	-	Living Building Challenge
GreenPASS	-	Green Performance Assessment System
GreenRE	-	Green Real Estate
CIDB	-	Construction Industry Development Board
PWD	-	Public Works Department
MyCREST	-	Malaysian Carbon Reduction and Environmental Sustainability Tool
FM	-	Facilities Management
AHP	-	Analytic Hierarchy Process
IFMA	-	International Facilities Management Association
ASHRAE	-	American Society of Heating, Refrigerating and Air-Conditioning Engineers
DOSH	-	Department of Occupational Safety and Health
MS	-	Malaysian Standard
NAPO	-	National Association of Professional Organizer
IAQ	-	Indoor Air Quality
OSHA	-	Occupational Safety and Health Act
ASID	-	American Society of Interior Design
CR	-	Consistency Ratio
CI	-	Consistency Index
RI	-	Random Index
VOC	-	Volatile Organic Compound
SBS	-	Sick Building Syndrome

ICOP - Industrial Code of Practice  
ISO - International Organization for Standardization

## LIST OF SYMBOLS

$\lambda \max$	-	Maximum eigenvalue
$n$	-	Number of parameters
$C$	-	Set of parameters
$a_{ij}$	-	Values of expert judgement
$W$	-	Relative priorities of the parameter
$W'$	-	Eigenvalue of the parameter
$X$	-	Normalized score value
$A$	-	Matrix A
$\leq$	-	Less than and equal to
$Y$	-	Overall score of occupant well-being
$A_1$	-	Normalized pairwise matrix
$^{\circ}\text{C}$	-	Degree celcius
$\text{m}$	-	Meter
$\text{s}$	-	Second
$\text{dB(A)}$	-	A-weighted decibels
$\mu\text{m}$	-	Micrometre
$\text{lux}$	-	Unit of illuminance



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# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Introduction**

This research aims to develop a measurement model of occupant well-being for Malaysian office building. The built environment industry was responsible to ensure indoor environment in building can preserve the well-being of building occupant, mainly because inadequate quality of indoor environment in office building contribute to adverse health effects, poor work performance, higher rates of sick leave and reduced employee productivity. The term of well-being has become a conventional agenda of sustainability, hence a real understanding on how office building can be designed and improved to support human well-being is imperative. The following sections will further detail the research background, problem statement, research questions, research objectives, significance of the research, overview of the research methodology and organization of the thesis chapters.

### **1.2 Research Background**

In 1987, a report named “Our Common Future” was published by the World Commission for the Environment and Development (World Commission on Environment and Development, 1987). In this report, sustainable development was introduced as a development that conforms the demands of the present without compromising the ability to help the future generations to meet their own needs (Imperatives, 1987). The concern of sustainable development was recognized in the United Nations Conference in Rio in 1992 as well as World Summit in 2002. Environmental, social and economic are the three main pillars proposed within the context of sustainable development. Through the years, the concept of sustainable

development is receiving greater attention in world-wide policies including the increasing relevance of building sectors toward sustainable building. The idea of sustainable building emerges from the incorporation of sustainable development concept that offers minimum environmental damage, while supporting improvements in economics and social aspects at local, regional and global context (Organization for Economic Co-operation and Development, 2002).

The sustainability strategy of most buildings is dominated by environmental protection and economic growth, whereas the social dimension was least explicit in attempts to shape sustainable building. Recent researches have shown that social sustainability has not attracted as much attention as environmental and economic sustainability (Zorzini et al., 2015; Yawar and Seuring, 2017; Kusi-Sarpong et al., 2019). It was revealed that the development of sustainable building has been interpreted and evaluated exclusively to the environmental perspective wherein the social and economic aspects are often side-lined (Lazar and Chithra, 2021). Similarly, previous studies on sustainable building have reported a lack of consideration on social aspects (Tomšič and Zavrl, 2018) and unhealthy balance between the three dimensions of sustainability (Komeily and Srinivasan, 2015). For example, the development of sustainable building has for many years been associated with energy performance without fully examining the impacts on occupant well-being such as glare concern caused by large window areas, overheating issue, increased noise level due to unbalanced ventilation system and exposure to poor indoor air due to inadequate ventilation rates (Broderick et al., 2017). Most decisions made during the conceptual design phase of a building are based on the energy performance and economic aspect, while end-user's requirement has been overlooked because there is no standard principle and lack of information about the requirements needed by the building occupant (Heydarian et al., 2017). Even in the context of smart buildings, the needs of building occupants are often ignored (Jia et al., 2019).

Although the environmental impact of building industry is important, the social aspects in sustainable building should not be neglected. Social dimension in the philosophy of sustainable development emphasizes the key features of human life including quality of life, environmental satisfaction, human well-being and health to

the global development agenda (Vallance et al., 2011). A sustainable building has to consider the impact of the building on the occupants as building is designed and constructed to be habitable by humans, hence the requirements of occupancy must be made to ensure the quality of life, prosperity and well-being of its inhabitants (Nimlyat and Kandar, 2015). In the current economic context, the role of building is not only limited to provide a shelter for the people but to preserve the well-being of the occupants (Prowler and Vierra, 2008). This is because majority of people spend about 80% to 90% of their time indoors rather than outdoors (Hulin et al., 2012) and a growing percentage of the population spends about 30% of their time working in office building (Morawska et al., 2017).

Despite frequently quoted exchangeable, well-being and wellness are different (Dodge et al., 2012). Wellness typically refers to human physical health whereas well-being is a multidimensional concept that includes an individual's physical and psychological needs; that can be sub-classified into physical, mental and emotional well-being corresponding to body, mind and spirit (Sunikka-Blank and Galvin, 2012). One of the most essential drivers of occupant well-being in building is the performance of indoor environment (Al Horr et al., 2016). Indoor Environmental Quality (IEQ) is defined as the performance of a building in providing an indoor environment with the qualities that positively affect the health and well-being of the occupant (Liang et al., 2014; Centre for Disease Control and Prevention, 2017). According to Storey and Pedersen (2006), a building's indoor environment influences various aspects of well-being in many ways. For instance, thermal comfort, indoor air quality, light quality, and acoustic comfort correspond to human physical well-being, while other elements such as interior design, opportunities for personal control, and engagement with nature are usually related to intellectual and emotional well-being (Ornetzeder et al., 2016). In addition, several studies have indicated that other parameters such as occupant control over the indoor environment, occupant privacy and workstation layout may also be associated with occupant well-being in office building (Frontczak and Wargocki, 2011; Kim and de Dear, 2013).

Indoor environment is a vital part of building and integral to the occupant well-being. The concept of well-being is particularly important in the context of office buildings, as occupants often seek comfort, health, relaxation, and refreshment in their working space. However, the issue of indoor environment has become a matter of concern in global sustainability as the concentrations of pollutants in the indoor environment is much higher compared to outdoor environment (Riley and Kamaruzzaman, 2016). In spite of the fact that working in a closed environment can protect humans from the unwanted nature exposure, the artificial environment of office building has created new risks to the occupant's well-being, for example, hidden moisture problems that cause mould, insufficient fresh air and the use of particular office equipment such as computers, printers or photocopiers that result in higher concentrations of certain substances in the indoor air compared to other confined spaces (Destailats et al., 2008; Sun et al., 2015).

Many research works have investigated the adverse impacts of indoor environments in office building on occupant well-being. For instance, occupant exposure to inadequate indoor conditions has been associated with adverse health effects, lower work performance, loss in productivity and higher rates of sick absence (Li et al., 2016; Andargie and Azar, 2019; Kaushik et al., 2020). Therefore, , it is becoming more essential to guarantee better condition of indoor environment in office building as occupant well-being have been closely linked to the performance of indoor environment.

Optimizing the indoor environment features is crucial to provide the benefits for the occupant well-being (Fisk, 2000). Several studies have demonstrated that the proper condition of a building's indoor environment leads to improvements in occupant well-being, including healthier occupants, more comfortable physical conditions, greater work efficiency, and lower rates of absenteeism (Li et al., 2016; Andargie and Azar, 2019). Traditionally, generic indoor environment parameters such as thermal, indoor air quality, noise and lighting were often used to measure occupant well-being, making them applicable for several contexts including home, schools and offices. However, with the improvement of working standard, the context-free of occupant well-being measurement in the literatures may not adequately capture other

essential criteria that can potentially contribute to occupant well-being specifically in the office building context. Therefore, the need for a measurement model that is able to assess the occupant well-being in office building is necessary and should be established.

### **1.3 Problem Statement**

In an office setting, the negative impact of poor indoor environment on employees well-being could be strenuous, which could lead to adverse health effects, lower work performance, loss in productivity and higher rates of sick absence (Li et al., 2016; Andargie and Azar, 2019; Kaushik et al., 2020). Prolonged exposure to poor indoor conditions is closely associated with various health complaints which have been described as building-related illnesses, adverse health effects and sick building syndrome symptoms. Researches have indicated that the health effects experienced by occupants are not limited to physical health condition such as headache, irritation of eyes, dry cough, itchy skin, dizziness and respiratory problems but include psychological condition of the occupant such as stress and anxiety (Martellotta et al., 2016; Savenkova et al., 2018). Globally, the World Health Organization (WHO) calculates that nearly 12.6 million people die each year as a result of living or working in unhealthy built environment (WHO, 2017). It has been estimated that 15 to 20 percent of the working population suffers from a chronic disease, with about 5 percent of those suffering from work-related causes (Wynne and McAnaney, 2004). The American Cancer Society reported that long period of sitting in workplaces, especially for more than 6 hours per day, are likely to cause more deaths than other diseases such as diabetes and heart illness (Patel et al., 2010). Studies by World Health Organization in Europe (WHO, 2004), and the BASE-study in United States (Apte, 2000) have found that environmental stressors in office building, for example, poor indoor air quality and inadequate lighting have been linked to negative stress that can cause short-term illness and long-term health problems.

According to a study by Nur Fadilah and Juliana (2012), poor indoor air quality in Malaysian office buildings has increased the risk of sick building syndrome symptoms such as headaches, strained eyes, dizziness, and stuffy noses among employees. This is supported by Yau et al. (2018), who have conducted an IAQ assessment at five office spaces in Malaysia. The study discovered that the relative humidity had exceeded the acceptable limit of 70%. The carbon dioxide concentration has exceeded 1000 ppm, and the formaldehyde has exceeded 0.1 ppm. Similarly, a study by Syazwan et al. (2013) investigated the connection between occupant symptoms and chemical exposure in the indoor environment of 200 office buildings in one of the busiest locations in Malaysia, the Klang Valley. The study found that the presence of formaldehyde and total volatile organic compounds in the office buildings caused severe mucosal and general indoor air symptoms among occupants, for example, headaches, exhaustion, and other neurological illnesses and symptoms. Therefore, improving indoor condition in Malaysian office buildings is critical to reducing symptoms that can lead to chronic health impacts among building occupants.

In addition to adverse health effects, the existing literature shows that insufficient or poor indoor environment in office building is associated with increased absenteeism and sick leave which has a further negative impact on occupant well-being (Mendell et al., 2015). Absenteeism is a serious problem that affects many sectors in the economy which arises from various issues. A growing body of research indicates that the issue of absenteeism is most obviously associated with health-related problems (Frick et al., 2013; Kocak et al., 2018). However, other studies have linked absenteeism problems to long working hours, job dissatisfaction and lack of motivation (Herrmann and Rockoff, 2012). Besides that, many research works have investigated the impact of poor indoor environment of occupant well-being with a measure of employees' rate of absenteeism. For example, a study by Soriano et al. (2018) indicated that the prevalence of inadequate indoor environment contributes to greater rate of absenteeism among employees. Finell and Nätti (2020) also found that workers who reported mould and dampness in their office indoor environment had higher rates of sick absence. From the year 2014 to 2017, the Organisation for Economic Cooperation and Development (OECD) reported that Slovenia had lost 10.0 to 10.8 days per person annually, followed by Canada with 7.4 to 8.0 days per person

per year and the United Kingdom with 2.1 to 2.2 days per person every year (OECD, 2018). In Malaysia, on the other hand, sickness absenteeism was observed to be growing in trend, whereby, the average employee absence in year 2016 was higher compared to 2015 from 2.35 days to 4.32 days (Malaysia Employer Federation, 2016).

Unsuitable indoor environment in office building also lead to productivity loss and poor work performance among employees. According to Ali et al. (2019), working performance is described as the result of a person towards carrying out a certain task over a set period of time. Meanwhile, productivity is defined as the rate of goods and services produced by a normal population of employees (Tantua and Godwin-Biragbara, 2020). In particular, there have been several studies conducted to investigate how office indoor environment affect not just the health of employees, but their productivity and work performance. Lamb and Kwok (2016) stated that an individual's resources tend to be diverted away from work performance by an unpleasant office indoor environment through additional stress on cognitive reserves and concentration. For instance, Ajala (2012) found that noisy office can reduce employee productivity by almost 40%. Siqueira et al. (2017) reported that increase in indoor air temperature has been linked with the reduction of physical and cognitive performance among occupants. Other study by Shi et al. (2013) exposed that increases in humidity can adversely affect occupant work performance. The productivity level and growth of Malaysian employees have exponentially decreased. According to Department of Statistics (2020), office-based employees' productivity level per employment dropped by 6 percent with a level of RM 84,172 per person. This performance was behind the 11th Malaysia Plan target of 3.2 percent annual growth. Approximately 86% of productivity issues arise in the indoor environment of office building (Feige et al., 2013), hence improving indoor conditions in office buildings is crucial and economically feasible as a better quality of indoor environment in office building can increase employee productivity by 20% (Clements-Croome, 2015).

Occupants, as end-users of office buildings, represent the highest percentage of business operation costs. Existing studies have acknowledged that decline in work performance caused by poor indoor environment has led to huge economic loss (Clements-Croome, 2015; Wu et al., 2021). As reported by AIA Malaysia (2017),



Malaysia experienced a high loss of productivity among office building occupants in 2017, when the average annual cost of health-related disease in the workplace was MYR 2.27 million per organisation. In the United States of America, office environment has been associated to workplace-related illnesses costing up to 225 billion dollars, and the health-related absenteeism costs accounted for approximately 153 billion dollars every year (Haverhals, 2018). In the European Union, work-related stress and mental health problems cost up to 269 billion euros annually (European Commission, 2002). Improving indoor environment performance may result in a significant increase in occupant productivity and organization profit (Fisk et al., 2012). However, in the current situations, many building owners and employers seem to neglect the contribution of creating a proper indoor condition on their business bottom line as suggested in the literatures (Rahim et al., 2014). Most of the building owners and employers tend to invest more in the energy efficiency and building appearance rather than pay sufficient attention to the functional aspects of a building for safeguarding the occupant's well-being. As a consequence, inadequate quality of indoor environment can cause loss in productivity and lead to additional costs every year for the organizations (Heerwagen, 2002).

Facilities management plays an important role in achieving the aim of sustainability in buildings. Traditionally, the main goal of facilities management service is to provide a high-quality environment on a cost-effective basis (using the available resources) in order to improve organizational performance (Atkin and Brooks, 2005). The role of facility manager is not only limited to facilities and resources management in buildings, but includes the management of people. Achieving service excellence and improving occupant efficiency are strategic to facilities management (Sindhu and Gidado, 2014). This is because, in the context of office building, employees are considered as the backbone of an organization, thus utilizing available resources and delivering an appropriate workplace environment according to the needs of employees are essential to enhance organization effectiveness and boost employee productivity, which in turn contribute to the well-being of occupant and sustainability (Clements-Croome, 2004).

Performance assessment is essential as enhancement strategies to improve the quality of indoor environment in office building for the benefit of occupant well-being. Performance means the output that people can produce with the least input or effort (Rolloos, 1997). Dorgan et al. (1994) refer to performance as the increased productivity and function of an organizational where increase in performance leads to reduction in absenteeism. Cascadia Region Green Building Council (2008) stated that performance assessment involves several process including reviews of past and present functioning, deriving strategies for future performance, comparing performance within and among facilities, assessing the performance toward the organization's goals and providing needed direction to management for decision-making. Assessing occupant well-being in office building is a great challenge and major concern in sustainable development, thus, it is necessary to develop a measurement model that is capable to assess the performance of indoor environment in office building in relation to occupant well-being. In addition, the measurement model should be measurable, comprehensive and easy in order to assess occupant well-being in office building. As said by management thinker, Peter Drucker; "You can't manage what you can't measure and if you can't measure it, you can't improve it" (Drucker, 1995).

Building certification systems is emerging to evaluate the performance of a building across the sustainability criteria such as environmental protection, economic growth and social aspects. Rating system was employed to indicate the performance level of a building towards sustainability. In the past decades, multiple concepts and tools have been developed to assess the performance of the built environment, buildings or specific aspects of the buildings. For example, through the development of green buildings that emphasizes the efficient use of resources throughout the building life cycle. Some examples of green building rating standards include Green Mark adopted in Singapore, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, Beaufort Region Environmental Assessment and Monitoring (BREAM) in United Kingdom, and Leadership in Energy and Environmental Design (LEED) in United States. Besides that, the Malaysia government has steadily introduced several programs or fiscal instruments for the promotion of sustainability in building industry. The Green Building Index is the first

building assessment tool developed in Malaysia, followed by Green Performance Assessment System (GreenPASS) and Green Real Estate (GreenRE) (GreenRE, 2017; Hamid et al., 2014). In the year 2016, Construction Industry Development Board (CIDB) and the Public Works Department (PWD) introduced Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST). This building assessment tool aimed to reduce carbon emissions and environmental impact from buildings across all levels of building life cycle including construction, operational, maintenance and demolition (Ohueri et al., 2019). Aside from green building rating tools, another well-established tool to evaluate building performance is known as Post-Occupancy Evaluation (POE), Living Building Challenge (LBC), Fitwel and WELL certification schemes.

In spite of the fact that various building assessment tools have been developed worldwide to assess the performance of buildings across the sustainability criteria, the impact of buildings on occupant well-being has received limited consideration and is scarcely emphasised in the existing building assessment tools. Although the WELL certification system is by far the most precise and comprehensive in assessing occupant well-being, the WELL certification cannot be applied effectively to the occupants of office buildings because the WELL certification is based on a set of universally applicable factors that can be applied to all different types of building. The assessment of occupant well-being in office buildings should be differentiated from the assessment of occupant well-being in residential buildings and other types of buildings, as occupants in office buildings engage in different activities and occupancy pattern that are subject to different assessment criteria with different requirements on the indoor environment. For example, the use of particular office equipment such as computers, printers, or photocopiers results in higher concentrations of certain substances in the indoor air compared to other confined spaces (Destailats et al., 2008; Sun et al., 2015). Furthermore, the generalised nature of the existing building assessment tools were unable to provide the same effective results when applied to different regions or countries that have different priorities, socioeconomic and climate conditions (Potrč Obrecht et al., 2019). Office buildings in Malaysia, for example, have significant cooling requirements due to the high intensity of solar radiation (Ossen et al., 2005). This is supported by Todd and Lindsey (2002), who indicated that building assessment

systems must reflect the national, regional, and local context in order to be accepted and used. Therefore, the direct application of existing building assessment tools to other countries or regions without considering the unique regional priorities is inappropriate to achieve the effective results for improvement (Charoenkit and Kumar, 2014; Shari and Soebarto, 2015).

These issues reveal the need to develop a measurement model that applies to occupant well-being in Malaysian office buildings with a holistic approach embracing the integral influence of multiple indoor environmental parameters on occupant well-being as well as the local requirements and standards. To date, limited studies in the literature have comprehensively assessed occupant well-being in the specific context of Malaysian office buildings. A set of parameters that contribute to occupant well-being in this context is essential, but this is unavailable in the literature because the studies have explored parameters independently. As such absence, the aim of this study is to bridge this knowledge gap by developing a novel measurement model for assessing occupant well-being that is tailored specifically for Malaysian office buildings by integrating all potential indoor environmental parameters that are significantly associated with occupant well-being in Malaysian office buildings. The development of the measurement model makes a theoretical contribution to supporting the effort of the government to make the building sector more concerned with social aspects of building sustainability by providing an actual reflection of building indoor conditions that impact the well-being of building occupants. Additionally, the measurement model is useful to guide the facility manager and building operator in improving the condition of the indoor environment in office buildings for the well-being of the occupants.

## **1.4 Research Questions**

By reviewing the previous studies, to date, there is a lack of relevant research in the assessment of occupant well-being particularly in Malaysian office building context to achieve a balance sustainability in building sector. Therefore, the research questions as below are raised:

- (a) What are the criteria and associated indoor environment parameters to assess occupant well-being in office building?
- (b) Are the criteria of occupant well-being and associated indoor environment parameters identified from published literatures applicable in the local context of Malaysian office building?
- (c) What is the measurement model for assessing occupant well-being in Malaysian office building?

## **1.5 Research Aim**

The aim of this study is to develop a measurement model for assessing occupant well-being that is tailored specifically for Malaysian office buildings. As occupant well-being is a growing concern in the building industry, a comprehensive approach to assess occupant well-being in the specific context of Malaysian office buildings is essential. The measurement model will be developed based on a four-stage procedure that includes identifying a set of criteria for occupant well-being and associated indoor environment parameters, verifying the criteria and associated parameters, calculating the weightage, and developing a measurement model.

## 1.6 Research Objectives

The research objectives have been designed to answer the research questions addressed above and generate knowledge for this research. The objectives of this research include:

- (a) To identify the criteria of occupant well-being and its associated indoor environment parameters in office building;
- (b) To verify the criteria of occupant well-being and its associated indoor environment parameters for Malaysian office building;
- (c) To develop a measurement model of occupant well-being for Malaysian office building.

The understanding of the interface between indoor environment condition and occupant well-being in office building are essential to enhance the formulation of requirements for architectural and building system design. Nevertheless, occupant well-being is not attributed by a single indoor environmental factor but multiple indoor environmental factors simultaneously. Several studies have reported that it is complicated to break down indoor environmental factors into categories and determine how these categories or indicators contribute to occupant well-being (Yang and Moon, 2019; Jin et al., 2020). To address these challenges, a set of criteria of occupant well-being and associated indoor environment parameters are needed to be proposed to assess occupant well-being in office building. Therefore, first objective of this study was formed to identify the criteria of occupant well-being and associated indoor environment parameters. Furthermore, the rationale for second objective was to ensure the criteria of occupant well-being and associated indoor environment parameters identified from published literature are applicable and accurately reflect the context of Malaysian office building. Lastly, for the third objective, the rationale was to develop a measurement model that mainly focuses on assessing occupant well-being as a whole for Malaysian office building.

## **1.7 Scope of the Study**

The scope of this study is purpose built office buildings in Malaysia. The rationale to select Malaysian office building context as that most employees in Malaysia spend at least eight hours of working hours in office building compared to other places, hence the impacts of office indoor environment on occupant well-being is highly significant. Previously, major focus has been given on the role of individuals, government and the community in promoting healthy behaviour and lifestyle, while there has been little focus in championing employee well-being at the office building. It is expected that improvement made for occupant well-being in office building can increase employee's productivity, lead to better business performance, reduction in building-related illness, controlled medical cost for companies and higher employee engagement. Furthermore, improving human well-being in building industry also has been highlighted as the key pillar in No.3 Sustainable Development Goals and the 11<sup>th</sup> Malaysia Plan.

The targeted respondents of this study consist of experts who are involved in office building management, facilities management, building engineering, occupational safety and health, as well as an expert from the green building confederation. The rationale to select these experts is because they have a considerable knowledge, valuable experience and professional qualification in managing office building conditions to provide a healthy, comfortable and conducive working condition for building occupants. Considering that the office building conditions involve several technical aspects of building systems, the viewpoint from these experts are essential to enable effective improvement to be made on office building condition for the benefit of occupant well-being.

## **1.8 Significance of the Study**

The building industry has shown a growing interest in improving the quality of indoor environment and preserving the well-being of occupants. The term of well-being has become a conventional agenda of sustainability in the building industry as many existing studies have reported the adverse impacts of inadequate indoor environment in office building on occupant well-being, for instance, productivity loss, increased rate of absenteeism and adverse health effects. Over the years, various building assessment tools have been developed worldwide to assess the performance of building. However, the existing building assessment tools scarcely considered the impact of building condition on occupant well-being. Despite several existing studies have addressed the requirements of occupant well-being in building, but the assessment criteria and indoor environment parameters are generalized in context. There has been relatively limited studies on the optimum approach to assess occupant well-being specifically in Malaysian office building context, therefore, this study has explored a novel approach to assess occupant well-being in Malaysian office building. This study has contributed in filling the knowledge gap by developing a measurement model that integrate all potential indoor environmental parameters that are significantly associated with occupant well-being in Malaysian office building context.

Furthermore, the findings of this study provide an efficient direction for facility managers and building operators in assessing occupant well-being in Malaysian office building and allowing them to identify which areas should be prioritized to enhance occupant well-being in Malaysian office building. The identification of the occupant well-being criteria and associated indoor environment parameters targeting the specific context (Malaysian office building) allowed the measurement model to be more focused and specific for an effective improvement. Furthermore, many international standards are now starting to shift towards people-centric regulations and guidelines for building design and engineering that focus on the social dimension, as explicitly featured in the United Nation Sustainable Development Goals No.3 to ensure healthy lives and promote well-being. This study makes an empirical contribution to indoor environmental quality enhancement strategies to maximise occupant well-



being. The measurement model developed in this study would help provide better understanding for architects, building engineers, building scientists, health professionals and facility managers on how to create a working environment that is perceived as comfortable, healthy, and pleasant for the well-being of the occupants and subsequently fulfil the demand for sustainable office buildings to promote a higher quality of human well-being.

## **1.9 Overview of Research Methodology**

This section provides an overview of the research methodology. Generally, this study was carried out in five stages: (i) literature review, (ii) verify the criteria of occupant well-being and associated indoor environment parameters, (iii) assign weightage for the criteria of occupant well-being and associated indoor environment parameters, (iv) develop a measurement model of occupant well-being for Malaysian office building, (v) report the findings and conclusion. Figure 1.1 shows a diagram of the research methodology overview. A more detailed description on research methodology will be provided in Chapter 3.

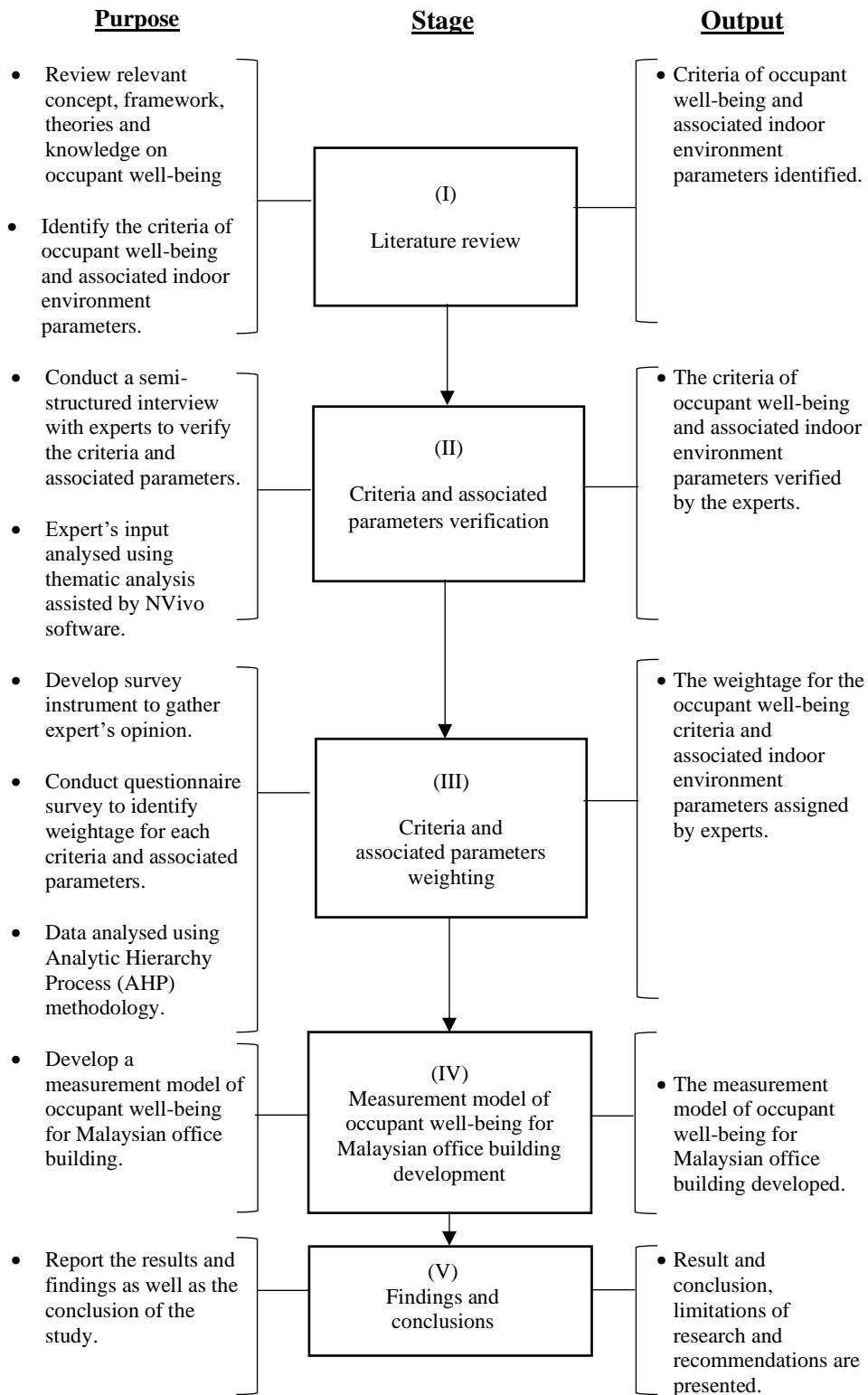


Figure 1.1 Overview of the research methodology

## **1.10 Outline of the Chapters**

This thesis is organized and presented in six chapters.

Chapter One, the introductory chapter, consists of eleven subsections. It begins with an introduction, followed by the background of the research, problem statement, research questions, research aim, a list of research objectives, the scope of the research, the significance of the research, an overview of the research methodology, the outline of the chapters and lastly a summary of the chapter.

Chapter Two includes a comprehensive literature review on the fundamental criteria of occupant well-being and associated indoor environment parameters which mainly focus on office building context. The review includes the literature on occupant well-being and indoor environmental quality as well as relevant models and theories for the interplay between indoor environment and occupant well-being. This chapter includes a theoretical review of person-environment fit theory and facilities management model and discusses the rationale to adopt the theory in this study as a fundamental basis to develop the conceptual framework. The sources of reference are mainly from academic literature such as journals, conference papers and books. Objective one will be achieved in this chapter.

Chapter Three highlights the designation of the overall research methodology employed in this study. This chapter details the research procedures and flow of arrangements to achieve each of the objectives in this study. Furthermore, this chapter include further explanations on survey instrument development, sampling technique, data collection and data analysis.

Chapter Four presents the results and findings of the analyses for objective two, which is to verify the criteria of occupant well-being and associated indoor environment parameters for Malaysian office building. In brief, this chapter includes three main sections: the background profile of experts, the results and findings from the thematic analysis and the discussion of the results.

Chapter Five covers the results and findings of the Analytic Hierarchy Process (AHP) analysis for the third objective of this study, which is to develop a measurement model of occupant well-being for Malaysian office building. This chapter contains four sections: the overall responses, the background profile of experts, the results and findings from the AHP analysis and the discussion of the results.

Lastly, Chapter Six concludes the main findings of this research and provides recommendations for future research.

### **1.11 Summary**

This chapter introduced the research background, relevance and motivation of the research. The objectives of this study and research questions were presented, followed by an overview of the research methodology, the scope of the study and the significance of the study. Finally, a summary of thesis structure was outlined with a brief description of each chapter. The following chapter reviews the existing literature in order to develop a clear understanding on the interface between occupant well-being and indoor environment in office building context.

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## LIST OF PUBLICATIONS

### Journal with Impact Factor

1. **Mansor, R.** and Sheau-Ting, L. (2020). Criteria for occupant well-being: A qualitative study of Malaysian office buildings. *Building and Environment*, 186, 107364. <https://doi.org/10.1016/j.buildenv.2020.107364>. **(Q1, IF: 6.456)**
2. **Mansor, R.** and Sheau-Ting, L. (2022). A measurement model of occupant well-being for Malaysian office building. *Building and Environment*, 207 (B), 108561. <https://doi.org/10.1016/j.buildenv.2021.108561>. **(Q1, IF: 6.456)**

### Indexed Conference Proceedings

1. **Mansor, R.** and Sheau-Ting, L. (2019). The psychological determinants of energy saving behavior. In *Sriwijaya International Conference on Science, Engineering, and Technology* (p. 012006). IOP Publishing. 10.1088/1757-899X/620/1/012006. **(Indexed by Scopus)**
2. **Mansor, R.** and Sheau-Ting, L. (2021). The role of building sector in preserving occupant health for a sustainable development: A review. In *IOP Conference Series: Earth and Environmental Science* (Vol. 801, No. 1, p. 012022). IOP Publishing. **(Indexed by Scopus)**
3. Seman, Z. M., Sheau-Ting, L., **Mansor, R.**, Siaw-Chui, W. and Zulfarina, S. (2020). Classroom illuminance: a case in Malaysian university. In *4th International Conference on Construction and Building Engineering & 12th Regional Conference in Civil Engineering (ICONBUILD & RCCE 2019)* (p. 012002). IOP Publishing. 10.1088/1757-899X/849/1/012002. **(Indexed by Scopus)**

## **Non-indexed Conference Proceedings**

- 1. Mansor, R** and Sheau-Ting, L. (2018). Psychological determinants of energy conservation behaviour among office building users: a structural equation modelling. In *the 7th International Graduate Conference on Engineering, Science and Humanities*. 13-15 August, Universiti Teknologi Malaysia, Malaysia.
- 2. Mansor, R.** and Sheau-Ting, L. (2018). What role can social marketing approach play to improve building user wellness?. In *the International Social Marketing Conference*. 15-16 July, James Cook University, Singapore. pp. 34
- 3. Mansor, R.** and Sheau-Ting, L. (2018). The Role of Facilities Manager In Improving Occupant Comfort in the Office Building. In *the 4th International Conference in Sustainability Initiatives: Case Studies in Malaysia, Philippines and Indonesia (SIMPI)*. 11-12 December. The Everly, Putrajaya, Malaysia.
- 4. Mansor, R.** and Sheau Ting, L. (2019). Occupant Health and Office Indoor Environment. In *the 1st International Graduate Conference of Built Environment and Surveying*. 24-25 June. Universiti Teknologi Malaysia, Malaysia.