

## Conference Paper

# Dynamic System Development: An Approach for Land Re-adjustment in Managing Slum Areas

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## Abstract

Land re-adjustment (LR) is a practical model in the management of land development in the urban development process. One of the most prominent issues in the management of slum improvement is the multiple ownership of the land. Most cities in developing countries, relocate and provide apartments for the inhabitants in handling a slum area. Tangerang City also has its problems in handling slums. In order to achieve sustainable development, we attempt to develop slum areas by considering three aspects: social acceptability, affordability, and environmental sustainability. The environmental aspect is analyzed by considering carbon footprint generated by community activities in the area with and without land re-adjustment. The Dynamics model then is chosen to formulate the relation between the availability of land, water resources, landfill capacity (landfill) and electricity supply capacity with consumption pattern of carbon footprint. There are major dynamic loops, namely: utility, population and housing causal loops. The dynamic model shows a causal link that population has generated the most variable loops, which then contribute to housing and utility needs. In managing slum areas, Land re-adjustment model is able to reduce carbon emissions to about 40 % compared to the other model from business as usual scenario.

**Keywords:** land re-adjustment, eco-design, social acceptability, affordability and environmental sustainability, dynamic model, carbon footprint

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## 1. Introduction

Studies show that one-third of the urban population in developing countries have very limited access to adequate housing, water supply and other sanitation infrastructures. These people live in overcrowded and slums and it is not easy to provide access to public clean water or other sanitation facilities for supporting their daily activities. Slum area with inadequate service was noticed as a negative aspect of urban growth. Slums have been known as a condition that will fade away with economic development. But somehow, it is economic development that leads to creating enormous economic disparities [1].

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Land readjustment (LR) for the infrastructure's development is feasible with the change in the situation of land ownership and adequate consensus of the users. For a sustainable urban LR, governance actors that should be integrated into a network. These issues are closely related to land governance. This method is used for developing and improving urban infrastructure. It also enhances the utility and value of land, so LR is not a land acquisition method, but a kind of land consolidation method. Implementation of an LR project, in certain areas, is accomplished by installing urban infrastructure utilizing the land contribution for public facilities, according to a layout plan. LR is implemented through "replotting." The conceptual framework of an LR project involves several unique concepts such as "replotting" and "contribution" [2].

National approaches to informal settlements, in particular, have generally shifted from forced slum clearances because it ignores the social problems into moderate technique by creating an enabling environment, trying to find unique local solutions for their housing and shelter problems. As an example in Yogyakarta, the Government of Indonesia proposed slum improvement programs without eviction. Social rehabilitation was included in this program, supported by a number of national policy documents launched to support this provision of adequate housing [3–5].

Other studies found that most of the inhabitant from the slum area in Tangerang Municipality prefer to stay and improve their neighborhood instead of moving to another location even it has a better environment [6]. Using an analytical hierarchy process (AHP), the population of the slum area in Tangerang Municipality accepted the provision of sanitation infrastructures as the best option in managing their environment [6]. It should be noted that providing sanitation infrastructures in an informal settlement with a high density of building is not an easy task. An irregular pattern of an existing area could be challenging. Limited area to provide sanitation facilities such as wastewater treatment, or other public facilities, brings the needs of a breakthrough in managing slum area. Local Government of Tangerang Municipality then considers integrating the LR scheme with the concept of eco-housing.

Indonesia was the first Southeast Asian country to adopt LR with the Renon District Project in Denpasar, Bali Province, being its first project [7]. LR in Indonesia is mainly funded from national, regional, or local budgets, or through the self-finance mechanisms of community initiatives. In Indonesia, implementation of land readjustment mostly occurs in provinces such as Bali Province which LR is well known beneficial for inhabitant. But those schemes focus on social acceptability dan financial scheme without consideration to provide eco-design and how it would affect GHG generated

to the environment. This paper tries to consider those aspects to complete effort in delivering a more sustainable environment.

## 2. Object of Study

Rapid economic growth and also population growth are the main reasons why urbanization in Tangerang Municipality becomes one of the problems faced by the local government. The location of Tangerang Municipality in West Jakarta and bordered with the international airport Soekarno-Hatta, which highly contributes to the position of Tangerang Municipality as new central business development and alternative housing location area after Jakarta. Further, the urbanization from rural areas now is taking place to the cities surrounding Jakarta, such as Tangerang, Bekasi, and Bogor and contributes to the growth of a population of Tangerang Municipality to 1,918,556 inhabitants. With a total area of approximately 164.55 km<sup>2</sup> (not included the area of international airport Soekarno-Hatta), the population density reaches 122 inhabitants /Ha and with a population growth of 4.62%/annum [8].

Geographical Information System (GIS) analysis shows that settlement areas dominate the Tangerang Municipality and there are about 430,094 housing units in Tangerang Municipality in 2013 with a ratio between the regular and irregular settlement of almost 3:7. The irregular settlement is defined as a settlement that grows without specific planning, which includes slum and squatter areas [9].

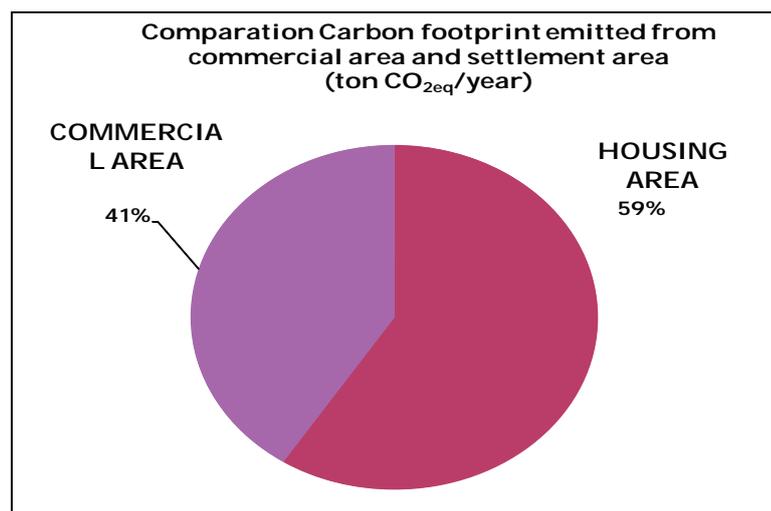
GIS analysis shows that the significant area of Tangerang Municipality is dominated by settlement areas and then followed by industrial areas and commercial areas as shown in **Table 1**. Based on building density we analyzed how the implementation of green building policy would affect the city sustainability in the future and describe how the settlement patterns would be spatially located in Tangerang Municipality area.

TABLE 1: Building Composition in Tangerang.

NO	TYPE OF BUILDINGS	UNIT	PERCENTAGE
1	Historical Building	18	0.0042
2	Public Facilities	5,065	1.18
3	Government Office	364	0.08
4	Industries	5,938	1.38
5	Settlement	417,581	97.09
6	Schools	1,128	0.26
TOTAL		430,094	100.00

Source: *Green Housing Evaluation Through Carbon Footprint Dynamic Model: Questioned the Urban Policy Sustainability*, [9]

The carbon footprint generated in each residential and commercial area was compared with the consideration that the two area types have similar building characteristics, in contrast to the industry area that each building in this type of area has specific characteristics [9]. The kind of production determines the consumption of energy and material for the industrial sector. Production of the carbon footprint from the industrial sector highly depends on what kind of goods produced. It is not directly related to the human consumption pattern. Thus, this article compares emission that generated only between residential and commercial areas.



**Figure 1:** Comparison of Carbon footprint emitted from commercial area and settlement area [ton CO<sub>2</sub>eq/year]. (Source: *Green Housing Evaluation Through Carbon Footprint Dynamic Model: Questioned the Urban Policy Sustainability*, [9])

The results of the analysis also show that the residential area produces more significant carbon emissions than from the commercial area. Considering the land cover of Tangerang City, which has more than 50% dominated by housing, it became clear that the implementation of green buildings concept should begin to focus on single homes.

The rising of slum and squatter area in Tangerang then becomes the object of priority issue in this study. There are 16 (sixteen) areas categorized as high slum area, 84 (eighty-four) areas classified as a moderate slum, and only 4 (four) areas categorized as low slum area [10]. The target of eco-housing in the integrated land readjustment scheme will be implemented in the Karanganyar administrative village (*kelurahan*) categorized as a moderate slum area. This study figures out whether LR and the concept of eco-housing can be applied as the best option to solve slum problems in Tangerang Municipality. Besides, the carbon footprint is chosen as one of the indicators to measure the sustainability of this project. Karanganyar has a population of about 12,833 people with an area approximately 3.28 km<sup>2</sup>, and the population density would be 3,913

people/km<sup>2</sup>. It consists of 3,833 families with the main occupation of the population as merchant [8].

### 3. Methodology

The methodology of this research is a descriptive method by presenting a systematic and factual description of slum area management and providing alternative solutions to existing problems. This study uses a quantitative approach that aims to obtain an orderly and accurate picture of the relationship between variables that affect the carbon footprint resulting from human activities. Based on the survey of the location and the secondary data, GIS analysis was conducted to delineate slum areas. Knowledge of the social acceptability of the population became one of the considerations in replanning to form land readjustment and eco-housing layout and design. Carbon footprint calculations are performed by converting the amount of water, electricity, and waste generated by residents and building materials constructed or destroyed to manage the slum area. Conversions are made based on literature studies stating the amount of carbon spent on specific activities. Dynamic system analysis is chosen because it can explain the relationship between the various complex variables that exist in the real world, although with limits and simplifications in certain conditions that cannot be done with conventional models.

### 4. Result and Discussion

#### 4.1. Site description and design

The first step of this study is surveying the location to delineate the area. As shown in **Figure 3**, the slum area in Karanganyar has a specific condition which has a riverfront side. At one point, this condition could be considered as a weakness because it causes problems with the maintenance of water the surface condition potential as a source of disease. On the other hand, the layout of the delineated slum area in Karanganyar has a great potential to be designed as a waterfront settlement.

LR is a technique used for both the development of new areas and the reorganization of the structured areas in urban regions. The conditions for this efficient application of the LR Method can be considered under seven headings including, cost recovery, sharing of the project benefits and costs, including of infrastructure constructions and

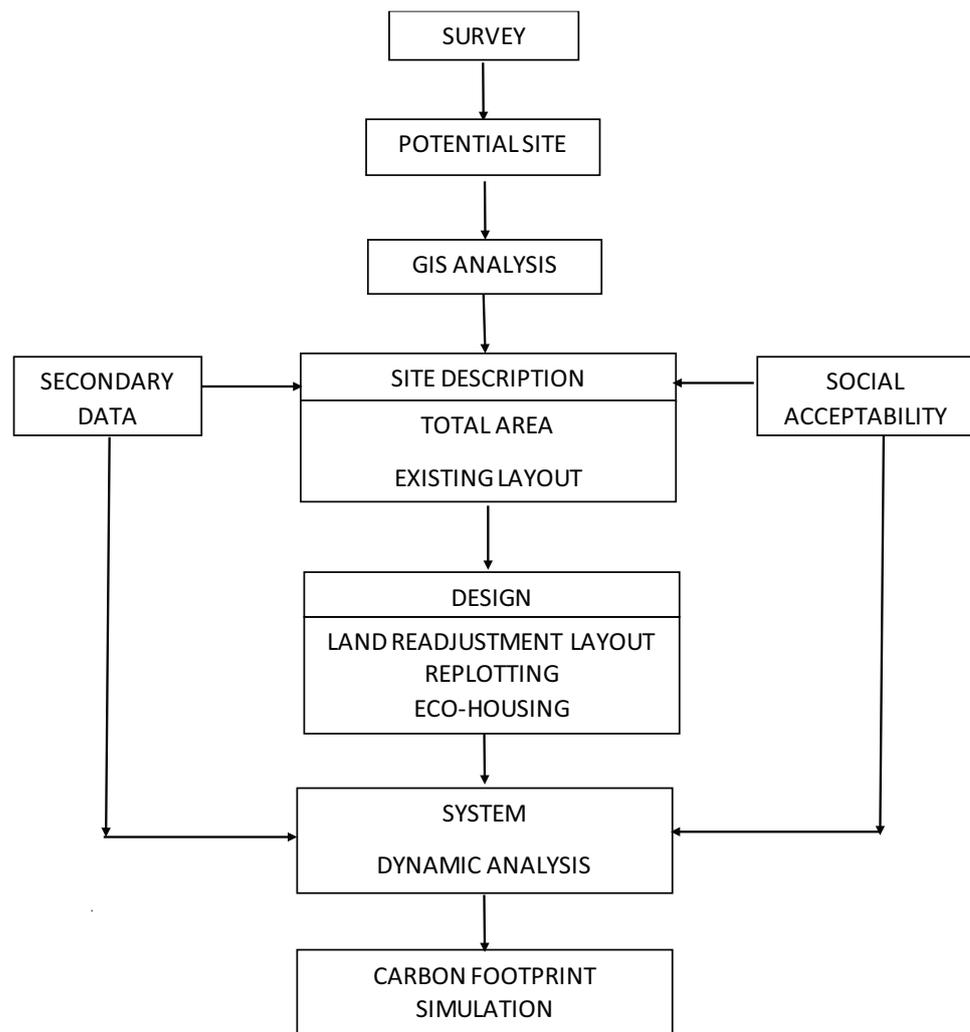
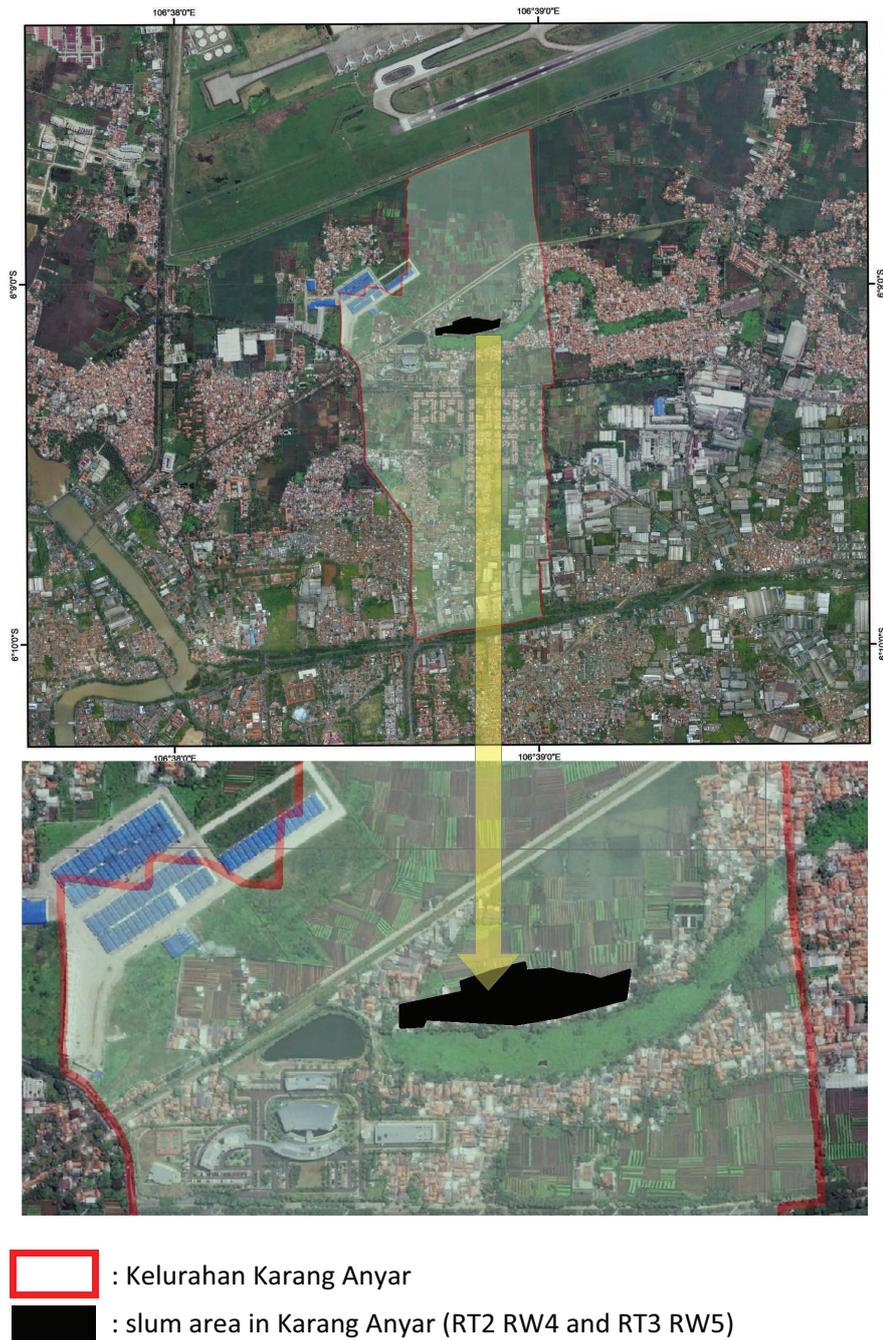


Figure 2: Methodology.

expenses of the LR process, conditions arising in terms of planning and public participation, number of technical personnel and management and quality of cadastral maps [11]. Replotting Karanganyar slum area was conducted to provide all public facilities for the existing inhabitants. There are 180 families in Karanganyar slum area with an average of 5 members in each family. With an area of about 4.15 Ha, it is necessary to build a two-story house to accommodate all family member's activities.

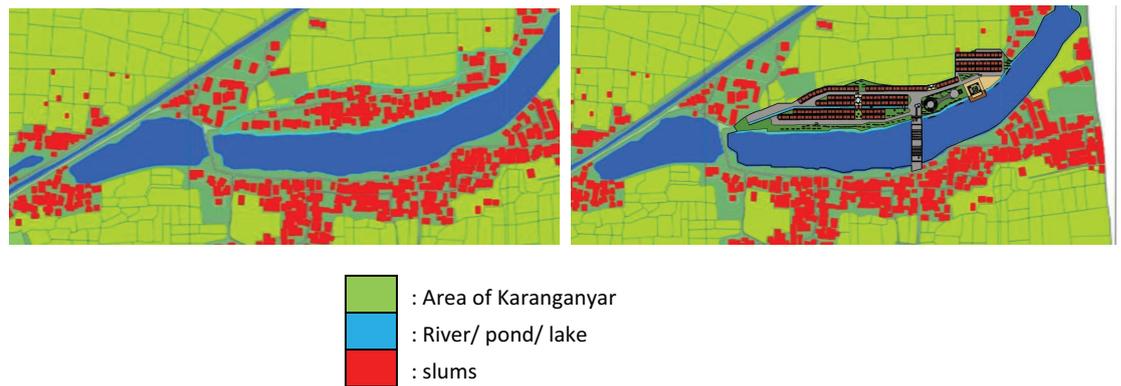
Every housing development by right should provide all the public amenities required. However, more often than not, developers of housing projects fail to provide all the necessary facilities satisfactorily. In many cases, the areas for public amenities are provided, but the amenities are either not constructed or take too long to be built. The integration between landscape and building should be established through a landscape scheme that is divided into garden sections that promote health, wellbeing, recreation, healing, agriculture, permaculture, and the medicinal [12]. **Figure 5** is the result of the



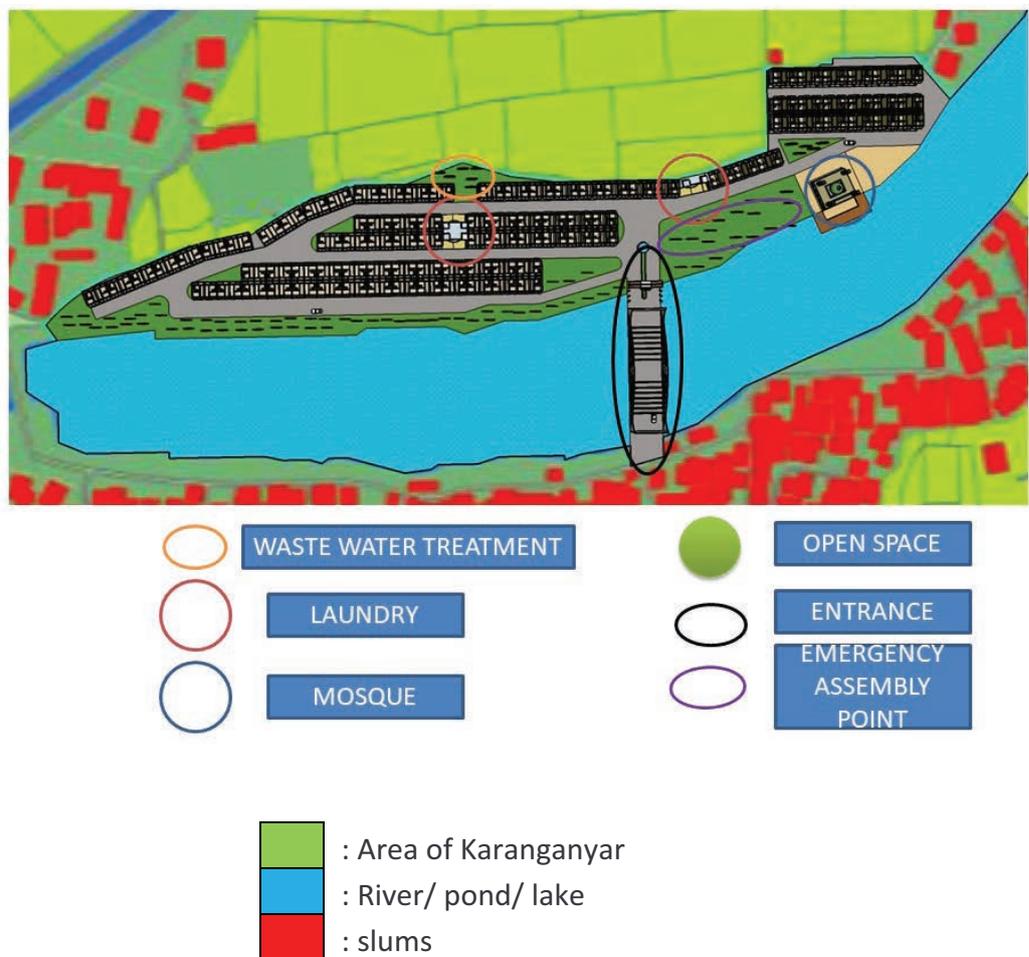
**Figure 3:** Delineated Slum Area in Karanganyar.

replotting process that accommodates all the need for public facilities on site. Some facilities were designed as public sharing such as laundry point. It benefits community interactions and also makes it easier to manage wastewater from the laundry facility since the sewage would be collected to a wastewater treatment plant to implement wastewater reuse-recycle process.

This concept has specific weaknesses and advantages that need to be evaluated, especially related to environmental impact. System dynamic will describe whether



**Figure 4:** [a]. Original Plots; (b). Land reform and improving public facilities, the positive aspects of the reorganization plan.



**Figure 5:** Housing Layout and its public facilities.

an LR project combine with the eco-housing concept will develop more sustainable environment or not.

### 4.2. System dynamics

In principle, the LR project will be developed based on the principles of eco-housing to maintain sustainable development. With the green building concept, it is expected that the GHG emissions produced can be minimized compared to an LR project without the green building concept. However, at the beginning of the implementation of this project, GHG emissions will increase due to the phase of destruction of existing buildings and construction of a new building.

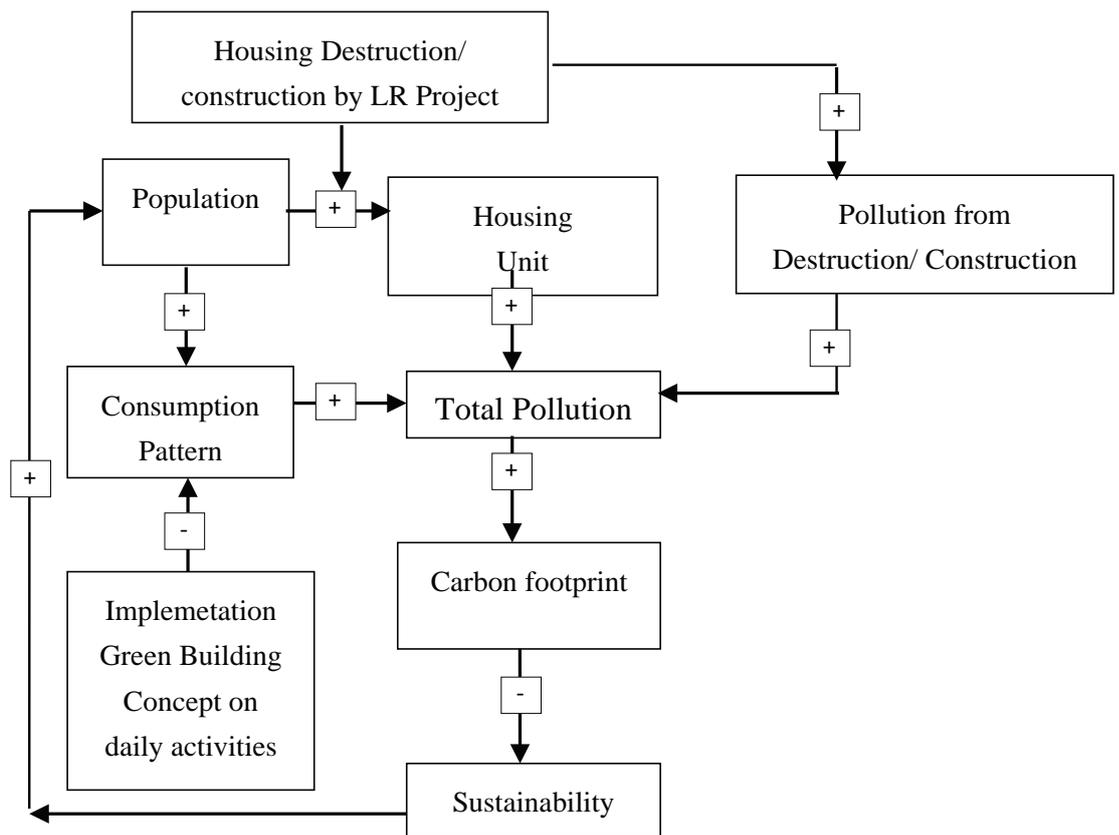


Figure 6: Causal Loop Diagram of The LR Project with Eco-housing Design.

The system dynamics was employed to measure whether this concept sustainable or not. All variables and assumptions used can be formulated into a causal loop diagrams (CLD) carbon footprint reduction model as described in **Figure 7**. Dynamics hypothesis formulated based on the environmental carrying capacity of Kelurahan Karanganyar, and in this case, we choose the availability of land, water resources, landfill capacity (landfill) and electricity supply capacity as variables involved in the model. Population growth will increase the need for land settlements, electricity consumption, and water consumption. Further, consumption in domestic activities will also affect the balance between supply and demand. The pattern of consumption is influenced by the level

of environmental awareness and tariffs of utilities. Correlation between variables will affect costs, which will provide feedback to the level of awareness it will then affect consumption pattern. All of these domestic activities will affect the carbon footprint per capita generated by the inhabitants of Karanganyar. Carbon footprint per capita will be used as an indicator of sustainability.

The system diagram below shows how each input variable interacts within the model that produces an output variable. Output variables become the basis for a strategy to achieve ideal conditions. Changes in input variables due to this strategy will again cause a difference in the output variable.

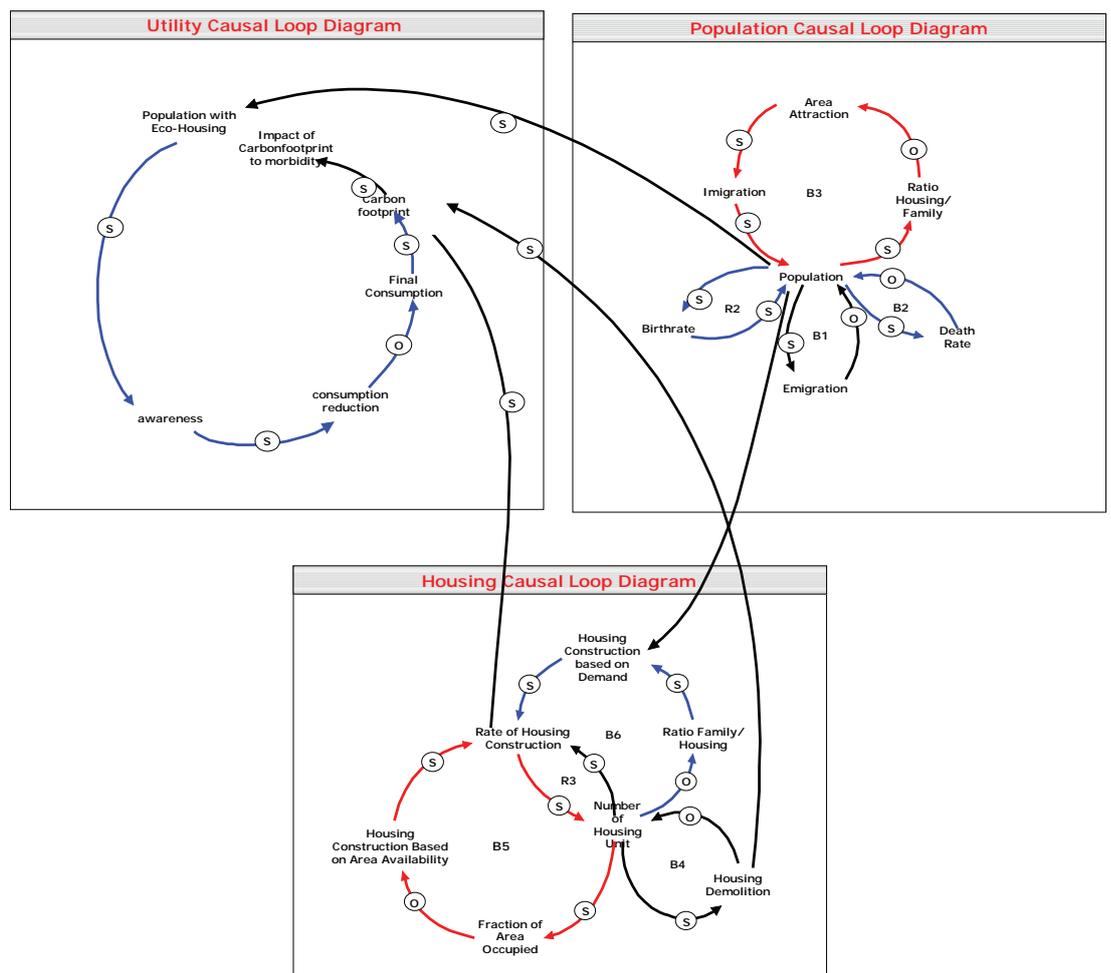
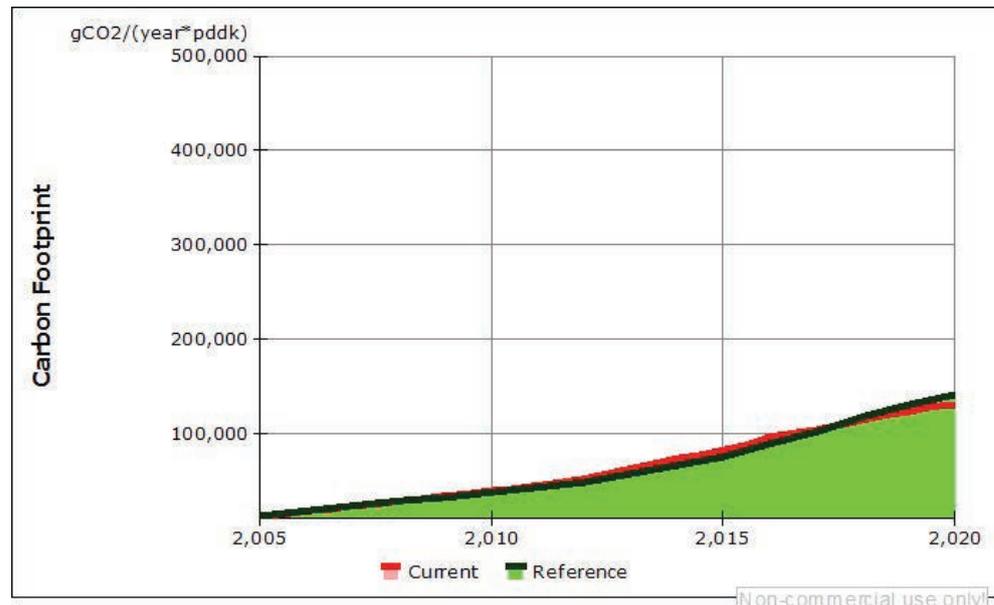


Figure 7: Dynamic Hypothesis.

The implementation of the green building would reduce carbon footprint in a quite significant amount. The eco-housing design that was described above is expected to be able to fulfill the criteria set by the LEED (Leadership in Energy and Environment Design). A building categorized as a green building will earn one credit point if able to reduce waste as much as 50% of waste production [13]. By using the graph function,

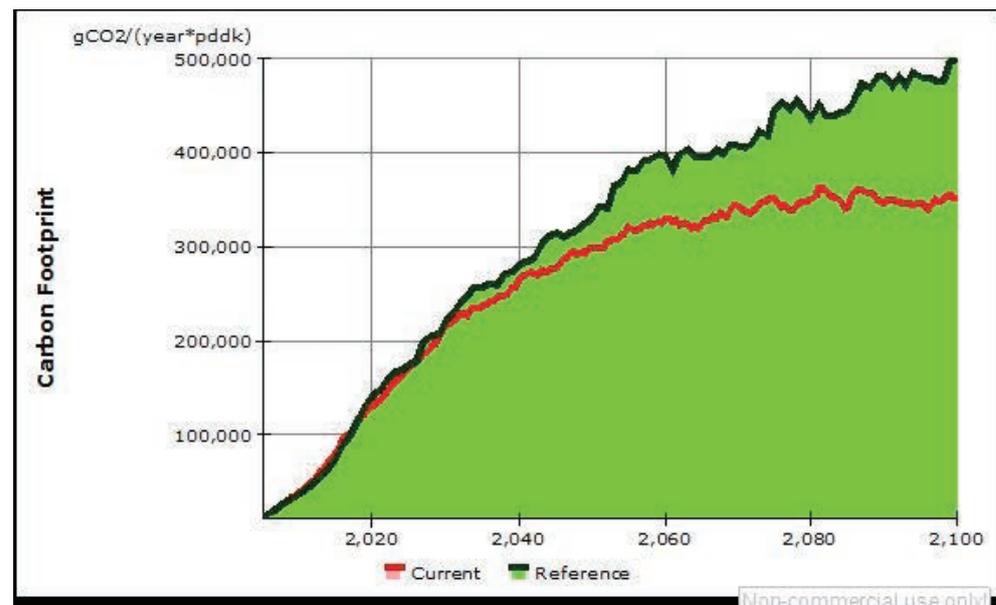
we can see that waste production per capita will be gradually reduced, and in 2025 reduction of waste production will achieve 50%. Another criterion of LEED is a capability to save 40% of electricity consumption from getting one credit point[13]. Similarly, with the waste reduction pattern, electricity consumption per capita also will gradually reduce since 2015 until it reaches 40% reduction in 2025.



**Figure 8:** Carbon footprint Pattern 2005-2020.

If we explore carbon footprint pattern at a short period (until 2020), we could find that LR project with the eco-housing concept will increase the amount of carbon footprint generated by the site. We should note that in this period, we have destruction and construction phase on the site and it would increase GHG emission. But if we run model of system dynamic analysis in the long term (**Figure 9**), we will find out that LR project with the eco-housing concept will decrease carbon footprint compare with carbon footprint with BAU (business as usual) scenario.

The simulation period was extended until 2100 to make it easier to observe the behavior of carbon footprint reduction by comparing two graphs of each scenario: the business as usual scenario and eco-housing scenario. The emission pattern of a carbon footprint per capita shown by the diagram in **Figure 9** shows that the emission pattern is almost typical, but with a smaller emission value if the population adopts the eco-housing design.



**Figure 9:** Dynamic model showing that eco-housing implementation will reduce carbon footprint per capita.

## 5. Conclusion

The LR is a method where a group of land-owners can join forces to develop or redevelop their land. In essence, it is a process in which land-owners pool ownership of scattered and irregular plots of agricultural land, build roads and central infrastructure, and then sub-divide the land into urban plots [14]. In the beginning, the real properties which are located in the study area must be audited.

Sustainable housing is a sector that can provide a significant impact on sustainable development. House should be classified as sustainable when it can meet almost all indicators of sustainable housing, including applications by residents on an ongoing basis to ensure their effectiveness [15].

Model reduction of the carbon footprint through the implementation of land readjustment and eco-housing design shows a positive correlation that the reduction of carbon footprint will increase the sustainability of the city. Implementation of eco-housing by reducing the production of waste at the source and the reduction of electricity consumption can reduce the carbon footprint significantly. Carbon footprint reduction can increase the capacity and lengthen Tangerang Municipality to reach for the carrying capacity limits.

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