Analysis of spatial parameter formulation in the effect of Green House Gas (GHG) emissions on food security in Surabaya

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Abstract. Surabaya is an urban area that has a population growth rate increasing every year, which is 0.52\% in 2010-2013 and increased to 0.55\% in 2013-2014. Increasing population growth has an impact on increasing urban food availability. Identification of food availability in Surabaya consists of agriculture and livestock sectors, namely rice production (X\textsubscript{1}), corn production (X\textsubscript{2}), cassava production (X\textsubscript{3}), beef cattle production (X\textsubscript{4}), dairy cow production (X\textsubscript{5}), buffalo production (X\textsubscript{6}), goat production (X\textsubscript{7}), horse production (X\textsubscript{8}), and poultry production (X\textsubscript{9}). Data reduction in sub-districts that have no contribution to the agricultural and livestock sector emissions results in 15 sub-district input data that have a contribution. The spatial regression process. Significance test on the independent variable shows global variables (G), namely rice production (X\textsubscript{1}), corn production (X\textsubscript{2}), cassava production (X\textsubscript{3}), dairy cow production (X\textsubscript{5}), buffalo production (X\textsubscript{6}), goat production (X\textsubscript{7}), and poultry production (X\textsubscript{9}). While the independent variables that show local variables (L) are beef cattle production (X\textsubscript{4}) and horse production (X\textsubscript{8}).

1. Introduction
Global climate change is caused by increased emissions of Green House Gases (GHG) due to various activities that encourage an increase in the earth's temperature. Increasing the temperature of the earth's surface is generated by the presence of sunlight radiation into the Earth's atmosphere, then part of this light changes into heat energy in the form of infrared rays absorbed by the air and the surface of the earth [1]. To resolve this issue, at the 2002 Earth Summit in Rio, was born climate change convention to stabilize the concentration of greenhouse gases in the atmosphere at a level does not endanger the climate system [2].

Climate is the main element of the metabolic system and plant physiology, so that global climate change will adversely affect the sustainability of agricultural development [3]. The agricultural sector, especially the food crops sector, is the sector that has the most impact on climate change. There are three main factors related to global climate change that impact on the agricultural sector are : changes in rainfall patterns, increased extreme climate events (floods and droughts), and increased air temperature [4]. Climate change has an impact on the food system in a number of ways including direct impacts on crop production to changes in markets, prices of food products, and supply chain infrastructure [5]. The largest distribution of GHGs in Indonesia are carbon dioxide (CO\textsubscript{2}), methane
(CH₄) and dinitrogen oxide (N₂O) [6]. In addition to CO₂, the second largest greenhouse gas that contributes to global warming in Indonesia is CH₄, the majority of which come from the agricultural sector, including livestock activities. The disruption of the food system due to the increase in urban temperature as a result of the increase in GHG emissions has a negative impact on the food security of the population. During the period 1981-1990, every district in Indonesia each year experienced a decline in rice production of 100,000 tons and in the period 1992-2000, the amount of this decline increased to 300,000 tons [7].

Surabaya is an urban area that has a population growth rate increasing every year, which is 0.52% in 2010-2013 and increased to 0.55% in 2013-2014 [8]. Increasing population growth has an impact on increasing urban food availability. Food availability in Surabaya consists of agriculture and livestock sectors. Agriculture sector consist of rice, corn, cassava and sweet potatoes. Whereas livestock sector consist of meat, eggs, milk and fish. Food supply activities that have a contribution to GHG emissions are activities arising from the agricultural sector including livestock. In this study will be studied further about how the effects of GHG emissions from the agricultural sector and livestock on food availability in Surabaya by analyze spatial parameter formulation from the GHG emissions.

2. Identification of food availability in Surabaya
Identification of food availability in Surabaya City through descriptive statistics from the data of the Surabaya Food and Agriculture Security Office. Food availability in Surabaya is divided into 2 sources, namely vegetable food production and animal food production. Land limitations in the city of Surabaya and the tendency of the characteristics of urban areas narrow the production of plant and animal foods in the districts of Surabaya.

The amount of production of the availability of vegetable and animal food in the city of Surabaya in 2016 was shown by the production of vegetable food, consist of: rice production (X1); corn production (X2); and cassava production (X3). Whereas animal food production consists of: beef cattle production (X4); dairy cattle production (X5); buffalo production (X6); goat production (X7); horse production (X8); and poultry production (X9). From the overall data in each district, the availability of vegetable food is dominant in the type of rice production. While the availability of animal food is dominant in poultry production. Food availability in Surabaya is concentrated on the West and South Surabaya regions, such as the Lakarsantri District and Karang Pilang District.

3. Calculate production of Green House Gas Emmisions (agricultural and livestock sector) in Surabaya
GHG emission production in Surabaya is calculated from 2 sectors, namely the agricultural sector and the livestock sector. Emissions from the agricultural sector are calculated from the total area of agriculture and emissions from consumption of urea fertilizer. This emission is obtained by multiplying the paddy field with the emission factor of rice field agricultural activity, which is 1.3 tons CH₄/ Ha of paddy field (Calculator GHG v1.0, 2012). For fertilizer consumption, to get the total emissions multiplied by 0.20 tons of CO₂/ton of fertilizer consumption. The calculation of total emissions from agricultural activities in the each district as follows:

| Districts     | Agriculture Area (Ha) | Emission Factor (CH₄/ Ha) | Urea Consumption (Kg) | Emission Factor (CO₂/ton) | Emission Production (Kg/year) |
|---------------|-----------------------|----------------------------|-----------------------|---------------------------|-----------------------------|
| Asemrowo      | 0                     | 0                          | 0                     | 0                         | 0                           |
| Benowo        | 217                   | 282.1                      | 42.120                | 8,424                     | 290,524,0                   |
| Bubutan       | 0                     | 0                          | 0                     | 0                         | 0                           |
| Bulak         | 109                   | 141.7                      | 51.041                | 10,2082                   | 151,908,2                   |
| Dukuh Pakis   | 0                     | 0                          | 0                     | 0                         | 0                           |
| Gayungan      | 9                     | 11.7                       | 1.800                 | 0.36                      | 12,060,0                    |

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Districts that do not have agricultural land, have 0 Kg emission. Whereas the districts with the most GHG emission production from the agricultural sector are Lakarsantri District with 1,139,834.2 Kg of emissions / year. In addition, the production of GHG emissions from the livestock sector is obtained by multiplying the total livestock by livestock emission factors from the GHG Calculator. Each cow is multiplied by the emission factor of 1 Kg / head, each dairy cow is multiplied by an emission factor of 31 Kg / head, each buffalo is multiplied by an emission factor of 2 Kg / head, each goat is multiplied by an emission factor of 0.2 Kg / tail, each horse is multiplied by an emission factor of 2.19 Kg / head, and each poultry is multiplied by the emission factor of 0.03 Kg / head. Following are the results of the calculation of emissions from the livestock sector in the city of Surabaya.

Table 2. GHG emission production from livestock sector

| Districts     | Beef Cattle Emissions (Kg) | Dairy Cow Emissions (Kg) | Buffalo Emissions (Kg) | Goat Emissions (Kg) | Horse Emissions (Kg) | Poultry Emissions (Kg) | Emissions Total (Kg/year) |
|---------------|---------------------------|-------------------------|------------------------|-------------------|---------------------|------------------------|--------------------------|
| Asemrowo      | 0                         | 0                       | 0                      | 0                 | 0                   | 0                      | 9.69                     |
| Benowo        | 0                         | 0                       | 0                      | 0                 | 0                   | 0                      | 7.32                     |
| Bubutan       | 0                         | 0                       | 0                      | 0                 | 0                   | 0                      | 10.68                    |
| Bulak         | 0                         | 0                       | 0                      | 0                 | 0                   | 0                      | 18                       |

Source: Analysis, 2018
Production of livestock GHG emissions in the Surabaya is shown by the large number of livestock in each district. The most dominant livestock contribution to emissions in each district is the type of poultry and the least is the horse. District with the most GHG emission production from the livestock sector are Wonocolo District with 6,990.87 Kg of emissions.

From the two sectors that show agricultural and livestock activities, the two emissions are summed up to get the total production of agricultural sector GHG emissions in the Surabaya.

**Table 3. GHG Emissions from livestock and agricultural sectors**

| Districts       | Agricultural Emission (Kg) | Livestock Emission (Kg) | GHG Emission Total (Kg) |
|-----------------|----------------------------|-------------------------|-------------------------|
| Asemrowo        | 0                          | 9.69                    | 9.69                    |
| Benowo          | 290,524.0                  | 7.32                    | 290,531.32              |
| Bubutan         | 0                          | 10.68                   | 10.68                   |
| Bulak           | 151,908.2                  | 18                      | 151,926.20              |
| Dukuh Pakis     | 0                          | 14.46                   | 14.46                   |

*Source: Analysis, 2018*
| Districts       | Agricultural Emission (Kg) | Livestock Emission (Kg) | GHG Emission Total (Kg) |
|----------------|----------------------------|-------------------------|-------------------------|
| Gayungan       | 12.060,0                   | 8.43                    | 12.068,43               |
| Genteng        | 0                          | 5.1                     | 5.10                    |
| Gubeng         | 0                          | 2.977,44                | 2.977,44                |
| Gunung Anyar   | 7.490,0                    | 17.82                   | 7.507,82                |
| Jambangan      | 5.200,0                    | 24.85                   | 5.224,85                |
| Karang Pilang  | 114.876,7                  | 144,78                  | 115.021,48              |
| Kenjeran       | 0                          | 4.98                    | 4.98                    |
| Krembangan     | 0                          | 16.26                   | 16.26                   |
| Lakarsantri    | 1.139.834,2                | 861,05                  | 1.140.695,25            |
| Mulyorejo      | 26.990,0                   | 11.47                   | 27.001,47               |
| Pabean Cantikan| 0                          | 2.34                    | 2.34                    |
| Pakal          | 492.072,0                  | 809,33                  | 492.881,33              |
| Rungkut        | 10.140,0                   | 41.07                   | 10.181.07               |
| Sambikerep     | 501.028,8                  | 27.94                   | 501.056,74              |
| Sawahan        | 0                          | 19.38                   | 19.38                   |
| Semampir       | 0                          | 8.28                    | 8.28                    |
| Simokerto      | 0                          | 3.3                     | 3.30                    |
| Sukolilo       | 63.870,0                   | 38.4                    | 63.908,40               |
| Sukomanunggal  | 0                          | 36.12                   | 36.12                   |
| Tambaksari     | 0                          | 27.48                   | 27.48                   |
| Tandes         | 7.140,0                    | 86.88                   | 7.226.88                |
| Tegalsari      | 0                          | 12.09                   | 12,09                   |
| Tenggilis Mejoyo| 0                          | 17.4                    | 17.40                   |
| Wiyung         | 102.220,0                  | 261.96                  | 102.481,96              |
| Wonocolo       | 10.760,0                   | 6.990,87                | 17.750,87               |
| Wonokromo      | 0                          | 9.33                    | 9.33                    |

Source: Analysis, 2018

4. Spatial parameter formulation in the effect of Green House Gas emission on food security in Surabaya

Analysis of spatial parameter formulation in the influence of GHG emission production on the food availability of Surabaya City was carried out by regression analysis. Independent variables used are food availability in each district from the agricultural and livestock sectors. Independent variables consist of rice production (X1), corn production (X2), and cassava production (X3). While animal food production consists of beef cattle production (X4), dairy cattle production (X5), buffalo production (X6), goat production (X7), horse production (X8), and poultry production (X9). While the dependent variable used is the total emissions from the agricultural and livestock sectors. Determination of spatial parameters for GHG variables is carried out on district data which has the contribution of the agriculture and livestock sectors. After getting the data that has been reduced, a regression analysis is performed to formulate variable parameters.

4.1. Data input cluster

The following data is the input of the cluster analysis process with 10 clusters. Then, it is obtained the districts that have a contribution to GHG through the production of the agricultural and livestock sectors.
From the data above, it shows that there are several districts that do not have a basis in both aspects of agriculture and livestock emissions, so they need to be reduced. The reduction process is based on cluster analysis by forming the tendency of 10 clusters.

Table 4. Dependent dan Independent Variables

| Districts     | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | Y   |
|---------------|----|----|----|----|----|----|----|----|----|-----|
| Asemrowo      | -  | -  | -  | -  | -  | -  | -  | -  | -  | 323 | 9.69 |
| Benowo        | 1041.16 | 87.91 | - | - | - | - | - | - | - | 244 | 290531.3 |
| Bubutan       | -  | -  | -  | -  | -  | -  | -  | -  | -  | 356 | 10.68 |
| Bulak         | 583.73 | -  | -  | -  | -  | -  | -  | -  | -  | 600 | 151926.2 |
| Dukuh Pakis   | -  | -  | -  | -  | -  | -  | -  | 12 | -  | 402 | 14.46 |
| Gayungan      | 45.84 | -  | -  | -  | -  | -  | -  | -  | -  | 281 | 12068.43 |
| Genteng       | -  | -  | -  | -  | -  | -  | -  | -  | -  | 170 | 5.1 |
| Gubeng        | -  | -  | -  | -  | 96 | -  | -  | -  | -  | 48  | 2977.44 |
| Gunung Anyar  | 24.61 | -  | -  | -  | -  | 45 | -  | -  | -  | 294 | 7507.82 |
| Jambangan     | 20.92 | -  | -  | -  | -  | -  | -  | 20 | 1  | 622 | 5224.85 |
| Karang Pilang | 424.57 | 14.65 | 64 | - | -  | 21 | 8 | 218 | 3  | 487 | 115021.5 |
| Kenjeran      | -  | -  | -  | -  | -  | -  | -  | -  | -  | 166 | 4.98 |
| Krembangan    | -  | -  | -  | -  | -  | -  | -  | -  | -  | 542 | 16.26 |
| Lakarsantri   | 4145.7 | 58.61 | 25 | 22 | 22 | 260 | - | 1935 | 1140695 |
| Mulyorejo     | 90.16 | -  | -  | -  | -  | -  | -  | 29 | -  | 189 | 27001.47 |
| Pabean Cantikan | -  | -  | -  | -  | -  | -  | -  | -  | -  | 78  | 2.34 |
| Pakal         | 1773.44 | 107.45 | 21 | 25 | 50 | -  | 111 | 492881.3 |
| Rungkut       | 34.26 | -  | -  | -  | -  | -  | -  | -  | -  | 1369 | 10181.07 |
| Sambikerep    | 1719.39 | 234.43 | 16 | -  | -  | 48  | -  | 78  | 501056.7 |
| Sawahan       | -  | -  | -  | -  | -  | -  | -  | 39  | -  | 386 | 19.38 |
| Semampir      | -  | -  | -  | -  | -  | -  | -  | -  | -  | 276 | 8.28 |
| Simokerto     | -  | -  | -  | -  | -  | -  | -  | -  | -  | 110 | 3.3 |
| Sukolilo      | 225.51 | -  | -  | -  | -  | -  | 27 | -  | 1100 | 63908.4 |
| Sukomanunggal | -  | -  | -  | -  | -  | -  | -  | -  | -  | 1204 | 36.12 |
| Tambaksari    | -  | -  | -  | -  | -  | -  | -  | -  | 916 | 27.48 |
| Tandes        | 25.68 | -  | -  | 6  | 2  | -  | 44 | -  | 336 | 7226.88 |
| Tegalsari     | -  | -  | -  | -  | -  | -  | -  | -  | -  | 403 | 12.09 |
| Tenggilis Mejoyo | -  | -  | -  | -  | -  | -  | -  | -  | 580 | 17.4 |
| Wiyung        | 388.25 | 8.69 | 8  | 8  | 10 | -  | 132 | 102482 |
| Wonocolo      | 25.36 | -  | -  | -  | 225 | -  | -  | -  | 529 | 17750.87 |
| Wonokromo     | -  | -  | -  | -  | -  | -  | -  | -  | -  | 311 | 9.33 |

Source: Analysis, 2018

Table 5. District Reduction Result

| Districts     | Clustering | Result |
|---------------|------------|--------|
| Asemrowo      | 1          | Reduce |
| Benowo        | 2          | No     |
| Bubutan       | 1          | Reduce |
| Bulak         | 3          | No     |
| Dukuh Pakis   | 1          | Reduce |
| Districts         | Clustering | Result |
|------------------|------------|--------|
| Gayungan         | 1          | Reduce |
| Genteng          | 1          | Reduce |
| Gubeng           | 1          | Reduce |
| Gunung Anyar     | 1          | Reduce |
| Jambangan        | 4          | No     |
| Karang Pilang    | 5          | No     |
| Kenjeran         | 1          | Reduce |
| Krembangan       | 4          | No     |
| Lakarsantri      | 6          | No     |
| Mulyorejo        | 1          | Reduce |
| Pabean Cantikan  | 1          | Reduce |
| Pakal            | 7          | No     |
| Rungkut          | 8          | No     |
| Sambikerep       | 7          | No     |
| Sawahan          | 1          | Reduce |
| Semampir         | 1          | Reduce |
| Simokerto        | 1          | Reduce |
| Sukolilo         | 9          | No     |
| Sukomanunggal    | 8          | No     |
| Tambaksari       | 9          | No     |
| Tandes           | 1          | Reduce |
| Tegalsari        | 1          | Reduce |
| Tenggilis Mejoyo | 4          | No     |
| Wiyung           | 10         | No     |
| Wonocolo         | 4          | No     |
| Wonokromo        | 1          | Reduce |

Source: Analysis, 2018

There are 15 districts data that are not reduced or have emission contributions in the agriculture and livestock sectors, namely Benowo District, Bulak District, Jambangan Subdistrict, Karang Pilang District, Krembangan District, Lakarsantri District, Pakal District, Rungkut District, Sambikerep District, Sukolilo District, Sukomanunggal District, Tambaksari District, Tegalsari District, Wiyung District, and Wonocolo District.

4.2. Regression spatial analysis

Spatial regression analysis with GWR4 software to obtain the formulation of spatial parameters from variables that have an effect on GHG in Surabaya City. The regression model used is Gaussian. For the first step, all independent variables fall into the Local (L) category. Kernel type used is Adaptive bi-square. Identification of variable X included in global (G) and local (L) parameters through t test. With a value of df = n - x = 15 - 9 = 6 and a probability of 15%. Identification provisions with t test: (1) There is no Global influence / variable (G): - t value < t table < t value < t table; (2) There is influence / Local (L) variable: -< value <-t table or t value> t table.

**Table 6. Spatial regression on independent variables with t-test**

| Variables   | t value  | t tabel (15%) | Global/Local |
|-------------|----------|---------------|--------------|
| X1: Rice production | 0.624059 | 1.65017 | Variabel Global (G) |
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Spatial regression process with Gaussian regression model and Adaptive bi-square Kernel type produces significant values. Significance test on the independent variable shows global variables (G), namely rice production (X1), corn production (X2), cassava production (X3), dairy cow production (X5), buffalo production (X6), goat production (X7), and poultry production (X9). While the independent variables that show local variables (L) are beef cattle production (X4) and horse production (X8).

5. Conclusion
The process of formulating the spatial parameters of the variables that have an effect on GHG in the Surabaya by reducing the data in districts that have no contribution to the agricultural and livestock emissions of the. There are 15 district input data that have contributed to the emissions of the agriculture and livestock sectors. The spatial regression process with GWR4 software uses a Gaussian regression model. The selected kernel type is Adaptive bi-square. Significance test on the independent variable shows global variables (G), namely rice production (X1), corn production (X2), cassava production (X3), dairy cow production (X3), dairy cow production (X5), buffalo production (X6), goat production (X7), and poultry production (X9). While the independent variables that show local variables (L) are beef cattle production (X4) and horse production (X8).

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