Sustainable House For Low-Income Community In Indonesia

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Abstract— Efforts to eliminate slum areas in urban areas are a global program undertaken in many developed and developing countries through the provision of housing for Low-Income Communities (MBR). In Indonesia, MBR house prices are limited to a maximum of IDR 200 million per unit, so developers effort to find ways to reduce costs to produce houses that meet the standards. This article reviews the house design for MBR which is not only cheap but qualifies for sustainability. The literature review resulted that this design should be able to accommodate a floor space of 10-13 m2 per capita as the optimum value of human social space. In addition, the results of the analysis require developers to provide a minimum green roof of 10% of the flat roof area, in order to lower the environmental temperature that affects the decrease of human aggressiveness and increase social attachment. Preferred materials were materials that were easy to obtain and cheap and certainly feasible to be building materials. Natural lighting during the day could be sunlight from closed glass windows and LED lights for night and enclosed spaces. Together with a number of other specifications, this article provided a concept of sustainable houses for MBR in urban environments that developers could use to reduce costs while ensuring sustainability. This concept refines the old concept that has been used by the government. The government needs to change standards and implement regulations that prohibit adding space or changing the shape of buildings. House prices with sustainable prototypes are slightly more expensive, but this is a compensation for unnecessary renovation while occupying the house. Keywords— sustainable house, low-income community, urban area.

1. Introduction

Lower middle-income population in developing countries effort to find a decent and affordable house. For some people, owning a house becomes even a dream to lead to a better life and long-term financial sustainability, even in developed countries [1]. It makes the government trying to provide various forms of assistance for residents to be able to reach their dreams with various forms of policy. The government of India for example, in 2009, was determined to realize India free from slum areas in five years. This policy unfortunately failed to achieve its objectives for the year 2014, the number of slum dwellers, even in Mumbai city, an increase from six million in 2004 to nine million in 2014, one million of them live in an area of only one square mile [2], making everyone has a space of only 1.6 x 1.6 meters. In order to the house can be a source of prosperity, the house cannot be simply inadequately built. Long-term sustainability requires a special design that keeps the house can survive for a very long time. It is becoming increasingly important for Indonesia as a country with a high intensity of the disaster. Even for the earthquake, during 1900-2009 occurred 14,000 earthquakes above 5 on the Richter scale [3], has not calculated other disasters that damaged houses as floods and landslides.

So far, the Indonesian government is focused on the quantitative effort to produce as much as possible houses for the middle-class community. In 2016, the government issued Government Regulation No. 14 of 2016 on the Implementation of Housing and Settlement Area. This regulation requires developers to build a regulation of 1: 2: 3, which is to build two medium-sized houses and 3 simple houses for each one built luxury house. This policy is part of a major program of government to provide one million houses for Indonesians. From one million houses planned, 700 thousand of them are directed to low-income communities. Since it was formulated in 2014 until the end of 2016, the program has succeeded in realizing 805,169 houses, 569,382 units of which were MBR houses [4]. This was actually far from sufficient because there was a need for one million houses every year for Indonesians [5]. It is supplied with Infrastructures, Facilities and Utilities (PSU) programs for low-income houses (MBR) to support the improvement of the quality of the subsidized housing environment. PSU has been given by the government to developers of MBR housing developers as developers feel that it is very difficult to produce quality houses at affordable prices. The government has determined that the largest subsidy house cost was IDR 200 millions, whereas the average cost of housing construction was currently well above that value. As a result, houses were built to the MBR subsidies were generally not suitable to live because of the constraints that came from the developer itself [6]. Even if the house was inhabited, residents must add new costs for renovations that should be used to pay for better housing [7]. Moreover, renovation and self-development efforts have resulted in aesthetic irregularities as well as neglect of health, comfort, and building tenure rules, so houses returned to new urban slums.

However, PSU was only helping for the needs of public infrastructure in residential areas. Developers still must effort to generate decent housing and sustainable. It is not only the demands of the Government. The UN, through UN-Habitat, has been pushing for the construction of the houses for MBR must not only livable, but also sustained, through five main criterias: durability of structure, sufficient living space, access to safe water, access to sanitation, and security against Eviction [8]. Based on these criterias, the United Nations concluded that in 2009, Indonesia was the largest country of the fifth in the number of occupancy was not feasible and unsustainable, covering 7% of the number of dwelling unfit for habitation and unsustainable world, and represented 23% of total houses in urban areas In Indonesia [8]. Study of the McKinsey Global Institute [8] theorized that there were four strategies you could take to generate sustainable MBR house while reducing the cost of building the house. The four strategies were finding land at the right price, reducing operational and management costs, adopting more efficient development processes, and increasing access to finance for buyers and developers. These strategies could reduce the cost of construction of the unit houses up to 20% to 50%. The academicians have also been trying hard to produce recommendations on the development of viable and sustainable MBR. Some examples of sustainable settlements in Indonesia have been provided, such as the Village Banjarsari, PPLH Eco-House, ITS Eco-House, and Kampung Improvement Program [9] that in spite of it, is still questionable eligibility for MBR. The situation in Indonesia has required a lot of attention to the ongoing efforts to produce a viable and sustainable MBR house. Developments in the academic field should be able to contribute in this effort. So that's why the following article attemps to formulate a viable and sustainable MBR house design for subsidized houses in Indonesia. It is expected to be able to provide solutions to the problem of untrustworthy subsidized houses that are currently complained of too minimal and less meet the needs, even for the MBR.

2. Literature Review

2.1 Low Income Housing

The scientific basis on the needs of low-income houses set of ideas of sociology of Chicago school of urban sociology after World War II, who believed that the size, population density, and heterogeneity in the city have an impact on the destruction of social norms and society [10]. Therefore, the city government certainly cannot resist the development that occurred. As an alternative, the city government should provide housing for low-income communities that decompose density, heterogeneity is isolated, and the size of the city does not grow horizontally, but vertically.

In line with this, owning house for MBR provides a number of economic, social and political changes for the urban environment. According to Shlay [10], this change included: The economic changes of the family: the family could begin to accumulate assets, changing from paper investments into property, forced to downsize, and made a fixed house prices, Social change of the family: the family experienced social stability, better family functioning, the emergence of life satisfaction, family members could participate in civic activity, positive cognitive and behavioral development, decreasing delinquency of children and adolescents, increasing school attendance and increasing health Mentally and physically, Political changes: decreased in criminal activity, increased political participation, increased commitment to the job, the possibility of taxation, and encouraged the growth of the population, Environmental changes: increased property values, growth concerns for maintaining property, increased stability around the settlements, reduced community neglect, and reduced pollution such as graffiti, garbage, and other forms of damage.

In Indonesia, the MBR house was defined as a house designated for families with household heads earning at least IDR 4 millions per month for a prosperous house footprint and IDR 7 millions per month for multi-layered houses. The house was set to have a maximum building area of 36 m2 with a minimum land area of 60 m2. These houses were built and sold at a price below IDR 200 million. This price varies for the islands of Indonesia, with the lowest prices in Java (non Jabodetabek) and Sumatera (non Kepri and Babel) of IDR 116.5 million and the highest in Papua, amounting to IDR 183.5 million, for the prosperous house footprint (PUPR Decree No. 348 / KPTS / M / 2015 concerning the prosperous house footprint). The building standards of MBR houses included: 1). The walls used brick, deep outer plaster and paint, 2). Roofs used wooden frames or lightweight steel frames. 3). Frames used standard woods, 4). The floors used 30x30 ceramics, 5). The bathrooms used fiber bathtubs and squat toilets, 6). Electric power of 900 or 1,300 Watts according to PLN standard.

2.2 Sustainable House

The concept of sustainable houses was growing in a different ways from the MBR house. While MBR houses were focused on efforts to respond to sociological issues, sustainable houses were directed at efforts to respond to broader issues, covering social, economic, and environmental issues. The definition of sustainable houses proposed by the EU stated that sustainable houses meet three aspects: construction, socio-economic, and eco-efficiency. The main point was that sustainable houses were houses that "effectively integrate low energy designs with materials that have minimal environmental or ecological impact, whether in manufacturing, use, or disposal, while maintaining social diversity" [9]. A study of the urban sphere in Indonesia by Larasati et al [9] concluded that sustainable houses built in urban areas in Indonesia must follow a number of guidelines, including: 1). Using sunlight passive design strategies, allowing sunlight into the house during the day along with the wind and the fresh air, reducing energy needs for light and air conditioning. 2). Using local natural materials as heat insulators, such as coconut fiber, reducing synthetic material waste and energy due to transport of synthetic materials. 3). Purification and recycling of water for household needs. 4). Using natural cleaning agent. 5). Development of community participation in reducing waste and processing waste into commercial products.

The points of recommendation above, however, must still be reconciled with the need to provide housing for the MBR. For example, is it possible to provide a house with opened natural ventilation in an urban environment filled with noise and air pollution? City residents use air conditioning do not only cool the room, but they also avoid air pollution in urban areas. In addition, even if house ventilation is opened, fresh air cannot enter because it is blocked by tall buildings. As a result, opened windows in the dense urban area only have been built in high-rise buildings. This is actually raises security issues because of the high risk of falling, especially in families with children.

Wazir’s study [11] on three housing in Palembang City recommends the importance of developing water bodies and green plants around the house to reduce the impact of Urban Heat Island (UHI). UHI is a phenomenon of increasing heat in urban areas due to urban geometry and human activity in it. Green plants should not be planted in the yard, especially the limited land for houses in urban areas. Green plants can be built with the concept of a vertical garden or planted on the roof of a house that is formed flat, rather than a saddle or a pyramid. Meanwhile, the existence of water bodies is to cool function, but it also serves as a fire prevention.

2.3 Sustainable House

In line with the above description, there were two main references that could be integrated to produce sustainable houses for MBR. The first, the study result of McKinsey Global Institute [8] recommended finding land at the right price, reducing operational and management costs, adopting more efficient development processes, and increasing access to finance for buyers and developers. Second, the results of the Wazir [11] and Larasati et al [9] studies of sustainable houses in urban areas. Both considerations were then used to develop a sustainable house design for the MBR that was presented. Meanwhile, Figure 1 below illustrated the framework used this study.

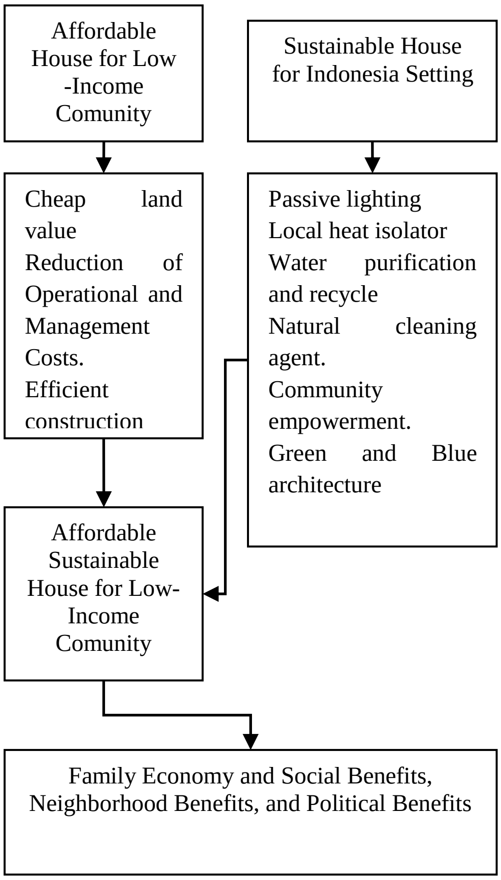

Figure 1. Research Thinking Framework

3. Results And Discussion

3.1 Optimum Occupancy for Sustainable House

The view that the number of occupants of a house became the first sustainability issue was raised by Fremlin [12]. In his analysis, in the next 900 years, without proper and right planning, people would reach their limit of existence when the population density has been 120 people per m2 of the earth's surface. The reason was that the heat generated by human activity has been such that it was not longer allowing biological growth at all. In a smaller scope, it could be at the problem of the number of residents in a house. The needs of the number of residents in a house can be determined from a variety of perspectives. From the perspective of disaster, with consideration of the needs of permanent living in a shelter in the event of a nuclear disaster, Blasley [13] stated that a person has a minimum floor area of 10 square feet, or 0.92 m2. Meanwhile, from an economic perspective, the density of 0.06 to 0.07 people per m2 (14-16 m2 per person) provides the lowest maintenance costs while 0.04 to 0.05 person per m2 (20-25 m2 per person) provided the highest maintenance costs [14]. It is the more spacious a building, the greater the cost of care needed.

National Standardization Board (BSN – Badan Standarisasi Nasional) [15] chose to use a biological perspective. In SNI No. 2003-1733-2004, BSN [15] stated that needs minimum floor area per person was the quotient of the needs of fresh air per person per hour in units of cubic meters divided by the minimum ceiling height. Experiments on human activities in the house from sleeping, cooking, eating, bathing, and sitting, it is known that adults need 16-24 m3 of fresh air per hour while children need 8-12 m3 per hour. From these results, with a ceiling height of 2.5 m, the minimum floor area per person is 9.6 m2 for adults and 4.8 m2 for children. This standard was far from the minimum standards in the UK, which was 37 m2 for a person. However, this standard was non-linear, depending on the number of people in the family. London City Policy provided 17 m2 per person for four people in two rooms [16]. The same was released by Parker Morris Report in 1961. Parker Morris Report assigned 30 m2 per person for an occupancy with one floor, but to 14 m2 per person for six person occupancy on one floor. Two-story buildings were only allowed for occupants of at least 4 people. In this case, 4 persons in two-story buildings were allocated 18 m2 per person, while for seven people to be 15 m2 per person [17]. If we take only a comparison of the average house size in the world, there was considerable variation in the minimum size, but all were above the minimum value of BSN [15]. Wilson [16] compared the per capita floor size from 15 countries and found the size of 15-89 m2 per capita. Hong Kong has a floor area of 15 m2 per capita while China is 20 m2 per capita. Meanwhile, Australia has 89 m2 per capita and the United States reaches 77 m2 per capita. If it was taken on average, the value of 52 m2 per capita can be drawn, equal to the average size in Germany (55 m2). However, the study of Liang et al [18] in sustainable office buildings in Taiwan found that the value of 0.10 to 0.15 people per m2 (7-10 m2 per person) became a value that did not disrupt the sustainability system in office buildings.

The sociological perspective has seen the connection between space and social problems such as crime, anomie, and tension among individuals in distress. Study in the slum neighborhood of Paris from Chombart de Lauwe was a 10-13 m2 value as the optimal value. The narrower, higher levels of social problems, meanwhile, the greater of the optimal value, psychological problems occur related to the relationship between parents and children. The value of 8-10 m2 is undesirable as well as the value of over 14 m2 [19]. To summarize, the following table provided the range for the area of occupancy per person based on the literature. From this table, the sociological perspective could be appointed as the main perspective. The sociological perspective showed the value of 10-13 m2 as the optimum value of human social space. This value also fulfilled BSNI minimum requirement and closed to minimum maintenance cost. This optimum value was also derived from studies in low-income neighborhoods so it was most ideal for reaching these social class needs. The size was too large that can cause psychological problems related to interpersonal relationships while the size was too small to cause problems of aggressiveness. Taking a middle value, then 11.5 m2 per person is the most ideal value for sustainability while facilitating MBR needs.

Table 1. Area Of Residential Based On Literature

m^2 per person	Description
0,92	Minimum size in a disaster emergency
4,8	Minimum biological size of children
7-10	Sustainable office size
9,6	Minimum biological size of adults
10-13	Optimum value of Paris's slum neighborhood
14-16	Minimum maintenance costs
17-18	Standard English for four persons in one house
20-25	High maintenance costs
55	The world average

3.2 Sustainable Building Materials

Overview of sustainable building materials was generally seen only from environmental aspects. For example, Joseph and Tretsiakova-McNally [20] reviewed sustainable building materials from the energy load and carbon load aspects. Table 2 showed the energy and carbon loads of each building material. The energy load was the amount of energy used in the life cycle of the material, from fabrication, use, and disposal. The same thing applied to the carbon load that measure how much carbon was embedded spent in the life cycle of materials. The lower the energy load and the carbon load, the more sustainable a building material. When viewed only in this way, the most sustainable alternatives were limestone, stone / gravel chipping, and rammed earth, as they have the lowest energy and carbon loads.

Table 2. Energy And Carbon Load Building Materials

Type of Material (1 ton)	**Embodied Energy (MJ/ton)**	**Embodied Carbon (kg of CO2/ton)**
Limestone	240	12
Stone/gravel chipping	300	16
Rammed earth	450	24
Soil cement	850	140
Concrete, unreinforced (strength 20 MPa)	990	134
Concrete, steel reinforced	1,810	222
Soft-wood lumber (large dimensions, green)	1,971	101
Soft-wood lumber (small dimensions, green)	2,226	132
Portland cement, containing 64–73% of slag	2,350	279
Portland cement, containing 25–35% of fly ashes	3,450	585
Local granite	5,900	317
Engineering brick	8,200	850
Tile	9,000	430
Soft-wood lumber* (small dimensions, kiln dried)	9,193	174
Steel, bar and rod	19,700	1,720
Polypropylene, injection molding	115,100	3,900

Source: Joseph dan Tretsiakova-McNally [20]. McKinsey Global [8] provided additional consideration that in addition to environmental sustainability, it was also feasible for MBR houses. Table 3 showed the alternatives of sustainable materials for walls, roof and finishing.

Table 3. Sustainable Materials For Mbr

	Material	**Description**
Walls	Fly-ash bricks	Made from fly-ash/volcanic ash along with sand, lime, and gypsum; used as a brick substitute for walls; created from by-products of power plants and industrial waste; environment friendly and cheaper substitute
	Clay fly-ash burnt bricks	Made from soil, fly-ash, sand, and fuel coal; replacement for conventional bricks; manufactured with less emissions and less fuel consumption
	Compressed earth blocks	Soil with minimum levels of clay compressed along with a small proportion of cement. In walls, interlocking blocks minimize mortar and plaster; low energy consumption during production; manufacturing machines can be made mobile
	Hollow concrete blocks	Cement, sand, and aggregates along with industrial waste such as fly-ash, blast furnace slag used to produce blocks that can substitute for bricks; energy and cost efficient, allows

	Material	Description
		faster masonry completion
	Cellular lightweight concrete	Cement, fly-ash, sand, and foaming agent; substitute for conventional bricks/blocks in multi-story buildings; reduction in deadweight can reduce costs in structure and foundation; high thermal insulation
	Ferrocement wall panels	Cement, sand, aggregates, fiber, and welded mesh combined to create panels of required shapes and sizes; allows for speedy construction
Roofing	Micro-concrete roofing tiles	Tiles made from cement, aggregates, and sand used in place of traditional tile, asbestos, and corrugated sheets; highly cost effective
	Ferrocement roofing channels	Cement, steel, and welded mesh suitable for large spans; speedy installation and 30% cost saving over traditional reinforced concrete roofing, 60-75% lower deadweight
	Reinforced concrete planks and joists	Cement and sand mixed with steel and binding wire; used for structural roofing, load bearing, and framed structures
Finishing	Bamboo mat boards	Bamboo and polymer boards are an alternative to plywood for use in partitions, door/window shutters, infill paneling, cladding, etc.
	Glass Reinforced Polymer (GRP) doors, shutters, and frames	Glass fiber, natural fibers, polyurethane foam, resins, and curing agents used as a substitute to wooden doors and shutters
	Mosaic and checkered flooring tiles	Cement, sand, aggregates, pigments, marble chips, and powder mixed to create mosaic tiles; used as cost effective flooring alternatives inside homes

Source: McKinsey Global Institute [8]. Although the above description was sufficiently specific to the sustainable materials for the MBR, these materials did not watch local situation. As an archipelagic country with a diversity of natural resources and industrial concentration, the prices of these items were more varied than a country that is fully mainland continent. Certain regions of Indonesia have different types of cheap sustainable materials. Bamboo was cheap and easily available in Java, but hard to get in Kalimantan. Cheap sustainable materials should consider local availability. In a typical situation, ordinary cement buildings were sufficient to meet sustainability needs.

This material did not have the embodied energy and carbon were large and readily available in big cities. This material did not have the embodied energy and carbon were large and readily available in large cities. This prevents the paradox of sustained efforts: sustainable efforts became unsustainable because of the unsustainability of the past. For example, the construction of sustainable houses in Britain has stopped. One reason was that sustainable building materials needed were not available in the area [21].

3.3 Roofing System

Especially for the roof, sustained efforts often fall short in efforts to replace the roofing material with sustainable materials. This was especially the buildings in Indonesia, where the saddle roof has become a norm that no longer needs to be evaluated. Flat roofs were viewed only as temporary roofs to wait for the construction of new levels. As a result, even if the house has a flat roof, the roof is allowed to have the bones of steel sticking out or used as a place to store goods as a substitute warehouse. Better step was to build a roof that was decorated plants. The green roof was able to cool the air in cities, increase drainage, and urban biodiversity. This was because the green roof provides a higher surface roughness. Roughness was defined as the degree of irregularity on the surface of the roofing material. This avoided misinterpretation that roughness was seen as the quantity of bulge on the roof surface. For example, if interpreted as a quantity of bulge, the tile was much rougher than asbestos, because the tile was modular and its arrangement on the roof was done in large amounts of stacking. This arrangement increased the amount of bulges. Meanwhile, asbestos was more subtle because the shape of large sheets. However, we could not interpret the bulge as rough because the bulges on the roof were uniformly directed. All these bulges were pointing toward the ground at the corner of the roof. Meanwhile, asbestos has a much rougher surface because of its brittle fibers. The direction of the bulge that appeared irregularly so microscopically, asbestos material was much rougher than the tile material. The irregular bulges were more aerodynamically meaningful because they inhibit and break the flow (convection) that was on the roof. Therefore, studies chose the definition of contours as irregularities on the surface of the material.

Zhao et al [22] considered that the surface roughness was the most important in reducing the urban heat island (UHI). In his study in the city in snow country and being found UHI was higher in rural areas while in the snow was found UHI is higher in urban areas, as it has long been known. This was because the snowy area of the countryside has a smooth surface, making it easier for heat to accumulate. In contrast, urban areas in the country the snow has a high roughness, resulting in heat actually split. The construction of a green roof did not require a large area. Use of a minimal green roof could only take up 10% of the roof space. The value of 10% is taken from the IMB policy approach made in Toronto, USA, where buildings with floor area of 2,000 - 4,999 m2 have 20% green roof [23]. The regulation did not provide a requirement for buildings with floor area below 2,000 m2 but if expanded, then the building should be below 2,000 m2 will have a proportion of about 10% .The rest could be used to hang clothes. Moreover, the use of flat roofs actually lower costs because developers did not need to build a more complex saddle roof.

These results were consistent with research Wazir [11] who found the roof of the importance factor in mitigating UHI. The more rough the roof cover, the lower the UHI. From three types of roof coverings: asbestos, tile, and zinc / metal, the most rugged types are asbestos and houses with asbestos cover produced the lowest UHI. The government certainly could not require housing builders to use asbestos roofs. This was because the asbestos was fiber-shaped and this form is prone to peeling off and lowering the durability of the roof. Instead, asbestos roughness was contributed by this fibrous nature so that there was gradation of fiber attachment to the main network of asbestos sheets. Houses with green roofs were more eligible aesthetic because the placement design could be managed with a great degree of freedom. Moreover, the green roof also allowed residents to experience increased productivity because it provided oxygen and natural coolness that allowed residents to move without the psychological disturbance from the aridity of views and thermodynamic disturbance of the arid house. Studies in the country showed that temperatures under green roofs could reach 32°C relative to outdoor temperatures of 42°C, better than regular roofs of only 38°C [24].

There were socio-economic advantages of greening besides UHI deterioration effects. Studies in Chicago showed that urban reforestation [25] increased in property values [26], increased tourism [27], and increased taxes [28]. As the city became green, there was a perception of increased value added by the city. The developers of housing was also understood that a green house tend to be more expensive than the arid house. But we expected here was not only a luxury house that has a green land, but also house to the middle. It could not be facilitated by adding soil, but it could be achieved by adding greenness to the roof of the house. In addition to economic benefits, biophilic urbanism provided social benefits of reduced aggressiveness and increased social attachment. Study in Chicago showed that within two years, buildings surrounded by green environments experienced a 52% reduction in crime cases rather than buildings surrounded by buildings [25]. A deeper investigation found that the contribution of green environments in reducing aggressiveness in these buildings amounted to 7-8% of the 52% reduction (other factors of law enforcement activity and so on) [29]. Another study also found that people who lived in housing that was surrounded by greenery has a social relationship more closely with their neighbors rather than arid environment [30].

The application of green roofing obligations to IMB has been implemented in Chicago [31] and Toronto [32]. Portland and Chicago city government provided tax reductions, fund incentives, or IMB bonuses on houses that made green roofs. Toronto and Copenhagen even required green roofs for newly constructed building. In Germany, an estimated 10% of houses with flat roofs (roofs grown) were covered by green roofs [33]. In the tropical context, the performance of green roofs have also been shown. Tan and Sia [33] observed green roofs in Singapore that reduced visible radiation and increased visual comfort, lowered surface temperatures, and reduced gas pollutants in the form of sulfur dioxide and nitrogen oxides. Tsang and Jim [35] even reported that the use of green roofs in the tropics has twice the effectiveness of green roofs in the four seasons. The weakness of the green roofs were more on the possibility of the presence of undesirable fauna such as mosquitoes [36]. But it could be overcome by providing natural predators such as lizards and geckos on the roofs of the house. Another weakness was the ability of a green roof to raise the pH of rainwater. Sakong's study [37] found that the rainwater that passed through the green roof has a pH of 6.29 while that through regular roof of 5.31. This was beneficial for people who used rain water as drinking water as residents in areas not yet covered such taps on the outskirts of Pontianak city [38]. But it also meant that the soil as green roof media containing pollutants such atmosphere that has been filtered. In order for pollutants did not to contaminate the houses, the soil should be isolated as best as possible so that rain water did not leak into the house. It was best accomplished with a special membrane for the purpose of green roofs. An important note regarding the use of a green roof was a house that must have a flat roof, such as house grown, or with a slope of less than 2% [32]. If we apply green roof obligations to the construction of houses and housing, then there are two options for developers. The first, did not build a sloping roof, but replaced it with a growing roof. Second, built a sloping roof, but provided a space large enough to be a green roof. It could be done even better if the house was built with a model of multilevel patio (terrace house). In both options, an extensive model was more desirable because it propagated the bulge on the roof surface making it more efficient in lowering the temperature than the intensive model [39].

There were two types of green roofs: extensive roofs and intensive roofs. Extensive roofs meant spreading green plants extensively on the roof of the house. Intensive roofs meant concentrating green plants at one point on the roof of the house. If the developer chose extensive roofs, then the houses that must be built should use the growing roofs as it provided ample space to become green roofs. The soil was spread over the roofs as the growing medium with a depth between 2-20 cm, depending on the type of plant. Moss required the least soil, while the grass requires the most soil. If you choose the extensive roof, means that developer simply provides a little space in the flat roof of the house to be a place to plant. Media planting on an extensive roof must be at least 15 cm deep so that the grass could grow. Plant placement models could use pot media, grass carpets, or soil on concrete. The more sloping roofs, the cost to keep the green roof system remained well higher.

3.4 Colors

Fallmann, Emeis, and Suppan study [40] used a simulation method to examine the correlation factors of heat reflective paint and green vegetation on UHI. It was found that roof paint replacements became reflective of heat lowering UHI 2°C while substitution of penetrating surfaces with green vegetation lowered UHI by 1°C. [41] used a survey method at Pin Sec district in Nantes, France, found that cold paint (high-albedo and emissivity) capable of lowering the UHI 91-97%. In line with this, then RMR building should be able to use color with albedo and high emissivity, which were bright colors.

3.5 Ventilation and Lighting

The problem of ventilation and lighting in a sustainable house is actually simple if the cost is not taken into account. To be sustainable, a house needs to have large ventilation and natural light. A large house could build large ventilations around the garden surrounding the house before it reached the fence of a wall that limits between the house environment and a noisy busy road. For MBR houses in large cities, the problem became complex. If the ventilation is opened, it will be exposed to outside air pollution Natural light could get in because there were not tall buildings around it. Another factor, which was sometimes overlooked in open ventilation recommendations, was the seasonal change of natural ventilation [42]. In certain seasons, natural ventilation actually cause the situation in the house was too hot, while at other times, causing rain water came in and made a moist interior of the house. The existence of natural ventilation must also adapt the placement took into account the surrounding environment such that maximized the quantity and pattern of air flow in the house [42]. A common solution was to induce wind with air conditioning or a fan. Instead, Wood and Salib [43] argued that in fact, the existence of air conditioning liberates the architecture from its dependence on natural ventilation. However, the use of air conditioning or fans resulted in additional electricity consumption and negative effects of the fan on health by lifting dust on the floor and the negative effects of air conditioning that actually heat up the room.

The problem of natural ventilation for urban architecture was a big design problem. Wood and Salib [43] stated that there was not a strong enough data to verify the design of what worked and what did not work. The solution offered by Wood and Salib [43] was with aluminum blind, which was still quite expensive for MBR houses. A cheaper version was available, the blind of glass. But often this type of blind was unsustainable because the opening-closing mechanism became rusty or worn in a short time. Within existing land constraints, which pushed MBR houses exposed to pollution-intensive highways, ventilation solutions could be done in the traditional way, by creating openings that leaded to the lowest altitude point of the building outside the house and openings that pointed at the point with the water source quite spacious, and openings that leaded to a point with a large tree. The close position of the water source allowed natural cooling to be provided by water vapor from the water body while a large tree provided a fresh oxygen stream for the residents of the house as well as describes a hot wind if it suddenly comes over the rough surface of the plant. Not every house has the advantage of the existence of large trees, large bodies of water, or no high-rise buildings, but this required that each sustainable MBR house should have an unique ventilation design, adapting to these three factors. Ventilation may even be up or upward to get in wind if the house is blocked by a large building on the side. Lighting problems did not have to come from natural sources. If there is not side of the building that opens to a relatively free area of air pollution, then an artificial lighting alternative is required. The current artificial lighting is actually quite advanced to provide a light source similar to natural light and minimal heat and energy saving. LED technology can help. Although quite expensive, LED lights have a long life and can be believed that in future developments, the price of LED lights will be cheaper as the needs grow. The alternative is to make windows out of glass. However, this is not possible for confined spaces and requires high privacy such as a bathroom or kitchen.

3.6 Consumption Pattern

MBR consumption patterns generally focused on food and other basic universal such as clothing universal [44]. Actually, the middle to upper income people also consumed these needs but the average price was higher. Surveys showed that MBR spended about 50-70% of their budget for food [45]. This adds importance of the availability of bins were large enough to accommodate the packaging of food consumed. The existence of waste bins ensured residents avoid disease. These bins must be representative enough for one house to assume responsibility for the elimination of waste clearly and no garbage dumping in one location that can cause aesthetic and health problems. In addition, consumption patterns that emphasized basic needs reduced the need for people to increase the size of the house. In order to the use of flat roof to be effective green roofs, the city government needs to build local laws that prohibit houses in a residential area MBR add high or increase. If you want to increase the level, then there should be a hot convection crusher such as a contoured roof or a level of bulge, planting green plants on the upper floors, or not functioning upstairs with activities that consume electrical energy larger than the ground floor. In addition, housing developers should provide a large tree that can prevent heat stored in terraced houses. This tree needs to be put on the roadside so as to block heat from the sun that is not stored in the building.

3.7 Land Requirements

This study took the value of 11.5 m2 per person as the ideal value for sustainability while also facilitating the needs of MBR. Meanwhile, the government determined that the standard of MBR house has a maximum building area of 36 m2 with a minimum land area of 60 m2. The average number of households consisted of 3 or 4 family members. With an ideal value calculation, three family members required a land area of 34.5 m2 while 4 family members required a land area of 46 m2 that exceeded the maximum building area for the MBR. Because of the limitations of this land, then the addition of floor area could be done by adding levels. It meant that the MBR house should have two levels so that it can provide a comfortable enough space for the MBR residents in the lives of their houses.

3.8 Optimum Distance Between House

Distance creates a space that satisfied the needs of society to gain choice and acquire unoccupied land for communal living necessities and individual existence [46]. In addition, the distance between houses allowed more awake privacy and reduced friction due to noise problems. Besides the social needs, the distance between buildings inhibits the spread of infectious diseases and pests such as mosquitoes, enabling airborne carrying and circulation, overcoming water catchment problems, avoiding wall cracks, and reducing the risk of fire propagation or earthquake damage. In general, local regulations put a distance of 1.5 meters as the minimum distance between houses that did not coincide for one-floor house. In the two-story house, the distance between the buildings was generally further. In other words, the size of the separation distance between houses was directly proportional to the height of the house. In a house with a height of 4.5 meters, the distance between buildings reached 3 meters, with the distance of the fence with the house each 1.5 meters. Two-story house has a height of 7-9 meters, so it required a distance of 4.5 to 6 meters.

4. Conclusion

The above discussions leaded to some conclusions that sustainable MBR houses in urban areas should:

a. Providing space with a floor area of 10-13 m2 per person. With a limit of 36 m2, then the house could only be occupied by three people. If the residents were more than three people then the house should have two floors. The number of residents more than six people were not allowed, as well as adding a further level.
b. Using building materials are easily available and cheap.
c. Being fairly close to water bodies.
d. Having a green roof.
e. Using bright colors.
f. Ventilated open to areas with low buildings, large trees, or water bodies.
g. Natural lighting during the day could be in the form of sunlight from the window glass enclosed and LED lights for illumination at night and closed space.
h. Having a garbage bin and representative garbage treatment room.
i. The distance of houses was set at 2 - 3 meters, while for the two-story building was set 4.5-6 meters.
j. One floor and two floors buildings could not be built in one lane so that the two-story building height did not block the one-floor building.

The characteristics of eco-friendly housing for low income people when combined with external factors such as low land prices, low cost management and house construction operations, efficient development methods, and the availability of good financing with low interest rates, as well as community empowerment to support sustainability , along with the utility system that prioritizes recycling and water purification, resulted in a house that was perfect in terms of sustainability and affordability for both developers and for low-income people. Wazir [47] has shown that a number of social institutions could be empowered to support efforts to increase environmental awareness in residential areas. The prototype generated by this study will be able to overcome the weaknesses that are owned by the current subsidy prototype house that has a low quality so it was not livable. It was seen as derived from the price too low so that the developer should minimize quality. Actually this is not necessary if sustainability can be raised as an added value. Giving the added value of sustainability, houses can be set up to the maximum price permitted by regulation, while high quality allows developers to be driven to apply to subsidized settlements as well as luxury and intermediate settlements. It does not only provide benefits developers, but it also motivate developers to build housing to MBR in large numbers without being pushed and forced by the government. Therefore, the prototype presented in this study is a refinement of the prototype house existing MBR.

In addition to changing the standards, the government can play a role by building regulations so that residents do not increase the building area or change to the building shape. This is an element that can not be separated from the sustainability of the building due to extensive additional effort or change in shape would be more likely to produce and design practices that are not sustainable, resulting in a decline in value and meaning of sustainability itself. People need to be made aware that renovation is not necessary because the design is indeed optimum. It costs a little more expensive is the cost of quality as a substitute for the renovation of possible consumer if the consumer buys a regular subsidy houses.

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