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A Holistic Review of Sustainable Housing Attributes

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Abstract

This paper conducts a holistic review of studies on sustainable housing, focusing on the holistic attributes that will impact the sustainable house value as a whole. By reviewing 18 articles on sustainable house previous research, this paper identifies and examines key criteria for sustainable housing, derived from environmental, economic, social, and physical perspectives. The analysis of this study found 9 characteristics or attributes that consist of Environmental; Energy Efficiency (1), Water Efficiency (2), and Waste Management (3). For Economic; Job Opportunity (4) and Economic Facilities (5), while for Social Dimension it includes Security and Safety (6), Amenities and Infrastructure (7). The author also adds the Physical Dimension as an additional to simplify the adjudication for building condition, the attributes for this dimension are Building Layout and Design (8), and Building Materials (9). These criteria serve as a framework for assessing sustainable housing and offer a foundation for future studies aimed at adapting sustainable practices to evolving needs. The findings aim to assist in understanding how sustainable housing holistic attributes can be valued in the adjudication process.

1. Introduction

A house is a fundamental necessity for human shelter. This need has become increasingly important due to urbanization, driven by migration from other regions and countries. Such movement into urban centers raises population levels; for example, by 2017, China's rapid urbanization had resulted in 342 million people migrating to urban areas (Lee et al., 2022). This growth increases the demand for housing, affecting both supply and demand in these regions. According to Lee et al. (2022), many cities have experienced rapid urbanization in recent decades, often emphasizing physical expansion. Additionally, UNDESA (2019) forecasts that by 2050, around 68% of the global population will reside in cities.

Further, Angela et al. (2022) highlight that rising urbanization has intensified the growth of slums, informal settlements, and other underserved areas. Despite the urgency of this issue, a comprehensive dataset providing statistical and spatial insights into the global distribution and characteristics of these deprived areas is still lacking. This gap underscores the pressing need to develop a robust data ecosystem capable of identifying and characterizing urban deprivation, as well as supporting a wide range of stakeholders in addressing it. The challenges arising from rapid urbanization have contributed to the emergence of the sustainable development agenda, which aims to foster a better living environment for all—particularly through enhanced and equitable housing development.

In Malaysia, sustainable housing development is increasingly being adopted by developers. Notable examples include the City of Elmina, Gamuda Cove, and KEN RIMBA projects, all located in the Klang Valley, which integrate sustainability concepts into their designs. In the Klang Valley area, it is about 72 projects that currently implement the sustainable house concept of development. This trend has led to a growing number of transactions for sustainable houses in the property market, highlighting the need for accurate valuation methods. However, there is still no comprehensive pricing model that holistically considers the three dimensions of sustainability—environmental, economic, and social—and their combined impact on house prices. Previous research on sustainable housing valuation has primarily focused on the singular effects of one dimension, such as the environmental impact on house prices, rather than addressing all three dimensions collectively.

Kucharska-Stasiak and Olbińska (2018) highlight earlier research suggesting that sustainability can increase a property's net income stream and reduce income risk, making it reasonable to assume that it may also affect property value. To investigate this, numerous studies have been conducted analyzing both revealed and stated preferences, including willingness to pay (WTP). These studies indicate that, in both continental Europe and the UK, most respondents believe sustainability impacts property prices. However, this belief is not yet strongly supported by market evidence. Establishing whether such a relationship truly exists would require long-term research involving a large sample of buildings. While such studies are still uncommon in Europe, initial steps have been taken.

From the above exploration, it can be said, that in order to produce solid market evidence or market information, for the price of a sustainable house to reflect the actual market value, the existence of empirical data, and comparable data for valuation purposes, the valuation adjudication shall consist of the impact of all three pillars of sustainable development namely Environment, Economic and Social pillar as a whole or the holistic way. The holistic approach then, will portray a real market value of the sustainable house. The holistic approach constitutes with holistic attribute of a sustainable house. It refers to an approach that considers the entire system of the house and its impact on the environment, economy, and society as a whole. It involves integrating various sustainable practices and principles across different aspects of the house design concept, construction, operation, and maintenance.

1.1 Sustainable Housing Concept

Sustainable housing can be simply defined following the Brundtland Commission's framework: it is a housing development that addresses the needs and demands of the current generation without compromising the ability of future generations to meet their own housing needs.

Adamec, Janoušková, and Hák (2021) propose that sustainable housing can be assessed through environmental, social, and economic indicators that reflect its long-term performance. According to UNHABITAT (2012), sustainable housing aims to achieve economic, environmental, and social goals. It includes housing designed to withstand hazards, accommodate individual preferences and control, provide value, and align with social and cultural priorities.

Said et al. (2017) define sustainable housing as housing that is accessible, cost-efficient, and incorporates environmental, social, economic, and aesthetic considerations into its design. Cost efficiency includes the optimal use of energy and water resources, along with effective waste management. Similarly, Rahman et al. (2018) emphasize that housing improvement is a critical economic sector, contributing significantly to urban development and sustainability. Additionally, Mehmood and Para (2013) explain that sustainable housing addresses social vulnerability, economic viability, and environmental sustainability within the housing context.

It is supported by Adabre and Chan (2020), citing Shen et al. (2011), describe sustainable development in housing as a dynamic process that integrates four key sustainability goals: economic, social, environmental, and institutional. Housing, as a fundamental social necessity, plays a vital role in shaping the quality of life and overall well-being of a nation's citizens. From this perspective, sustainable housing can be defined as a residential environment that offers appropriate facilities and amenities, thereby contributing to the occupants' well-being through environmental, economic, and social sustainability dimensions.

From Figure 1.1 Malaysia Overall Performance on Sustainable Development Goals 2030 implementation in the year 2021, Malaysia has been ranked 65th over 165 countries involved, identified a moderate improvement for SDG 11 which to produce sustainable cities and communities there is an increase in annual mean concentration of particulate matter and access to improved water source and piped in urban population. While there is a decrease in satisfaction with public transport. This conveys a meaning that, Malaysia is in the process of implementing sustainable cities through sustainable housing development which is related to the Malaysia Housing Policies 2018-2025.

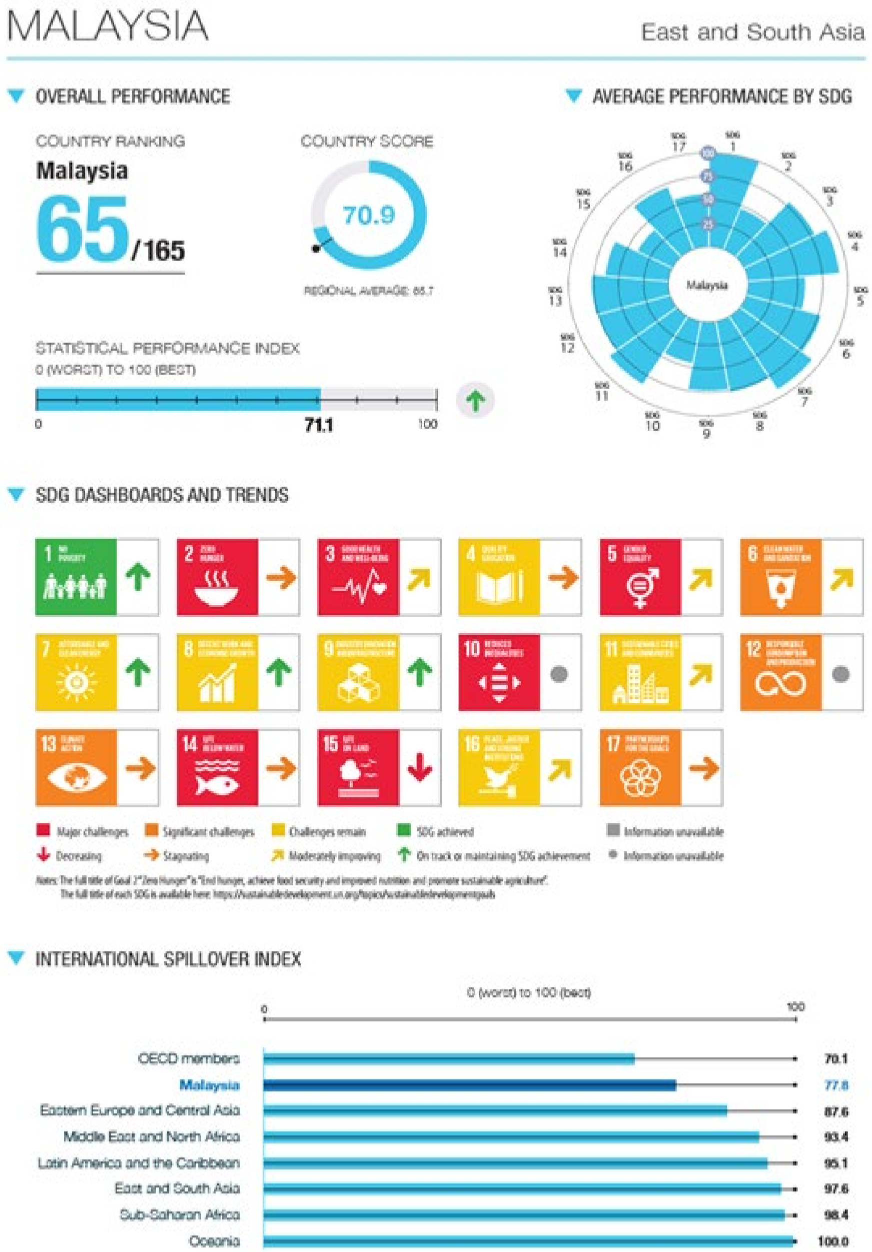

Fig. 1 *Malaysia's overall performance on sustainable development goals 2030 implementation in 2021*

1.2 Key Criteria of Sustainable Housing

The key criteria for sustainable housing, integration of the following perspectives, derived from existing studies:

1.2.1 Environmental Criteria

Sustainable housing must minimize environmental impact through energy efficiency, water conservation, and the use of eco-friendly materials. This includes designing homes that optimize natural resources, reduce carbon footprints, and promote recycling. Key factors in this dimension include the use of green energy sources (such as solar and wind), emission reduction, and efficient water management (Ruíz et al., 2023; Nainggolan et al., 2020).

1.2.2 Economic Criteria

Sustainable housing also involves cost-efficiency throughout its lifecycle—from construction to operation and maintenance. Economic sustainability focuses on affordability, resource-efficient technologies, and minimizing the long-term costs of housing, such as energy bills and repair expenses. Affordable housing solutions that incorporate sustainable technology without inflating costs are crucial (Ruíz et al., 2023).

1.2.3 Social Criteria

This dimension ensures that housing promotes social equity, inclusiveness, and quality of life. It includes designing spaces that foster community interactions, provide safety and accessibility, and meet the needs of diverse populations. Social sustainability also emphasizes cultural adequacy and the alignment of housing projects with the social fabric of the area (Ruíz et al., 2023; Nainggolan et al., 2020).

1.2.4 Physical Criteria

Housing should also meet physical sustainability standards, ensuring resilience to climate change and environmental hazards. Durability, structural integrity, and the ability to withstand natural disasters are crucial. Additionally, housing should be adaptable, enabling future modifications and improvements without extensive resource use (Nainggolan et al., 2020).

1.3 Sustainable Building Design Principles

The *Whole Building Design Guide* (WBDG, 2024) explains that the definition of sustainable building design evolves over time, yet six fundamental principles continue to persist:

- **Optimize Site Potential**

  Creating sustainable buildings begins with carefully selecting the site, which may involve reusing or rehabilitating existing structures or choosing a brownfield, greyfield, or previously developed area. The location, orientation, and landscaping of buildings influence local ecosystems, transportation options, and energy consumption. Integrating smart growth principles is essential in project development, whether for a single building, a campus, or a large complex like a military base. Ensuring physical security is also vital in site planning, including the positioning of access roads, parking, vehicle barriers, and perimeter lighting. In both new construction and retrofitting, the site design must align with sustainable principles to ensure project success. Sustainable building sites should manage, control, or treat storm-water runoff effectively and aim to support the native plants and wildlife of the area through thoughtful landscaping.

- **Optimize Energy Use**

  As demand for fossil fuels rises and concerns about energy independence, security, and the visible impacts of global climate change intensify, it becomes crucial to reduce energy consumption, enhance efficiency, and prioritize renewable energy sources in federal facilities. Enhancing the energy performance of existing buildings is a key step toward achieving greater energy independence. Both government and private organizations are increasingly dedicated to creating and operating net-zero energy buildings to substantially reduce reliance on fossil fuels.

- **Protect and Conserve Water**

  Fresh water is becoming increasingly scarce in many regions of the United States. Because construction alters the ecological and hydrological balance of natural land, sustainable buildings should aim to reduce impervious surfaces, thereby minimizing ecological impact. They should also prioritize efficient water use and, where possible, reuse or recycle water for on-site needs. Delivering potable water to homes requires substantial energy for pumping, transport, and treatment, often involving chemicals to ensure safety. Additionally, sewage treatment carries considerable environmental and financial costs.

- **Optimize Building Space and Material Use**

  As the global population grows (projected to exceed 9 billion by 2050), the consumption of natural resources will continue to rise, and the demand for goods and services will further strain available resources. It is essential to utilize materials in a well-integrated and efficient way to maximize their value, prevent 'upstream' pollution at the source, and conserve resources. Sustainable buildings are designed and operated to use and reuse materials efficiently throughout their entire life cycle and can be adapted for future use. Materials chosen for sustainable buildings are intended to minimize life-cycle environmental impacts, including global warming, resource depletion, and toxicity. Environmentally preferable materials reduce negative effects on human health and the environment, enhancing worker safety, lowering liabilities, and cutting disposal costs.

- **Enhance Indoor Environmental Quality (IEQ)**

  A building's indoor environmental quality (IEQ) greatly affects the health, comfort, and productivity of its occupants. Sustainable buildings prioritize maximizing natural light, ensuring proper ventilation and moisture control, optimizing acoustics, and selecting materials with high Volatile Organic Compounds (VOC) emissions. IEQ principles also highlight the importance of allowing occupants control over systems like lighting and temperature.

- **Optimize Operational and Maintenance Practices**

Incorporating considerations for a building's operations and maintenance during the initial design phase can lead to improved work environments, increased productivity, lower energy and resource costs, and reduced risk of system failures. Involving building operators and maintenance personnel in the design and development phases ensures optimal functionality and maintenance of features like stormwater systems that minimize the building's environmental impact. It is also important to recruit, develop, and train skilled maintenance staff to manage the sophisticated systems of high-performance buildings effectively. Designers can specify materials and systems that are easier to maintain, require minimal water, energy, and toxic chemicals, and reduce overall life-cycle costs. Additionally, facilities should include metering systems to monitor the progress of sustainability efforts, such as reductions in energy and water consumption and waste generation, both on-site and within the building.

1.4 Sustainable Housing Holistic Attributes

Chau et al. (2015) describe a "characteristic" as a feature that differentiates one housing project from another. Wong and Susilawati (2018) observe that real estate agents often promote sustainability features that enhance occupants' health, safety, and access to more efficient facilities—attributes that increase perceived value throughout a property's lifespan. It can be defined, sustainable features as elements that enhance the health, safety, and facilities available to occupants throughout the lifespan of a home. Thus, the term "sustainable features" can also be interpreted as "sustainable characteristics" or "sustainable attributes," given the lack of a standardized term to describe the essence of a sustainable house. Additionally, Mohammad @ Masri et al. (2021) emphasize material aspects of housing quality—such as functionality and construction elements—that buyers prioritize (Mohamad @ Masri et al., 2021). They draw on Yazdanfar and Nazari (2015), who argue that *physicality*—defined as quality, physical elements, and functionality—contributes significantly to creating a high-quality residential environment.

This study aims to enhance the potential for sustainability in housing research by examining sustainability in housing through the practices and applications discussed in previous studies related to this topic. That research will be compiled and characterized into nine sustainable housing attributes. These nine attributes will be represented by coding in Table 1.2 Sustainable House Holistic Attributes. The attributes in this study are as follows:

Table 1 *Sustainable house holistic attributes*

Dimensions	Attributes	Coding
Environmental	1.Energy Efficiency	EE
	2.Water Efficiency	WE
	3.Waste Management	WM
Economic	4.Job Opportunity	JO
	5.Economy Facilities	EF
Social	6.Security and Safety	SS
	7.Amenities and Infrastructure	AI
Physical	8.Building Layout and Design	BLD
	9.Building Material	BM

For the Environmental Dimension, United Nations, 2015 explains that housing should be planned, constructed, and utilized to minimize environmental impact and promote sustainability. Regarding the Economic Dimension, housing plays a significant role in national economies, serving as both a driver of economic vitality and a means to meet people's essential needs. The Social Dimension focuses on fostering social inclusion and participation, enhancing public health, ensuring transparency, supporting community well-being, and a concern for ethical processes. While physical dimensions represent the condition of the house building itself.

2. Method

This paper identifies the holistic attributes of sustainable housing based on the holistic review of 18 articles from previous research frameworks related to sustainable housing as shown in Table 2. The term holistic means the attributes cover all three pillars of sustainable housing dimension that is environmental, economic, and social. The code at the end of the sentence indicates the most prominent aspect among the nine holistic attributes of a sustainable house. This study found 9 characteristics or attributes that consist of Environmental; Energy Efficiency, Water Efficiency, and Waste Management. For Economic; Job Opportunity and Economic Facilities, while for Social Dimension include Security and Safety, Amenities, and Infrastructure. The author also adds the Physical Dimension as an additional to simplify the adjudication for building condition, the attributes for this dimension are Building Layout and Design, and Building Material.

2.1 Sustainable House Previous Research

Table 2 *Previous research framework*

No.	Previous Research		
	Title of Article	Authors/Year	Attributes
1.	Indicators of Sustainable Housing Development (SHD): A Review and Conceptual Framework	Ng Ming Yip, Jamilah Mohamad, Goh Hong Ching (2017)	1.Physical (BLD) 2.Social (SS) 3.Environment (EE, WM,WE) 4.Economic (JO,EF)
2.	Assessing Sustainable Housing Indicators: A Structural Equation Modeling Analysis	Mahla Tayefi, Nasrabadi, Hossein Hataminejad (2019)	1.Physical Dimension (BLD&BM) 2.Environmental Dimension (EE, WM, WE)
3.	Sustainable Housing Practices in Malaysian Housing Development: Towards Establishing Sustainability Index	Abu Hassan Abu Bakar Khor Soo Cheen Rahmawaty (2011)	1.Environmental (EE, WM, WE) 2.Social (SS) 3.Economics (JO, EF) 4.Building Forms (housing)(BLD) 5.Site/Land uses (BLD) 6.Communication & Transportation (AI)
4.	Residential Building Quality Measurement and The Relationship With House Prices : A Study of Houses in Klang	Muhammad Hilmi Mohammad @ Masri, Mohd Farid Sa'ad, Najman Azman, Mohd Hasrol Haffiz Aliasak (2021)	1.Functionality (BM) 2.Presentation (BLD) 3.Environment (EE) 4.Amenities (AI) 5.Community (AI) 6.Management (SS)
5.	Hierarchical Structure Determination of Value of Residential Real Estate. Residential Property Value and Location Externalities	Tom Kauko (2003)	1.Locational Quality (AI) 2.Physical attributes of the house (BLD) (BM)
6.	How To Measure Sustainable Housing A Proposal For An Indicator-Based Assessment Tool	Jacub Adamec, Svatava Janouska, Tomas Hak (2021)	1.Environmental (EE,WM,WE) 2.Economic (JO,EF) 3.Social (SS) 4.Institutional(SS)
7.	Consumer Behaviour In The Valuation Of Residential Property A Comparative Study In The UK, Ireland And Australia	Jacqui Daly, Stuart Gronow, Dave Jenkins Frances Plimmer (2003)	1.Location(AI) 2.Proximity to amenities(AI) 3.Accessibility garage(BLD) 4.Low maintenance(EE) 5.Locality (place to live)(AI) 6.Accomodation(SS) 7.Interior décor and design (BLD) 8.Roof tiles (BM) 9.Brick construction(BM) 10.Manageable garden(BLD) 11.Large plot (BLD) 12.Within price range(nill) 13.Neighbourhood Aspect (SS) 14.Aesthetic appearance(BLD)

No.	Previous Research		
	Title of Article	Authors/Year	Attributes
			15.Well built (BM) 16.Fire resistance (BM)
8.	Reflecting Sustainability In Property Valuation-Defining The Problem	Ewa Kurcharska-Stasiak, Katarzyna Olbinska (2018)	1.Energy Efficiency (EE) 2.Reduced impacts on the environment(EE) 3.Increased functionality, serviceability, durability, and adaptability (BM) 4.Ease of conducting maintenance, servicing, and recycling activities (EE & WM) 5.Increased comfort and well-being of occupants (BLD)
9.	A Situational Study on Sustainable Housing Features In Johor	T Kamaruddin, R Abdul Hamid, N A S Rohaizam (2020)	1.Affordability(nill) 2.Availability in the market(nill) 3.Sufficient number of housing(nill) 4.Great variety of green and quality housing (BLD) 5.Design, size, and comfort (BLD) 6.Natural and social environment (BLD) 7.Energy efficiency and waste management (EE and WE) 8.Secure and friendly neighborhood (SS) 9.Accessibility to schools, health, and other services(AI) 10.Established technical and hygienic requirements (WM)
10.	The Potential Market For Sustainable Housing Under The Contingent Valuation Method City Of Palmira	Maria Victoria Pinzon Botero, Stephany Byaney Villota Ortiz (2019)	1.Reduction in drinking water consumption(WE) 2.Water losses and residue (WE) 3.Alternative resources(EE) 4.Energy Efficiency (EE) 5.Reduction in non-renewable energy(EE) 6.Waste management (WE) 7.Material's Properties (in structure, enclosures, roof, floors)(BM) 8.Implementation of regional materials(BM) 9.Thermal comfort (EE) 10.Indoor Air Quality(EE) 11.Visual Comfort(EE) 12.Hearing Comfort(EE) 13.Innovation in design(BLD) 14.Environmental design(BLD) 15.Contamination(EE) 16.Environmental culture(EE) 17.Urban equipment(BM) 18.Sensitivity(SS) 19.Quality of infrastructure (road, leisure, spaces…)(AI)

No.	Previous Research		
	Title of Article	Authors/Year	Attributes
			20.Site security (design and management)(SS) 21.Land use (BLD) 22.Daylight and sunlight exposure(BLD) 23.Capital cost(EE) 24.Cost Lifecycle(EE) 25.Environmental cost(EE) 26.Local materials(BM) 27.Improvement on local work (SS) 28.Localisation(AI)
11.	Reflecting the Sustainability Dimensions on the Residential Real Estate Price	Marilena Mironiuc Elena Ionascu Maria Carmen Huian and Alina Taran (2021)	1.Economic (JO,EF) 2.Social(SS) 3.Environmental(EE,WE,WM) 4.Institutional(SS)
12.	Sustainability In Property Valuation: Theory and Practice	David Lorenz Thomaz Lutzkendorf (2008)	1.Flexibility and adaptability (BLD) 2.Energy efficiency and savings in water usage (EE AND WE) 3.Use of environmentally friendly and healthy building products and materials(BM) 4.High functionality in connection with comfort and health of user and occupants (EE) 5.Construction quality; ease of conducting maintenance, servicing and recycling activities(EE) 6.Compliance with/over-compliance with legal requirements in the areas of environmental and health protection (EE) 7.Reduced impacts on the local and global environment(EE)
13.	Towards A Sustainability Assessment Model for Affordable Housing Projects: The Perspective of Professionals In Ghana	Michael Atafo Adabre Albert P.C Chan (2020)	1.Rental cost of housing facility in relation to household income(nill) 2.Housing price in relation to the income of household(nill) 3.Maintainability of housing facility (EE) 4.End users' satisfaction (SS) 5.Functionality of housing facility (EE) 6.Other life cycle cost of housing facility (EE) 7.Safety performance of housing facility (EE) 8.Commuting cost from the location of housing facility to public facilities (AI) 9.Quality performance (EE) 10.Energy and water efficiency of housing facilities (EE&WE) 11.Environmental performance of housing facility (Eco-friendly) (AI)

No.	Previous Research		
	Title of Article	Authors/Year	Attributes
			12.Aesthetic view of completed housing facility(BLD) 13.Reduced occurance of disputes and litigations(nill) 14.Stakeholders'/ neighbourhoods' satisfaction with housing project(AI) 15.Technical specification of housing facility (AI) 16.Technology transfer(nill)
14.	Measuring The Social Sustainability Of New Housing Development: A Critical Review Of Assessment Methods	Tim Dixton (2019)	Component of Social Sustainability 1.Amenities and infrastructure (AI) 2.Social and cultural life (SS) 3.Voice and influence (SS)
15.	10 Criteria of Sustainable Housing: A Literature Review	Susanti Muvana Nainggolan, Ova Candra Dewi and Toga H Panjaitan (2020)	1.Physical buildings (BLD &BM) 2.Energy use (EE) 3.Waste, Water and Wastewater (WWW) – (WE & WM) 4.Site and surroundings (AI) 5.Human behavior (SS) 6.Quality of housing (JO,EF) 7.Social culture and values (SS) 8.Communication and transportation (AI) 9.Safety and comfort (SS) 10.Price and availability(nill)
16.	A Holistic Conceptual Scheme for Sustainable Building Design in the Context of Environmental, Economic and Social Dimensions	Arzuhan Burcu Gultekin, Handan Yucel Yildirim and Harun Tanrivermis (2018)	1.Site efficiency (BLD) 2.Energy efficiency (EE) 3.Material efficiency (BM) 4.Resource efficiency (EE) 5.Cost efficiency (EE) 6.Health and well-being((BLD) 7.Public awareness (BLD)
17.	Assessment of Social Sustainability Indicators in Mass Housing Construction: A Case Study of Mehr Housing Project	Ali Karjia, Asregedew Woldesenbetb,, Mostafa Khanzadic, and Mohammadsoroush Tafazzolid (2019)	1.Construction & Community (BLD & AI) 2.Health, Safety & Risk (SS) 3.Livability (EE) 4.Neighborhood Characteristics (AI)
18.	Sustainable Housing Indicators and Improving the Quality of Life: The Case of Two Residential Areas in Baghdad City	Dr. Eng. Jakleen Qusen Zumaya and Prof. Dr. Jamal Baqir Motlak (2021)	1.Affodable housing(nill) 2.Conditions of the dwelling unit to live (BLD) 3.Social services (SS) 4.Infrastructure (AI) 5.Transport (AI) 6.Identity (SS) 7.Safety and security (SS) 8.Environmental pollution (EE)

Note: Nill is the attribute not significant for this study. Price and affordability are not included because this research to identify attributes that affect house prices.

3. Illustrations

From Table 3 it can be seen Energy Efficiency (EE) as 1st criterion has become the main concern of attributes as it has been discussed on frequency 16 articles out of 18. The second attribute is the Building Layout and Design (BLD) frequency of 14 articles. While Safety and Security (SS) discussed on frequency 12 articles as a 3rd important attribute. On the 4th Amenities and Infrastructure frequency 11 articles, 5th Water Efficiency (WE) which is 10 articles. 6th Building Materials (BM) has been discussed by 9 articles, 7th Waste Management 8 articles, and for the 8th, 9th it is 5 articles discussed about Job Opportunity (JO) and Economic Facilities (EO).

Table 3 *Sustainable housing attributes frequency*

ARTICLE NO.	ATTRIBUTES								
	EE	WE	WM	JO	EF	SS	AI	BLD	BM
1	/	/	/	/	/	/		/	
2	/	/	/					/	/
3	/	/	/	/	/		/	/	
4	/					/	/	/	/
5							/	/	/
6	/	/	/	/	/	/			
7	/					/	/	/	/
8	/		/					/	
9	/	/	/			/	/	/	
10	/	/	/			/	/	/	
11	/	/		/	/	/			/
12	/	/						/	/
13	/	/				/	/		/
14						/	/		
15	/	/	/	/	/	/	/	/	/
16	/							/	/
17	/					/	/	/	
18	/					/	/	/	
FREQUENCY	16	10	8	5	5	12	11	14	9

3.1 Energy Efficiency (EE)

Energy efficiency has been a favorable attribute this is because from 18 articles, 16 articles or authors select it as an attribute. Nainggolan et al. (2020) explain their study about sustainability aspects and limitations on energy. They elaborate on energy as a sustainable housing criterion that energy use by the building, building emission, the use of technology for new energy resources, maintenance, etc. Other than that, Vasiliy Stoikov and Violetta Gassiy (2018) describe energy efficiency in housing as a critical tool for sustainable development, noting that sustainable buildings represent the culmination of advancements in energy-efficient construction. They explained that energy-efficient buildings must integrate a comfortable indoor climate, maximize the use of natural energy, and optimize the building's energy systems as a cohesive unit. Energy efficiency in buildings refers to the actual or estimated energy consumption for everyday functions such as heating, water heating, cooling, ventilation, and lighting.

In essence, energy efficiency means achieving the same results or completing the same tasks with less energy, thereby minimizing energy waste. It involves optimizing the use of energy in various systems, processes, or appliances so that the energy input is minimized while maintaining the desired performance. In the context of buildings and housing, energy efficiency can be achieved through measures such as:

- **Insulation:** Proper insulation reduces the need for heating and cooling by keeping indoor temperatures stable.
- **Efficient appliances:** Using energy-efficient appliances (e.g., refrigerators, washers, HVAC systems) that consume less electricity or fuel to perform the same functions, motion sensors, light sensors, and solar panels.
- **Lighting:** Switching to LED or other energy-saving lighting options that use less power compared to traditional incandescent bulbs.

- **Windows and doors:** Installing energy-efficient windows and doors that prevent air leaks and help maintain indoor temperatures.

For example, Etchells Building Design (2021) proposes that sustainable housing should empower *passive design strategies*, including site and building orientation, spatial zoning, thermal mass, ventilation, and shading. These are complemented by insulation, heating, and cooling systems tailored to specific climate conditions. The goal of energy efficiency is not merely to reduce energy consumption, but also to lower energy costs and minimize environmental impacts, such as carbon emissions. In sustainable housing, energy efficiency is a fundamental criterion because it contributes to both environmental sustainability—by reducing greenhouse gas emissions—and economic sustainability—by decreasing household utility expenses.

3.2 Water Efficiency (WE)

Ng Ming Yip et al. (2017), Tayefi Nasrabadi and Hataminejad (2019), Abu Hassan Abu Bakar et al. (2014), Adamec et al. (2021), Kamaruddin et al. (2020), Pinzón Botero and Villota Ortiz (2019), Mironiuc et al. (2021), Lorenz and Lützkendorf (2006), Adabre and Chan (2020), and Nainggolan et al. (2020) identified water efficiency as one of the key sustainable housing attributes. These studies highlight the significant role that water efficiency plays in promoting sustainability in residential development.

Water efficiency refers to the optimized use of water resources to minimize waste, reduce consumption, and promote sustainability. It focuses on achieving the same tasks—whether in homes, industries, or agriculture—using less water, which helps conserve this vital resource and reduce the burden on water supply systems.

In sustainable housing, water efficiency can be achieved through various strategies, including:

- **Low-flow fixtures:** Installing water-saving devices like low-flow faucets, showerheads, and toilets, which reduce water use without compromising functionality.
- **Efficient irrigation systems:** Using drip irrigation or smart irrigation systems that deliver water directly to the roots of plants, minimizing evaporation and runoff.
- **Greywater recycling:** Reusing wastewater from sinks, showers, and washing machines for non-potable purposes, like irrigation or toilet flushing.
- **Rainwater harvesting:** Capturing and storing rainwater for later use, such as for landscaping or non-drinking household purposes.
- **Smart appliances:** Using washing machines, dishwashers, and other appliances that are designed to use water more efficiently.

Water efficiency contributes to sustainability by reducing the demand for freshwater, lowering water bills, and minimizing energy use related to water treatment and distribution. It also helps to mitigate the environmental impact on local ecosystems, particularly in areas facing water scarcity.

3.3 Waste Management (WM)

Several scholars—including Ng Ming Yip et al. (2017); Tayefi Nasrabadi and Hataminejad (2019); Abu Hassan Abu Bakar et al. (2014); Adamec et al. (2021); Kucharska-Stasiak and Olbińska (2018); Kamaruddin et al. (2020); Pinzón Botero and Villota Ortiz (2019); and Nainggolan et al. (2020)—have identified waste management as a critical attribute of sustainable housing.

UN-HABITAT (2016) emphasizes that housing sustainability is closely tied to environmental sustainability, particularly through the implementation of well-designed waste management systems, such as organized rubbish disposal and recycling programs. Waste management encompasses the methods and strategies used to manage waste from its generation to its final disposal. This includes activities such as waste collection, transportation, treatment, and disposal, along with initiatives to reduce, reuse, and recycle materials. The primary objective of effective waste management is to minimize the negative environmental, economic, and social impacts associated with waste while maximizing resource recovery and sustainability.

In the context of sustainable housing, waste management can include the following practices:

- Waste reduction: Encouraging the reduction of waste at the source by using fewer materials, opting for reusable products, and avoiding single-use items.
- Recycling: Segregating recyclable materials such as paper, plastic, glass, and metals from regular waste so that they can be processed and reused in the production of new products.
- Composting: Converting organic waste (e.g., food scraps, yard waste) into compost, which can be used as a nutrient-rich soil additive for gardens and landscaping.
- Proper disposal: Ensuring hazardous materials, such as batteries, electronics, and chemicals, are disposed of through safe and regulated channels to avoid environmental contamination.

- Waste-to-energy systems: Some sustainable housing developments integrate systems that convert waste into energy, either through incineration (with emissions control) or anaerobic digestion, which produces biogas.
- On-site waste treatment: Installing waste treatment technologies like septic systems or greywater treatment systems that process waste on-site to reduce the need for large-scale infrastructure.

Effective waste management contributes to environmental sustainability by reducing the amount of waste sent to landfills, minimizing pollution, conserving natural resources, and promoting a circular economy where materials are reused and repurposed. It also supports economic sustainability by reducing costs associated with waste disposal and creating opportunities for resource recovery.

3.4 Job Opportunity (JO) and Economic Facilities (EF)

According to UN-HABITAT (2012), sustainable housing should be integrated with employment opportunities and commercial facilities to support a more holistic living environment. Similarly, previous studies by Ng Ming Yip et al. (2017), Abu Hassan Abu Bakar et al. (2014), Adamec et al. (2021), Mironiuc et al. (2021), and Nainggolan et al. (2020) have also emphasized these two attributes in their research on sustainable housing.

A housing area is considered economically viable if it offers job opportunities and economic facilities that meet the community's needs. Economic attributes are a critical factor in evaluating the overall sustainability of a housing area. This is because secure employment provides income stability, enabling residents to meet daily needs, support their families, pursue education, and afford essentials such as food and groceries.

While, economic facilities such as banks, shops, hypermarkets, and shopping malls can attract people to purchase, invest, and reside in a housing area, especially when accompanied by economic benefits like manufacturing sectors, small-to-medium enterprises, and professional services such as banks, law firms, and insurance companies. However, buyers interested in high-end housing often prefer properties located away from manufacturing sectors due to concerns about heavy traffic and pollution issues.

3.5 Security and Safety (SS)

Ng Ming Yip et al. (2017), Mohammad @ Masri et al. (2021), Abu Hassan Abu Bakar et al. (2014), Daly et al. (2003), Kamaruddin et al. (2020), Pinzón Botero and Villota Ortiz (2019), Nainggolan et al. (2020), and Mironiuc et al. (2021) have identified security and safety as key attributes in their studies on sustainable housing.

UN-HABITAT (2012) emphasizes that the health and safety aspects of sustainable housing must be adequately addressed, including the following: (i) Physiological hazards such as dampness, mold, smoke, extreme temperatures, and building-related pollutants like asbestos and radiation; (ii) Psychological hazards such as overcrowding, lack of security, insufficient or excessive lighting, and noise; (iii) Infection-related hazards stemming from poor hygiene, inadequate sanitation and drainage, contaminated water supplies, and infectious diseases; (iv) Accident-related hazards including falls on stairs or between levels, electrical risks, fires, burns, collisions, cuts, and strains; and (v) Environmental hazards such as landslides, earthquakes, tsunamis, and air pollution. Examples of security and safety aspects are fire-resistant materials, non-slip floor finishes, adequate lighting for corridors, safety glass, guard house, vertical circulation roads, paving, fencing, and lighting.

In the context of sustainable housing, security and safety refer to the practices, designs, and technologies used to protect both the occupants and the environment while ensuring long-term resilience. These factors are essential for creating livable, healthy, and sustainable communities. In summary, security and safety in sustainable housing encompass strategies to protect human health, reduce environmental risks, and maintain the long-term viability of both the structure and the community.

3.6 Amenities and Infrastructure (AI)

For amenities and infrastructure, 11 articles choose it as one of their attributes. In sustainable housing, amenities and infrastructure are vital in fostering environmental sustainability as well as social and economic well-being. They improve residents' quality of life, support community development, and promote efficient resource use. Hall (2014) highlights that sustainable housing aims to enhance occupants' quality of life by balancing individual needs and comfort within the social dimension alongside the environmental and economic aspects of sustainable development. Ahmad et. al (2017) further state that housing reflects a community's identity and serves as a medium for expressing sociocultural values. It is supported by Braganca et. al (2010) and Tawayha et. al (2015) who note that a community’s sociocultural values are evident in its daily practices, beliefs, residential architecture, occupations, and gastronomy. Ahmad et al. (2017) and McKeown (2016) suggest that measurable social sustainability comprises factors such as health, safety, education access, community participation, identity, employment opportunities, and security. Similarly, Dikmen (2005) emphasizes key sociocultural elements in housing design, including family size, privacy, safety, and religious needs.

From the resident's perspective, Hall (2014) identified nine priority categories in social sustainability: a high-quality living environment, good school access, neighborhood safety, cleanliness, early childhood education, integrated social housing, coordinated planning, community outreach, and public amenities. ISO 21929-1 (2011) supports this by outlining social sustainability indicators like access to essential services (transport, green spaces), good indoor air quality, flexibility in space usage, safety, and aesthetics.

Furthermore, Angeliki and Lang (2021), citing Dempsey et al. (2011), explain that social sustainability encompasses both physical and non-physical aspects—such as a sense of belonging, community cohesion, stability, mutual support, access to housing, essential services, public transport, and walkable neighborhoods.
Miller and Buys (2013) found that factors influencing sustainable housing outcomes in subtropical Australia, highlighting social cohesion as a key aspect. She references the Ecovillage building code (Australia), which emphasizes several considerations: first, community-oriented design that fosters social interaction, such as restrictions on boundary fencing; second, home offices, which provide a lifestyle opportunity while reducing transportation needs; third, accessibility through "adaptable" or "universal" house designs that accommodate people at different life stages and allow flexibility in the use of space throughout the house's lifespan; and finally, privacy, security, and safety, ensured through features like visual and acoustic privacy and measures to promote personal safety and security between buildings.

Onu (2015) concur that the social dimension of sustainable housing primarily focuses on its impact on people's quality of life, both in the present and for future generations. UN-HABITAT (2012) defines social sustainability in housing as the creation of affordable, high-quality, inclusive, and diverse dwellings—incorporating mixed-tenure and mixed-income communities—that are secure, healthy, and well-integrated into the broader socio-spatial systems of human settlements. This indicates that housing can be considered socially sustainable when it is decent, safe, secure, healthy, inclusive, and supports mixed-tenure arrangements while being seamlessly connected to other aspects of human settlements.

Examples of amenities and infrastructure include Worship placement, schools, medical centers, sports facilities, community space, communal parking areas, speed limit, public transport facilities, pedestrian-friendly streets, playgrounds, ICT infrastructure, vehicular circulation, gated and guarded community.

From the reviewed literature, it is evident that the social dimension of sustainable housing encompasses a variety of elements. However, these elements share a common foundation: addressing the needs and desires of people. This is achieved through the design of the house, which must prioritize occupant and community comfort, social cohesion, well-being, and safety and security. The table below outlines these elements. In summary, amenities and infrastructure in sustainable housing aim to create a harmonious balance between environmental conservation, social well-being, and economic efficiency. They ensure that residents live in comfort while minimizing their ecological footprint.

3.7 Building Layout and Design (BLD)

Building layout and design have been discussed in 14 articles out of 18. It seems important because relates to the design itself. In sustainable housing, building layout and design are critical components that enhance energy efficiency, reduce environmental impact, and promote occupant well-being. These aspects focus on optimizing space, resources, and natural conditions to create a sustainable and comfortable living environment. Many housing scholars and researchers frequently use the term "decent housing" without delving into its precise definition.

Habitable housing refers to a dwelling suitable for human habitation, meeting criteria such as (i) structural integrity, (ii) absence of required repairs, (iii) freedom from health-threatening dampness, (iv) adequate lighting, heating, and ventilation, (v) sufficient facilities for food preparation and cooking, (vi) a properly located water closet exclusively for occupants, (vii) a conveniently placed bath or shower and washbasin with a reliable supply of hot and cold water for exclusive use, (viii) access to clean water, and (ix) an efficient drainage system for foul, waste, and surface water (Krieger and Higgins, 2002). Additionally, a sound state of repair implies that a house's critical components are in good condition, do not require immediate major repairs, and pose no safety risks (Housing Support Unit, 2000). In essence, decent housing is defined as accommodation that is fit for habitation, with adequate access to basic social amenities, visual and thermal comfort, and protection from noise pollution.

In summary, the building layout and design in sustainable housing focus on energy efficiency, environmental integration, health, adaptability, and community engagement. These designs optimize the use of natural resources, minimize environmental impact, and provide a comfortable and adaptable living environment for residents.

3.8 Building Material (BM)

Building materials were a focus in 9 out of 18 reviewed articles, highlighting their importance in sustainable housing by minimizing environmental impact, improving energy efficiency, and promoting health and well-being. Modern frameworks emphasize eco-friendly, renewable, and durable materials as essential to achieving sustainability goals. For instance, Asdrubali et al. (2012) emphasize the potential of natural fiber and recycled rubber panels (e.g., flax, cork, kenaf) for sound absorption and thermal insulation, highlighting their recyclability and low health impact. Similarly, Ciaburro et al. (2024) propose innovative honeycomb composite panels made with recycled membranes that deliver acoustic performance while serving circular economy principles. Integrating acoustic design early in project planning—such as reinforcing passive solar walls for insulation and sound control—echoes the holistic sustainability approach advocated by sustainability-oriented designers.

To address the attribute of acoustic comfort within Internal Environment Quality (IEQ) in sustainable housing, it can be concluded that acoustic comfort can be achieved through the use of sound insulation and conditioning materials integrated into the building. These materials enhance the acoustic experience for occupants and may include ceiling absorbers, eco-friendly walls and panels, reinforced concrete walls, shock absorbers, insulated glass and window frames, and wall-mounted panels. Sustainable building materials are selected based on their ability to reduce environmental impact, enhance energy efficiency, and promote occupant health and well-being. These materials are often renewable, recyclable, locally sourced, non-toxic, and energy-efficient, helping to lower the carbon footprint of buildings and contribute to a healthier, more sustainable built environment.

Table 4 is a refined table from the previous framework and its features. Their features have been chosen from the related building design techniques and materials used and installed for the sustainable house. This table covers all the dimensions and the important goals to be achieved. It can be said holistically listed in one table.

Table 4 *Holistic attributes of sustainable house*

No.	Holistic Attributes of Sustainable House		
	Dimension	Attributes	Features
	Main	Sub-Criteria	Sub to Sub Criteria
1.	Environmental	Energy efficiency	i.Natural ventilation ii.Natural lighting/Passive Daylight iii. Impact of vegetation/Landscaping iv. Site and building orientation v. Solar panels vi. LED Lighting vii. Motion sensor viii. Light sensor
		Water Efficiency	i.Rainwater harvesting systems ii.Greywater System iii.Dual flush toilet iv.Faucet Aerator
		Waste Management	i.Rubbish collection ii.Recycle arrangement
2.	Economic	Job Opportunity	i.Offices ii.Government Offices iii.Private Entity iv.Small medium enterprises
		Economy Facilities	i.Bank ii.Shops iii.Hypermarket iv.Shopping mall
3.	Social	Security and safety	i.Fire resistant materials ii.Non-slip floor finishes iii.Adequate lighting for corridors iv.Safety glass v.CCTV vi.Guard House vii.Vertical circulation road viii.Paving, fencing and lighting

Online Journal for TVET Practitioners Vol. 10 No. 3 (2025) p. 80-97

		Amenities and infrastructure	i.Worship placement ii.Schools iii.Medical Centre iv.Sport Facilities v.Community Space vi.Communal Parking Areas vii.Speed Limit viii.Public Transport Facilities ix.Pedestrian Friendly Street x.Playground xi.ICT Infrastructure xii.Vehicular Circulation xiii.Gated & Guarded Community
4.	Physical	Building Layout and Design	i.Suitable floor planning ii.Suitable stair condition iii.Suitable railing design iv.Structural stability v.Free from repair vi.Free from dampness prejudicial to health occupants vii.Adequate provision for lighting, heating and ventilation viii.Satisfactory facilities for the preparation and cooking of food ix.Suitably located water closet for the exclusive use of occupants x.Suitably located fixed bath or shower and wash hand basin provided with satisfactory supply of hot and cold water for the exclusive use of the occupants xi.Adequate supply of wholesome water xii.Efficient system for draining of foul, waste and surface water xiii.Adaptability for change or renovation xiv.Home offices
		Building Material	i.Reinforced Concrete Wall ii.Acoustical ceiling tiles iii.Ceiling Absorbers iv.Wall mounted panels

4. Conclusion

From this study we can identify the holistic attributes of sustainable houses have four important dimensions which are environmental, economic, social, and physical. These four dimensions have their own attributes for example the environmental dimension includes energy efficiency, water efficiency, and waste management. The economic dimension is derived from job opportunities and economic facilities that are available within the housing area. For the social dimension the security and safety, amenities, and infrastructure. Last for the physical it consists of building layout and design, and building material. Each attribute has its own features being chosen from the related building design technique and material used and installed for the sustainable house, which are Energy Efficiency; natural ventilation, natural lighting/passive daylight, impact of vegetation/landscaping, site and building orientation, and solar panels. LED lighting, motion sensor, and light sensor. Water Efficiency; rainwater harvesting systems, greywater systems, dual flush toilet, and faucet aerator. Waste Management; rubbish collection and recycling arrangement. Job Opportunity; offices, government offices, private entities, small and medium enterprises. Economy Facilities; bank, shops, hypermarket, and shopping mall. Security and Safety; fire resistance materials, non-slip floor finishes, adequate lighting for corridors, safety glass, CCTV, guard house, vertical circulation road and paving, fencing, and lighting. Amenities and Infrastructure; worship placement, schools, medical center, sports facilities, community space, communal parking areas, speed limit, public transport facilities, pedestrian-friendly street, playground, ICT infrastructure, vehicular circulation, and gated and guarded community. Building Layout and Design; suitable floor planning, well-maintained stairs and railings, structural soundness, absence of needed repairs or health-damaging dampness, sufficient lighting, heating, and ventilation, adequate kitchen facilities, conveniently placed water closet for occupants' exclusive use, a fixed bath or shower and wash basin with reliable hot and cold water supply for exclusive occupant use, access to clean water, an efficient drainage system for waste and surface water, and adaptability for modifications, renovations, or home office setups. For the last Building Material; reinforced concrete wall, acoustical ceiling tiles, ceiling absorbers, and wall-mounted panels.

These holistic attributes and their features can be outlined for sustainable house adjudication or valuation purposes thus adjusting to the prevailing needs. For future research, it is suggested researchers find a way for these holistic attributes can act as a checklist in the valuation process for sustainable houses, so that, all of this effort is implemented in the real field and may provide solid empirical data in the market thus create sustainable house transaction data and index in the Property Market Report.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Siti Hamidah Salim, Abdul Hadi Nawawi, Noraliza Basrah;* ***data collection:*** *Siti Hamidah Salim;* ***analysis and interpretation of results:*** *Siti Hamidah Salim, Abdul Hadi Nawawi, Noraliza Basrah;* ***draft manuscript preparation:*** *Siti Hamidah Salim. All authors reviewed the results and approved the final version of the manuscript.*

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