Optimization of settlement land use through carbon footprint approach in The North Balikpapan

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Abstract. Limited land in the downtown area as well as the increasing amount of new activities centre causes residential development leads to North Balikpapan. This area is an urban fringe with vast protected forests as buffer zone and catchment area for the city and surrounding area. Land conversion in this area will increase hazard risk of inundation, water quality decrease and increased CO₂ emissions. Therefore, development should be maintained environmental stability. One of the rights applied approach is carbon footprint that is capable to measure the balance between production and absorption needs of CO₂ emissions. To find the optimal land allocation, we used carbon footprint calculation from the household activities, identify the factors of settlement growth, and use Linear Programming analysis. Analysis’ results show that settlement activities in North Balikpapan produce 108,362.4 tCO₂/year or equivalent with 618.50 Ha green space. Meanwhile, the development of settlement in North Balikpapan is affected by social demographic, developer initiative, environmental condition, public facilities availability, economical structure, and policy factors. According to those factors, optimal allocation of settlement area in North Balikpapan is only about 4,510.01 Ha. With that condition, it still able to absorb CO₂ emissions from inside or outside the area around 2.751 tCO₂/year.

Keywords: Carbon Footprint, CO₂ emissions, Household, Land optimization.

1. Introduction
The development of the city characterized by population growth and the level of urbanization will trigger rising needs of housing [1]. City spaces availability are limited, which created a natural alternative selection in fulfilling the space needs for living and other functions of activities will always take up spaces in the suburbs [2]. Thus, the limited availability of land in the city center and is supported by the existence of the availability of the infrastructure can spur the development of neighborhoods to the suburbs.

Balikpapan City is a city with a fairly rapid population development. This can be seen from the increasing number of residents of the city of Balikpapan in the last 5 years of 7.58% [3]. Based on Statistic of Balikpapan City, it is known that the composition of the population resides in district of North Balikpapan of as much as 154,908 people in the year 2014 and this number increased by 5.92% in 2015 be 164,081 people. The increase in the number of population will certainly lead to increased
needs for housing. It is also aligned with the new growth center around the northern city of Balikpapan which had been contained in the Spatial Plan area Balikpapan City year 2012-2032.

According to the final report of the Development Plan of housing and Settlement in Balikpapan city 2014 [4], the growth of settlement area also followed by increasing housing units, the number of houses in North Balikpapan are 19.9% out of total houses in 6 districts at Balikpapan and becoming the district with highest housing growth. It is noted that North Balikpapan has 8.83% of housing growth rate increase from the past year, while another districts’ increase is only less than 7%. Thus, North Balikpapan becomes a strategic place to be created as a new settlement area.

On the other hand, the North Balikpapan is a suburb which has open green space as well as the vast protected forest which serves to maintain the balance of the environment and the survival of the community and the city of Balikpapan the surroundings. North Balikpapan has two location of the protected forest, those are protected forest of Wein River area 1,967.848 Ha and protected forest of Manggar River area 2,342.945 Ha [5]. Kodoatie & Sjarief [6] state that the development of population and economic growth lead to much going on over the function of land conservation became a waterproof area resulting in a decrease in the quality of water availability, increased surface flow which led to an increase in potential flood, as well as reduced land sinks of CO2 emissions.

The development of activities in one area turn the land use intensity becomes high which directly or indirectly will affect to the production increasing of greenhouse gas emission [7]. According to Study of an inventory of Greenhouse Gas emissions the energy sector by the Ministry of energy and mineral resources in 2013 [8], the needs of energy in household sector reached for 29% which is the second highest need after industrial sector by the value of 41%. As the impact of citizens number growth, the needs of settlement area in North Balikpapan is also increasing and could be indicated to affects the production increasing of Carbon dioxide (CO2) emission in North Balikpapan.

In order for the development of settlements in the North Balikpapan does not give negative impact to the environment, should consider the environmental conditions so favorable balance and harmony between environment with development of settlements. One of the approaches that can be used to analyze environmental conditions in the North Balikpapan approach is through carbon footprint. Through this approach, knowable conditions environmental balance between the production of CO2 emissions and absorption of CO2 emissions on land. Therefore, this research was conducted to find out the proportion of land suitable for settlement and land use optimization to determine sustainable settlements in North Balikpapan through carbon footprint approach.

2. Methods
The purpose of this study is to determine optimization of settlement land use in North Balikpapan by using analysis method that consists of analyzing land needs to absorb emission from settlement activities through Carbon Footprint approach, analyzing factors that influence settlement development, and analyzing the optimization of settlement area in North Balikpapan.

There are two sub-analysis in land needs as a form of settlement activity consume analysis, those are the calculation of Carbon Footprint analysis in North Balikpapan and analysis in land needs to absorb CO2 emission or the result of Carbon Footprint calculation. The calculation of Carbon Footprint is use to know the value of CO2 emission that created by settlement area. Carbon Footprint calculation divided into 2 type which are, Primary Carbon Footprint and Secondary Carbon Footprint.

Primary Carbon Footprint of settlement activity that calculate in this study is cooking activity carbon footprint by the using of LPG and kerosene also the transportation of total production based on each fuel use. Secondary Carbon Footprint calculated from CO2 household electricity usage total production. The formula of CO2 emission from cooking fuels, transportation fuels, and electricity consumption are shown in equation, (1), (2), and (3).

\[ CO_2\text{ Emission from Cooking activities} = F_{t}\times EF_{CO2}\times NCV \quad (1) \]
CO\textsubscript{2} Emission from Transportation \quad = \quad E\textsubscript{FCO2} \times FC \quad \quad (2)

CO\textsubscript{2} Emission from Electrical Consumption \quad = \quad E\textsubscript{FCO2} \times EC \quad \quad (3)

Explanation:

- \text{FCy} \quad \quad \quad : \quad \text{LPG and Kerosene usage (Kg/month)}
- \text{EFCO2} \quad \quad \quad : \quad \text{CO\textsubscript{2} emission factor (gr/MJ)}
- \text{NCV} \quad \quad \quad : \quad \text{Net Calorific Value (MJ/Kg)}
- \text{FC} \quad \quad \quad : \quad \text{Gasoline and Diesel fuel consumes (Liter/month)}
- \text{EC} \quad \quad \quad : \quad \text{Monthly electricity usage (kWh/month)}

Emission factor value and Net Calorific Value (NCV) in each kind of fuel is based on standard that set by IPCC Guideline year 2006 [9]. Emission factor and NCV value for cooking fuel are shown in Table 1.

| No  | Fuel     | Emission Factor (gr/MJ) | NCV (MJ/Kg) |
|-----|----------|-------------------------|-------------|
| 1   | LPG      | 63,1                    | 47,3        |
| 2   | Kerosene | 71,9                    | 43,8        |

Source: IPCC (2006)

CO\textsubscript{2} emission factor for transportation fuel according to IPCC Guideline year 2006 [9], Gasoline and Diesel are 69,3 gr/MJ and 74,1 gr/MJ. CO\textsubscript{2} emission factor of electricity usage based on the average of power plant and fuel in Indonesia, the CO\textsubscript{2} emission factor achieved is 7,42 \times 10^{-4} tons CO\textsubscript{2}/kWh.

Land needs analysis is use to know the extents of land that able to absorb CO\textsubscript{2} emission as a result of household consume in North Balikpapan. In this study, the type of land cover and absorbance refer to IPCC Guideline year 2006 [9]. From the guideline, the CO\textsubscript{2} absorbance in local green open space is close to paddy fields absorbance capacity that reached for 175,20-ton CO\textsubscript{2}/Ha/year.

Analyzing technique that use to determine influencing factors in North Balikpapan settlement development is Content Analysis technique. Content Analysis technique is an analyze which relies on found codes in data recording text while interview is conducted with the subject on the spot. The step of Content Analysis technique according to Krippendorff [10] are unitizing, stakeholder analysis method sampling, data collecting, coding, data reducing, and concluding.

In formulating the optimization of North Balikpapan settlement area, this study uses Linear Programming analysis technique. Linear Programming is an analysis tools that use to solve optimization problems (maximize and minimize) by using mathematics model in order to solve by considering the existence of limitations [11]. Linear programming analysis stages consist of element determination in Linear Programming (decisions variables, objective functions, and limit functions), formulating objective function model, formulating limit functions, and modelling of Linear Programming through LINGO 11.0 Software.

3. Result and Discussions

3.1. Analyzing land needs as a form of settlement activity consume through carbon footprint approach

There are two sub-analysis in land needs as a form of settlement activity consume analysis, those are the calculation of Carbon Footprint analysis in North Balikpapan and analysis in land needs to absorb CO\textsubscript{2} emission or the result of that Carbon Footprint calculation. These are the details of each sub-
analysis below.

3.1.1. Carbon footprint analysis in North Balikpapan
According to the results of CO₂ emission calculation through Carbon Footprint approach in North Balikpapan, it’s noted that the total of LPG and Kerosene CO₂ emission reached for 1,702.55 tons CO₂/month, with Graha Indah sub-district as the highest with 421.60 tons CO₂/month, followed by Muara Rapak sub-district with 344.90 tons CO₂/month, and Batu Ampar sub-district with 307.94 tons CO₂/month. Those three sub-districts are those with the highest number of household in North Balikpapan. Thus, LPG and Kerosene CO₂ emission in North Balikpapan are affected by the number of household in each sub-district.

Whilst the total CO₂ emission in North Balikpapan is 62.07 tons CO₂/month, with the highest emission contributor in Batu Ampar sub-district which is 18.78 tons CO₂/month, followed by Muara Rapak sub-district with 12.04 tons CO₂/month, and Karang Joang sub-district with 11.26-ton CO₂/month. Batu Ampar and Karang Joang are sub-districts that have a quite far distance to the downtown, while Muara Rapak is a sub-district with the highest number of household, therefore it fair to say that CO₂ transportation emission is affected by transportation user mobility and household amount.

Once the CO₂ emission calculation for cooking fuel and transportation fuel are obtained, then the total of primary CO₂ emission in North Balikpapan is obtained by the value of 1.764.62 tons CO₂/month. Next, the total of secondary CO₂ emission in North Balikpapan based on the calculation is 7.265.58 tons CO₂/month, with Muara Rapak as the highest CO₂ emission producer with 2.028.16 tons/CO₂/month.

Therefore, settlement consumption which consist of cooking fuel usage, transportation fuel usage, and electricity usage that produced by 50.766 household in North Balikpapan produce CO₂ emission by the value of 7.502.66 tons/CO₂/month. CO₂ total emission in North Balikpapan are shown in Table 2.

| No | Sub-District     | Primary Emission of CO₂ (ton/month) | Secondary Emission of CO₂ (ton/month) | Total Emission of CO₂ (ton/month) |
|----|------------------|--------------------------------------|---------------------------------------|----------------------------------|
| 1  | Muara Rapak      | 356.94                               | 1.671.22                              | 2.028.16                         |
| 2  | Gunung Samarinda | 276.73                               | 1.499.61                              | 1.776.34                         |
| 3  | Batu Ampar       | 326.72                               | 1.635.77                              | 1.962.49                         |
| 4  | Karang Joang     | 301.27                               | 729.37                                | 1.030.64                         |
| 5  | Gunung Samarinda Baru | 71.20 | 428.86                                | 500.06                            |
| 6  | Graha Indah      | 431.76                               | 1.300.75                              | 1.732.51                         |
|    | **Total**        | **1764.62**                           | **7.265.58**                          | **9.030.20**                     |

*Source: Analysis Result, 2017*

In this example we can see that there are footnotes after each author name and only 5 addresses; the 6th footnote might say, for example, ‘Author to whom any correspondence should be addressed.’ In addition, acknowledgment of grants or funding, temporary addresses etc might also be indicated by footnotes.

3.1.2. Analysis of land needs to absorb CO₂ emission or the result of carbon footprint calculation
Calculation of land needs is a follow-up analysis from the calculation of CO₂ emission in North Balikpapan. In this analysis, the type of CO₂ absorbance land cover that used is paddy field that well known to have CO₂ absorbance capacity for 175.20 tons/CO₂/ha/year. That choice is based on green space condition in the study area that has less absorption capacity cause the area is not fully- forest,
then according to IPCC Guideline (2006) paddy fields has less absorption capacity than forest area. In
the previous analysis, it’s noted that total emission of CO2 in North Balikpapan reached for 9.030,20-
ton CO2/month, therefore the total emission for a whole one year is 108.362,4-ton CO2/year, and the
extents of land that needs to absorb CO2 emission is 618,50 hectares of green spaces in minimum
value.

3.2. Analysis of factors that influenced settlement development in North Balikpapan
Determination of factors that influence settlement development in North Balikpapan used as a way to
determine the optimization of land needs, especially in formulating the limitation or constraint.
Determination of factors that influence settlement development in North Balikpapan in this study
conducted by Content Analysis Method with the purpose of confirming and exploring some factors
influencing settlement development in North Balikpapan based on opinions of some key stakeholders.
Those factors will be used as input data towards equations in Linear Programming analysis in the next
step. The results of the content analysis are shown in Table 3.

Table 3. Factors of content analysis results

| Indicator                          | Factor                                      | Factor Discusse (%) | Number of Stakeholder Confirmed | Node   |
|------------------------------------|---------------------------------------------|---------------------|---------------------------------|--------|
| Demographic                        | Population                                  | 5.7                 | 3                               | Confirmed |
|                                    | The number of workforces                     | 4.9                 | 3                               | Confirmed |
| Housing Developer Initiative       | The number of Housing Developers            | 3.3                 | 3                               | Confirmed |
|                                    | Housing Area                                | 3.3                 | 3                               | Confirmed |
| Environmental Condition            | Protected Forest Area Availability          | 11.4                | 4                               | Confirmed |
|                                    | Green Open space Availability               | 12.2                | 4                               | Confirmed |
| Public Facility Availability       | The number of Education Facilities          | 12.2                | 4                               | Confirmed |
|                                    | The number of Trade and Services            | 7.3                 | 4                               | Confirmed |
|                                    | The number of Health Facilities             | 2.4                 | 3                               | Confirmed |
|                                    | The number of Worship Facilities            | 2.4                 | 3                               | Confirmed |
|                                    | The number of Transportation Support Facilities | 3.3                 | 3                               | Confirmed |
|                                    | Road Availability                           | 4.1                 | 4                               | New     |
| Economical Structure               | Gross Regional Domestic Product             | 6.5                 | 5                               | Confirmed |
| Urban Planning Policy              | The Extents of Allocated Area Based on Spatial Plan | 10.6                | 6                               | Confirmed |
| Strategic Location                | The Existence of National Project / New Forefront | 10.6                | 6                               | New     |

*Calculated from all statement in the interview transcript and from all stakeholders
Source: Analysis Result, 2017

3.3. Analysis of settlement land use in North Balikpapan
The process of settlement land use optimization in North Balikpapan using Linear Programming
analysis through LINGO 11.0 software. This analysis consists of some points such as formulating
objective function, formulating constrain function, and running the optimization linier programming
based on both functions.
3.3.1. Formulating objective functions

In this study, decisions variable is based on 5 area divisions which are the extent of settlement area (X1), the extent of protected forest (X2), the extent of green area (X3), the extent of industrial area (X4) and other extents (X5). Other extents consist of public facility and trade & services area. Formulating those decisions variables are considering the existing condition and spatial planning in the study area. Since the objective functions are based on CO2 emission then the modelling results minimized the amount of emission towards the environment and each area has a standard CO2 emission coefficient value and CO2 absorption capacity in each hectare of land use. Areas that produce CO2 emission are settlement area (X1), industrial area (X4), and other areas (X5). In settlement and other areas, standard coefficient of emission producer is obtained from the previous carbon footprint calculation, wherein the production of CO2 emission per hectare area is 59.61 tons CO2 per year. It means that in factual condition, the addition of 1 ha of housing area can raise CO2 emission about 60 tons per year.

The standard of CO2 emission measurement produced by industrial activities is used from previous study result. According to Setiawan, et al [12] with their study entitled “Carbon Footprint from Industrial activities in The City of Surabaya”, the CO2 emission produced by industrial area is about 98.028.6 tons/year with the extent of industrial area by about 245 Ha, which means that every hectare area of industrial area is provided CO2 emission of 400,12 tons CO2/year.

Furthermore, for the CO2 emission absorbance area consists of protected forest area (X2) and green space area (X3). Absorbance standard in those two kinds of areas are based on IPCC Guideline year 2006, so, the CO2 emission absorbance standard for the protected forest area is 569,40 tons CO2/ha/year and 175.20-ton CO2/ha/year for the green space area. Those standard then turned into coefficient in objective function, and the equation of study objective functions is shown in Eq. (4).

\[
\text{Min. CO}_2 \text{ Emission} = 59.61X_1 - 569.40X_2 - 175.20X_3 + 400.12X_4 + 59.61X_5 \tag{4}
\]

From the optimization formula it can be seen that every built-up land use will produce emissions and vice versa green land will absorb it. The optimization that will be sought is a condition when the difference in production and absorption of emissions generate a lowest value.

3.3.2. Formulating limit functions or constraint

Limit Functions or Constraint is a linear formula that contains decisions variable and explains the constraint that able to take. In this study, limit functions are obtained from the result of content analysis based on libraries’ synthesis and stakeholders/experts’ opinions. The results of limit functions or constraint are shown in Table 4.

**Table 4. Limit functions or constraint synthesis**

| No | Constraint                                      | Condition Analysis                                                                 |
|----|------------------------------------------------|------------------------------------------------------------------------------------|
| 1  | CO2 Emission Absorbance Area Needs             | 1) The result of green space needs calculation by 618,50 Ha is assumed as the minimum value of area to absorb CO2 emission from settlement activities in North Balikpapan. |
|    | X3 ≥ 618.50                                    | 2) If 1,817.7 Ha settlement area needs the minimum value of 618,50 Ha green space to absorb CO2 emission, then one-hectare area of settlement requires minimal 0,34 hectare of green space. |
|    | 0.34X1 ≤ X3                                    |                                                                                   |
| 2  | Population                                     | In 2032, the projection number of citizens is assumed to have the same density with current condition which is                     |
| No | Constraint | Condition Analysis |
|----|------------|---------------------|
| 3  | The number of workforces $446,33X4 + 43.21X5 \geq 43.775$ | 90.72 people/Ha, so the total area should be able to accommodate the number of projected citizens by 243.277 people in 2032. |
|    | Housing Developer Initiative | Industrial area and the other types of build-up land is assumed to give impacts toward the citizen welfare through job vacancy availability for as the minimum value as the number of current workforces. |
| 4  | The number of Housing Developers and The Extent of Housing Area $X1 > 1.710.08$ | The provision of new settlement area is in the minimum value of housing area that currently planned by 75 developers in North Balikpapan. |
| 5  | Protected Forest Area Availability $X2 = 4.310.74$ | The function of protected forest is extremely fundamental to environment stability and Balikpapan citizens sustainability. In order to take care of this condition, the current extent of protected forest have to be preserved as well. |
| 6  | Green Open space Availability $X3 \geq 618.50$ | From the previous analysis result, the current green open space extent is still able to absorb CO2 emission until the projected year, so they must be nurtured. The minimum extent of green space as the result of carbon footprint calculation in North Balikpapan is 618.50 Ha. |
| 7  | The number of Education Facilities, Trade and Services, Health Facilities, Worship Facilities, Transportation Support Facilities, and Road Availability $0.47X1 \leq X5$ | The extents of current public facilities are 858.10 Ha with the extents of existing settlement area for 1.817.7 Ha, then one-hectare area of settlement needs 0.47 areas of public facility. |
| 8  | Gross Domestic Regional Product (GDRP) $658.23X1 + 2.642.767.48X4 + 33.003.15X5 \geq 69.157.980.54$ | The use of settlement area, industrial area, and other area must be able to guarantee the increasing of region economy, so in this limitation it assumed that 1.817.7 Ha of settlement area are having Gross Domestic Regional Product by the value of IDR. 1.196.466.16, 15 Ha of industrial area with IDR. 39.641.512.19, and 858.10 Ha of other areas with IDR 28.320.002.19. |
| 9  | The District Area $X1 + X2 + X3 + X4 + X5 = 13.287$ | The extent of land provision in North Balikpapan should not violate the provisions of the city planning policy and should be exactly equal with district area. |
| 10 | Allocation of Settlement Area $X1 \leq 4.510.11$ | |
| 11 | Allocation of Protected Forest Area $X2 \leq 4.310.74$ | |
| 12 | Allocation of Green Open space | |
Area X3 ≤ 3.565,6
13 Allocation of Industrial Area
   X4 ≤ 420,96
14 Allocation of Office, Trade and
   Services, Public Services Area
   X5 ≤ 1.047,61

Source: Analysis Result, 2017

3.3.3. Optimization of land use
Optimization of settlement land use in this study is conducted by using LINGO 11.0 software. All
equations which have been formulated in the previous explanation, consists of objective functions and
limit function or constraints, are used in linear programming analysis to calculate an optimal and
extent allocation. The following table explains the results of the analysis obtained.

Table 5. Solution report from model analysis

| Variable | Value | Reduced Cost |
|----------|-------|--------------|
| X1       | 4510.01 | 0            |
| X2       | 4310.74 | 0            |
| X3       | 3565.6  | 0            |
| X4       | 15     | 0            |
| X5       | 885.55 | 0            |

| Infeasibilities | 0 |
|------------------|---|
| Objective Value  | -2,751,591 |

Source: analysis

Based on the results of the solution report in the table above, it can be seen that the reduced cost
value (changing in the optimal value of the objective function) for each variable is 0 (zero), so the
value of all variables has reached optimal conditions. In addition, Infeasibilities of the model reached
zero or the value generated from the analysis does not violate the function of the constraints previously
formulated, so that the model analysis is suitable for use.

The allocation of land area in each land use can be known through the values listed in the row
value, so that the optimal proportion of land use with the minimum CO2 emissions produced can be
achieved when the settlement area (X1) is about 4,510.01 Ha which is followed by a proportion of
other types of land use in a row are protected forest area (X2) of 4,310.74 Ha; the area of green land
(X3) is 3,565.6 Ha; industrial land area (X4) of 15 Ha; and other land area (X5) of 885.55 Ha. The
proportion of land use in this output can be seen more clearly in the following figure 1.
In this model, settlement has the largest land area of 33%. The land area of the settlement relates to the number of inhabitants and the provision of land to meet the need for housing. North Balikpapan as an area that has experienced rapid development certainly requires a large area of residential land but must still maintain a balance of green land area as a CO2 emitter from residential activities.

With this proportion of land use, North Balikpapan will have a surplus condition as indicated by the objective value in table 1, the substitution value between the land allocation value resulting from the modeling and the objective function. The amount of surplus that occurs is -2,751,591 tons. Thus, the green area in North Balikpapan is strongly able to absorb CO2 emissions produced by built-up land and also able to absorb emissions from outside to around 2.751 ton.

The other consequences from analysis result, it can be obtained that with the proportion of land use North Balikpapan will have population growth about 407.128 people; The citizen density is 3,080,80 people/Km²; the number of workforce is 44,960 people; and get the Gross Domestic Regional Product is IDR 71,836,141.39 Million.

4. Conclusion
Based on the conducted results in this study, it could be concluded that:

- The results of the analysis of the calculation of the carbon footprint in North Balikpapan shows the energy consumption the use of cooking fuel, the use of transportation fuels, and the use of electricity generated from 50,766 households in North Balikpapan contribute 108.362,4 tons of CO2 emissions /year. It minimum requires 18.50 Ha of the green space to absorb the CO2 emissions.
- The factors that influenced the development of settlements in North Balikpapan based on the results of a content analysis are: (a) the social group factors consisting of the factor of demographic factors population and the number of workforces; (b) The initiative housing developers factors consisting of the factor of the number of residential developers and the extent of settlement area; (c) the group of environmental conditions consisting of the factor of protected forest availability and the green space availability; (d) The group of the public facilities availability consisting of the factor of the number of educational facilities, health facilities, trade and services, worship facilities, and supporting transport facilities; (e) the group of local economic structure consisting of the factor of GDRP; and (f) the group of spatial policy plan consisting of the factor of land allocation on Spatial Plan Area documents.
- The Results of the optimization of land through a linear programming analysis showed that the allocation of settlement land area by 4,510.11 Ha; (2) land area protected forest by 4,310.74 Ha; (3) the broad green fields by 3,565.6 Ha; (4) industrial land area by 15 Ha; and (5) the other land area by 885.55 Ha.
5. References

[1] Jauhari A and Render B. 2013. *Dampak Pembangunan Perumahan Terhadap Perubahan Penggunaan Lahan Dan Kondisi Sosial-Ekonomi Penjual Lahan Di Kecamatan Mlati (Impact of Housing Development on Changes in Land Use and Socio-Economic Conditions of Land Sellers in Mlati District)*. Journal of Bumi Indonesia, Volume 2 Number 2.

[2] Yunus, H.S. 2000. *Struktur Ruang Kota (City Space Structure)*. Yogyakarta: Pustaka Pelajar.

[3] Central Statistic of Balikpapan City. 2017. *Balikpapan In Figures Year 2016*. Balikpapan

[4] Housing and Settlement Agency of Balikpapan City. 2014. *The Final Report of the Development Plan of housing dan Settlement in Balikpapan city*. Balikpapan

[5] Environmental Agency of Balikpapan City. 2012 *Buku Hijau Kota Balikpapan (The Report of Environment Condition in Balikpapan)*. Balikpapan

[6] Kodoatie, R.J and Syarief, R. 2010. *Tata Ruang Air (Water Management System)*. Yogyakarta: ANDI.

[7] Novanda, E. 2015. *Persebaran Spasial Produksi Emisi Karbon Dioksida Dari Penggunaan Lahan Permukiman di Kawasan Perkotaan Gresik Bagian Timur (Spatial Distribution of Production of Carbon Dioxide Emissions from Land Use in Settlements in the Eastern Gresik Urban Area)*. Journal of Teknik ITS Volume 4 Number 1.

[8] Indonesia Ministry of Energy and Mineral Resources. 2013. Review of Inventory of Greenhouse Gas Emissions in Energy Sector. Jakarta: Data and Information Technology Center for Energy and Mineral Resources

[9] IPCC 2006 *Guidelines for National Green House Gas Inventories (Intergovernmental Panel on Climate Change)*

[10] Krippendorff K 2004 *Content Analysis: An Introductions to its Methodology (Second Edition)* (California: Sage Publication)

[11] Heizer, J. and Render, B. 2006. *Operations Management (7th Edition)*. Jakarta: Salemba Empat

[12] Setiawan, R.Y, Boedisantoso R, and Razif M. 2010. *Study of Carbon Footprint from Industrial Activity in Surabaya City*. Proceeding of National Seminar on Environmental Technology VII Surabaya. ISBN: 978-602-95595-2-1. Surabaya, 25 – 26 October 2010.