

## **Sustainable Building Improving Environmental, Social and Economic Performance for Tropical Climate**

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**Abstract:** Sustainable Building: Improving Environmental, Social, and Economic Performance for Tropical Climate is a comprehensive book that delves into the essential aspects of creating sustainable and healthy indoor environments for non-residential buildings, with a specific focus on tropical climates. It serves as a valuable resource for students, academics, designers, and stakeholders in the building sector, providing insights and guidance for enhancing building designs and achieving improved indoor conditions. The book covers a wide range of topics, with a particular emphasis on indoor environmental quality (IEQ) parameters and their impact on occupant comfort, health, wellbeing, performance, and productivity. By addressing these factors, the authors aim to contribute to the development of sustainable, green, and healthy built environments, paving the way for a brighter future.

**Keywords:** Sustainable, performance, climate, policies, green



# **SUSTAINABLE BUILDING**

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FOR TROPICAL CLIMATE**

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# DEDICATION

To my passionate colleagues and all those dedicated to have a sustainable future, this book is dedicated to you. Your unwavering commitment to improving environmental, social, and economic performance in tropical climates is an inspiration. Through your innovative ideas and diligent efforts, you have transformed the built environment, creating spaces that harmonize with nature and enhance the well-being of people.

To my colleagues, thank you for your collaboration, expertise, and unwavering support. Your shared vision and dedication have been instrumental in advancing this book and sustainable building practices. It is through our collective efforts that we are shaping a more resilient and sustainable future.

May this book serve as a testament to our shared commitment and inspire us to continue pushing the boundaries of sustainable buildings.

Thank you for being my valued colleagues and partners on this transformative journey.

Together, let us build a sustainable world for generations to come.

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# PREFACE

The world is facing significant environmental and societal challenges, from climate change and resource depletion to population growth and urbanization. In fact, sustainable buildings play a pivotal role in addressing the multifaceted challenges posed by climate change, while also driving economic growth, improving energy efficiency, and enhancing human health and comfort. By integrating environmentally responsible solutions which provides a comfortable and healthy environment for human in building design, construction, and operation, sustainable buildings significantly reduce greenhouse gas emissions, helping mitigate climate change impacts.

In this context, the role of sustainable buildings becomes increasingly vital. A sustainable building is more than just an architectural structure; it is a harmonious integration of design, construction, and operation that minimizes negative impacts on the environment while optimizing social and economic benefits. This book, “Sustainable Building: Improving Environmental, Social, and Economic Performance for Tropical Climate,” aims to provide you with a comprehensive understanding of the importance of sustainable building practices and their profound impact on human’s life and our planet.

Chapter 1 sets the foundation by introducing the concept of sustainable buildings. We delve into the intricate relationship between buildings and their environment, highlighting the significance of green rating tools that enable us to assess the environmental performance of structures. Additionally, we explore the social and economic aspects of sustainable buildings, emphasizing their potential to improve the quality of life and foster economic growth.

The urgency to address climate change cannot be overstated, and Chapter 2 deepens our understanding of the direct link between indoor environment and occupants. We examine the importance of high-performance indoor environments that prioritize the health, comfort, and energy efficiency of occupants. We delve into crucial aspects such as indoor air quality, lighting quality, acoustics, and their impact on the well-being and productivity of individuals. Moreover, we explore the connection between indoor environments and the transmission of diseases, shedding light on the role sustainable buildings play in safeguarding public health.

Moving forward, Chapter 3 focuses on green and high-performance office buildings. We uncover the green buildings performance, highlighting their role in driving sustainable practices. We also explore the symbiotic relationship between building performance and productivity, particularly within the office building typology. Through case studies and real-life examples, we illustrate how sustainable office buildings can enhance productivity while promoting a healthier and safer working environment, especially in light of the transformative impact of the COVID-19 pandemic.

Chapter 4 delves into energy efficiency building codes and policies, recognizing their pivotal role in curbing greenhouse gas emissions and combatting climate change. We explore the immense energy consumption of buildings and the need for energy-efficient solutions. From international standards and regulations to voluntary and mandatory building codes, we delve into the strategies and policies that can drive positive change. By prioritizing energy efficiency and adopting sustainable practices, we can mitigate the environmental impact of buildings and pave the way for a more sustainable future.

Finally, in Chapter 5, we conclude our journey with a reflection on the key insights gained throughout the book. We emphasize the critical role of sustainable buildings in improving environmental, social, and economic performance. By integrating sustainable practices into our built environment, we have the power to shape a future that is environmentally responsible, socially inclusive, and economically viable.

We hope that this book serves as a valuable resource for architects, engineers, policymakers, and individuals passionate about sustainable building practices. It is our aim to inspire and empower readers to embrace sustainable design, construction, and operation, particularly within tropical climates. By fostering awareness and understanding of the multifaceted benefits of sustainable buildings, we can collectively create a better future for ourselves and generations to come.

Now, let us embark on this enlightening journey together, where sustainability and innovation converge to shape a world of thriving, resilient, and sustainable buildings.

# CHAPTER 01

## WHAT IS A SUSTAINABLE BUILDING?

Climate change is undoubtedly one of the existential crises and threats facing the global human community. Overcoming and addressing such a global threat requires global cooperation from governments, industry, and down to each individual. One such global cooperation is the Paris Agreement, a legally binding international treaty on climate change adopted by 196 Parties at the Conference of Parties 21 (COP 21) in Paris on 12th December 2015 (UNFCCC, 2021). The Paris Agreement sets a global warming limit of well below 2 degrees Celsius, and preferably to a 1.5 degree Celsius limit, compared to pre-industrial levels (UNFCCC, 2021). At the most recent COP 26 in Glasgow in November 2021, the mutual aim is to achieve a net-zero emissions for all industries, including the construction industry and building sector (WGBC, 2021).

Increased levels of carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels influence atmospheric concentrations, which will eventually increase global temperatures and sea levels - the effects of climate change (IPCC, 2005, 2007). Global atmospheric greenhouse gas concentrations have exceeded the natural range over the last 650,000 years, because of human activities since the industrial revolution in the 18th century (IPCC, 2007). According to the Intergovernmental Panel on Climate Change (IPCC), GHGs are mainly made up of concentrations of carbon dioxide-CO<sub>2</sub>, methane-CH<sub>4</sub>, nitrous oxide-N<sub>2</sub>O, and halocarbons- a group of gases containing fluorine, chlorine, or bromine (IPCC, 2007).

Carbon dioxide is one of the key greenhouse gases contributing to global warming and causes roughly 60% of the enhanced greenhouse effect or global warming (Graham, 2003; IPCC, 2007; UNDP, 2007; UNEP, 2007; United Nations, 1998). In 2000, almost 23 billion tonnes of carbon dioxide emitted worldwide and 28% came from North American territories; 0.09% came

# CHAPTER 02

## HIGH PERFORMANCE INDOOR ENVIRONMENT

This Chapter will discuss elements of what constitutes a good and healthy high quality indoor environment which promote health and occupants' satisfaction quality (IEQ), in terms of thermal comfort, indoor air quality (IAQ), lighting and , acoustics. These elements are important in its connection to occupant's wellbeing, health health, and comfort, which closely affect occupant's performance and productivity. Chapter 2 also will discuss elements of unhealthy indoor environment and its connection to transmissible diseases such as the Covid-19.

- **INDOOR ENVIRONMENTAL QUALITY AND WELLBEING**

Indoor environmental quality (IEQ) are generally defined as the indoor conditions of a building that can affect occupant's health, comfort, productivity, morality and wellbeing (Visher, 2007; Fisk, 2002; Al horr et al., 2016). Indoor environmental comfort can be divided into three (3) categories. First is an ambient environmental condition, which includes human's basic needs like lighting, noise, thermal quality, and air quality (Vischer, 2008). Second is the furniture and space layout as ergonomic furniture, office territory, equipment location and moving line, which affects occupant's feeling, sense of privacy and social status (Bordass & Leaman, 2006). Final category includes process issues like user participation in design, making a decision, company's objectives that affect occupants' sense of ownership or sense of loyalty (Calder, 2007). All these three factors have a direct effect on occupant satisfaction and wellbeing from IEQ (Vischer, 2008).

Wellbeing is a concept that encompasses the multidimensions of a human's physical, psychological, social and personal needs and is closely related to his or her surrounding environment (Mansor & Sheau-Ting, 2020). Therefore, the quality of indoor environment is an essential indicator for a building occupant's wellbeing and in this section, the book deliberates fundamental

# CHAPTER 03

## GREEN AND HIGH PERFORMANCE BUILDINGS

Introduction of the green office created a new method in construction, to evaluate the aspects of offices and figure out whether it is a green office or not. The United Kingdom pioneered and established the first green building rating system known as “Building Research Establishment Environmental Assessment Method” (BREEAM) in 1990. The United States then established a rating system eight years after in 1998, known as “Leadership in Energy and Environmental Design” (LEED). More countries have established rating systems subsequently, such as Australia (Green Star) in 2003, Singapore (Green Mark) in 2005 and Malaysia (Green Building Index) in 2009. This Chapter will also discuss the interdependent relationship between building performance and productivity, focusing on the office building typology. The Chapter begins with an introduction of what constitutes a high-performance building, proceeding to factors that influence workplace performance and consequently how it impacts productivity. Finally, the chapter discusses the new norm of working environments proceeding from the outcome of COVID-19 pandemic and how it has impacted the working space towards a healthier and safer environment.

- **GREEN BUILDINGS PERFORMANCE**

Building performance evaluation has earned increased attention in recent years, particularly with respect to green offices. Renewable energy, passive design alternatives, sustainability, and energy efficiency have become an important goal across the globe for design teams with an emphasis on implementation of robust indoor environmental performance. Investment in green offices encompasses corporate responsibility strategies as a response to sustainable issues such as the effects of global warming (Francesco & Levy, 2008), and the minimization of harmful effects on the environment. Green offices aim to reduce the ecological footprint and greenhouse gas emissions, and reduction



# CHAPTER 04

## ENERGY EFFICIENCY BUILDING CODE AND POLICIES

Year 2020 showed the largest decline in global primary energy consumption and carbon emissions from energy use with 4.5 and 6.3 percent respectively. By country, the United States (US), India, and Russia contributed significantly to the decline, which is the largest seen since World War II. The rate of decline needs to sustain for the next 30 years to match the goals by most of the world's governments outlined in the Paris Agreement particularly in reducing global greenhouse gas (GHG) emissions and ultimately, limiting the global temperature increase to below 2 degrees Celsius and pursuing efforts to limit the increase to 1.5 degrees Celsius. Improving energy efficiency in buildings, transportation, shipping, and other industrial processes is one of the most important ways to reduce greenhouse gas emissions and fight climate change.

Unfortunately, building sectors through the construction and operation of buildings are accounted for almost one-third of total energy consumption globally and nearly 15 percent of direct Carbon dioxide (CO<sub>2</sub>) emissions (IEA, 2021e). Growing number of world population increases the demands of building and electric energy, and subsequently depleting the availability of energy resources. Most of this is used for a variety of purposes including air-conditioning, space heating, vertical transportation, lights, and computers. However, it is not impossible to eliminate energy demand in our buildings as it represents enormous opportunities to produce what people need without burning of fossil fuels and without adding CO<sub>2</sub> to the atmosphere. As argued by Eley (2016), buildings constitute a big part of the environmental problem, but they also represent great opportunities to save energy and reduce environmental impact.

# CHAPTER 05

## CONCLUSION

This book has presented various points of view in addressing the topic of sustainable buildings and the significant role of indoor environmental conditions to building occupants. This book has identified critical parameters of IEQ and their relationship with occupants' satisfaction as well as identifying critical factors contributed to each character of IEQ. This book offers a holistic outlook on the indoor environment factors for sustainable design and green buildings that contributed to occupants' satisfaction and proposed a model for providing optimum air temperature to enhance satisfaction and energy-saving.

Chapter 1 began with the introduction to sustainable buildings, such as sustainable design and green buildings in terms of features related to environmental, social and economic approaches to the building sector. This introduction provides a brief glimpse of how designers and stakeholders can gain awareness of sustainability in their building design. The main takeaway from Chapter 1 can be concluded that the economic and social aspects of sustainable building must be highlighted, as much as the environmental aspect. Circular economy and life cycle assessment (LCA) can help designers understand the long term economic impacts of their building design, even before the building is constructed and design for better economical solutions. In terms of social aspect of sustainable building, designers should focus on both psychological and physiological impacts of their design towards building occupants, particularly how it affects user's health and work performance in office settings.

Chapter 2 further discusses what has been introduced in Chapter 1 in terms of the social aspect of sustainable building design, focusing in particular the compositions of what constitutes a healthy building from elements of indoor environmental quality (IEQ) and its effects on occupant's health,

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