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Sustainable housing indicators.
A statistical review of Indonesia's housing sector

Lasma Melinda Siahaan, Erlina, Badaruddin, Rujiman

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Abstract. *Sustainable housing is a concept for urban planning, the goal of which is building a living environment that is fully sufficient for today's demands and future generations' needs, addressing social and ecological issues. Sustainable housing includes sustainable building principles, which are applied to the aspects of planning, constructing, and managing living environments. This research aims to contribute to the understanding of sustainable housing in Indonesia by assessing the sustainability index of housing indicators within a comprehensive framework and considering various factors that impact people's quality of life. The research findings indicate that the sustainability index values for economic, social, and environmental dimensions show a quite sustainable range. it means that the housing is designed and built with a balanced consideration of its impact on the economy, society, and the environment. Although overall the three dimensions show sustainability, it is necessary to improve several indicators in each dimension that are not sustainable, such as maintenance and operating costs; safety and security; and waste management.*

1. Introduction

Housing sector in Indonesia plays a fundamental part in the development of the country's socio-economic welfare but the challenges are immense. The notion of the green city, which has been used in the Indonesian context, mainly illustrates the idea of green open spaces and yet does not contribute much to the enhancement of sustainability of the urban area (Zain et al., 2022). The demographic transformation across the different Indonesian parts has intensified the growth of slum areas and poor housing standards (World Bank, 2021).

Sustainable housing development is essential for achieving the United Nation's Sustainable Development Goals. The development of sustainable housing refers to the construction and operation of environmentally, socially and economically sustainable homes (Adabre et al., 2022). Sustainable housing is defined by several indicators that capture environmental, social and economic dimensions. Environmentally speaking, it involves using resources well, avoiding waste and reducing carbon footprints. Socially, it looks at making people feel safe and cared

for in their neighborhoods. Economically, affordability and maintaining economic stability are its main aims. These indicators are crucial in assessing the sustainability of housing projects or policies (Ruíz & Mack-Vergara, 2023).

In recent years, Indonesia's government has introduced several initiatives that are aimed at promoting sustainable housing. Initiatives such as 'One Million Houses' program look at increasing the number of affordable homes available and simultaneously making them sustainable. Furthermore, policies that promote green building standards and renewable energy integration have been put in place to facilitate transition towards more sustainable housing practices. Nevertheless, Indonesia still struggles with achieving sustainable housing (Pane et al., 2023).

However, Indonesia still encounters challenges on sustainable housing. It is because of the obstacles that are present in Indonesia upon developing and implementing sustainable housing concepts. Demographic represents the primary challenge faced by Indonesia. This is because this country has a huge and ever-increasing population with inadequate homes for most households. According to data from Badan Pusat Statistik-Indonesia 2023 (BPS-Statistics Indonesia), the percentage of households that live in suitable homes was 63.15%. Suitable houses must satisfy four criteria; minimum floor area per capita (7.2 square meters), availability of clean water sources, adequate sanitation facilities and built resilience against hazards (Statistics Indonesia, 2023).

The second challenge faced is the lack of land availability for housing development. This has led to high housing prices, making them inaccessible to all segments of society. According to data from BPS-Statistics Indonesia 2023, 84.79% of the population own their own homes, while the remaining 15.21% are renters or temporary contract holders. Furthermore, the existing housing development has not been able to improve the quality of life for the Indonesian people. The presence of slum housing is an indicator of a decline in the quality of life. Data shows that the percentage of slum housing areas in Indonesia has decreased since 2021 and 2022. In 2021, the percentage of slum housing areas was 9.12%, and in 2022, it was 8.93%. However, some provinces still have a percentage of slum housing areas above 10.00%. Additionally, in 2023, the total percentage of slum housing areas in Indonesia was 7.94% of all households. This means that approximately 8 out of 100 households in Indonesia live in slum housing areas (Statistics Indonesia, 2023).

The objective of this research is to contribute to the understanding of sustainable housing in Indonesia by assessing the sustainability index of housing indicators within a comprehensive framework and considering various factors that impact

people's quality of life. Specifically, sustainable housing indicators are considered a unified economic, social, and environmental metric. By examining the sustainability index, this review aims to highlight progress achieved, identify ongoing challenges, and propose recommendations to enhance the housing sustainable in Indonesia.

2. Literature review

Sustainable housing indicators are crucial tools for evaluating and guiding the development of housing that meets the needs of both present and future generations while balancing economic, social, and environmental factors (Piparsania & Kalita, 2022). In the context of Indonesia, a rapidly developing country with significant urbanization and environmental challenges, sustainable housing is vital for fostering long-term socio-economic stability and ecological health. Sustainable housing is a multidimensional concept that encompasses several key aspects. It is a comprehensive approach to housing development that considers not only economic factors but also social and environmental (Adamec et al., 2021).

2.1. Economic sustainability

Economic sustainability in housing projects means that the project can generate income and reduce expenses while also benefiting society and the environment (Menberu, 2023). It's crucial to consider economic sustainability alongside social and environmental sustainability for a comprehensive approach to sustainable development. Economic sustainability is significant because it ensures that the housing project can generate sufficient income and be well-maintained in the future, which is essential for both residents and the community at large (Tang et al., 2021). This includes making sure that housing is affordable, financially attainable, and economically feasible for a wide range of people (Saidu & Yeom, 2020).

2.2. Social sustainability

Social sustainability in housing means that housing must have a clear social responsibility towards residents and the surrounding community. Housing that is oriented towards social sustainability must prioritize the quality of life for residents and contribute to the quality of the environment and community (Amoah, 2023). In this context, housing must have a commitment to participate

in various programs and activities that enhance the quality of life for residents and the community.

It should focus on creating inclusive, safe, and resilient communities, with access to essential services and opportunities for social integration (Hernández et al., 2023).

2.3. Environmental sustainability

Environmental sustainability plays a crucial role in ensuring housing sustainability by mitigating the environmental impact of construction practices. Environmental sustainability for housing refers to the practice of designing and building homes that minimize their impact on the environment while ensuring the well-being of both the occupants and the planet (Ruíz & Mack-Vergara, 2023). This approach involves integrating eco-friendly materials, energy-efficient systems, and waste reduction strategies into the construction process (Quidel et al., 2023).

2.4. Sustainability indicators

To evaluate sustainable housing in Indonesia, several indicators are typically employed across the economic, social, and environmental dimensions (Rahmawati et al., 2022). These indicators provide a comprehensive framework for assessing the sustainability of housing developments (Adamec et al., 2021).

1. Economic dimensions:
   a. Affordability: Measures the ability of average households to afford housing.
   b. Cost of Living: Assesses the overall cost of maintaining a certain standard of living, including housing, utilities, transportation, and groceries.
   c. Maintenance and Operating Costs: Assesses the long-term costs of maintaining and operating sustainable housing.
2. Social dimensions:
   a. Accessibility: Access to Livable Residential Buildings.
   b. Safety and Security: risk of natural disasters.
   c. Health and Well-being: Reflects the potential for indoor air pollution, such as smoking behavior.
3. Environmental dimensions:
   a. Energy Efficiency: Energy consumption per household and integration of renewable energy sources.
   b. Water Management: Water usage, recycling, and conservation practices.

c. Waste Management: Systems for reducing, reusing, and recycling household waste.

Sustainable housing in Indonesia requires a comprehensive and multi-faceted approach that integrates economic, social, and environmental considerations (Jones, 2017). By employing a robust set of indicators and theoretical frameworks, stakeholders can better understand the current state of housing sustainability and identify pathways for improvement. Overcoming the challenges and leveraging the opportunities inherent in sustainable housing will be essential for Indonesia's long-term development and the well-being of its citizens (Fitriani & Ajayi, 2022).

3. Method

3.1. Research Design

This study follows an evaluative research design, which is an approach used to assess the effectiveness, efficiency, relevance, and impact of a program, policy, or project (Bowes et al., 2023). The focus of evaluative research is to collect and analyze data to determine whether the desired goals have been achieved and provide recommendations for future improvements. In the context of this study, it allows for a comprehensive evaluation of various sustainability indicators related to the housing sector.

3.2. Research Question

1. How great is the sustainability index of economic, social and environmental dimensions in Indonesia for housing development?
2. What are the economic, social and environmental indicators that can be used to actualize sustainable housing in Indonesia?

3.3. Research Methodology

The method used in this study refers to the Handbook on Constructing Composite Indicators (CI) published by the Organization for Economic Co-operation and Development (OECD) (OECD, 2008). CI can summarize complex and multidimensional realities, making it very useful in measuring complex concepts such as sustainable housing. Therefore, the CI method can capture various aspects related to sustainable housing in a single integrated index.

It also allows for equal weighting of each component, making it transparent and data driven. This eliminates subjectivity and ensures more accurate results. Using the CI method in analyzing the sustainable housing index can provide more accurate, transparent, and easy-to-understand results, as well as enabling more effective decision-making. Here are the steps in the Sustainable Housing Index Analysis:

1. Identify and select key indicators for assessing housing sustainability.

We have identified nine (9) components of sustainable housing indicators, which can be categorized into three main dimensions: economic, social, and environmental. Here are the specific indicators under each category:

   a. Economic Indicators: Affordability, Cost of Living, & Maintenance and Operating Costs
   b. Social Indicators: Accessibility, Safety and Security & Health and Well-being.
   c. Environmental Indicators: Energy Efficiency, Water Management & Waste Management.

2. Collect relevant quantitative data from official sources such as the BPS-Statistics Indonesia, the Ministry of Public Works and Housing, as well as reports and surveys from research institutions and non-governmental organizations.

3. Normalize the data to ensure that all indicators are on the same scale, making them comparable. The normalization technique used is min-max normalization on a scale of 0-1.

Method Maximum-Minimum using the following calculation formula:

$$\mathrm{Ii} = \frac{\mathrm{x} - \min(\mathrm{x})}{\max(\mathrm{x}) - min\ (x)}$$

Where Ii is the value of a normalized indicator, x is the initial value of the indicator, and max(x) and min(x) are the maximum and minimum values of x, respectively.

4. Assign weight to each indicator based on its relative importance to housing sustainability. Determining the weight of each indicator is carried out using the Analytic Hierarchy Process (AHP) method. The Analytical Hierarchy Process (AHP) is a decision-making method developed by Thomas L. Saaty

in the 1970s. It is used to solve complex multi-criteria problems by breaking them down into simpler elements and then combining them back into a hierarchy. AHP is a decision support model that decomposes complex problems into simpler elements. It allows users to integrate subjectivity and objectivity in the decision-making process and helps identify the most important factors in complex situations. AHP allows the use of priorities for each indicator, so that it can determine the indicators that have the most influence on housing, decision-making, handling complexity, and flexibility in various applications. In this study, the weighting of the indicators is as follows:

a. Economic Indicator: 40% (0,4)

b. Social Indicator: 30% (0,3)

c. Environmental Indicator: 30% (0,3)

The determination of these indicator weights is based on the relative importance of each indicator, with the economic indicator being considered more critical in the concept of sustainable housing due to its direct impact on affordability for the community.

5. Calculate the sustainability index score for each region or housing category by combining the normalized values and indicator weights. The general formula for the index is:

$$\text{Sustainability Index} = \sum(\text{Indicator Value x Indicator Weight})$$

Furthermore, the Sustainability Index (SI) scores are split into five categories which imply the level of sustainability achieved in regard to the following scale:

$0.0 < SI \leq 0.2$: Very unsustainable

$0.2 < SI \leq 0.4$: Unsustainable

$0.4 < SI \leq 0.6$: Quite Sustainable

$0.6 < SI \leq 0.8$: Sustainable

$0.8 < SI \leq 1.0$: Very Sustainable

6. Analysis and Interpretation: Analyze the index results to identify regions or housing categories with the best and worst performance in terms of sustainability. Interpret the findings to provide insights into the factors influencing housing sustainability.
7. Formulation of Recommendations: Based on the analysis, formulate strategic recommendations to improve housing sustainability in Indonesia. Recommendations may include enhancing government policies, promoting green housing practices, and increasing public awareness about the importance of sustainable housing (OECD, 2008).

3.4. Data collection technique

Data collection in this research used secondary data collection methods. Secondary data collection techniques are used to gather information that has already been collected by someone else, in this case, the BPS-Statistic Indonesia. Secondary data is used in research because it is already available and accessible, making it easier to use without having to collect primary data from scratch, which may be difficult or costly to access. Additionally, secondary data often has higher validity and reliability because it has already been processed and checked by others, ensuring that the data used in the research has good quality. Furthermore, secondary data can have better quality and specifications because it has already been processed and checked by others, allowing researchers to use more accurate and relevant data for their research (Bowes et al., 2023).

The secondary data comes from the publication of data by BPS-Statistics Indonesia. Badan Pusat Statistik (BPS) is a Non-Ministerial Government Agency that reports directly to the President. BPS aims to become "A Provider of High-Quality Statistical Data for a Prosperous Indonesia" and its mission includes improving the quality of human resources in Indonesia, enhancing the country's productive and competitive economic structure, and promoting balanced and equitable development (Statistics Indonesia, 2023).

Data collection is done by downloading data from the BPS website[1] regarding the 2023 Indonesian Housing and Settlement Statistics Report, the 2023 Housing and Environmental Health Indicators, and the 2023 Statistical Yearbook of Indonesia. The locations sampled for this research were 34 provinces in Indonesia. All provinces in Indonesia were chosen to be able to describe the condition of Indonesia as a whole.

[1] https://www.bps.go.id/

4. Results and Discussion

4.1. General overview of Indonesia

Indonesia is a country located in Southeast Asia, comprising more than 17,000 islands. It is the world's fourth most populous country, with a population of over 273 million people. The country is known for its rich cultural heritage, diverse geography, and vibrant economy. Geographically, Indonesia is situated between the Indian and Pacific Oceans, with the equator passing through the center of the country. Indonesia has a land border with Papua New Guinea on the island of Papua, Malaysia on the island of Borneo, and East Timor on the island of Timor. Additionally, the country has a maritime border with Singapore, Vietnam, Thailand, the Philippines, Australia, Palau, and India. The country's landscape is characterized by volcanic mountains, rainforests, and coral reefs. The climate varies from tropical to temperate, with two main seasons: dry and wet.

Figure 1. Map of Indonesia

Indonesia is a federal republic with a parliamentary system of government. The country is divided into 34 provinces, each with its own governor and local government. The capital city is Jakarta, which is also the country's largest city and economic hub. Indonesia has a diverse economy, with major sectors including agriculture, manufacturing, and services. The country is a significant producer of palm oil, rubber, and coffee, and it is also a major exporter of textiles and electronics. The country's economy has experienced significant growth in recent years, driven by investments in infrastructure and the services sector.

One sector that has a significant impact on the development of regions and the economic growth of Indonesia is the housing sector. The housing sector plays a crucial role in the Indonesian economy by impacting economic growth, welfare, and financial stability. Public housing infrastructure development can stimulate economic growth by opening isolated areas, reducing production costs, and creating new economic centers (Nurdini et al., 2021).

Housing financing policies, like the Liquidity Facility of Housing Financing (FLPP), aim to improve low-income communities' welfare and boost economic performance through reallocation of resources (Adianto & Gabe, 2022). Additionally, the housing sector's turmoil can directly affect the domestic economy and financial stability, emphasizing the importance of macroeconomic variables and inflation-targeting frameworks in managing asset prices and preventing crises. Efforts to enhance housing financing efficiency, such as through primary housing financing improvements and stable bond markets, are essential for providing affordable housing for low-income individuals and driving economic development in Indonesia (Sun & Yiu, 2021). Despite government programs addressing housing backlogs, challenges persist, necessitating strong supervision and supportive regulations.

The house has developed into a place for various basic activities, building a family, raising children, and educating and instilling cultural values. Along with the development of the Republic of Indonesia, as mandated by the 1945 Constitution, the provision of housing is directly handled by the government through the Ministry of Public Works and Housing, particularly the Directorate General of Housing. As a stakeholder in housing activities in Indonesia, we need to educate the public about the history of housing in Indonesia from various eras. Here's Historical Development of Housing in Indonesia year by year (Suparwoko, 2013):

Table 1. Historical Development of Housing in Indonesia

Year	Historical Event
1924	The colonial government facilitated Dutch government employees.
1925	Kampung Improvement Program The first program in Surabaya (Kampong Verbetering) aimed at Dutch interests, namely Empowerment.
1926	Construction of public housing. Construction of Loji, a large house owned by Dutch officials.

1932	First village improvement program (renewal program); village improvements to prevent the spread of disease from spreading to Dutch housing (bubonic plague), including by repairing drainage and providing information about healthy homes.
1950	Healthy Public Housing Congress in Bandung Healthy housing to improve welfare. Formulate minimum housing standards. Immediately form a public housing agency with the APBN.
1952	The Development Cash Foundation (YKP) targets 12,000 houses. Housing developments carried out by YKP include Tenggilis and Jemur Handayani Public Housing (PERUM) in Surabaya, as well as housing near Unmer in Malang.
1953	Dutch housing was secured by the military. Urban residents are lazy about building houses, because they are too lazy to deal with the housing affairs office. However, this does not happen in rural communities
1955	Implementation of Land and Building Tax (PBB) LPMB, a research institute on housing was inaugurated in Bandung on March 1, 1955. It also functions as the United Nation Regional Housing Center (UNRHC). Determining the structure and sanitation of house construction.
1960	MPRS Decree no. 2 / 1960: In the housing sector, you should build houses that are healthy, cheap, enjoyable and meet moral requirements. Housing arrangements are held. Construction of housing facilities by the government. Built in an industrial area
1969	KIP is implemented in Jakarta.
1972	National Housing Workshop. National Housing Coordinating Board (BKPN). National Urban Development. City Urban Development Corporation, State City Development Company. Financial institutions Real Estate was formed on May 6, 1972. KPR starts running. BIC (Building Information Center) changed to PITB (Building Engineering Information Center)
1974	REI was formed simultaneously with Perumnas.
1976	New residential areas began to appear, such as in Jakarta and Medan.
1979	KIP becomes a National program.
1984	Core houses appear. Core 16 m^2 and rooms 5 m^2
1989-2000	PT. Prosperous Board ---- Board Bank. Housing Development Focuses on Groups (P2BPK) Home loans are also provided by private banks.
2000 – Present	Construction of Rusunawa/Rusunami Self-Help Housing: BSP2S and PKP.

The main challenges faced in designing affordable housing in Indonesia involve property owners, architects, and the government. These challenges include limited floor space, high density, and poor living conditions. The history of housing development in Indonesia has gone through several stages, from the Dutch colonial period to the post-independence era. Housing development has been a priority for the government, with various institutions and programs established to improve the quality of life for residents. However, several challenges still need to be addressed, including limited floor space and poor living conditions. The current goal of housing development is not just to provide residential units but rather to ensure that the needs of housing are met, prioritizing the quality of life of the community, including affordability, environmental friendliness, and ease of access to various sectors.

4.2. How great is the sustainability index of economic, social and environmental dimensions *in Indonesia for housing development?*

Indonesia has committed to achieving sustainable development goals (SDGs) that cover three main dimensions, namely economics, social, and environmental. Furthermore, you can see the percentage indicators for each dimension of sustainability in Table 2.

Table 2. Percentage data of sustainable housing indicators in Indonesia. Source: BPS-Statistic (2023).

Indicators	Economic	Social	Environmental
Affordability (Ec1)	84,79		
Cost of Living (Ec2)	5,82		
Maintenance and Operating Costs (Ec3)	0,7		
Accessibility (S1)		63,15	
Safety and Security (S2)		16,4	
Health and Well-being (S3)		70,77	
Energy Efficiency (En1)			97,93
Water Management (En2)			96,97
Waste Management (En3)			86,29

From table 2 we can see the percentage of indicators for each sustainability dimension. Due to the unequal distribution of data on these indicators, it is

necessary to normalize the data. Data normalization is essential for comparing data from different indicators. Since each indicator has its own set of basic data, it's important to bring them all to a common scale. This allows for meaningful comparisons between the indicators. The process of normalization involves transforming the data so that it falls within a specific range. In this case, we are using the Maximum-Minimum method, which scales the values between 0 and 1. A value of 0 represents the minimum value in the dataset, while a value of 1 represents the maximum value. By normalizing the data, we ensure that all variables are treated equally and can be compared with one another. This removes any biases or discrepancies that may arise due to differences in the original scales of the data.

Method Maximum-Minimum using the following calculation formula:

$$\mathrm{Ii} = \frac{\mathrm{x} - \min\,(\mathrm{x})}{\max\,(\mathrm{x}) - min\,(x)}$$

The normalized data results are in Table 3.

From Table 3, we can see that all the indicators from each sustainability dimension already have data that are normally distributed, which scales the values between 0 and 1. Next, we will perform weighting on each indicator using the AHP method. At this stage, each normalized value for each indicator will be multiplied by its dimension weight. The indicators from the economic dimension, namely Affordability (Ec1), Cost of Living (Ec2), and Maintenance and Operating Costs (Ec3), will be multiplied by a weight of 40% (0.4). Meanwhile, the indicators from the social dimension, namely Accessibility (S1), Safety and Security (S2), and Health and Well-being (S3), will be multiplied by a weight of 30% (0.3). Finally, the indicators from the environmental dimension, namely Energy Efficiency (En1), Water Management (En2), and Waste Management (En3), will be multiplied by a weight of 30% (0.3). The results of the indicator weighting are shown in Table 4.

Then we combine all the indicators for each economic, social, and environmental aspect. We repeat this process again to calculate a final sustainability index value. By looking at the aggregation results of each indicator in the economic, social, and environmental dimensions (as shown in Table 5), we can see that the sustainability index falls within a *quite sustainable* range.

Table 3. Data normalization results

Indicators	Calculation formula: $\mathbf{Ii} = \frac{\mathbf{x} - \mathbf{min}\ (\mathbf{x})}{\mathbf{max}\ (\mathbf{x}) - \boldsymbol{min}\ (\boldsymbol{x})}$	Normalization result
Affordability (Ec1)	$Ec1 = \frac{84,79 - 0,70}{84,79 - 0,70}$	1,00
Cost of Living (Ec2)	$Ec2 = \frac{5,82 - 0,70}{84,79 - 0,70}$	0,06
Maintenance and Operating Costs (Ec3)	$Ec3 = \frac{0,70 - 0,70}{84,79 - 0,70}$	0,00
Accessibility (S1)	$S1 = \frac{63,15 - 16,4}{70,77 - 16,4}$	0,86
Safety and Security (S2)	$S2 = \frac{16,4 - 16,4}{70,77 - 16,4}$	0,00
Health and Well-being (S3)	$S3 = \frac{70,77 - 16,4}{70,77 - 16,4}$	1,00
Energy Efficiency (En1)	$En1 = \frac{97,93 - 86,29}{97,93 - 86,29}$	1,00
Water Management (En2)	$En2 = \frac{96,97 - 86,29}{97,93 - 86,29}$	0,92
Waste Management (En3)	$En3 = \frac{86,29 - 86,29}{97,93 - 86,29}$	0,00

Table 4. Analytic hierarchy process results

Indicators	AHP
Affordability (Ec1)	0,40
Cost of Living (Ec2)	0,02
Maintenance and Operating Costs (Ec3)	0,00
Accessibility (S1)	0,26
Safety and Security (S2)	0,00
Health and Well-being (S3)	0,30
Energy Efficiency (En1)	0,30
Water Management (En2)	0,28
Waste Management (En3)	0,00

Table 5. Sustainability Index

Dimensions	Sustainable Index
Economic	0,42
Social	0,56
Environmental	0,58

The value of each economic, social, and environmental dimension is 0.42; 0.56, and 0.58. When calculated overall, this dimension reaches a value of 1.56, indicating the highest level of sustainability. In the context of housing, this can mean that the housing sector in Indonesia has achieved a high standard in all three dimensions of sustainability. A value that is quite sustainable indicates that the housing sector has reached a relatively stable level and can meet the needs of the community and has integrated environmental and social aspects into its development process, but still has some shortcomings that need to be improved.

Table 5 shows that among the three dimensions reflecting sustainable housing in Indonesia, the economic dimension has the smallest sustainability value (0.42). This economic dimension requires serious attention and improvement from stakeholders to ensure its impact on the implementation of sustainable housing, as it has the most significant influence on the quality of life of the community. The economic dimension plays a crucial role in sustainable housing by ensuring affordability, maximizing profits, and minimizing costs while also enhancing social and environmental aspects (Ghaffar & Aziz, 2021).

Sustainable housing projects need to focus on economic sustainability to achieve multiple planning objectives, such as reducing transportation costs, improving incomes, and providing infrastructure for the poorest of the poor (Menberu, 2023). Incorporating economic sustainability in affordable housing programs is essential to address the economic, social, and environmental challenges faced in urban areas. Additionally, sustainable housing planning should consider the economic benefits derived from environmental and social sustainability, leading to significant gains at both individual and societal levels (Mironiuc et al., 2021).

By evaluating the economic sustainability of urban forms and incorporating economic considerations in housing projects, cities can achieve better economic performance, environmental quality, and social equity, contributing to overall sustainable development. Adabre & Chan (2020) presented a sustainability assessment model for affordable housing in Ghana, consisting of four indices, with household satisfaction being the most significant index. According to Hasan

et al. (2024), sustainable development should also be able to generate interest in affordable housing and low living costs within residential areas. Overall, the economic dimension not only affects affordability and financial viability but also influences decision-making, policy implications, and the overall sustainability of housing projects.

Besides that, social and environmental dimensions also play a crucial role in sustainable housing by ensuring the well-being of communities. Social sustainability, often overlooked compared to environmental and economic aspects, is vital for human well-being, inclusiveness, and community benefits. It involves addressing basic human needs and integrating social and environmental aspects to meet welfare criteria (Goh et al., 2023).

Sustainable housing aims to reduce the environmental impact of buildings, which account for a significant portion of global energy consumption and resource use (Cubukcuoglu, 2022). Governments incentivize environmentally conscious practices in real estate development through tax credits and grants, promoting the construction of green buildings to mitigate carbon emissions and resource depletion (Regodon et al., 2022). By integrating green building practices, such as energy-efficient design and water conservation measures, sustainable housing not only reduces environmental harm but also contributes to long-term ecological preservation and intergenerational justice.

4.3. What are the economic, social and environmental indicators that can be used to actualize sustainable housing in Indonesia?

Next, we will analyze indicators that form the dimensions of economy, society, and environment, which can support the implementation of sustainable housing in Indonesia. This is done to identify which indicators need to be improved and enhanced so that they can support the sustainability of housing in Indonesia.

4.3.1. Economic sustainability

From Table 4, we can see some indicators of every dimension of sustainable housing in Indonesia. Among the economic dimension indicators that have higher sustainability value, affordability is one. This means that the most crucial aspect suggesting sustainability for housing within the economic dimension is affordability. The concept of sustainable affordable housing choice involves factors such as housing price in relation to income, rental price in relation to income, building type (Ezennia & Hoskara, 2019).

Having a high score for the affordability indicator of housing in Indonesia signifies that a significant portion of Indonesians can financially afford to buy or rent a home (Heylen, 2021). This translates to housing in Indonesia being relatively accessible for a large part of the population. Compared to other countries, Indonesian house prices tend to be lower. This stems from factors like cheaper construction costs, and government policies promoting affordable housing development. The Indonesian government has implemented various policies to improve housing affordability. These include subsidized housing programs, development of apartment complexes (rumah susun), and streamlined property permitting processes. Besides that, Current Indonesian mortgage rates (Kredit Pemilikan Rumah/KPR) are low. This makes home loans more accessible and affordable for the public.

However, it's important to acknowledge that housing affordability isn't uniform across Indonesia. In densely populated urban areas, house prices might still be out of reach for many. Additionally, a portion of the population lacks access to formal financial services, hindering their ability to obtain mortgages.

Therefore, the government and other stakeholders need to continuously strive to improve housing affordability in Indonesia. This can be achieved through various means:

a) Increasing Supply of Affordable Housing: Constructing more houses at accessible prices for low-income earners.

b) Providing Housing Subsidies: Offering financial assistance to low-income individuals for buying or renting a home.

c) Enhancing Access to Formal Financial Services: Assisting low-income earners in obtaining mortgages and other financial products.

d) Strengthening Housing Regulations and Policies: Implementing regulations and policies that encourage the development of affordable and high-quality housing.

Through sustained efforts, Indonesia's housing affordability can be enhanced, ensuring that everyone has access to decent and affordable housing (Adianto et al., 2021).

Next, the indicators for Cost of Living and Maintenance and Operating Costs have low sustainability values. In the context of Indonesian housing, a low score in the Cost of Living and Maintenance and Operating Costs indicator signifies

that the living expenses, maintenance, and operational costs for that housing are relatively high compared to other options (Saldaña-Márquez et al., 2019).

Living expenses in Indonesia, including housing costs, significantly increase due to inflation and rising construction material prices. This makes housing costs more expensive and difficult for people to meet their basic needs. Operational and maintenance costs for housing also increase due to rising maintenance and other operational costs. This makes housing costs more burdensome for people, resulting in a low sustainability value for housing in Indonesia. Besides that, Indonesia faces resource constraints, such as water and energy shortages, which affect operational and maintenance costs for housing. This makes housing costs more expensive and difficult for people to meet their basic needs (Che-Ghani et al., 2016).

This low indicator score can negatively impact the sustainability of the housing in a few ways:

a) Increases financial burden: High living, maintenance, and operational costs can strain residents financially, and in some cases, make housing unaffordable (Fulcher et al., 2022).

b) Lowers investment value: Housing with high operational costs is less attractive to potential buyers, potentially decreasing its investment value (Garrido-Jiménez et al., 2022).

c) Increases environmental impact: High energy and water consumption can contribute to greenhouse gas emissions and pollute the environment (Shang et al., 2023).

4.3.2. Social sustainability

From a social dimension, two indicators that have a value of sustainability are Accessibility and Health and Well-being. Accessibility and Health and Well-being are two crucial indicators within the social dimension of sustainability. They reflect how well a society fulfills the basic needs and fundamental rights of its citizens and creates conditions that enable them to live healthy and prosperous lives (Leão & Neiva, 2022). Accessibility refers to the ability of individuals to access and utilize various resources and opportunities available in society. This includes access to:

a) Basic services, such as education, healthcare, clean water, sanitation, and housing

b) Economic opportunities, such as jobs, training, and entrepreneurship

c) Social participation, such as involvement in decision-making and community activities

d) Freedoms and human rights, such as freedom of expression, assembly, and religion (Fedchyshyn et al., 2023).

Health and Well-being refers to a state of optimal physical, mental, and social health that allows individuals to live meaningful and productive lives. This includes:

a) Physical health, such as being free from disease and having the physical capacity to perform daily activities

b) Mental health, such as being free from stress, anxiety, and depression, and having the ability to manage emotions and adapt to change

c) Social health, such as having positive relationships with family, friends, and community, and feeling accepted and valued (Hu et al., 2021).

These two indicators are closely linked. Good accessibility allows individuals to meet their basic needs and improve their physical and mental health. Good health, in turn, enables individuals to fully participate in social and economic life (Okitasari, 2022). There are many things that can be done to improve accessibility and health and well-being in a society. Here are some examples:

a) Developing policies and programs that promote accessibility, such as inclusive education programs, affordable healthcare, and disability-friendly infrastructure

b) Investing in disease prevention and health promotion, such as health education programs, access to nutritious food, and providing open spaces for physical activity

c) Supporting communities and organizations that work to improve accessibility and health, such as disability advocacy groups, public health organizations, and community development programs (Serano & Li, 2022).

While the Safety and Security indicator from the social dimension does not show sustainable values in housing in Indonesia. Here are several factors that might contribute to the Safety and Security indicator from the social dimension not showing sustainable values in housing in Indonesia:

a) *Infrastructure Limitations*: Indonesia has limited infrastructure, such as roads, electricity, and water, which can affect the safety and comfort of homeowners. These limitations can lead to low sustainability levels.

b) *High Crime Rates*: Indonesia has high crime rates, which can make homeowners feel unsafe and uncomfortable. These crimes can include theft, violence, or environmental crimes.

c) *Limited Public Services*: Public services like police, fire departments, and ambulances can be ineffective in addressing safety and comfort issues. Limited public services can lead to low sustainability levels.

d) *High Housing Costs*: Housing costs in Indonesia can be very high, making it difficult for some people to buy safe and comfortable homes. Limited financing options can lead to low sustainability levels.

e) *Limited Education*: Education on safety and comfort can be lacking in Indonesia, so some people may not know how to maintain safety and comfort in their homes. Limited education can lead to low sustainability levels.

f) *Government Ineffectiveness*: The government in Indonesia can be ineffective in addressing safety and comfort issues, such as high crime rates and infrastructure limitations. Ineffectiveness can lead to low sustainability levels.

g) *Community Limitations*: The community in Indonesia can be less involved in addressing safety and comfort issues, such as not following rules or not maintaining home safety. Community limitations can lead to low sustainability levels (Dixon, 2019).

To address the unsustainability aspect of housing in Indonesia, on Safety and Security indicator under social dimension that does not have a sustainable number of values, several things can be done. Firstly, it is important to improve infrastructure such as roads, electricity and water to ensure that homeowners are safe and comfortable. Infrastructure limitations may result into low levels of sustainability thus by improving infrastructure, we will enhance sustainability (Abed, 2017).

Secondly sea-based crimes such as piracy and drug trafficking require law enforcement and surveillance. The government needs to beef up its law enforcing systems as well as put in place strong surveillance systems for ensuring safety while at sea in Indonesia. This measure can help reduce crime rates and keep sea travel safe. Thirdly human resource development plays a vital role too. It would also improve the maritime safety if fishermen and sailors went through more training courses to acquire new skills. Skilled human resources are vital in keeping up with the security measures of Indonesian seas. Fourthly improvement of ship

quality is crucial too. Ships operating within Indonesian boarders should meet safety standards set by the government. Enhancing ship quality can also be beneficial in guaranteeing the security during sea travel within Indonesia (Janssen & Basta, 2022).

Fifthly, international cooperation is crucial. By increasing cooperation with other countries in the region, we can develop policies and safety standards applicable to Indonesian waters. This will help maintain the safety of sea travel and promote sustainability. Sixthly, modern technology plays a vital role. Equipping ships with advanced navigation and communication systems can significantly improve the efficiency and safety of ship operations, ultimately contributing to safer sea travel and increased sustainability. Lastly, public education on home safety and comfort is essential (Gurmu et al., 2022).

4.3.3. Environmental sustainability

Subsequently, from the environmental dimension, indicators of Energy Efficiency and Water Management show sustainable values in housing in Indonesia. This statement highlights the importance of energy efficiency and water management in ensuring sustainable housing practices in Indonesia. It emphasizes the need for environmentally friendly practices in residential construction and management to achieve long-term sustainability. Energy efficiency refers to the reduction of energy consumption and waste, while water management involves the efficient use and conservation of water resources (Bellot & Fiscarelli, 2020).

The Indonesian government has taken several steps to support energy efficiency in housing. The government aims to reduce final energy consumption by 17% compared to the Business-as-Usual scenario by 2025 and reduce GreenHouse Gas emissions (GHG) by 29% by 2030. Additionally, the government has launched the Energi Transition Mechanism (ETM) Country Platform, a main coordination to promote fair and accessible energy transition, which aims to reduce carbon emissions by approximately 50 million tons by 2030 and 160 million tons by 2040 (BPS-Statistic, 2023).

The government has also set Minimum Energy Performance Standards (MEPS) for various household appliances such as Air Conditioners (AC), Light Emitting Diode (LED) lamps, rice cookers, refrigerators, and fans. This helps consumers choose energy-efficient appliances by looking at the energy efficiency label with the number of stars displayed. Furthermore, the government encourages building managers and residents to implement effective energy management, which

includes having an energy manager, developing energy efficiency programs, conducting regular energy audits, and implementing audit recommendations.

The government also promotes the development of energy-efficient electronics while enhancing the industry, making energy efficiency and the industrial ecosystem part of the economic growth machine. Moreover, the government encourages public participation in building energy awareness in both work and residential environments. Residents can start saving energy by taking simple steps such as turning off lights and appliances, unplugging chargers, and setting AC temperatures between 24-27°C. Overall, the Indonesian government's efforts to support energy efficiency in housing involve various strategies aimed at reducing energy consumption, promoting energy-efficient appliances, and increasing public awareness of energy conservation.

Related to water management, The Indonesian government has taken several initiatives to support water management in housing, including setting targets for sustainable water resource management in 2024, such as 100% of housing with access to safe drinking water, 30% of housing with piped water supply, increasing national water capacity by approximately 2.3 billion cubic meters, and sustainable irrigation water supply from dams covering around 355,800 hectares (BPS-Statistic, 2023).

Additionally, the government has developed coastal defense structures and coastal protection systems to ensure the safety of the North Java Coastal Corridor and to develop water supply systems and wastewater treatment facilities at the housing and city scales. Monitoring systems have also been developed to support the control of land subsidence and groundwater extraction, as well as to enhance national water resilience. Indonesia has also initiated programs for land stability and ecosystem-based approaches to ensure the availability of clean water with sufficient quantity and quality.

The Presidential Regulation Number 37 of 2023 on the National Water Resource Policy (Jaknas SDA) has been enacted to enhance national water resilience and implement the provisions of Article 10, letter a, and Article 11, letter a, of Law Number 17 of 2019 on Water Resources. Therefore, these initiatives aim to improve access to safe drinking water that is safe, equitable, and accessible to 100% of the population, as well as to enhance water efficiency in all sectors.

If energy efficiency and water resource management have shown sustainability values, it is not the same with waste management. That happens because of several reasons:

a) *Lack of Regulatory Framework*: Waste management is often governed by less stringent regulations compared to energy efficiency and water resource management. This lack of regulatory oversight can lead to inadequate waste disposal practices and a lack of accountability.

b) *Limited Public Awareness*: Public awareness about the importance of proper waste management is often limited. This lack of understanding can contribute to the persistence of poor waste disposal practices and inadequate waste management strategies.

c) *Economic Factors*: Waste management can be a costly endeavor, especially for developing countries. The high costs associated with waste disposal and treatment can lead to inadequate waste management practices, as governments and communities may prioritize more pressing economic concerns.

d) *Technological Limitations*: Waste management often relies on outdated technologies and methods, which can be less effective in managing waste efficiently. The lack of modern and efficient waste management technologies can hinder efforts to improve waste management practices.

e) *Lack of Community Engagement*: Waste management is often seen as a community responsibility, but community engagement and participation are crucial for effective waste management. The lack of community involvement can lead to inadequate waste management practices and a lack of accountability (Pane et al., 2023).

To address the disparity in waste management compared to energy efficiency and water resource management, several solutions can be implemented, including developing comprehensive regulatory frameworks to ensure sustainability and efficiency in waste management, increasing public awareness and participation in waste management processes, deploying modern and effective technologies for waste recycling and processing, optimizing waste management costs by reducing unnecessary expenses, and enhancing intersectoral coordination among government, organizations, and academia to develop more effective and sustainable waste management strategies (Aliu, 2022). By adopting these solutions, it is hoped that waste management can be improved in terms of efficiency and sustainability, thereby reducing the disparity with energy efficiency and water resource management.

5. Conclusions

The research findings indicate that the sustainability index values for economic, social, and environmental dimensions show a quite sustainable range. If the economic, social, and environmental dimensions show a quite sustainable range in Indonesian housing, it means that the housing is designed and built with a balanced consideration of its impact on the economy, society, and the environment. Housing that shows a quite sustainable range across these three dimensions can offer significant benefits to its residents, the local community, and the environment. From economic dimensions, the maintenance and operating costs indicators have the lowest sustainability value. This suggests that maintenance and operating costs for housing in Indonesia are too high compared to the standard or average of other sectors. Next, from a social dimension, indicators of safety and security have the lowest sustainability value. This low sustainability value indicates that the level of safety and security in housing is very low. The low sustainability value of the 'Waste Management' indicator within the environmental dimension suggests that household waste is not being effectively managed. This lack of effective waste management leads to negative environmental impacts. This area requires action for promoting improvement.

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Authors

Lasma Melinda Siahaan (*corresponding author*) melinshn@students.usu.ac.id
https://orcid.org/0000-0002-0897-4526
Study Program of Regional Planning, Graduate School, Universitas Sumatera Utara, Jln. Prof. Maas, Medan, Indonesia.

Erlina erlina@usu.ac.id
Study Program Accounting, Universitas Sumatera Utara, Medan, Indonesia.

Badaruddin badaruddin@usu.ac.id
Study Program Sociology, Universitas Sumatera Utara, Medan, Indonesia.

Rujiman rujiman.ira66@gmail.com
Study Program Development Economics, Universitas Sumatera Utara, Medan 20155, Indonesia.

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