IDENTIFICATION OF POTENTIAL IMPACTS OF CLIMATE CHANGE AND THE ADAPTATION OPTIONS IN LOW-COST STRATA RESIDENTIAL BUILDING IN MALAYSIA

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ABSTRACT

Climate change phenomenon such as continuing rising of global temperature, extreme variations in rainfall, increase rapidly of extreme weather events causing a wide range of impacts that affect almost every aspect of human lives from water supply and environmental to housing and communities in number of ways. Being a worldwide phenomenon, there has been growing interest to study how climate change and its impacts unfold regionally, including in Malaysia, for instance in strata residential properties that provide multi spaces living to the community. Residential strata buildings play a key role in providing liveable community places and environment especially in higher density of population and greater construction of buildings and infrastructure e.g. Kuala Lumpur, Penang and Johor Bahru. Thus, this review paper presents a comprehensive overview of the latest research and development of climate change adaptation in residential buildings. The primary objective of this paper is to identify the potential impact of climate change and adaptation options in low-cost strata residential building. These impacts and adaptation options were selected based on an extensive literature review. Literature available on climate change in Malaysia is thoroughly reviewed to identify possible changes in temperature, rainfall, extreme weather events, floods, river discharges, soil moisture, sea level rise, salinity, etc., that could affect the property sector of Malaysia. Finally, this paper identifies and outlines the potential risk and impacts that a low-cost strata residential buildings could have on the vulnerability, resilience and adaptive capacity of buildings in a way to develop the risk-based adaptation framework which currently is still limited and will be beneficial in planning and managing liveable community especially in low-cost strata residential in Malaysia.

KEYWORDS _ *Climate change, property management, strata building*

INTRODUCTION

Climate change is resulting in a wide array of impacts that affect nearly every facet of human existence, spanning from water supply and environmental conditions to housing and communities in various ways. According to the Intergovernmental Panel on Climate Change (IPCC), there has been an annual increase in the average global temperature of approximately 0.85°C, and this trend is expected to persist in the coming decades (IPCC, 2018). The evidence is clear that climate change has emerged as a significant threat, primarily due to its adverse effects, including the continuous rise in global temperatures (Shahid, 2017), erratic patterns of rainfall (Guilding et al., 2015), a rapid increase in extreme weather events resulting in flooding, coastal erosion, and other natural disasters (Mohamed Rashidi et al., 2021), and the elevation of global sea levels (Bagheri et al., 2018).

As a global crisis, there has been a growing interest in examining the regional manifestations of climate change and its impacts, including its effects in Malaysia (Daniel Tang, 2018). Malaysia's climate is shifting in tandem with global climate change trends (Mayowa et al., 2015). Experts have cautioned Malaysians about the consequences of climate change, including heavier rainfall, more severe storms, and increased flooding (New Straits Times, 2019). Multiple studies have also confirmed rising temperatures, sea levels, and extreme weather events in Malaysia, leading to heightened daily temperatures that are expected to persist. Peninsular Malaysia, in particular, has witnessed an increase in extreme occurrences, such as an elevated number of days with heavy rainfall, strong winds, and thunderstorms (MMD, 2019).

In recent years, the property sector has placed greater emphasis on climate change risks (Parkinson, 2019). Shahid et al. (2017) noted that while the impact of climate change on the property sector lacks comprehensive documentation and review, it is anticipated that the sector could be particularly vulnerable due to variable climate patterns, related extreme events, and policies aimed at mitigating greenhouse gas (GHG) emissions. Many countries, including Malaysia, are actively engaged in reducing CO2 emissions, with Malaysia committing to a 45% reduction in carbon dioxide emissions by 2030 (CarbonBrief, 2015). The Malaysian government has also acknowledged the impacts of climate change and introduced the National Policy on Climate Change in 2009 to encourage resource efficiency and environmental conservation. For instance, the Eleventh Malaysian Plan (2016–2020) includes a strategic focus on promoting sustainability and resilience through green growth (EPU, 2015). There is also a strong emphasis on enhancing energy efficiency in buildings, industries, and households through initiatives such as Energy Performance Contracting, raising public awareness about energy labelling, and promoting relevant building standards like ISO50001.

It is worth noting that a significant portion of energy consumption, carbon dioxide emissions, and solid waste is directly or indirectly linked to the Malaysian property industry (Shahid et al., 2017). Globally, the real estate sector accounts for 40% of annual global energy consumption and over 20% of worldwide carbon emissions. Considering this, it becomes increasingly imperative for practitioners and key stakeholders in the property industry, particularly those involved in the management of high-rise or strata buildings, to incorporate climate change considerations into their practices.

There is a pressing need for research focused on identifying elements for integrating climate change adaptation into property management practices, specifically for strata residential buildings. These elements serve as essential features that can be adapted, modified, and applied following a thorough assessment tailored to each building's unique conditions and environment. Consequently, this paper contributes novel insights into potential adaptation strategies for strata buildings that are resilient to climate change, drawing from an extensive review of relevant literature. A comprehensive examination of climate change risks for low-cost residential strata buildings in Malaysia is essential, along with the development of effective adaptation measures to address climate change impacts.

METHODOLOGY

The methodology for this review paper on climate change impacts and adaptation options in low-cost residential buildings involves a systematic approach. It begins with a focused literature search in reputable databases over the past decade, filtering for peer-reviewed sources in English. Inclusion and exclusion criteria are applied, followed by a rigorous screening process and data extraction from selected studies. The findings are thematically synthesized, and the paper is structured with an introduction, methodology, literature review, conclusion, and references. Peer review and finalization ensure the paper's reliability, offering a comprehensive overview of climate change impacts and adaptation strategies in low-cost residential buildings.

THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON LOW-COST STRATA BUILDINGS

Residential strata buildings play a vital role in providing sustainable living environments, particularly in densely populated areas with extensive urban development, such as Kuala Lumpur, Penang, and Johor Bahru. The prevalence of strata properties in major cities is a response to challenges like limited urban land availability, soaring land prices, and sustained demand from urban residents. These strata residences constitute nearly 30% of the overall housing stock, totalling 5,398,133 units, and account for almost 50% of the upcoming supply of 480,060 units (Hamzah & Abdullah, 2018). This underscores the substantial environmental and sociocultural transformations they can bring, contributing significantly to sustainable urban living. Such endeavours align with the Malaysian government's ongoing initiatives aimed at enhancing the quality of life as a crucial element of sustainable living. Several sets of indicators, including the Malaysian Wellbeing Index, the Malaysian Urban Rural National Indicators for Sustainable Development, and the Malaysian Family Wellbeing Index, are employed to gauge urban quality of life. Consequently, it can be inferred that climate change adaptation for strata residents in major Malaysian cities would have a positive impact on their overall quality of life.

The recent focus of the Malaysian government, as outlined in the Housing Policy 2018-2025, centres on creating liveable communities and improving the wellbeing of the bottom 40% income (B40) households. Alice et al. (2017) have pointed out that low-cost housing projects in Malaysia have been a significant solution to meet the housing needs of urban B40 households. They emphasize that low-cost housing has become less responsive to regional climate conditions, potentially affecting residents' satisfaction and comfort, which are integral to their physical and psychological wellbeing. Consequently, it becomes imperative to project potential climate changes on a local scale and identify and quantify all potential impacts, facilitating the adoption of optimal adaptation measures.

Low-cost strata buildings, often characterized by multi-story structures with individually owned units, are particularly susceptible to the impacts of climate change due to their limited resources for adaptation and maintenance. Here are some of the key climate change impacts on low-cost strata buildings as summarised in Figure 1:

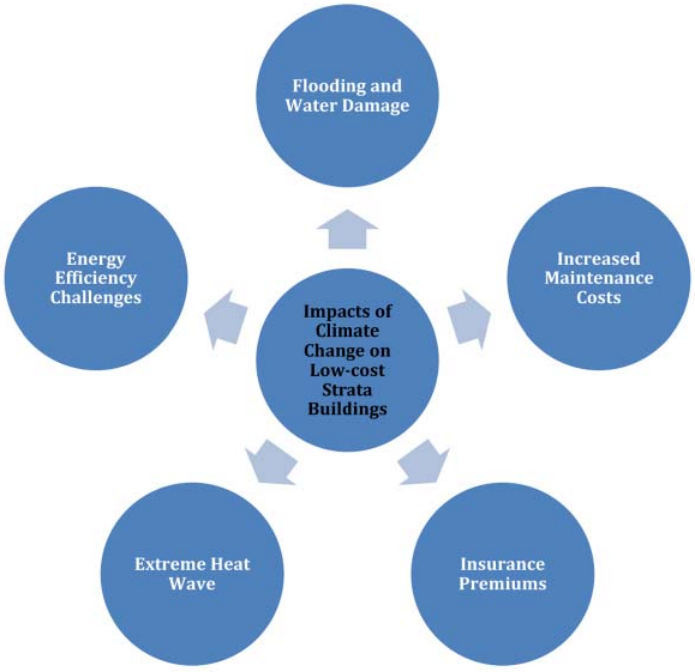

Figure 1: The Five Impacts of Climate Change on Low-Cost Strata Buildings

Flooding and Water Damage

Every year in Malaysia, floods emerge as the most significant natural disasters, affecting 4.9 million people and causing damage totalling millions of dollars, (Abdul Mohit & Mohammed Sellu, 2013). Abdul Rahman (2009) also stressed out that in Malaysia, the frequency of floods, which are one of the climate-related disasters, has been notably high. As stated by Rosmadi et al. (2023), floods have become a prevalent occurrence in Malaysia. Nonetheless, in recent years, there has been a significant rise in both the frequency and severity of these floods, primarily attributable to the effects of climate change. Among these climate-related disasters are small-scale flash floods, which pose a substantial risk to various facets of the ecosystem, particularly in densely populated urban centers which include low-cost strata buildings that are often located in flood-prone areas or regions with inadequate drainage systems. Climate change can exacerbate flooding, leading to water damage to ground-level units and basements, as well as potential structural damage of buildings, (Wobus et al., 2021; Jiachang et al., 2021;).

Extreme Heat Wave

Suparta and Yatim (2017) defined extreme heat wave as a prolonged duration of unusually high temperatures, which is expected to occur more frequently, last longer, and become more intense as the Earth's climate continues to warm. Numerous studies record elevated mortality rates linked to extreme heat events, (Mora et al, 2017). Tan et. al, (2021) studied the impact of climate change on a five different cities in Malaysia and concluded that there is a noticeable and consistent increase in temperatures observed across all five locations. High-rise low-cost strata buildings may become uncomfortably hot during heatwaves, especially if they lack adequate insulation and energy-efficient cooling systems. Since low-cost housing is typically viewed as a government initiative rather than a

profitable venture, developers are unlikely to prioritize quality and performance in low-cost housing projects. The majority of sustainable construction initiatives and demonstration projects have been executed in commercial buildings, office spaces, and private residences, (Zaid & Graham, 2011). Wan Mohamad et. al (2018) added that residents of low-cost housing often encounter numerous challenges associated with inadequate housing conditions, including issues pertaining to maintenance, comfort, health, safety, and security services. This further exacerbates the impact of climate change, especially concerning extreme heat, on low-cost housing. In many instances, low-cost housing design has traditionally overlooked concerns related to thermal comfort. Consequently, these types of houses often exhibit elevated indoor air temperatures during daytime hours, as reported by Tinker et al. (2004). Rising temperatures can lead to increased heat stress, particularly in urban areas with a high concentration of buildings. Buildings can absorb and retain heat, causing discomfort for occupants and increasing the need for air conditioning, which in turn raises energy consumption. This can lead to increased energy costs for residents.

Increased Maintenance Costs

Climate change-related impacts, such as flooding and extreme weather, can result in more undesirable frequent repairs of the exteriors of buildings and maintenance needs (Barelas, 2021). Low-cost strata buildings may struggle to cover these costs, leading to deferred maintenance and deteriorating building conditions. Grontoft (2011) also added that an increase of maintenance cost of building surfaces and facades is reported due to climate change.

Insurance Premiums

As the risk of climate-related damages increases, insurance premiums for low-cost strata buildings may rise, placing an additional financial burden on unit owners. Ehsan et al. (2022) stated that climate risk insurance schemes can offer incentives to mitigate adverse financial consequences but may not be economically feasible for individuals with lower incomes.

Energy Efficiency Challenges

Older low-cost strata buildings may lack energy-efficient features, making them less resilient to rising energy costs associated with increased cooling demands during heatwaves. Most of the low-cost housing in Malaysia are focusing on affordability rather than sustainable elements (Syed Jamaludin et al. 2018). The study by Zaid and Graham (2017) revealed that households residing in Malaysian public low-cost housing units consume energy at levels surpassing the benchmarks established by the World Energy Council and the International Energy Agency, as measured by the Building Energy Index (BEI) in kWh/m²/year. This observation highlights the absence of energy efficiency regulations pertaining to buildings in Malaysia, encompassing both residential and non-residential structures. Furthermore, Hassan et al. (2014) pointed out that the Malaysian modern residential house types require air conditioning to endure the hot tropical climate, a contrast to traditional Malay houses. This results in an increase in global energy consumption by residents especially in multi-unit strata buildings. Daud et al. (2023) also argued that residential consumers have been identified as a crucial target market for energy conservation and monitoring energy usage in the residential sector, which is the largest energy consumer, is challenging due to the complexity of energy usage patterns.

THE CLIMATE CHANGE ADAPTATION OPTIONS IN LOW-COST STRATA RESIDENTIAL BUILDINGS

Adaptation entails alterations in processes, methods, and infrastructure to mitigate potential harm or capitalize on opportunities linked to climate change. For instance, the implementation of climate-resilient building design and construction becomes imperative to minimize the adverse effects of climate change on real estate, as highlighted by Shafaghat et al. (2016).

The impact of climate change on low-cost residential buildings is a pressing global concern. As extreme weather events become more frequent and severe, residential structures face an increased risk of damage and disruption. To address these challenges, researchers and practitioners have been exploring a variety of adaptation options to enhance the resilience of residential buildings and improve the quality of life for their inhabitants (Ren et al., 2011; Bamdad, 2023; Bamdad et al., 2022; Stagrum,2020; Oliver et al., 2017; Huang & Hwang, 2016)

Low-cost residential buildings, often housing economically disadvantaged communities, face unique challenges in adapting to climate change due to limited resources and infrastructure. Climate change impacts such as extreme heat, flooding, and storms can disproportionately affect these communities. Effective adaptation strategies are essential to minimize risks and enhance resilience. Figure 2 shows the climate change adaptation options for low-cost strata buildings

Figure 2: Climate Change Adaptation Options for Low-Cost Strata Buildings

Building Envelope Improvements

Loo (2017) defined building envelope as physical separator between the exterior and interior of a building. He further emphasized that an effective building envelope adapts suitably to the local climate by using wall materials and designs that are appropriate for the specific climatic conditions. Approximately half of the energy losses from heat transfer are attributed to the building envelope. Consequently, designing an optimal building envelope is imperative to minimise the energy consumption of buildings (Baglivo et al.,2023; Verichev et al.,2021). Sohail et al. (2017) suggested building envelope improvements as a cost-effective adaptation option. This study explores strategies like insulation, cool roofs, and reflective coatings to reduce heat gain in low-cost residential buildings. It emphasizes the potential for energy savings and increased comfort. Kamaruzzaman et al. (2016) reported that research conducted in Malaysia anticipate a possible decrease in energy usage ranging from 15% to 25% in existing buildings by implementing energy-efficient measures which involve enhancing the building's envelope by incorporating appropriate insulation materials to minimize heat loss.

Various research have highlighted the significance of using climate-appropriate building envelope to enhance thermal comfort. For example, Al-Absi et al. (2021) investigates the effectiveness of phase change materials (PCMs) as a passive cooling technology to improve the indoor thermal

environment for more comfortable conditions for buildings in Malaysia. The output showed a significant improvement in the indoor thermal environment, especially when using lower transition temperatures and higher quantities of PCMs. The study by Anwar et al. (2021) revealed that among the options considered, natural ventilation and a green wall at the front of the building are the most effective choices for lowering overall energy consumption.

Recent studies worldwide have noted a significant reduction in energy consumption, ranging from 30% to 50%, attributed to modifications in building envelopes. These changes include improvements like thermal insulation in roofs and walls, external walls and roofs with shading, the incorporation of overhangs and wing walls in windows, as well as the use of reflective-coated glass for window glazing, (Anand, et al. 2023).

Community-Based Adaptation

As the impacts of climate change become increasingly severe, the need for community-based adaptation strategies in low-cost housing has gained attention in both research and practice. Community-based adaptation involves engaging residents in the adaptation process. McNamara et al. (2020) highlighted the importance of community participation in identifying local vulnerabilities and developing context-specific solutions for low-cost housing. One of the foundational steps in community-based adaptation is vulnerability assessment. Scholars such as Adger et al. (2018) stress the importance of comprehensive vulnerability assessments tailored to specific low-cost housing communities. These assessments consider various factors, including socio-economic conditions, infrastructure, environmental hazards, and community capacities. Once vulnerabilities are identified, resilience-building measures can be devised. Community engagement is a central pillar of effective climate change adaptation. Extensive research by Moser and Satterthwaite (2009) and Forsyth (2013) underscores the value of involving residents in decision-making processes, adaptation planning, and implementation. Inclusion of local knowledge, preferences, and needs enhances the ownership and success of adaptation initiatives. On the other hand, investing in climate-resilient infrastructure and housing upgrades is also imperative. Study conducted by Mukheibir et al. (2017) demonstrate the benefits of measures such as flood-resistant housing designs, improved drainage systems, and retrofitting of existing structures. These upgrades not only enhance physical resilience but also improve the quality of life for low-cost housing residents.

Ecosystem-based approaches have gained prominence for their potential to bolster resilience. Research by Vesseur (2021) and Hobbie and Grimm (2020) advocates for initiatives like urban green spaces, tree planting, and sustainable landscaping in low-cost housing communities. These approaches mitigate climate impacts, enhance biodiversity, and offer additional co-benefits, such as improved air quality. Ramyar and Zarghami (2017) also suggested the use of green infrastructure such as creating various green spaces that can enhance climate resilience.

Energy-Efficient Technologies

Energy efficiencies as one of passive building design strategies prove beneficial for addressing climate change, both in terms of mitigation and adaptation, as they enhance energy efficiency and reduce greenhouse gas (GHG) emissions. The findings of the study by Usta and Gok (2022) demonstrate that key solutions for adapting the impacts of climate change include energy-saving control methods, energy-efficient lighting equipment, end-user electricity usage patterns, as well as management technologies and systems designed to harness solar energy for electrical generation. Pajek et al. (2022) recommend the implementation of Passive Building Design that optimize the building's orientation, insulation, window placement, and natural ventilation to reduce the need for mechanical heating or cooling. This approach helps maintain comfortable indoor temperatures while

minimizing energy consumption. Another strategies suggested by Derler (2022) is installation of energy-efficient lighting systems, such as LED or CFL bulbs, significantly reduces electricity usage for lighting. These technologies also have longer lifespans, reducing maintenance costs. The use of smart lighting application for energy saving also been strongly suggested by Soheilian et al. (2021) in their study focusing on user well-being in the residential environment. Rainwater harvesting systems also been recognised as a effective energy efficiency tool by modifying residential environments to optimize the utility of available water for domestic use, (Pandey et al., 2023).

Climate-Responsive Design Guidelines

Various academics contemplate that design guidelines have the potential to serve as a tool for educating and transferring essential climate change knowledge from scientific research to practical design applications (Klemm et al., 2018). Climate-responsive design guidelines for residential buildings play a pivotal role in promoting sustainable and comfortable living environments. These guidelines offer architects and designers valuable insights into adapting residential structures to local climate conditions, (Kosir, 2019). Looman (2017) introduced a framework aimed at offering decision-support for climate-responsive design. This framework encompasses three fundamental elements: performance, process, and architectural outcomes. The performance aspect pertains to the evaluation of thermal comfort and energy efficiency associated with a design solution. The process component involves the application of energy functions, their impacts on collaborators, and adherence to design principles. Lastly, the architectural consequences factor addresses how a design solution influences the overall appearance of the architectural design.

CONCLUSIONS

The phenomenon of climate change is anticipated to have a significant impact on low-cost residential strata buildings, which serve as multifaceted living spaces for communities. Therefore, in line with the recommendations of the IPCC (2012), prioritizing the vulnerability and resilience of housing, infrastructure, and buildings is crucial. Establishing effective governance, policies, and incentives is essential for proactive engagement in climate change adaptation. The planning and implementation of adaptation measures are critically necessary to minimize building maintenance costs while fostering sustainable urban environments and communities, as highlighted by Snow and Prasad (2011). Alzahrani and Boussabaine (2016) pointed out that climate change-related risks have adverse consequences on building operations, efficiency, and occupant comfort. Consequently, De Wilde and Coley (2012) emphasize that the daily operation of buildings will be affected by the climate change phenomenon. It is widely acknowledged that the wellbeing of building occupants is influenced by how various components of the building environment are managed and maintained.

Adapting low-cost residential buildings to climate change represents a multifaceted challenge that entails a combination of building enhancements, community involvement, sustainable landscaping, adoption of energy-efficient technologies, and the integration of climate-responsive design principles. These adaptation options, as supported by the aforementioned journal articles, offer valuable insights into addressing the specific vulnerabilities of low-cost housing in the context of a changing climate.

Hence, property managers, who serve as custodians of these buildings, have a critical role to play in ensuring climate-resilient development that aligns with national sustainability goals. Property managers must proactively monitor and assess climate change risks, as previous studies have demonstrated the significant impact of climate change on both buildings and the broader community. To prepare adequately, property managers must anticipate the ways in which climate change will affect their properties and devise protective measures. Consequently, the climate change adaptation approach within residential property management has become increasingly important.

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