

Redefining Interiors: Sustainable Design Innovations for Health, Security and Environmental Well-Being

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ABSTRACT

The demand for healthier living environments has spurred a need for interior design solutions prioritizing health, security, and sustainability. This study explores the integration of smart, sustainable innovations in Malaysian residential interiors, aligning with the Sustainable Development Goals (SDGs). Using a qualitative methodology, the research utilizes case studies, observations, and interviews with interior designers to evaluate advancements not yet widely adopted in the local market, such as smart ventilation, bioactive materials, and adaptive lighting. Findings reveal that incorporating automated air purification, eco-friendly materials, and biometric security significantly enhances occupant safety and health. Furthermore, bio-integrated elements like living walls and strategic natural lighting effectively reduce stress and promote mental well-being. The research identifies that while the adoption of these technologies is in its infancy in Malaysia, they offer scalable solutions for improving indoor air quality and energy efficiency. This study contributes to the emerging field of smart interiors by providing a framework for addressing health and security challenges within the Malaysian urban context. By showcasing practical strategies for holistic well-being, the research serves as a resource for designers, architects, and policymakers. Ultimately, the findings advocate for a paradigm shift in local practice, positioning health, security, and environmental sustainability as core principles for future residential development.

1. INTRODUCTION

In an era of rapid urbanization and environmental challenges, the design of residential interiors is evolving to prioritize not only aesthetics but also health, security, and sustainability. Globally, innovations in smart technologies, bioactive materials, and adaptive systems are reshaping interior spaces to create environments that support the physical and mental well-being of occupants. For example, smart ventilation systems, such as automated air purifiers and humidity control, improve indoor air quality, while bioactive materials like antimicrobial surfaces and sustainable finishes enhance both health and environmental impact. Additionally, adaptive lighting systems, which adjust based on the time of day or occupancy, contribute to circadian rhythm regulation and overall comfort. Countries like Japan have made significant strides by integrating such innovations into residential interiors, demonstrating their effectiveness in enhancing occupant well-being. These advancements align with the World Health Organization (WHO) guidelines, which emphasize the critical role of interior environments in promoting health, safety, and sustainability.

However, in Malaysia, the adoption of these cutting-edge technologies and design strategies remains limited, with insufficient emphasis on creating interiors that cater to both environmental and human health needs. Current

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residential interiors often lack smart features like air purification systems, biometric security, and biophilic design elements, such as living walls and natural light integration, which have proven benefits for mental well-being. Living walls, also known as green walls or vertical gardens, are structures covered with vegetation that grow directly on or along the surface of walls. These walls typically consist of a vertical frame or support structure that holds soil or other growth media, allowing plants to grow upward, either indoors or outdoors. The benefits of living walls include improving indoor air quality by absorbing toxins and releasing oxygen, providing insulation and energy efficiency by regulating temperature, and enhancing the aesthetic appeal of a space.

This gap highlights an urgent need to explore and implement solutions that bridge global advancements with Malaysia's unique cultural, environmental, and socioeconomic context. By introducing locally relevant, innovative strategies for sustainable and health-focused design, this research aims to provide actionable insights that can reshape the Malaysian interior design landscape.

This study focuses on how integrating smart technologies, sustainable materials, and bio-integrated elements, such as green walls and eco-friendly insulation, can transform Malaysian homes into healthier, safer, and more sustainable living spaces. By examining both local and international practices, this research seeks to offer a framework for enhancing interior environments that not only align with the Sustainable Development Goals (SDGs) but also improve the quality of life for residents. Through this approach, the study advocates for a paradigm shift in Malaysia's residential interior design practices, aiming to redefine home environments as spaces that foster holistic well-being through innovation and sustainability.

2. LITERATURE REVIEW

The design of residential interiors plays a pivotal role in fostering environments that support the health and well-being of their inhabitants. As urbanization continues to accelerate globally, and environmental challenges such as climate change and air pollution intensify, there is an increasing recognition of the need for homes that prioritize not only aesthetics but also health, safety, and sustainability. This literature review explores the existing body of research in three key areas that form the foundation of this study: cultural context of healthy home, foundations of healthy home, and sustainable and smart home design, with a specific focus on the integration of Global Sustainability Indicators (SDGs) and Green Building Index (GBI) in Malaysian residential interiors.

Research by Hosseini, Mursib, Nafida, & Shahedi (2012) suggests that in many Southeast Asian countries, including Malaysia, traditional living practices emphasize the importance of natural ventilation, light, and the use of local materials that are deeply rooted in cultural and environmental values. These design principles, while traditional, often align with modern concepts of health and well-being. For instance, in Malaysian homes, the use of open floor plans, large windows, and courtyards that facilitate cross-ventilation reflects a cultural approach that prioritizes natural elements in home design. However, with rapid urbanization, the challenge lies in integrating these traditional practices with modern requirements, including energy efficiency and advanced security systems.

Cultural expectations around family safety and privacy also shape design choices, with residential buildings often incorporating private spaces that cater to the family unit, a concept that is deeply ingrained in the local Malaysian context (Sulaiman, 2016). The role of spatial configurations such as the orientation of rooms, entrance, and the use of barriers for privacy reflects the need for security within the home. As the adoption of contemporary technologies increases, it is essential to consider how these innovations can align with local cultural values while maintaining a focus on health and safety.

The WHO (2018) emphasizes the critical importance of indoor air quality and overall environmental conditions in promoting both physical and mental health. Ventilation systems, particularly smart ventilation technologies that adjust airflow based on indoor air quality, are increasingly recognized as vital to maintaining healthy living environments. Studies show that well-designed natural ventilation through windows, vents, and open spaces is essential for reducing the buildup of indoor pollutants such as carbon dioxide, formaldehyde, and particulate matter (Norback, Hashim, Ali, & Hashim, 2021). In Malaysia, where high humidity levels and tropical climates prevail, passive ventilation, including ventilated roof spaces and the strategic placement of windows, is a key component of

sustainable home design.

Research suggests that the use of sustainable materials, such as low-VOC paints and antimicrobial surfaces, plays a critical role in maintaining cleanliness while reducing environmental harm (National Center for Healthy Housing, 2023), that materials are integral to preventing the growth of mold and mildew, which can negatively affect respiratory health. Furthermore, adequate waste management systems and the adoption of eco-friendly cleaning products help create hygienic living spaces that support overall well-being (Lytle, 2023). Beyond basic physical security, modern residential design now incorporates biometric sensors, smart locks, and automated security systems that provide residents with real-time protection. Technologies have been shown to not only reduce the risk of crime but also enhance the overall sense of safety and well-being within the home (Li, Du, & Lei, 2021). The integration of these security features, particularly in urban areas, is becoming increasingly relevant, as concerns over crime and personal security grow.

The growing demand for sustainable and smart homes is reshaping residential interior design practices worldwide. In line with the Global Sustainability Goals (SDGs), particularly those focused on Good Health and Well-being (SDG 3) and Sustainable Cities and Communities (SDG 11), interior design is evolving to include smart technologies and sustainable materials that reduce environmental impact while enhancing occupant health. In Malaysia, the adoption of these technologies is still in its early stages, with the market primarily focusing on conventional construction practices. However, the frameworks like the Green Building Index (GBI) offer a promising step toward the integration of sustainable and smart solutions in residential design. Research by Che Mohd Nasir, Wan Ismail, Aziz, Anuar, Md Alwi, & Mohd Razali (2023) highlights that the GBI certification system encourages the use of energy-efficient designs, sustainable materials, and green technologies, which directly support the goals of the SDGs. Homes certified by GBI are more likely to incorporate features such as solar panels, rainwater harvesting systems, and energy-efficient appliances, which contribute to both the health and environmental sustainability of the home (Green Building Index, 2019).

3. METHODOLOGY

This study employed a qualitative research approach to examine the housing standards that contribute to a healthy living environment in Malaysia, focusing on three GBI-certified residential case studies: Eco World- Eco Forest, Semenyih, Eco World - Eco Majestic, Semenyih, and Setia Marina 2, Eco Glade (G3), Cyberjaya. These case studies were selected based on the alignment with sustainability principles and their relevance to the study's focus on healthy living environments. The first method employed was non-participant observation. This involved the researcher observing the physical spaces and features within the selected residential buildings, with particular attention to elements such as ventilation, spatial planning, interior materials, cleanliness, and safety and security features. The aim of the observation was to gather data on how these factors are integrated into the built environment and to identify any recurring patterns or themes related to housing standards conducive to living environment. Interviews were conducted with designers and architects associated with the selected residential case studies. These semi-structured interviews were designed to explore the key themes related to residential design including spatial organization, ventilation strategies, interior material selection, safety measures, and the overall lifestyle supported by the residential environment. Interview questions were developed deeper into the professionals' perspectives on the integration of sustainability, health, and well-being in residential design.

Following data collection, thematic analysis was conducted using ATLAS.ti version 9, a qualitative data analysis software. This process involved generating initial codes from the interview and observation data. The themes were then systematically grouped and analysed in relation to key aspects of housing design, such as ventilation, cleanliness, safety, security, occupants' lifestyles, design features, and residents' well-being. These themes were categorized according to the study's research objectives, with a particular focus on the relationship between housing standards and health outcomes. The analysis aimed to understand how the design features observed in the case studies either support or hinder health and well-being. The emerging themes were subsequently cross-checked against the data from the observation phase to ensure consistency and accuracy in the identified patterns.

4. ANALYSIS AND FINDINGS

Table 1 below are the findings from observations conducted at three selected case studies, highlighting key design elements and their impact on creating a healthy living environment.

Table 1. Findings from Observations on Sustainable Interior Design Practices

Element / case study	Eco Forest	Setia Marina 2	Eco Majestic
			
	Fig. 1 Eco Forest (Fieldwork, 2024)	Fig. 1 Setia Marina 2 (Fieldwork, 2024)	Fig. 1 Eco Majestic (Fieldwork, 2024)
Ventilation	Seamless connections between dining, living, and bar areas enhance airflow and visual coherence. Large sliding doors in the living room and bedroom strengthen the indoor- outdoor connection, allowing natural light and fresh air to flow freely. White-painted walls create an inviting, airy ambiance, easy access to private balconies adds a sense of tranquillity & connection to nature.	Strategic windows and ceiling fans enhance ventilation, while exhaust fans in kitchens and bathrooms remove pollutants. Double-glazing, passive cooling techniques, and air filtration systems improve air quality and regulate indoor temperatures effectively.	The master bedroom has a balcony for fresh air, while large windows and sliding doors in the living and dining areas enhance natural light and connect to the outdoors. Bedrooms feature strategically placed windows for optimal daylight.
Cleanliness	Regular dusting, vacuuming, and disinfection of high-touch surfaces to prevent germs. Routine maintenance of HVAC systems and bathroom ventilation ensures air quality and prevents mold, while emptying trash bins avoids odours	Regular cleaning, air conditioning maintenance, and dust filters ensure good air quality. Material choices, like tiles and laminate flooring, enhance aesthetics and easy to clean. Trash bins are emptied Daily.	Upholstered furniture is regularly cleaned to remove dust and allergens. The bathroom is kept clean, and the bed features a white duvet. White walls enhance the tranquil feel.
Safety and security	Well-planned spatial layouts, ensuring clear separation between public and private spaces, particularly for children's safety. Bedrooms at first floor enhance privacy, the integration of CCTV provides added security. Smart systems for tv & fans improve convenience, energy-efficient windows with double glazing enhance insulation and safety.	1200 mm high fence for protection, aluminium-framed glass windows for safety, security system with CCTV and a 3-tiered card system. Secure indoor parking, upper-floor bedrooms, and a double guard house enhance overall security.	1.5 mm mild steel fence integrated with brick walls for design and security. Security doors feature fingertip locks, and alarm systems enhance safety. Double-glazed windows, durable materials, and strategically placed CCTV cameras.

Interior material and finishes	Materials are selected for durability, aesthetics, and maintenance. Flooring like hardwood, tile, and carpet. Rugs prioritize comfort and upkeep, while cabinets use moisture-resistant materials like wood or MDF. Low-VOC paints and durable lighting enhance indoor air quality and functionality.	Tiles at busy areas are easy to maintain, timber flooring in bedrooms adds warmth. The car porch, terrace, and balcony feature durable surfaces, and the staircase has elegant timber. Ceramic tiles are used in the bathrooms and kitchen, with smooth plastered ceilings and white-painted walls	Design features scratch and stain-resistant materials, sustainable fabrics, and eco-friendly furniture. Bedrooms use natural wood and cotton for warmth, hardwood flooring offers durability. Seamless walls, pebble wash, timber accents, and cement render for floor
Facilities	Ample wardrobe space for organized living. Outdoor green areas provide a serene retreat, fostering relaxation and a connection with nature. A strategic laundry area near the entrance, with a glass ceiling, enhances aesthetics and promotes well-being through natural light.	Green spaces, including a fruit orchard, spice garden, and playground. It promotes an active lifestyle with facilities like a lookout deck, amphitheatre, jogging trail, and sports courts. Essential fittings, power sources, and a solar water heating system support sustainable living.	Bedroom features an en-suite bathroom and study area. The kitchen is linked to a functional yard, with ample storage ensures versatility. An outdoor seating area offers a retreat, and the family hall provides a cozy space for relaxation. All three bedrooms are conveniently located near the family hall for easy access.

Observations revealed that interior layouts and design choices such as the integration of natural ventilation, green spaces, and biophilic elements contribute to improved physical and mental well-being of residents. Spaces designed with natural light, proper ventilation, and ergonomic furniture were found to foster a healthier, more comfortable living environment. Effective safety measures, such as controlled access points, surveillance systems, and well-secured entryways, were integral to creating secure living environments. Sustainable building materials, energy-efficient systems, and waste management strategies were commonly incorporated into the design, reducing the environmental footprint of the homes and contributing to their long-term sustainability. The results further indicate that a balanced integration of health, security, and environmental considerations in interior design not only enhances quality of life but also ensures the long-term viability of housing solutions. This study emphasizes the interconnectedness of these elements in creating sustainable, secure, and health-promoting living spaces.

The interviews conducted with architects and designers from the three selected case studies provided valuable insights into the integration of sustainable design practices, health, and security features in residential interiors. The qualitative data collected from these interviews was coded and analysed using Atlas.ti, which allowed for the identification of recurring themes and patterns related to health, security, and environmental well-being. From the interviews, it organized around three main themes: Ventilation, Cleanliness, and Safety and Security, which are critical factors in creating a healthy and sustainable living environment. Additionally, two supporting themes, namely design features and residence well-being, further enhance the understanding of how interior design impacts the overall quality of life within the studied homes. Table below presents key findings derived from interviews with architects and designers, focusing on their approaches to creating residential spaces that promote health, well-being, and sustainability.

Table 2. Insights from Interviews with Architects and Designers

Theme	Key Findings
Ventilation	- Large windows, ceiling fans, sliding doors, and air filtration systems improve airflow and air quality, with plants reducing allergens. - Open to green areas, enhancing ventilation and maintaining privacy. - Airflow, energy efficiency, and pollutant reduction, especially for vulnerable residents. - Supports both physical health and emotional well-being by fostering openness with nature. - Ventilation is integrated into the overall design, enhancing comfort and sustainability.

Cleanliness	• Seamless surfaces in kitchens and bathrooms for easy maintenance. • Dedicated spaces for waste segregation and recycling. • Built-in storage for cleaning tools and supplies. Plumbing designed for easy cleaning tasks. • Regular cleaning routines improve air quality and reduce health risks. • Durable materials support cleanliness and maintenance. • Prioritizing cleanliness for a hygienic, sustainable home environment.
Safety & Security	• Sturdy doors, windows with toughened glass, and smart systems (CCTV, motion sensors). • Strategic window placement and landscaping for privacy and tranquillity. • Anti-slip flooring and durable finishes for safety. • 24-hour surveillance, access control, and secure parking. • Combining physical, technological, and environmental elements for a safe, secure home.
Design Features	• Optimized airflow and natural light through strategic window placements • Sustainable practices and energy-saving technologies. • Smart storage and easy to clean surfaces for a tidy space. • Balconies and gardens for relaxation. • Multifunctional spaces for universal design. • Design enhances comfort, convenience, and quality of life.
Health & Well-Being	• Incorporating natural ventilation, air filtration, and non-toxic materials to improve indoor air quality. • Designing furniture and layouts that promote physical health, offering comfort and support to reduce strain. • Integrating plants, green walls, and nature-inspired design elements to foster relaxation and mental well-being. • Soundproofing materials, acoustic treatments, and strategic layout to minimize noise and enhance comfort. • Creating functional, organized, and flexible spaces that cater to residents' needs.

The interviews revealed a strong consensus among architects and designers that incorporating the main themes of ventilation, cleanliness, and safety & security is essential for creating healthier, more sustainable living environments. These themes were supported by design elements that enhance health and well-being, contributing to the overall quality of life for residents. By focusing on both practical and aesthetic aspects of design, these spaces foster a harmonious balance between functionality, security, and occupant health. The combined insights from the interviews with architects and designers, as well as the observations conducted, highlight the importance of a holistic approach in residential design. The core themes of ventilation, cleanliness, and safety & security are pivotal in fostering healthy, comfortable, and sustainable living environments. Design elements such as natural ventilation, accessible waste management, robust safety measures, and thoughtful spatial organization were consistently prioritized across both interviews and observations.

5. CONCLUSION

A significant conclusion is that interior design elements such as natural ventilation, seamless cleaning solutions, and integrated safety features are not merely aesthetic choices but crucial factors that directly contribute to the well-being of residents. In Malaysia, the tropical climate and high humidity are prominent, ensuring adequate ventilation is essential for maintaining indoor air quality and reducing reliance on energy intensive cooling systems. The integration of natural light, strategic window placements, and passive cooling elements proves to be an effective and sustainable approach.

The study also underscored the importance of cleanliness and hygiene in residential interiors. Designers and architects increasingly prioritize easy to clean surfaces and built-in storage for cleaning supplies, contributing to healthier living environments. Waste management, including the design of spaces for proper waste segregation, also emerged as a key factor in promoting cleanliness and environmental sustainability. This focus on hygiene aligns with the increasing demand for healthy homes in Malaysia, particularly amidst concerns over air quality and the spread of

diseases. Security and safety were found to be integral to interior design, particularly in urban areas where privacy and protection from external threats are significant concerns. The incorporation of advanced technologies, such as CCTV systems, motion sensors, and secure locking mechanisms, enhances both physical safety and residents' peace of mind.

Additionally, the research demonstrates how sustainable and health-conscious interior design can address environmental concerns. The integration of energy-efficient technologies, sustainable materials, and biophilic design principles also supports Malaysia's broader environmental goals. These innovations reduce the carbon footprint, promoting long-term sustainability and healthier living spaces for both current and future generations.

In conclusion, this research confirms that sustainable design practices in interior architecture are essential for creating healthier, safer, and more environmentally responsible residential environments. By prioritizing health, security, and environmental well-being, this study offers valuable insights for designers seeking to create spaces that enhance both individual well-being and environmental sustainability. Future studies could explore the long-term impact of sustainable interior design on residents' health and well-being after extended occupancy, providing deeper insights into how elements like air quality, noise control, and lighting influence mental health and comfort.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Authors' Contributions To ensure proper credit and accountability, the individual contributions of the authors are specified as follows:

Siti Nuratirah Che Mohd Nasir: Substantial contribution to the conception and design of the work; and the acquisition, analysis, and interpretation of data.

Salmiah Aziz: Conceptualization, methodology, and overall project supervision. Responsible for communication with the journal and ensuring the integrity of the final manuscript.

DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

During the preparation of this work, the authors used Gemini (Google) to improve the readability and language quality of the abstract and manuscript. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

ETHICS STATEMENT

This study was reviewed and approved by the Institutional Ethics Committee of Universiti Malaysia Kelantan. All procedures involving human participants were in fulfilment of the ethical standards of the 1964 Helsinki Declaration. Informed consent was obtained from all participants, and data anonymity was strictly maintained throughout the study.

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