

**INFLUENCES OF GREEN BUILDING
TECHNOLOGY(GBT) ADOPTION ON
COMMUNITY RESILIENCE IN THE CONTEXT
OF COVID-19 PANDEMIC**

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**SCHOOL OF CIVIL ENGINEERING
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ADOPTION ON COMMUNITY RESILIENCE IN THE CONTEXT OF
COVID-19 PANDEMIC

by

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after endorsement has been obtained from supervisor)

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ABSTRAK

Teknologi Bangunan Hijau (TBH) yang juga dikenali sebagai Pembinaan Hijau, adalah pelaksanaan reka bentuk yang bertanggungjawab terhadap alam sekitar dan efisien dari segi sumber daya sepanjang kitar hayat suatu struktur, bangunan, atau ruang komersial. Bangunan hijau melindungi sumber-sumber semula jadi yang berharga disamping meningkatkan kualiti kehidupan. Wabak Covid-19 kini membawa kepada perubahan dan kita harus menyesuaikan cara kita membina persekitaran hidup bagi menangani pandemik ini. Persekitaran hidup yang sihat dan selesa diperlukan untuk kesejahteraan mental dan fizikal. Penerapan Teknologi Bangunan Hijau (TBH) memberi banyak pengaruh terhadap penghuninya berdasarkan aspek kelestarian yang berkait dengan pandemik Covid-19. Walau bagaimanapun, industri pembinaan di negara kita masih lagi kekurangan dari segi ciri-ciri bangunan hijau untuk berhadapan dengan cabaran-cabaran pandemik Covid-19. Covid-19 telah membawa kepada suatu perspektif baru dalam reka bentuk bangunan kediaman kontemporari, menandakan bahawa keadaan kehidupan harus dipertimbangkan semula dan dipertingkatkan untuk ketahanan yang lebih baik terhadap pandemik ini. Penyelidikan ini bertujuan untuk mengenalpasti pengaruh penggunaan Teknologi Bangunan Hijau (TBH) terhadap ketahanan masyarakat dalam konteks pandemik Covid-19 dari perspektif kelestarian. Hasil kajian menunjukkan bahawa elemen kelestarian tentang aspek persekitaran mempunyai pengaruh yang paling signifikan terhadap penggunaan TBH. Adalah diharapkan agar penyelidikan memberi input dan idea kepada pemegang taruh sektor pembinaan dalam menyedari bahawa penerapan TBH memberikan pelbagai manfaat terhadap ketahanan masyarakat sambil memerangi pandemik Covid-19 selain dapat digunakan sebagai rujukan masa depan untuk kajian perbandingan.

ABSTRACT

Green Building Technology (GBT), which is also known as Green Construction, is the implementation of environmentally responsible and resource-efficient design throughout the life cycle of a structure, building, or commercial space. Green buildings protect valuable natural resources while improving our quality of life. The Covid-19 epidemic is bringing about changes and we may adjust the way we construct our living environments to handle the pandemic. A healthy and comfortable living environment is necessary for mental and physical well-being. Green Building Technology (GBT) adoption gives many influences towards its occupants based on the aspect of sustainability in relation to the pandemic of Covid-19. However, the construction industry in our country is still lacking in terms of the characteristics of green building to face the challenges of Covid-19 pandemic. Covid-19 has led to a new perspective in contemporary residential building design, indicating that living circumstances should be reconsidered and upgraded for better resilience towards this pandemic. This research aims to determine the influences of Green Building Technology (GBT) adoption on community resilience in the context of Covid-19 pandemic from the perspective of sustainability. The results from the survey shows that sustainability elements of environmental aspects had the most significant influence on the adoption of GBT. It is expected that this research provide inputs and ideas to the construction stakeholders in realizing that GBT adoption provides various benefits towards community resilience while combating Covid-19 pandemic besides can be used as future references for comparative studies.

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LIST OF ABBREVIATIONS

GBT	Green Building Technology
TBH	Teknologi Bangunan Hijau
RII	Relative Importance Index

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Green technology is the development and application of products, equipment and systems used to conserve the natural environment and resources, which minimises and reduces the negative impact of human activities (National Green Technology Policy, 2017). Green Building Technology (GBT) refers to green technology which is being applied to building construction projects. Ultimately, it is possible to classify or label a completed building as a green building based on the adoption of green technology attributes.

December 2019 saw an outbreak of the coronavirus disease (Covid-19) which has spread widely around the world. When facing major public health crises, prevention and regulation are crucial elements. The areas for resident activities are confined to communities and they need to stay indoors in order to control the outbreak. Therefore, building designs and constructions play an important role in preventing and managing Covid-19 virus as an important consideration in our daily lives. Community and building-based prevention and control measures have become one of the most important methods of fighting against the epidemic. These include self-isolation, community management, elevator disinfection, environmental cleaning, open windows for natural ventilation, etc. (Wang et al., 2020).

For Covid-19 prevention and control, the criteria for green buildings are advantageous. Apart from natural ventilation, green buildings put a lot of emphasis on indoor disinfection, waste and information management, control of air quality and

water quality, as well as stable operation of construction equipment and disease response skills (Dodo, 2020).

By offering basic functions and convenient conditions, Green Building Technology will reduce the risk of contamination and avoid cross-infection. The building itself should also “isolate” the virus as much as possible to reduce the risk of infection (Wang et al., 2020). For example, by controlling the collusion of air and pollutants, controlling the exhaust backflow of kitchens and bathrooms, setting up effective water seals to reduce the risk of virus transmission through drainage pipes and stools, controlling the concentration of indoor particulate matter, optimising the building space and plane layout to enhance the effectiveness of natural ventilation.

With the decreasing number of cases of Covid-19, economies and individuals return to work as business operations and industries begin to reopen. Adopting green building technology in shopping malls, offices, warehouses and other public spaces will help reduce the spread of coronavirus within them and avoid potential disease outbreaks from standing in good stead (Zengkun, 2020). In addition, Green Building Technology can stabilize work and living environment during the epidemic in terms of performing various prevention and control measures (Wang et al., 2020). This will ensure the protection of occupants’ health and safety in relation to water quality aspects and providing convenient and systematic public service facilities such as supermarkets, vegetable markets, hospitals and other public service facilities.

Therefore, community involvement is important in reducing the spread of Covid-19, minimising the negative psychosocial impact of lockdown interventions and enabling recovery. When confronted with pandemic threats, it is unclear if society is adequately aware and robust enough in terms of public health emergency

preparedness, public hygiene policies and civic-mindedness. Effective pandemic control needs more than just efficient and capable healthcare and surveillance systems. The new Covid-19 pandemic has alerted the international community as having a major effect on public health, well-being and people's everyday lives.

In relation to the current scenario of Covid-19 pandemic, developing and increasing community resilience towards this pandemic can help us to better appreciate a community's long-term ability to resolve and recover from adversity and uncertainties. Physical and psychological health, connectivity, social connectedness and integration, besides organizational participation are all factors that contribute to community resilience. Indeed, in the fight against Covid-19, collective responsibility and the sacrifice of individual interests are critical, especially in the protection of vulnerable and at-risk populations (Yip et al.,2021).

Community resilience is a concept which refers to the capacities of communities to provide this necessary participation in times of crisis. Community resilience has been defined as ‘communities and individuals harnessing local resources and expertise to help themselves in an emergency, in a way that complements the response of the emergency services’ (Drury et al., 2020).

Community resilience should be understood as more than simply the absence of vulnerability, rather it is ‘a process linking a network of adaptive capacities to adaptation after a disturbance or adversity. Linking this network of adaptive capacities will enable authorities and communities to collaborate towards ‘overcoming adversity, whilst also potentially changing, or even dramatically transforming, (aspects of) that adversity’ (Drury et al., 2020).

1.2 Problem Statement

Although there are housing policies of countries and cities pertinent to Covid-19 (Kaklauskas et al., 2021), it is important to determine the relevancy of GBT and the wellbeing of people related to the dispersion of Covid-19. Additionally, there are various problems related to building design and according to Awada et al. (2021) due to Covid-19 pandemic, understanding about how different features of buildings such as ventilation, humidity, etc. impact on occupant health has become paramount.

While facing the outbreak of the Covid-19, our country does not have a specific guideline or policy on building design which is environmentally friendly or sustainable with the consideration of Covid-19 condition. It includes the inadequate of the operation strategies of central air-conditioning systems, insufficient requirements for disinfection of the main functional areas and public facilities as well as lack of the building emergency mechanism for similar epidemic. Further studies in the area of GBT adoption is vital to complement other related studies in Malaysia. This includes the area of solar photovoltaic (PV) technology as a part of renewable energies in Malaysia to meet the energy demands through the low-carbon pathway (Vaka et al., 2020), besides studies in innovation and environmental performance (Ahmad and Ali, 2020) and water quality status (Nadzir et al., 2020; Najah et al., 2020).

The above-mentioned studies have led to a growing interest in determining the influences of Green Building Technology (GBT) adoption on community resilience in the context of Covid-19 pandemic. In addition, However, it is not clear in the literature what role and influence GBT aspects play in the development of community resilience in relation to Covid-19 pandemic from sustainability perspectives.

1.3 Research Question

In order to investigate the association of Green Building Technology (GBT) with community resilience, sustainability and Covid-19 pandemic, the following question have been formulated to guide this research and to support the investigation:

“What are the benefits of Green Building Technology (GBT) that impacted on the resiliency of community in the context of Covid-19?”

The above question will explore how GBT can influence the way community deal with buildings, in terms of their design, internal layout and external environment as perceived by a group of community in the practical sense of their daily activities based on their experience and opinions.

1.4 Research Objectives

The research is performed to achieve these objectives:

1. To determine the influences of Green Building Technology (GBT) adoption on community resilience in the context of Covid-19.
2. To measure the weightage of GBT influences from the perspectives of community resilience in the context of Covid-19.
3. To compare the sustainability elements of Green Building Technology related to community resilience in the context of Covid-19.

1.5 Scope of Work

This research focuses on the benefits of green building technology adoption on community resilience in the context of Covid-19. The area of this research involves civil engineering fields such as the construction industry, architectural firms, contractors and etc.

The main focus of this research is on the weightage of green building technology influences from the perspectives of community resilience. In other words, this research involves the study of influences of green building technology on community resilience while coping with Covid-19 virus from the perspectives of internal and external layout or surroundings of built environments. Apart from that, this research also compares the sustainability elements of green building technology adoption.

1.6 Dissertation Outline

This thesis contains five chapters. Chapter 1 introduces the overall research which includes background study, problem statement, research question, research objectives and scope of work. Chapter 2 is on the literature review where it explains the previous studies on the benefits of green building technology and current studies about the relationship between green building technology and Covid-19 including the sustainability elements. Next is chapter 3, where it comprises the methodology of this research. This chapter describes the flows and procedures to collect data and obtain the result for the research. Chapter 4 is the discussion part where the data collected from the questionnaire survey was analysed. The analysed data was then presented, analysed and the results are also discussed. Finally, the last chapter in this dissertation is chapter 5. In this chapter, conclusions are made based on findings from this research. This research is intended to serve as a foundation for the construction industry and future studies about the benefits of green building technology adoption during the pandemic of Covid-19 from sustainability aspects.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The links between cities, health, and the environment have been reinforced due to high concentrations of citizens and economic activities in urban areas. Cities are not only responsible for environmental and health issues, but they also hold the key to a more prosperous economy and future. In the construction industry, green building is seen as a viable option for achieving long-term environmental, economic, and social goals.

December 2019 marked the beginning of a novel disease outbreak, which later called Covid-19 by the World Health Organization (WHO, 2020). The Covid-19 pandemic brings various changes in our daily lives and we should change the way we build our living spaces to go along with it. Therefore, a safe and comfortable living environment is important for mental and physical well-being (Tokazhanov et al., 2020).

The three key aspects of buildings that have been checked during quarantines are health and safety, the environment and comfort (Megahed and Ghoneim, 2020), besides to undergo significant transformations toward sustainability. Buildings can provide some health and safety protections to their residents (Zhang and Mohandes, 2020), such as the use of modern touchless devices, adequate hygiene to reduce the risk of infection, and the development of greener and more intimate spaces that can aid in the recovery and improvement of mental states.

Apart from that, according to Hitt et al. (2021), the current Covid-19 pandemic has jolted the international community, having a major effect on public health and individual's everyday lives. As a context, community resilience can help us better

appreciate a community's ability to resolve and recover from adversity (Delgado et al., 2021). Physical and psychological wellbeing, connectivity, social connectedness and inclusion, and organizational participation are all components of community resilience as presented in Figure 2.1.

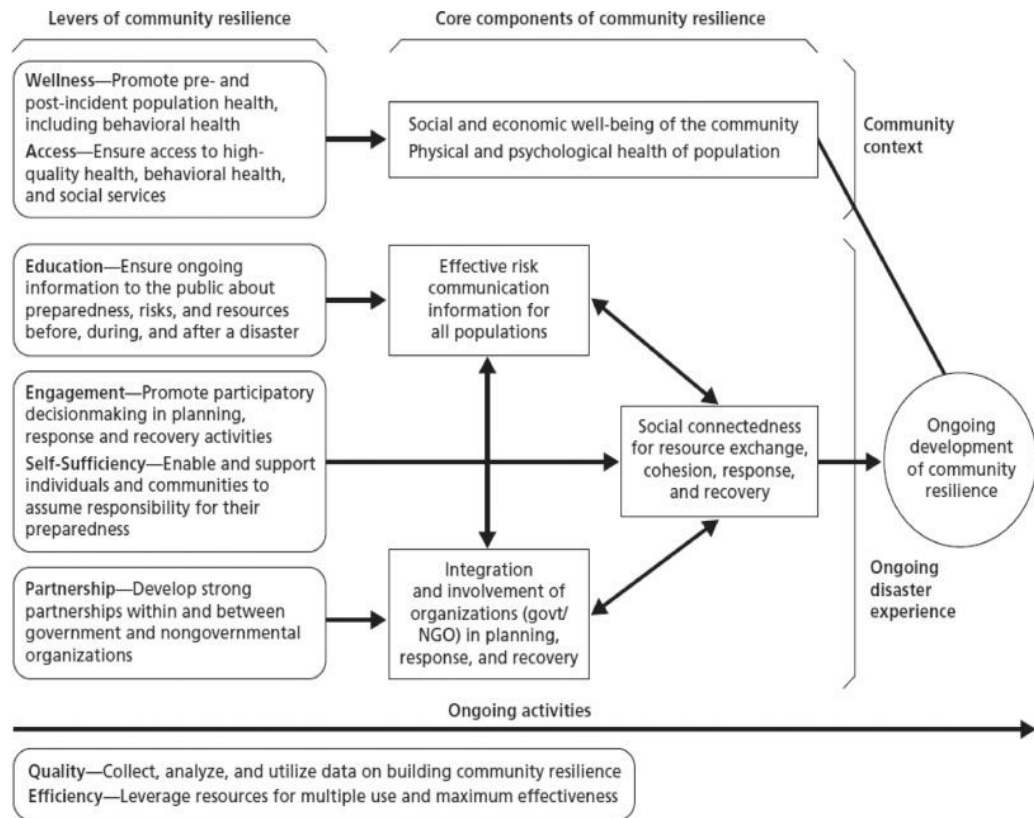


Figure 2.1: Components of community resilience (Source: Yip et al., 2021)

Although civic-mindedness and social responsibility are an equally essential component, they have not been adequately stressed in this context. Indeed, in the fight against Covid-19, collective accountability and the sacrifice of individual interests are critical, especially in the protection of vulnerable and at-risk populations (Yip et al., 2021).

2.2 Green Building Technology in the Construction Industry – Sustainable Development Goals (SDGs) (United Nations)

Green Building Technology (GBT) is a method that can be used to manage the issues of climate change and sustainability. In the construction industry, green building technology includes characteristics on reduced natural consumption, energy and water efficiency towards sustainability requirements to improve health and environment (Solanki and Nayyar, 2019).

GBT has raised the public's awareness in recent years due to global climate change and the construction industry is also aware that natural resources will be depleted if it does not practice sustainable development (Darko et al., 2017). Based on the fact that the design of built environment has various impacts on human being and the earth, experts are beginning to focus on the design and construction of buildings using sustainable practices that will support the construction industry with a more responsible way to manage natural resources (Kibert, 2016).

Since the implementation of green building technologies (GBTs) is a promising route to improve a building's sustainability efficiency, GBTs are gaining traction in the global construction community (Chan et al., 2017). Moreover, green buildings are widely recognized as an efficient way of addressing the demand for sustainable growth in the construction industry (Darko and Chan, 2017).

Green building is referred as "the discipline of constructing buildings and procedures over a building's whole life cycle that are environmentally responsible and resource-efficient" (Zhao et al., 2019). As a result of the development of green buildings, negative environmental effects and increased usage of productive resource will be significantly reduced. Hence, since the past two decades, there has been an

increasing emphasis on green building growth, resulting in a global move toward green buildings (Chan et al., 2017).

Greenhouse gas (GHG) emissions continue to be the key driver of global warming and climate change, and buildings are a major source of GHG emissions (World Data, 2021). According to the United Nations Environment Programme (UNEP, 2021), buildings are responsible for more than 40% of all GHG emissions globally and they account for up to 40% of overall energy consumption and 30% of GHG emissions.

Based on a study, in some countries such as Hong Kong, buildings account for nearly 70% of GHG emissions (Chan et al., 2017). These facts demonstrate that sustainable building development will greatly reduce the amount of GHG pollution released into the environment by the construction industry and as a result, the need to improve building sustainability efficiency has become a huge concern for the construction industry in recent years (Chan et al., 2017).

The Sustainable Development Goals (SDGs) have been formulated to provide humanity with a viable future. SDGs necessitate multidisciplinary research efforts due to the multidimensional nature of sustainability. The 17 Sustainable Development Goals (SDGs) and their priorities are at the core of the United Nations (UN) 2030 Plan for Sustainable Development, which was adopted in 2015 by the UN General Assembly's 193 member states (United Nations, 2021).

SDGs is proposed to implement foundations of sustainable development, with the aim of improving global health and well-being by facilitating the elimination of all types of inequity and injustice, promoting climate change, quality education, gender equality, peace, and social justice and the goals are stated clearly in their objectives (ranging from five to twelve targets per goal) (United Nations, 2021).

SDGs are derived from the three pillars of sustainable development, which are the economic, social, and environmental pillars, to ensure the long-term viability of humankind on earth. The SDGs are usually viewed and addressed separately, but some of them are interconnected, with nuanced and not always obvious associations that can result in positive or negative outcomes.

Even though the SDGs are acknowledged as a priority, their implementation is not progressing as predicted (Asadikia et al., 2021), with various rates and challenges, partly due to the current pandemic background (van Zanten and van Tulder, 2020). Indeed, Covid-19 has sparked an unanticipated global crisis, with tragic repercussions for the lives and wellbeing of almost the entire world's population (Bontempi et al, 2021).

2.3 Benefits of Green Building Technology Adoption

Green building is all about improving one's well-being, generally in terms of the environment, health, and community. Eventually, green buildings harmonize with local climate, traditions, culture and the surrounding environment (Shafiei et al., 2017). Green buildings are able to sustain and improve the quality of human life whilst maintaining the capacity of the ecosystem at local and global levels (Balaban and de Oliveira, 2017). They are among the most important tools for achieving a variety of global goals, including combating climate change, fostering healthy and prosperous societies, and boosting economic development.

GBTs have a wide range of environmental, economic and social benefits based on an increasing GBT acceptance and expansion in combination with an increasing awareness of climate change issues. Generally, green buildings provide higher performance reflected from energy efficiency, water efficiency and carbon emission

reduction compared with conventional buildings (Zhang and Liu, 2018). Table 2.1 below shows the benefits of GBT based on environment, economy and social perspectives.

Table 2.1: Green Building Benefits

Environment	Economic	Social
Enhance and protect biodiversity and ecosystem	Creates, expands, and shapes markets for green product and services	Enhances occupant's comfort and health
Reduce waste stream	Optimises life-cycle of economic performance	Improves aesthetic qualities
Improve air and water quality	Improves occupant productivity	Improves overall quality of life
Conserve and restore natural resources	Reduces operating costs	Minimises strain on local infrastructure

Source: Construction Industry Development Board (CIDB, 2016)

2.3.1 Environmental Benefits

Our climate and the natural environment are two of the most significant forms of benefits that green buildings can give. Green buildings can not only reduce or eliminate negative impacts on the environment, but they can have a positive impact on the environment by generating their own energy or increasing biodiversity. Apart from that, green buildings also improved air and water quality, reduced pollution, natural resource conservation and regeneration, and biodiversity and habitat protection (Darko et al, 2013). It also can reduce heat gain, especially when buildings are built and oriented to maximize the use of daylight (Simpeh and Smallwood, 2018). According to MacNaughton et al. (2018), commercial buildings will benefit most from green

building technology in terms of CO₂ reduction, followed by residential buildings and public buildings.

The idea of environmentally-friendly buildings is usually implemented by applying it in a building, apart from the standard energy conservations solutions, it also involves in water management, including introduction of water-saving equipment, water treatment, re-use of waste water and rain water (Wu et al., 2017).

Reduction of construction and demolition waste is a critical component of sustainable building design. Indeed, the recycling rate has to be above 90% in order to mitigate the obvious environmental impacts of construction and demolition waste which means reused and recycled materials in new buildings (Zuo and Zhao, 2014).

Environmental benefits derived from green building technology are not only beneficial to the environment, but also profitable to the construction stakeholders and consumers as it is cost-saving in terms of water, energy, waste and material efficiency (Zhang et al., 2018).

2.3.2 Economic Benefits

There are many economic advantages of green buildings. The advantages are both direct and indirect. To begin with, direct economic benefits include a shorter payback period for green buildings due to lower energy, water, and health costs, as well as an increase in revenue (Olubunmi et al., 2016). Second, there is a decrease in operating costs because green buildings save money by reducing energy use, water consumption, and building maintenance costs (Dwaikat et al., 2018). Third, green buildings are more valuable than non-green buildings because their owners and developers can charge higher rents and have higher occupancy rates (Leskinen et al., 2020).