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Willingness to pay for climate change mitigation: application on big cities in Central Java, Indonesia

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Abstract

This research aims is to map the climate condition on the cities and to explore willingness-to-pay (WTP) for climate change mitigation. Geographic Information System (GIS) is mapped cities climate condition and Choice Modeling (CM) is measured the people's awareness for mitigating the impacts. The valuation variables are WTP, socio-economy and alternative mitigation choice. WTP is the maximum payment in various bid choices, it is between Rp 0,- to Rp 210.000,-. The alternative choices are plant trees, develop city forest, and public transportation improvement. Sample is defined by Watson formula, which is about 300 respondents in three cities, randomly. In terms of supports, the research's findings are on spatial analysis and mitigation choices. Spatial analysis shows the climate condition in the Surakarta, Semarang and Magelang. WTP survey with CM approach focuses on climate change mitigation in the three cities.

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Keywords: climate change; mapping; economic valuation; choice mitigation; willingness to pay

1. Introduction

Climate change happens as a natural process and human activities include in. Increasing of earth temperature makes ice smoothing, raising sea level, variability on nature temperature, and global warming. It causes arid, paddy

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failed, hampered ecosystem, clean water scarcity, biodiversity degradation, forest fire, and disease. Stern (2007) says climate change is part of economy problem. On business as usual situation, when developed countries ignore the emission effect, the loss is 14 percent of global Gross Domestic Product (GDP) in twenty one century. The replacement cost is about 2 percent to 5 percent of global GDP and adaptation cost is 0.5 percent of developed countries' GDP. It shows adaptation cost is lower than replacement cost. Indonesia has 132.4 million hectare forest for reserve of CO_2 (*carbon sink*). The forest is important to share 85 percent on emission descent. Community involvement is doing by reforestation and planting the tree.

This research focuses in mapping the cities and people's WTP of climate change impact in urban areas. GIS is used to map the climate condition in three cities . Saptutyningsih and Suryanto (2009), Sen, *et al* (2010), Yusuf, *et all* (2010) and Cowelland Zeng (2003) using GIS to map the vulnerability of flood in DIY province, typhoon, climate change in Southeast Asia and also modelling of vulnerability of weather change. People's awareness to pay to reduce the climate change impacts is measured by WTP. WTP also analyzes individual characteristics and personal motives related to other people's interest and alternative to avoid the risk. Le Van An, et.al (2006) do the research on community participation to overcome typhoon. Socio-economy condition has significant influence on decision making process by stakeholders. Sen, *et.al* (2010) found the gap on need and socio-economy condition to overcome the disaster. The community condition influence to their ability to adaptation. Vulnerability of climate change in South East Asia mostly happen in region which is has low to middle income (Yusuf and Fancisco, 2010). Dell, et al (2008) used panel data to analyze the impact of long term climate change. This study found the impact of climate change is influence to worse economy growth in poor countries. Choice Modeling (CM) is used by Chaisemartin & Mahe (2009) to estimate people's awareness to pay for planting the tree on climate mitigation. Roson (2003) used Computable General Equilibrium (CGE) to do an economy analysis on climate change. Cost-Benefit Analysis (CBA), Multi Criteria Analysis (MCA) is used by Brouwer and Van Ek (2004) to control flood. The study showed traditional control is more effective than techical control, such as build the new dam.

2. Methods

2.1. Geographic Information System (GIS)

This study used by Geographic Information System (GIS) to map the vulnarable areas of climate change in two big cities in Central Java Province. GIS is a set of hardware, software, geography and personal data to show the information on geographycal reference. GIS can be used to access potential risk (Connors, 2006). **Wood dan Good (2004) uses GIS to identify earthquake and tsunami on airport and harbour.** Rashed (2003) estimates the social vulnerability on earthquake, Dai (2003) estimates rainfall characteristic to minimize sag risk. Parson, *et.al* (2004), Zerger (2002), dan Cowell and Zeng (2003) use GIS to identify flood risk and mitigation and the model of risk.

2.2. Choice Modeling

Choice modeling (CM) is valuation technique to estimate the value the environment as non market goods. It is a stated preference technique, which estimates the people's preference for climate mitigation choices. CM requires primary data and uses a survey on people to choose the mitigation choice. The questions, called choice set, present to the respondents for bidding mitigation choices. CM study requires the amount of sample size around 1000 valid responses (Bennet, 2008). Smaller samples are possible where respondents can be expected to answer a big number, more than eight of choice sets in each questionnaire.

Sample of primary data is gathered by random sample (Scheaffer et.al., 1996). The sample size based on Watson formula (1993)

$$n = \frac{4Z_{1/2\alpha}^2 p(1-p)}{(\omega)^2} \quad (1)$$

where:

n = sample size
p = proportion of successfull
q = proportion residu (1-p)
$Z_{1/2\alpha}$= coefisient
ω = tolerance of false on population of left side (L) and right side (R), so
ω = L+ R

The research function is WTP = f (*socio-economy, mitigation choices*). Dependent variable is willingness to pay (WTP). It is maximum payment of respondent which is paid for climate change adaptation. The bids are Rp 0 to Rp 210.000. Mitigation choices as a dependent variables are Planting tree (TREE), City forest (FOREST), Public Transportation Improvement (TRANSPORT). Independent variables are: Income (INC), Age (AGE), Education (EDUC), Gender (SEX), Marital Status (MAR), Long stay (LONG), House owner (OWN), Family size (FAM)

3. Result and Discussions

3.1. Spatial Anaysis of Study Area

Based on survey, content of NO_2 in the Surakarta air is 24.32 µg/Nm^3, SO_2 is 6.91 µg/Nm^3, and O_3 is 3.73 µg/Nm^3 in avarage. There are under the tresshold, 316 µg/Nm^3 for NO_2, 632 µg/Nm^3 for SO_2, and 200 µg/Nm^3 for O_3. The survey is conducted in fiften points of monitoring. It is shown on figure 1.

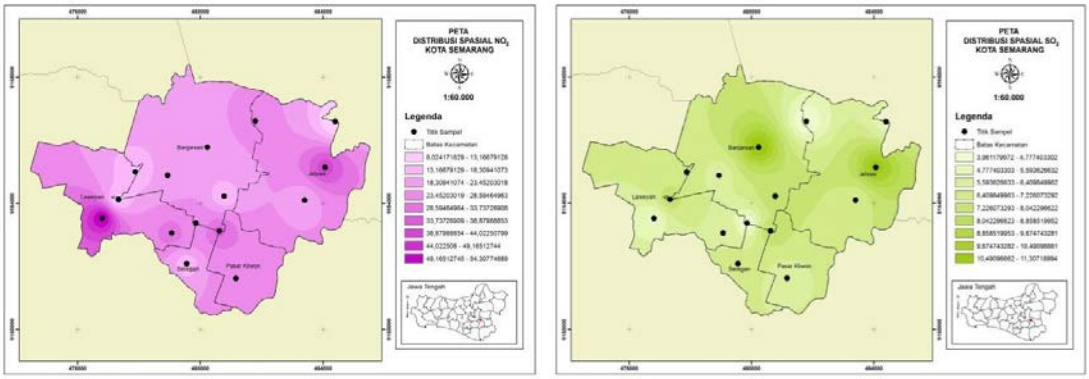

Fig. 1. Spatial Mapping of NO_2 and SO_2 in Surakarta
Source : estimation of secondary data, 2015

In Semarang, content of NO_2 in the air is 165.94 µg/Nm^3 and SO_2 is 0.10 µg/Nm^3 in avarage. There are also under the tresshold. The survey is conducted in four stations of monitoring. It is shown on figure 2.

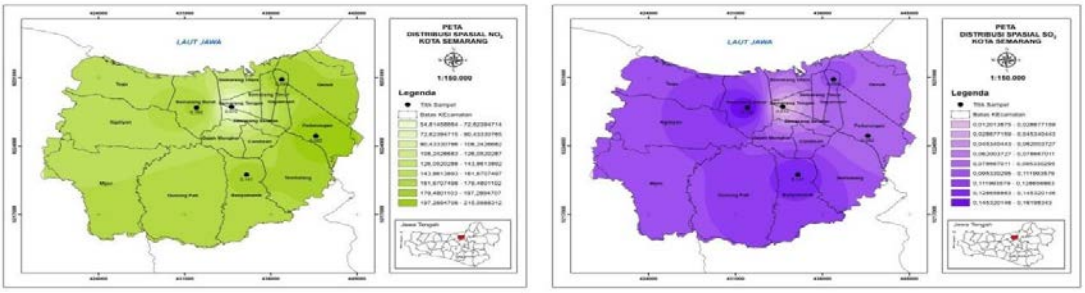

Fig.2. Spatial Mapping of NO_2 and SO_2 in Semarang
Source : estimation of secondary data, 2015

In Magelang City, content of NO_2 in the air is 10.6 µg/Nm^3 and SO_2 is 5.6 µg/Nm^3 in avarage. There are also under the tresshold. The survey is conducted in two stations of monitoring in Mungkid area and Salam area.

3.2. Empirical Result

The high impacts of climate change in Surakarta, Semarang, and Magelang City are human health, availability of clean water, and environmental condition. As a respondent prediction, the problems are getting worse in five, ten, and twenty years. Local government policy is needed to solve the environmental problem. It must be increasingly every year.

Mitigation choices in study area are planting tree (TREE), city forest (FOREST) and public transportation improvement (TRANSPORT). The choices are categorized on eight options:

1. Status Quo, do nothing on mitigation choices.
2. Planting tree (TREE)
3. City forest (FOREST)
4. Public transportation improvement (TRANSPORT)
5. Planting tree (TREE) and public transportation improvement (TRANSPORT).
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7. City forest (FOREST) and public transportation improvement (TRANSPORT)
8. Planting tree (TREE), city forest (FOREST) and public transportation improvement (TRANSPORT)

The cost for set choices is needed. Table 1 shows the cost of mitigation choices and the score. Score is estimated by respondent's choices.

Table 1. Mitigation Choices Cost for Climate Change

No	Mitigation Choices	Option Cost (per year)	Surakarta	Semarang	Magelang
1	Status Quo	Rp 0,-	6	13	26
2	Tree	Rp 40.000,- - Rp 60.000,-	33	40	34
3	Forest	Rp 60.000,- - Rp 75.000,-	5	6	8
4	Transport	Rp 60.000,- - Rp 75.000,-	10	4	6
5	Tree and Forest	Rp 100.000,- - Rp 135.000,-	10	18	13
6	Tree and Transport	Rp 100.000,- - Rp 135.000,-	8	4	1
7	Forest and Transport	Rp 120.000,- - Rp 150.000,-	11	4	3
8	Tree, Forest and Transport	Rp 160.000,- - Rp 210.000,-	23	11	9

Source: primary data, 2015

The highest score is planting the tree in three cities. In surakarta city, option combination of planting tree, city forest, and public transportation improvement is the second high score, option planting tree and public transportation improvement becomes third. In Semarang City, the second high score is planting tree and city forest and option status quo becomes third. Meanwhile, in Magelang, the second high score is status quo and combination of planting tree and city forest becomes third.

There are some reasons why respondent has status quo. In three cities, the first reason is industries must be pay in big portion because they are the main source of air pollution. The second reason in Surakarta and Semarang are, respondent doesn't have enough money to pay more to mitigate the climate change. In Magelang, the second reason

is no benefit fo next generation. Table 2 show the reason why respondent has status quo.

Table 2. Respondent Reasons for

Reason Why Status Quo	Surakarta	Semarang	Magelang
Main source of pollution (industries) must pay more	125	49	26
I have no enough money to pay more	104	49	25
Government have to pay	96	42	25
I can't believe the program will be success	94	38	25
No risk on climate change	91	37	25
I will pay if the community pay it	76	35	25
I don't have enough information on climate change mitigation	74	35	25
No benefit for next generation	72	35	26
I will avoid the risk with my own money	68	34	24

Status Quo
Source: primary data, 2015

Risk management is the important things in climate change mitigation. Based on survey data, respondent rely the management on local government and also central government. It shown in table 3.

Table 3. Risk management

Risk Management	Surakarta	Semarang	Magelang
Local government	28,4%	33,7%	36.3%
Regional institution	20,7%	17,0%	16.9%
Central government	14,9%	23,9%	22.6%
Local NGO	7,2%	13,0%	16.1%
Own management	0,0%	0,4%	8.1%
Greenpeace	0,0%	0,4%	36.3%
Community	0,0%	10,5%	16.9%
Others	13,5%	1,1%	22.6%
No answers	15,3%	0,0%	16.1%

Source : primary data, 2015

3.3. Estimation of Model

The model is

$$WTP = ß_0 + ß_1SEX + ß_2AGE + ß_3EDUC + ß_4FAM + ß_5INC + ß_6LONG + ß_7MAR + ß_8OWN + e \quad (1)$$

which: SEX is gender, AGE is age of respondent, EDUC is respondent education level, FAM is family size, INC is income, LONG is length of stay, MAR is marital status, and OWN is house owner.

Result of estimation is not directly interpreted. It need to calculate the odds ratio. Odds ratio is used to measure the effect of independent variable change to dependent variable (Gujarati,2004:602). Table 4 shows the Odds Ratio of the three cities.

Table 4. Odds Ratio of the three cities

Variables	Coefficient	*Odd Ratio*	Probability
SEX	-0,006	1,134	0.9789
OWN	0,318	1,374	0.3077
MAR	-0,743	0,476	0.0054
LONG	-0,005	0,995	0.4292
INC	0,000	1,000	0.4882
FAM	0,003	1,003	0.9518
EDUC	0,126	1,134	0.0021

Source : Primary data, 2015

The influence of each variable to mitigation choices in three cities is described as:

a. Variables of Sex and Family Size have no influence to WTP on mitigation choices

b. House owner has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent owner will increasing WTP 30.77 percent
c. Marital status has influence to WTP statistically significant in 5 percent degree of freedom. Single person will decreasing WTP 0.54 percent
d. Length of stay has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent length will decreasing WTP 42.92 percent
e. Income has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent income will increasing WTP 48.82 percent
f. Variable of education level influence WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent education level will increasing WTP 0.21 percent

4. Conclusion

a. Mitigation choices in study area are planting tree (TREE), city forest (FOREST) and public transpotation improvement. The choices are categorized on eight options

   1) The highest score is planting the tree in three cities. In Surakarta city, combination of planting tree, city forest, and public transportation improvement is the second high score; option planting tree; and public transportation improvement becomes third. In Semarang City, the second high score is planting tree; and city forest and option status quo becomes third. Meanwhile, in Magelang, the second high score is status quo and combination of planting tree; and city forest becomes third.
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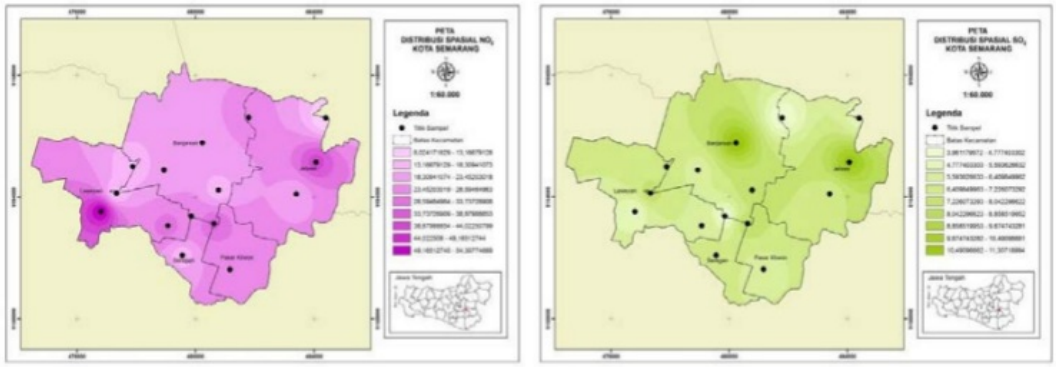

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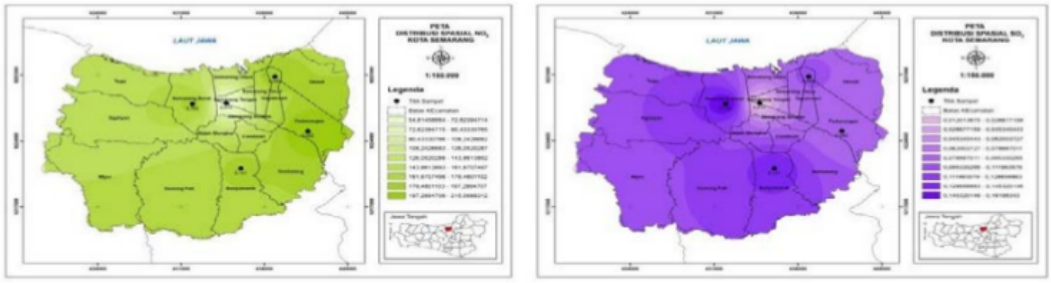

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The cost for set choices is needed. Table 1 shows the cost of mitigation choices and the score. Score is estimated by respondent's choices.

Table 1. Mitigation Choices Cost for Climate Change

No	Mitigation Choices	Option Cost (per year)	Surakarta	Semarang	Magelang
1	Status Quo	Rp	6	13	26
2	Tree	Rp 40.000,- - Rp 60.000,-	33	40	34
3	Forest	Rp 60.000,- - Rp 75.000,-	5	6	8
4	Transport	Rp 60.000,- - Rp 75.000,-	10	4	6
5	Tree and Forest	Rp 100.000,- - Rp 135.000,-	10	18	13
6	Tree and Transport	Rp 100.000,- - Rp 135.000,-	8	4	1
7	Forest and Transport	Rp 120.000,- - Rp 150.000,-	11	4	3
8	Tree, Forest and Transport	Rp 160.000,- - Rp 210.000,-	23	11	9

Source: primary data, 2015

The highest score is planting the tree in three cities. In surakarta city, option combination of planting tree, city forest, and public transportation improvement is the second high score, option planting tree and public transportation improvement becomes third. In Semarang City, the second high score is planting tree and city forest and option status quo becomes third. Meanwhile, in Magelang, the second high score is status quo and combination of planting tree and city forest becomes third.

There are some reasons why respondent has status quo. In three cities, the first reason is industries must be pay in big portion because they are the main source of air pollution. The second reason in Surakarta and Semarang are, respondent doesn't have enough money to pay more to mitigate the climate change. In Magelang, the second reason

is no benefit fo next generation. Table 2 show the reason why respondent has status quo.

Table 2. Respondent Reasons for

Reason Why Status Quo	Surakarta	Semarang	Magelang
Main source of pollution (industries) must pay more	125	49	26
I have no enough money to pay more	104	49	25
Government have to pay	96	42	25
I can't believe the program will be success	94	38	25
No risk on climate change	91	37	25
I will pay if the community pay it	76	35	25
I don't have enough information on climate change mitigation	74	35	25
No benefit for next generation	72	35	26
I will avoid the risk with my own money	68	34	24

Status Quo
Source: primary data, 2015

Risk management is the important things in climate change mitigation. Based on survey data, respondent rely the management on local government and also central government. It shown in table 3.

Table 3. Risk management

Risk Management	Surakarta	Semarang	Magelang
Local government	28,4%	33,7%	36.3%
Regional institution	20,7%	17,0%	16.9%
Central government	14,9%	23,9%	22.6%
Local NGO	7,2%	13,0%	16.1%
Own management	0,0%	0,4%	8.1%
Greenpeace	0,0%	0,4%	36.3%
Community	0,0%	10,5%	16.9%
Others	13,5%	1,1%	22.6%
No answers	15,3%	0,0%	16.1%

Source : primary data, 2015

3.3. Estimation of Model

The model is

$$WTP = ß_0 + ß_1SEX + ß_2AGE + ß_3EDUC + ß_4FAM + ß_5INC + ß_6LONG + ß_7MAR + ß_8OWN + e \quad (1)$$

which: SEX is gender, AGE is age of respondent, EDUC is respondent education level, FAM is family size, INC is income, LONG is length of stay, MAR is marital status, and OWN is house owner.

Result of estimation is not directly interpreted. It need to calculate the odds ratio. Odds ratio is used to measure the effect of independent variable change to dependent variable (Gujarati,2004:602). Table 4 shows the Odds Ratio of the three cities.

Table 4. Odds Ratio of the three cities

Variables	Coefficient	*Odd Ratio*	Probability
SEX	-0,006	1,134	0.9789
OWN	0,318	1,374	0.3077
MAR	-0,743	0,476	0.0054
LONG	-0,005	0,995	0.4292
INC	0,000	1,000	0.4882
FAM	0,003	1,003	0.9518
EDUC	0,126	1,134	0.0021

Source : Primary data, 2015

The influence of each variable to mitigation choices in three cities is described as:

a. Variables of Sex and Family Size have no influence to WTP on mitigation choices

b. House owner has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent owner will increasing WTP 30.77 percent
c. Marital status has influence to WTP statistically significant in 5 percent degree of freedom. Single person will decreasing WTP 0.54 percent
d. Length of stay has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent length will decreasing WTP 42.92 percent
e. Income has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent income will increasing WTP 48.82 percent
f. Variable of education level influence WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent education level will increasing WTP 0.21 percent

4. Conclusion

a. Mitigation choices in study area are planting tree (TREE), city forest (FOREST) and public transpotation improvement. The choices are categorized on eight options

1) The highest score is planting the tree in three cities. In Surakarta city, combination of planting tree, city forest, and public transportation improvement is the second high score; option planting tree; and public transportation improvement becomes third. In Semarang City, the second high score is planting tree; and city forest and option status quo becomes third. Meanwhile, in Magelang, the second high score is status quo and combination of planting tree; and city forest becomes third.
2) There are some reasons why respondent has status quo. In three cities, the first reason is industries must be pay in big portion because they are the main source of air pollution. The second reason in Surakarta and Semarang are, respondent doesn't have enough money to pay more to mitigate the climate change. In Magelang, the second reason is no benefit fo next generation.

b. The influence of each variable to mitigation choices in three cities is described as:
1) Variables of Sex and Family Size have no influence to WTP on mitigation choices
2) House owner has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent owner will increasing WTP 30.77 percent
3) Marital status has influence to WTP statistically significant in 5 percent degree of freedom. Single person will decreasing WTP 0.54 percent
4) Length of stay has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent length will decreasing WTP 42.92 percent
5) Income has influence to WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent income will increasing WTP 48.82 percent
6) Education level influence WTP statistically significant in 5 percent degree of freedom. Increasing 1 percent education level will increasing WTP 0.21 percent

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