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The study of residential life support environment system to initiate policy on sustainable simple housing

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Abstract. This study aims to initiate sustainable simple housing system based on low CO_2 emissions at Griya Martubung I Housing Medan, Indonesia. Since it was built in 1995, between 2007 until 2016 approximately 89 percent of houses have been doing various home renewal such as restoration, renovation, or reconstruction. Qualitative research conducted in order to obtain insights into the behavior of complex relationship between various components of residential life support environment that relates to CO_2 emissions. Each component is studied by conducting in-depth interviews, observation of the 128 residents. The study used Likert Scale to measure residents' perception about components. The study concludes with a synthesis describing principles for a sustainable simple housing standard that recognizes the whole characteristics of components. This study offers a means for initiating the practice of sustainable simple housing developments and efforts to manage growth and preserve the environment without violating social, economics, and ecology.

1. Introduction

The increase population of major cities in Indonesia demands a huge amount of housing and requires them to be implemented in a sustainable manner that does not harm the environment, social life, economy, and culture [1]. In the meantime, little attention has been given either by government agencies and society to putting sustainable housing policy into practice, particularly for low CO_2 emissions in the middle and lower income residential area. This emission of CO_2 is not merely caused by the process of construction, but also by the whole dynamic of systems in the simple housing areas. [2].

According to Ministry of Housing Strategic Planning Year 2015-2019, Indonesia's upcoming five-year plan is to build 1.367 million units of subsidized housing. This plan brings 2 (two) fundamental questions. First, can the construction of settlements and large-scale housing can be sustained? Second, what is the impact for a sustainable city? These questions raise a number of challenges and difficulties. In particular, cities now grow and develop increasingly complex, and thus self-sustaining housing problem is further complicated [3].

Efforts to minimize the emission of CO_2 in urban residential area is becoming more challenging in terms of planning, designing and building more sustainable housing. The processes of land development for housing, construction, house alterations, and finally house demolitions are also processes that vastly damage the environment, especially related to the CO_2 emission produced [4]. Furthermore, the generation of CO_2 emission is also presented in the implementation of simple housing, due to the manufacturing process of building materials and the transportation of these materials, the use of equipment during the construction process, and household activities when the house is inhabited [5], [2].

This study brings forth issues that are not fully yet adopted by the general design of simple housing, particularly ideas on how components of residential life support environment in simple housing can be regulated in initiating sustainable simple housing. This study develops a standard for introducing sustainable simple housing system based on low CO_2 emissions, using the case of the simple housing at Griya Martubung I Medan, Indonesia in order to obtain insights into the behavior

of complex relationships between various components of residential life support environment that relates to CO_2 emissions. Through this study, we initiate good environmental planning and design instruments to prevent and mitigate the increase in CO_2 emissions. This study deliberately discusses strategies to initiate low CO_2 emissions of simple housing.

2. Method

This study has been conducted using both quantitative and qualitative techniques. The quantitative technique is applied to study and analyze the residential life support environment system of Griya Martubung I Housing, such that we could determine which components have most to affect the sustainable housing. Descriptive qualitative approaches were then carried out to explain problems which may be encountered by homeowners with respect to the residential life support environment system of Griya Martubung I Housing. Interviews with homeowners have been conducted to get the first hand information on the understanding the need for sustainable simple housing concept and problem in Indonesia. The location of this study was at Griya Martubung I Simple Housing, Medan (see Figure1.)

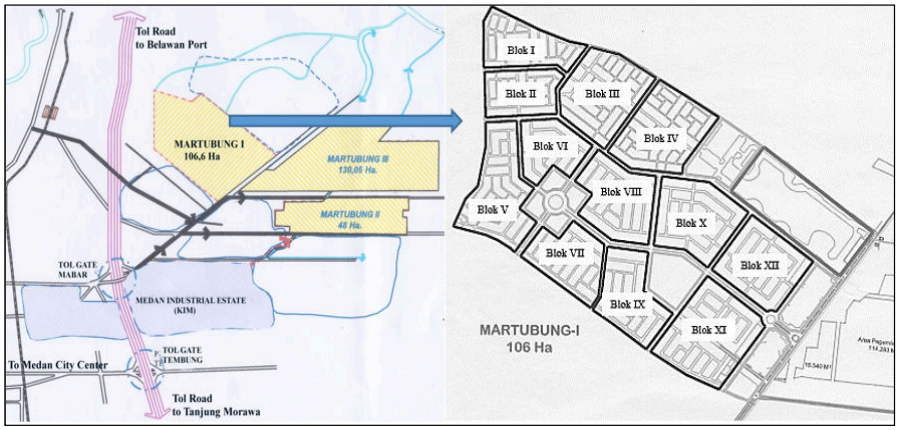

Figure 1. The Location Map of Griya Martubung I Housing

128 questionnaires were distributed to determine residents' level of awareness and understanding on residential life support environment system concepts for sustainable simple housing at Griya Martubung I. The dwellers were selected from 12 blocks of housing at Griya Martubung I as the survey's target. Likert scale was used to measure their perceptions. The variables, indicators and methods used in this study were shown in Table 1.

Table 1. Variables, Indicators & Methods

Dependent Variable	Independent Variable	Methodology
Social and public facilities	• Seating facilities • Lighting facilities • Pedestrian facilities • Accessibility	• Questionnaire • Interview • Field Observation • Photograph
Commercial facilities	• Seating facilities • Lighting facilities • Pedestrian facilities • Accessibility	• Questionnaire • Interview • Field Observation • Photograph
Green open space	• Comfort • Safety • Cleanliness • Interestingness/appeal	• Questionnaire • Interview • Field Observation • Photograph

	• Comfort for pedestrians • Accessibility	
Temporary landfill	• Safety • Cleanliness • Interestingness/appeal • Comfort for pedestrians • Accessibility	• Questionnaire • Interview • Field Observation • Photograph
Man-made pool	• Comfort • Safety • Cleanliness • Interestingness/appeal • Comfort for pedestrians • Accessibility	• Questionnaire • Interview • Field Observation • Photograph

3. Results and Discussions

3.1. Creating Low CO_2 Emissions Of Sustainable Simple Housing

In Indonesia, physical changes of housing in the form of restoration, renovation, or reconstruction are part of housing development dynamics, and they happen in conjunction with the increase of infrastructure demand due to the growth and development of the housing residents' needs. House alterations and the dynamics of residential life in simple housing are a complex interaction system that is associated with the production of CO_2 emission to air [2]. This emission of CO_2 is not merely caused by the process of construction, but also by the whole aspect of utilizing the space in residential areas [6].

The emission of CO_2 produced by a housing is closely related to activities that use non- renewable energy resource. The greater each activity's dependency on energy usage, the greater the emission of CO_2 produced by an urban housing's implementation system [7]. Through utilization and regulation of space, a sustainable simple housing with low CO_2 emission can substantially be built. In relation with Griya Martubung I Housing, the livelihood activities of its residents rely on every resource in and around the housing areas. The links between the various components of the residential life support environment system play a part in producing CO_2 emission, and determining the initiation of sustainable simple housing. The various components arise from space utilization and regulation in the housing implementation and inhabiting, and includes access, green open space, structure plan and hierarchy, pedestrian, utilities, public facilities, social and commercial facilities, temporary landfill, man-made pool.

Observation done from July 2016 until September 2016 on house alterations at Griya Martubung I shows that in the period of 2007 until 2016, 89% of homes (2830 housing units), houses of type 29, type 36 and type 54 went through a variety of physical changes such as; restoration, renovation, and reconstruction. Table 2. shows that the overall changes of these houses are accompanied by the generation of huge amount of CO_2 emissions into the air [8], [9]. It should be noted, however, that the generation of CO_2 emissions is not only caused by the construction of space utilization in the residential area [6], [10].

A study done by Afiaty [11] shows that alterations to bigger types of houses such as type 54 in Griya Martubung I are no longer affected solely by the need of room functionality, but also by the purpose of inner space aesthetics. Alterations in the form of adding rooms or extension of building that differs from the house's original structure will change the existing building structure and material. Table 3 explains some underlying factors that may be controlled to reduce CO_2 emission at Martubung I Housing. The change of building structure and material produces CO_2 emission to air. Therefore, efforts for initiating sustainable housing can be done only if every underlying factors of house alteration can be controlled. The design of home system components can affect the increase of carbon

generation in case of repair activities, changes, or additions to area of the home building. In addition, various activities in the house uses air conditioning and light, which also have an mpact on the increase in CO2 emissions.

Tabel 2. Total CO_2 emissions result from Physical Changes At Griya Martubung I Housing from 1995 - August 2016

No	Housing Type	Renovation		Restoration		Reconstruction		Total Unit
		Unit	Kg-C	Unit	Kg-C	Unit	Kg-C	
1.	29	223	121,606	197	259,748	163	690,126	583
2.	36	615	463,366	509	671,113	315	1,336,678	1439
3.	54	348	589,359	255	336,223	205	867,949	808
Total		1186	**1,174,331**	961	**1,267,084**	683	**2,894,753**	**2830**

Tabel 3. Matrix of Factors of House Alterations

No.	Underlying Factor	Data	Reasoning	Restraining Factors
1.	Number of head of households	Data of the number of head of households at every block and field survey	If the number of head of household in a house increase, then the member of the family and need for room increases too	The awareness that a house should be for one head of household needs to be developed and socialized to members of community.
2.	Average number of residents between 4 and 5 people	Data of the number of head of households at every block and field survey	The bigger the number of house residents, the bigger the number and area of rooms needed	House type does not confirm to the number of family members. The type 29 for 3-4 family members, type 36 for 4-5 family members and type 54 for 5-6 family members
3.	The majority of residents work as civil officers (47%) and private employees (41%)	Field survey August 2016– September 2016	A steady job gives opportunity to residents to do house alternations	Careful access to funding for house construction / repair, even though there is a steady job
4.	55% of Griya Martubung I residents have high school education	Field survey August 2016– September 2016	The higher the resident's education level, the bigger the awareness of need for rooms	High level of education affects the amount of income, and the awareness to save energy
5.	The majority of residents are 40 - 50 years old	Data of number of head of households at every block, and field survey	With the big number of residents in their productive ages, horizontal activities among the residents more intensive, and increase the need for social rooms among residents	Activities for productive ages are mostly outdoor activities. Awareness social-cultural relationships among residents develop

One of the contributing factors of house alteration dynamics at Griya Martubung I is the number of householder, or the increasing number of residents in a house. More residents in a house certainly demands for a larger house area with more complex building scheme. In consequence, house alteration

needs construction technology to condition the space, especially to handle ventilation, lighting, and house utility systems that become more complex with the addition of building area. The whole construction technology system affects energy utilization at residential areas, and certainly does not conform to the generation of sustainable simple housing scheme.

Meanwhile, to determine the minimum space requirements for each person that resides in a house required the basic activities of the residents. Table 4 shows a relationship matrix between a house with its residents and the house alterations done by the residents. According to Undang Undang Republik Indonesia No. 1 Tahun 2011, on Housing and Settlement Areas section 22 verse 3, the standard for a house's floor area is at least 36 (thirty six) square meter, with the assumption that the space area requirement per person is 9 (nine) square meter, and the average height of the ceiling is at least 2.80 m.

Since its establishment in 1995, a big number of house alterations have been made at Martubung I Housing. The reason for the alterations is that the residents needed to extend the area of rooms available. The house owner performs alterations to be able to support indoor activity needs of the house residents. Other than the need for additional room, relatively bad building material quality is also one of the underlying factors of house alterations. Table 4 shows some factors that relate with building material changes in correlation with house residents. There are a couple reasons for house residents changing the building material of their house. The reason of material change by residents of Martubung I Housing is mainly because the quality of building material does not yet conform to the residents' preferences, and because of the age of the building material. The whole alteration done needs energy that causes increase of CO2 emission. The residents' accessibility capacity varies and comes from diverse sources. The various types of financing sources for house alterations affects the end result of house alterations. Figure 2 illustrates the relationship scheme between residents' income with building material and CO_2 emission produced from the house alteration.

Tabel 4. Matrix of House Residents and House Alterations Correlation

Underlying Factors	Effect to House	Alteration Done by Residents
Quality of building material generally low and not conforming to standards	Shorter age of building material resulting in recurrent need for changing, and low quality of construction	House residents do repair by changing building material (restoration)
Design of house does not conform to the preference and need of residents	• Low quality of building structure • Insufficient room availability • Increase need of rooms • Decline of comfort inside of house	• Do renovation to change house structure • Redesign by repositioning certain room functions, such as the kitchen, bathrooms. • Adding room sand extending house • Redesign of windows
Implementation of house construction does not conform to building standards	• Bad quality of house • Residents desire for a new house structure	House reconstruction, by building a totally different house from the original (former house structure)

3.2. Griya Martubung I Housing As Residential Life Support Environment System

Since the Griya Martubung I Housing is about 20 kilometers to the city center of Medan, residents always require an easy access in and out of the housing. From observation and interview, it is acknowledged that in general, the dwellers of Griya Martubung I Housing use private transport instead of public transport for their daily activities. Figure. 3 illustrates some of main components of residential life support environmental system of the Griya Martubung I Housing as follows; a main access, temporary land fill or temporary garbage dump site, green open space, streets and drainage.
Qualitative investigations showed that many environmental factors are closely affecting the release of CO_2 to air from the whole dynamics of simple housing system. A unique System Relationship Model (SIM) for Griya Martubung I Housing is then developed with the goal to initiate sustainable simple housing by synthesizing the components of the housing's residential life support environmental system.

Figure 4. visually defines the interactions among the components that sustain the housing and the dwellers' way of life. The conclusion of this study is useable on condition that Griya Martubung I is inhabited. The components of residential life support environmental system are access, structure and hierarchy, distance, gas and water supply, electricity and phone line, streets and drainage, public transport, public facilities, social facilities, commercial facilities, man-made pool or ponds, temporary garbage dump site, and green open space.

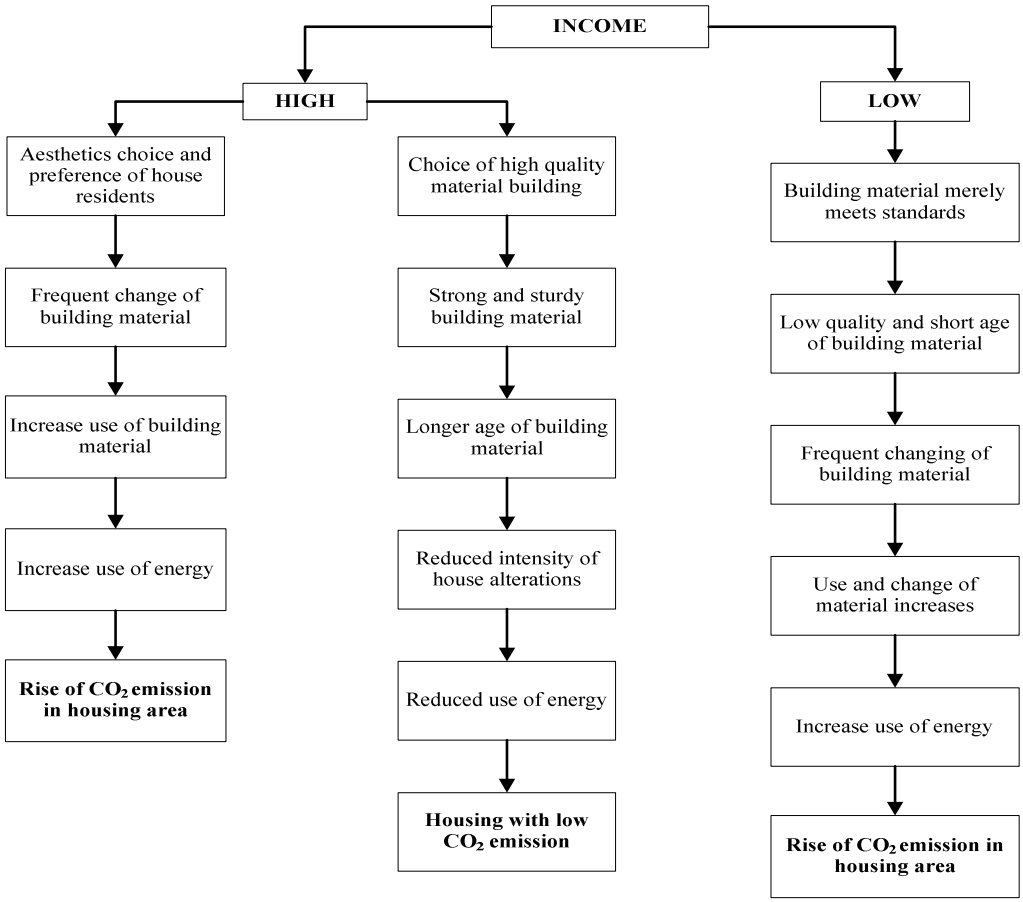

Figure 2. Diagram of Resident's Income, Choice Building Material and CO_2 Emission.

Figure 4 also qualitatively indicates that the system components considerably determine the inter-

relationship between all areas in and around the housing to initiate sustainable simple housing. The schematic model shows that access is an important component to initiate life support environment in Griya Martubung I housing. Distance, structure and hierarchy will establish a pattern of the dwellers' activities to fulfill their life in and around of housing. Similarly, structure and hierarchy play a significant role in determining the locations of public facilities, social facilities, commercial facilities as well as public transport network to fulfill basic public mobility needs in and around Griya Martubung I housing.

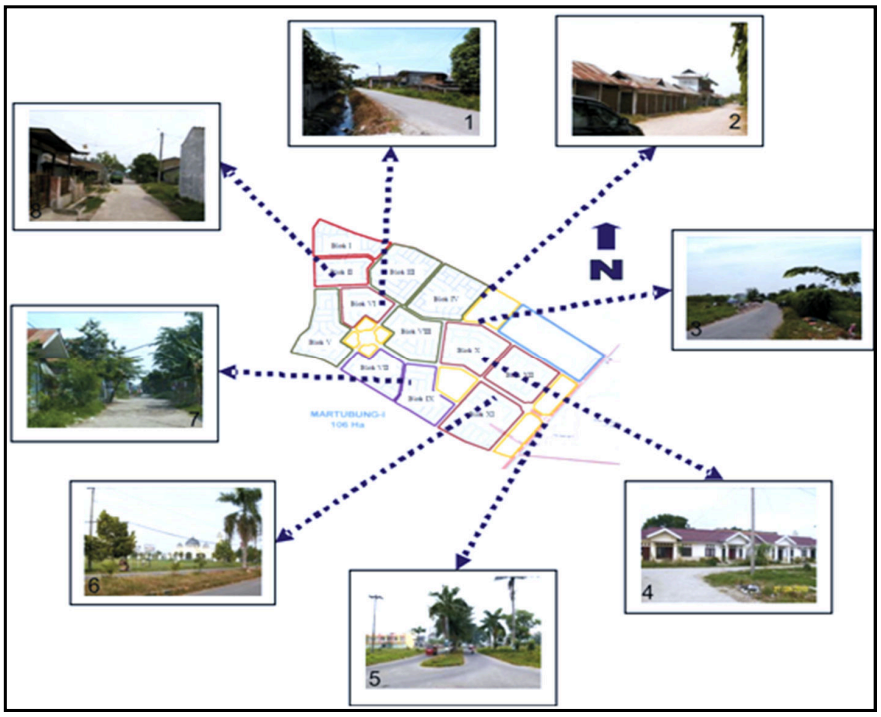

Figure 3. Some of **C**omponents of Residential Life Support Environmental System In The Griya Martubung I, Medan

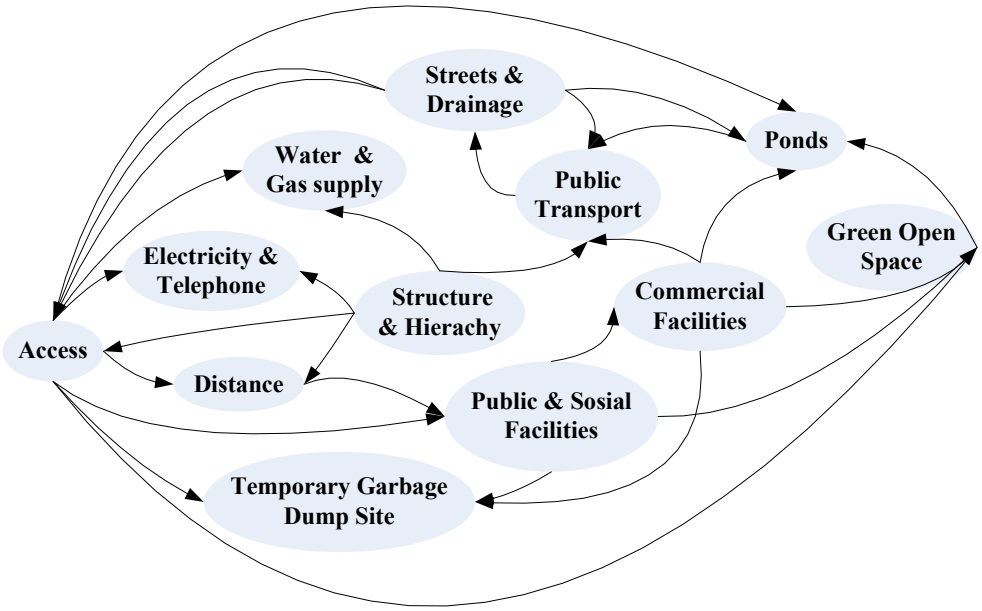

Figure 4. Residential Life Support Environment System of Griya Martubung I

Accessibility to temporary garbage dump site or temporary landfill should be easily reached from each block of the housing. At the moment, the temporary garbage dump is located at the northern part of the housing site, which is only close to block IV and block X. Consequently, dwellers from the other 10 blocks extensively depend on motorcycles to upload their garbage. Having this in mind, it is preferable for the housing management to provide a garbage container around of each block of housing, and later on collect them to dump into temporary landfill.

One remarkable finding from this study relates with the pond that is located in the eastern part of the site (figure 5.). This pond is a man-made pool which exist as a part of cut and fill works for the purpose of Belawan-Tanjung Morawa (Belmera TOL-Road). This pond can be greatly used for social, economic, and environment reasons in developing sustainable simple housing. The pond can functioned not only to collect unnecessary rain water, but also improves the microclimates of the surrounding area of the Griya Martubung I. The pond can effectively create huge impact on living condition in the housing area by filtering out adverse climatic effect.

Figure 5. Man-made ponds in eastern part of Griya Martubung I

3.3. Initiation Strategy to Create Sustainable Simple Housing

This study has been clearly identified that the dynamics of living in Griya Martubung I carry out simply to prepare housing for low income people. What reveals from this study is that there is a need from now on to adopt policy which measured the whole interrelationship of components of residential life support environment system. This measure in need due to the increase requirements for living in more sustainable simple housing in Indonesia.

In general, not many housing planning and design policy exists that directly administers the components of resident life support environmental system to decrease CO_2 emission in the development of simple housings. Some policies that relate with the steps of reducing CO_2 emission in the development of simple housings are: regulations on building density, green open spaces, and regulations on house lot areas. However, there is still need for policies that directly relate to the utilization of components in simple housing, such as regulations on road networks, regulations on centers of activities, control of public and social facilities' locations, control of public transportation, distance between buildings, control of household waste, and control of gas waste caused by the use of household utensils and instruments. To include these in documents of housing development we should refer to policies in the related fields, such as transportation, environment, and energy.

Based on our observation in this study, accessibility and public transport are two important components to initiate sustainable simple housing. From the 128 respondents, it was known that as many as 93% of Griya Martubung I residents use their own transportation mode daily. More specifically, 11% use cars, and 82% use motorcycles as means of transportation to support their daily activities. Residents' perception about characteristics of accessibility in Griya Martubung I were not quite good; the total score for accessibility was 2.52. Based on the correlation of distance, working area, travel time, and transportation mode used, it is shown that the residents of Griya Martubung I Medan work relatively far from their house, and thus do not use the mode of walking to support their activities. Nevertheless, as one determinant factor in initiating sustainable simple housing, it is a misfortune that the housing is not provided with pedestrian facilities for walking activities, especially inside the housing area. Indeed, pedestrian facilities for pedestrians in Griya Martubung I are not yet provided.

Another aspect that has not been acknowledged is the extent to which the green open space policies have been implemented and what are their effects particularly to support the sustainable life in the housing area. The greenness of Martubung I was perceived as quite good by its residents with a total score of 3.10. This perception of greenery stems from the presence of plants in the surrounding area of housing. However, the study shows that green open space in the Martubung I is 3.4% of the total 1,063,099 m^2. This does not yet conform to Undang-Undang no.1 tahun 2011 section 28 and 29, on Housing and Settlements Areas [12], which states that the standard for green open space should be 30% of the total of housing area.

In general, experience of housing development practices only addresses the aspect of correctness or distortion of space utilization, based on land usage that has been established before. Meanwhile, the change of utilization intensity such as usage of roads and man-made pond, that results in the generation of CO_2 emission, is rarely discussed. This observation was made from the usage of existing temporary landfill in Martubung I housing. Residents' perception about the temporary landfill is quite good with a total score of 2.82. Nevertheless, there were still some trash that were not correctly disposed, and the capacity of the trash bins around the housing area were still minimal. For example, there were no the trash bins especially in the playground area.

Attractiveness of man-made pond in Griya Martubung I, Medan was perceived as quite good with a total score of 2.67. This was supported by various events that were frequently held, the existence of many people visiting the pool. However, the availability of playground area next to it is needed as well as the availability of eating and drinking area in the surrounding area of the ponds.

One possible way to initiate sustainable life in simple housing areas is by optimizing the people flows around and inside various land usage for social, public, and commercial reasons. Movements happen when there is constant open space that does not interfere with the speed of passing vehicles. In relation with sustainable housing, the general approach for transportation in land use planning is usually done by distributing centers of activities, public facilities, and social facilities in proximity with housing. This will reduce the operational distance of vehicles and ease residents to walk around the housing area. The road networks generally should go with policies for sustainable housing. For Griya Martubung I, accessible public, social, and commercial facilities around and inside the housing area were perceived as good with the total score of 3.18

This research reveals that 5 (five) main components play a significant role to generate sustainable simple housing such as; accessibility, green open space, temporary landfill, man-made pool or pond, and public, social, and commercial facilities. Figure 6. shows that none of component was perceived as very good. For dwellers, the overall components were perceived as quite good with the total score of 2.86. From the findings, the following things are considered to be important in initiating simple housing developments.

(1) Improvements of housing planning and design policy that directly relate to the utilization of components in simple housing, such as regulations on road networks, regulations on the centers of activities, control of public and social facilities' locations, control of public transportation, distance between buildings, control of household waste, and control of gas waste caused by the use of household utensils and instruments.
(2) Promotion of compact housing development which measured the whole interrelationship of components on the policy making.
(3) Development of control policy to prevent excessive usage of the components.
(4) Promotion of man-made pool as a basic standard of sustainable simple housing.

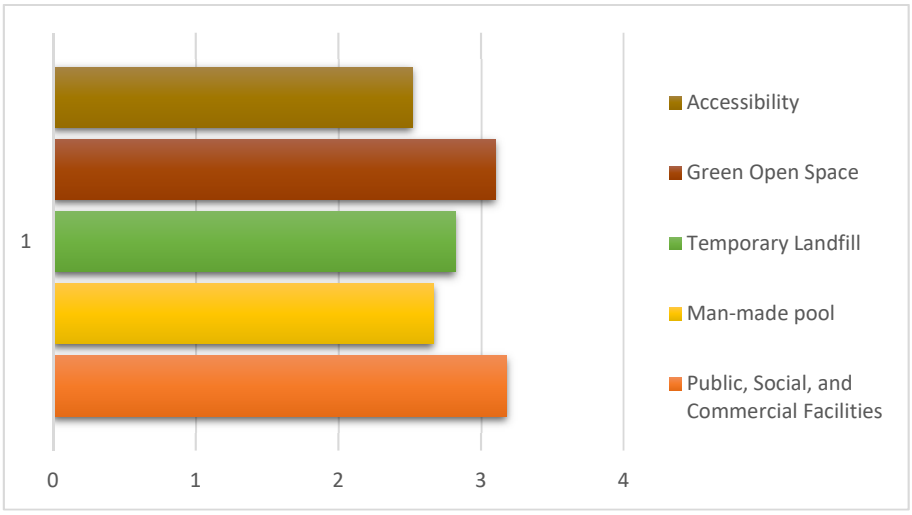

Figure 6. Residents' perceptions about main components of housing life support environment at Griya Martubung I Simple Housing – Medan, Indonesia

Conclusions

This study has shown that 5 main components of residential life support environment system such as accessibility, green open space, temporary landfill, man-made pool, and public, social and commercial facilities play an important roles in proposing sustainable simple housing. Establishment of developing of the components still needs in relation to control residential life support environment. By establishing a tight policy on a construction permit, any changes made would conform to rules, policies and regulations of low CO_2 emissions in this simple housing area.

This study shows that the emission can be kept low if the dynamics of Griya Martubung I Housing is maintained by controlling components of residential life support environment. Based on the components of the system, ideas on policy to reduce CO_2 emission can be realized. These include appropriate concepts on housing alterations; affordable low-emitted construction technology system; establishment of rules and policy to use low-emitted local materials; distribution of centers of activities, public facilities, and social facilities in proximity with housing blocks; enforcement of the role of the management to control excessive usage the overall components required to support activities and the use of public transport for mobility needs and to minimize the use of energy.

Acknowledgments

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