Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.4, No.26, 2013

Dominant Factor Analysis That Influence the Sustainability of Quality Control of Water Resources in Bogor, Indonesia

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Abstract

Waste from households and industry are discharged into water sources, especially to the river without prior treatment processes result in water pollution. The purpose of this study to seek answers about whether the dominant factors that influence the sustainability of water resources quality control in Bogor. The analysis in this study used the method of measuring water quality and Multidimensional Scaling (MDS) analysis. The experiment was conducted in Bogor, Indonesia from January to September 2012. This study used primary data from the results of measurements of water quality and survey to the public. Multidimensional analysis of the results of the quality control of water resources in Bogor, Indonesia showed less sustainable status. In this study obtained three-dimensional unsustainable the legal dimension, education and ecology. Key factors that affect the sustainability of the dominant control of the quality of raw water resources in Bogor, Indonesia is (1) a formal education in influencing public perceptions and attitudes towards pollution, (2) Consistency enforcement against perpetrators of pollution, (3) availability of wastewater treatment plants, (4) the pattern of behavior of the people taking out the trash, (5) The level of purchasing power in influencing the behavior of pollution.

Keywords: pollution, education, quality control, water resources, multidimensional scaling

1. Background

Bogor, Indonesia is one area that have crisis (shortage) of clean water. Water service in 2008 in the city of Bogor has reached 47. 99% of the entire population of the city, the rest use water from dug wells, well pumps, branded bottled water, water recharge, springs (RPJMD, 2010). In Bogor Regency, water services in 2008 reached 56. 86% consisted of 15% service taps and the rest of the population outside the PDAM services through the provision of rural water supply systems by the government. Increased coverage of water supply by government elements only 1-2% per year. The low coverage of clean water, such as reduced availability of water resources and environmental capacity, due to blockage of water bodies / rivers by relatively high sedimentation (RPJMD, 2009).

Condition of the raw water source for clean water in Bogor as Ciliwung River deteriorated due to domestic sewage and polluted Cisadane River. Conditions showed that the quality of raw water for water supply in Bogor requires proper monitoring and control efforts to use water that is carried out effectively, efficiently, and sustainably without adverse environmental impact. This prompted the need for the study of the dominant factors that influence the sustainability of the quality control of water resources in Bogor.

Coverage of water services in Bogor still low and the condition of the river has been polluted water quality, especially in congested areas already heavily polluted industries. Symptoms of lack of clean water and water quality degradation indicated in industrial and densely populated areas. Exploitation of ground water and water pollution is not controlled, either by industry or by society. Ignorance of the public about the dangers of waste discharged into the aquatic ecosystem directly without having to first treatment can aggravate water pollution. In

addition, the lack of industry awareness, which are located adjacent to the river dispose their waste directly into the water bodies will reduce the ability of water to purify themselves, thus exacerbating the condition of the raw water source for clean water.

Quality of water resources are polluted or passed the quality standard limits can be influenced by various factors of various dimensions. With regard to such matters formulated problem in this study as follows:

1) How does the physical condition of water resources, in particular the quality of the river water as a source of raw water in Bogor?
2) What factors are the dominant influence on the quality control of water resources and sustainability in Bogor?

The purpose of this research is to find answers about the physical condition of the quality of river water sources in particular. In addition, look for the dominant factors that influence the quality control of water resources in Bogor by way of measuring the quality of river water as a source of raw water for water supply in Bogor. In addition to analyzing the sustainability iti also seen in five dimensions, ie dimensions of ecology, economics, law, education, and social. This study is expected to provide input for improvement of the quality management of water resources in Bogor. The result is also expected to reduce the pollution of raw water for water supply in Bogor.

2. Methods

Research carried out in the Bogor region had identified water pollution and / or environmental damage. Research sites in Bogor Regency were around Cileungsi River which is the source of raw water in the District of Citeureup and District of Gunung Putri. In Bogor City research were conducted around the Cisadane River which is the source of raw water in the Eastern District of Bogor and South District of Bogor. Site selection study done intentionally (purposive sampling) for the fourth district is a district that passed watershed designation as a source of raw water to the level of pollution and environmental damage are quite high. The study was conducted during the 9 months from January 2012 to September 2012.

This study used primary data collected directly from field surveys for water quality measurements and questionnaires to the respondents to explore the factors that influence the quality control of water resources. Respondents include public/community leaders, educators and education personnel, civil servants, private employees/employers in industry. Then further analysis Multidimensional Scaling (MDS) to determine the status of water resources sustainability. Data analysis was performed by MDS analysis based Simamora (2005) and Kavanagh (2001) with the modification of Rapfish tools for social research on Microsoft Excel 2007. Data for MDS analysis obtained from interviews with 107 respondents/interviewees, 55 people in the city of Bogor and 52 people in Bogor Regency.

Results of analysis of water resource sustainability Bogor expressed in the sustainability index that reflects the status of water resource sustainability in Bogor based on current conditions. The value is determined by the range of values between 0-100%. Criterion is not sustainable or bad, if the value of the index lies between 0 to 24.99%. Criteria are less sustainable if the index value lies between 25 to 49.99%. Criteria quite sustainable if the value of the index lies between 50 to 74.99%. Criteria of Sustainable, if the value of index lies between 75-100% (Kavanagh, 2001). Analysis of the sustainability of water resources Bogor, multidimensional nature of the five dimensions examined in this study include three dimensions of sustainable development is a pillar of the dimensions of ecological, economic, and social, and the two other dimensions become important liaison and to contribute to the success of sustainable development namely education and legal dimensions. Then analyzed the attributes in each dimension by using leverage analysis that aims to see the sensitive attributes in contributing to the sustainability dimension.

3. Result and Discussion

Water quality conditions of the city of Bogor and Bogor Regency can be seen in Table 1, which shows that only the parameters of temperature and pH that meet the specified criteria for quality standards, while TSS, BOD, COD, total phosphorus, total nitrate generally were above the threshold criteria for quality standards specified. Results of this study showed that some parameters were observed above the criteria set forth by the Government Regulation no. 82 yr. 2001 and Indonesia Health Minister Regulation no. 416 yr. 1990. This means that the water quality at the study sites (eight sampling points) does not meet the water quality criteria for class 1, or in other

words, less suitable as raw material drinking water. The multidimensional analysis of raw water resources Bogor made based on current knowledge (Figure 1), the sustainability index values obtained for 40.15%, including the status means less sustainable. This value is obtained based on 54 ratings attributes (Table 1) of the five dimensions of the dimensions of ecological sustainability, economics, law, education, and social.

Multidimensional analysis of the results of the method Rapfish Adaptation of water resources management of the Bogor shows that among the five dimensions, dimensions that have the highest sustainability index is the economic dimension, the social dimension followed both in the category of sustainable enough. The results show that the ecological dimension, the legal dimension and the dimension of education entered the category of less sustainable.

Sensitive attributes that contribute to the sustainability index value is based multidimensional analysis leverage each dimension by 26 of the 54 attributes. These attributes need to be improved forward to improve the sustainability of the status of water resources management Bogor. The improvements aim to increase the capacity of the attributes that have a positive impact on the increase in value of the index of sustainability and minimizing the attributes that likely have an adverse effect or decrease the value of sustainability indices.

MDS analysis results using the method of adaptation Rapfish sustainability index values obtained for the ecological dimensions of 42.22% with less sustainable status, the economic dimension of 53.18% with a fairly sustainable status, the social dimension of 52.20% with a fairly sustainable status, educational dimension of 38.34% with less ongoing status, and legal dimensions of 35.22% with less sustainable status. Attributes are assessed based on the current conditions. The index value of the five dimensions of sustainability MDS analysis results can be seen in Figure 2. On the concept of sustainable development should integrate at least three pillars of development, namely ecological, economic, and social. This concept basically agreed globally since the convening of the United Nations Conference on the Human Environment in Stockholm in 1972, with the hope to be able to meet the needs of the present without compromising future generations to meet their needs (WCED, 1987). In addition to the according to the Brundtland Commission, sustainable development is not a rigid condition of the alignment, but rather a process of change so that the exploitation of resources, direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as current needs. Regard the above statement with sustainability values on each dimension in this study, that all index values of each dimension of sustainability does not have to have the same great value. This is due to the Bogor area has different issues, so the priority dimension to what is more dominant concern will also be different. Composite sustainability index value of the fifth dimension is seen here still in the category of less sustainable. Therefore it is in order to improve sustainability in every dimension should really pay attention to sensitive attributes primarily on law and educational dimensions. However, on the other dimensions also remain to be improved sustainability status, by looking at the sensitive attributes that can improve the sustainability status of all dimensions (Table 2).

Based on the analysis to leverage the attributes of each dimension (Table 1), obtained five attributes were sensitive and affect the level of sustainability of the ecological dimension to control the quality of raw water in Bogor, namely (1) drainage conditions, (2) water availability, (3) availability of wastewater treatment plants, (4) Control of the destructive force of water, and (5) Reforestation around the raw water source. In the economic dimension, obtained by six attributes which were sensitive to the sustainability index value, (1) purchasing power level close to industry, (2) The level of purchasing power near water sources, (3) unemployment rate, (4) Feasibility of the business environment, (5) near the income level of the industry, (6) The income level of the people close to water sources.

Sensitive attributes that contribute to the sustainability index value on the legal and institutional dimensions, namely (1) The consistency of law enforcement against perpetrators of pollution, (2) socialization regulations / rules regarding pollution control, (3) conservation activities conducted water resource managers / PDAM , (4) Control of pollution by water resource managers / PDAM, (5) Concern educational institutions to control pollution. Leverage analysis results obtained by five attributes that are sensitive to the educational dimension of sustainability indexes are (1) The effect of formal education on the behavior of the source of raw water, (2) The effect of formal education on the perception of the source of raw water, (3) informal education influence the perception the raw water source, (4) Effect of experience on the behavior of the raw water source, and (5) The influence of electronic media on perception, behavior, and participation in pollution control. In the social dimension, the five attributes that are most sensitive to the value of sustainability indices, namely (1) the public health status, (2) the behavior of littering, (3) The level of community involvement in Customer Communication Forum taps, (4) the public perception of the price of water, (5) The level of public awareness of the quality

control of the raw water source. Attributes that need to be managed and continuously improved in order to better overall dimensions of sustainability index value increases in the future. Management attributes is done by increasing the leverage of each attribute that positively impact and hit every attribute that can negatively impact the sustainability index multidimensional.

MDS-Rapfish analysis results, also showed that all attributes assessed against the sustainability status of quality control of raw water resources Bogor, quite accurately, thereby providing better results and analysis can be justified, as evidenced by the stress value is only between 13-14% and the coefficient of determination (R2) obtained between 0.94 to 0.97. This is in accordance with the opinion of Hsu (2004), which states that the analysis is quite adequate if the value of the stress is smaller than the existing provisions, the value of 0.25 (25%). The coefficient of determination (R2) generated from this study approached the value of 1.0. Quality of the analysis is said the better if the larger value of the coefficient of determination (close to 1). Therefore, based on two parameters (stress and R2 values) showed that all the attributes used in the analysis of the sustainability of water resources quality control of incoming raw Bogor in category relatively well in explaining the fifth dimension analyzed. The stress and the coefficient of determination values as shown in Table 4. This situation shows that the analysis conducted in this study have considerable repetition and relatively stable in each test, as well as can be said to avoid data entry errors and missing data (Kavanagh, 2001).

The relatively small differences in Table 3 and Table 4 also show that the analysis of the sustainability of water resources quality control of raw Bogor using MDS method has a high level of confidence (Pitcher, 1999). Therefore, the results of this analysis can be recommended to be used as one tool in assessing the rapid evaluation (rapid appraisal) the sustainability of the resource management system in a region or area.

4. Conclusions and Suggestions

4.1 Conclusions

Based on the results obtained the following conclusions:

1) The physical condition of water resources in Bogor has now exceeded water quality standards that have been set. Results of the analysis on the raw water quality is known that only the temperature and pH parameters that meet the specified criteria for quality standards. TSS, BOD, COD, total phosphorus, total nitrate generally was above the threshold standards. In addition, heavy metal mercury (Hg) Cadmium (Cd) and lead (Pb), were detected in the water bath. Although its value is still below the quality standard limits but still have to watch out because it could potentially interfere with the microbial life that lives in it and jeopardize human utilizing the water.
2) A multidimensional analysis of quality control of raw water resources, including the status Bogor less sustainable. The results show that there are three dimensions that is unsustainable legal dimension, education, ecological dimension.
3) The key factors are the dominant influence on the sustainability of water resources quality control Bogor is (1) a formal education in influencing public perceptions and attitudes towards pollution, (2) Consistency enforcement against perpetrators of pollution, (3) availability of wastewater treatment plant, (4) The pattern of behavior of the people taking out the trash, (5) The level of purchasing power in influencing the behavior of pollution.

4. 2 Suggestions

In order to strengthen the quality control policies related to water resources based on multidimensional analysis examined suggested as follows:

1) The Government and local authorities need to further strengthen the implementation and consistency in the implementation of environmental education in all schools, and also in non-formal education (non-formal and informal education) to increase environmental awareness and public participation in the quality control of raw water sources and control of environmental degradation in the generally.
2) Government policy and local governments in the field of environmental law enforcement needs to be strengthened by a consistent manner, followed by the award (reward) to the people who have shown concern and activity in the control of environmental damage, including the quality control of water resources, and providing penalties or sanctions (punishment) is unequivocal that violate policies or rules.

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Table 1. Water quality parameters at study sites, City of Bogor (Stations 1-5) and Bogor Regency (Station 6-8).

Parameter	Quality Standard*	City of Bogor				
		St 1	St 2	St 3	St 4	St 5
Physical						
Temp (°C)	± 3	25. 8	26. 2	26. 7	26. 1	25. 2
TSS (ppm)	3	4*)	1	2	2	5*)
TDS (ppm)	6	58*)	54*)	52*)	54*)	61*)
Chemistry						
pH	6-9	8. 09	7. 8	7. 82	7. 81	7. 82
BOD (ppm)	2	0. 9	1	1. 05	0. 95	1. 1
COD (ppm)	4	12. 56*)	8. 11*)	13. 11*)	11. 44*)	4. 78*)
Total P (ppm)	0. 005	0. 039*)	0. 005	0. 077*)	0. 08*)	0. 106*)
Total N (ppm)	0. 008	0. 1*)	0. 008	0. 008	0. 006	0. 012*)
Pb (ppm)	0. 005	< 0. 005	< 0. 005	< 0. 005	< 0. 005	< 0. 005
Cd (ppm)	0. 001	< 0. 001	< 0. 001	< 0. 001	< 0. 001	< 0. 001
Hg (ppm)	0. 0002	< 0. 0002	< 0. 0002	< 0. 0002	< 0. 0002	< 0. 0002

Parameter	Quality Standard *	Bogor Regency		
		St 6	St 7	St 8
Physical				
Temp (°C)	± 3	25. 8	26. 2	26. 7
TSS (ppm)	3	104*)	7*)	161*)
TDS (ppm)	6	160*)	146*)	162*)
Chemistry				
pH	6-9	7,25	6,46	7,37
BOD (ppm)	2	3,8*)	1,45	5,5*)
COD (ppm)	4	18,74*)	12,72*)	15,73*)
Total P (ppm)	0. 005	0,128*)	0,026*)	0,197*)
Total N (ppm)	0. 008	0,35*)	0,034*)	0,55*)
Pb (ppm)	0. 005	< 0. 005	< 0. 005	< 0. 005
Cd (ppm)	0. 001	< 0. 001	< 0. 001	< 0. 001
Hg (ppm)	0. 0002	< 0. 0002	< 0. 0002	< 0. 0002

Marks:
* Quality Standar: Government Regulation no. 82 yr. 2001 (Quality Class no.1) and Indonesia Health Minister Regulation no. 416 yr. 1990
*) exceeded the quality standard

Table 2. Attributes of the five dimensions of sustainability of water resources Bogor

Dimension	Rank	Score	Sensitive Attributes
Education Dimension	1	2,15	Influence of formal education on the behavior of the raw water source
	2	2,1	Influence of formal education on the perception of the source of raw water
	3	1,87	Influence on the perception of informal education at the raw water source
	4	1,43	Experiences influence the behavior of the raw water source
	5	1,35	Influence of electronic media on perception, behavior, participation
	6	1,23	Informal education influence the behavior of the raw water source
	7	1,19	Influence on the perception of the experience of the raw water source.
	8	0,83	Influence on the behavior of non-formal education in the raw water source
	9	0,64	Influence on the perception of non-formal education in the raw water source
	10	0,39	Print media influence on perception, behavior, participation
Legal and Institutional Dimension	1	2,83	Consistency of enforcement against perpetrators of pollution
	2	2,43	Socialization pollution regulations ban
	3	1,85	Conservation of water sources by water resource managers / PDAM
	4	1,64	Pollution control by water resource managers / PDAM
	5	1,59	Educational institutions to control pollution concern
	6	1,33	Concern in the industrial pollution control
	7	1,22	NGO concerns on pollution control
	8	0,19	Management responsibility raw water source / PDAM in pollution control
	9	0,15	Their support in pollution control
	10	0,1	Support NGOs in pollution control
Ecological Dimension	1	3,28	Drainage conditions
	2	2,8	The availability of clean water
	3	2,62	Availability of Wastewater Treatment Plants
	4	2,21	Controlling force of water
	5	2,06	Greening around the river

Dimension	Rank	Score	Sensitive Attributes
	6	1,7	Residential land use
	7	1,48	Suitability clean river program (PROKASIH)
	8	1,05	Settlement conditions
	9	0,41	Availability of landfill
	10	0,28	Water conservation
Economic Dimension	1	9,85	The purchasing power of the people close to the industry
	2	8,39	The purchasing power of the people close to water sources
	3	7,79	The unemployment rate
	4	6,64	Feasibility of the business environment
	5	6,49	Income levels near industrial
	6	6,39	Income levels close to water sources
	7	5,1	Provision charge of Corporate Social Responsibility (CSR) taps
	8	4,43	PDAM financial health
	9	3,83	Feasibility industrial environments
	10	3,19	Levels of revenue (PAD)
	11	3,15	Support costs of raw water management
	12	2,29	Industry business opportunities
	13	1,87	Provision of financial support environmental
	14	1,23	PDAM financial support from government
Social Dimension	1	2,39	Health status of the community
	2	2,15	Behavior of people throw garbage
	3	1,5	Community involvement in PDAM Customer Communication Forum
	4	1,43	Public perceptions of water price
	5	1,37	The level of public awareness of water quality control
	6	1,35	Level / frequency of conflict issues that occur in public water
	7	1,23	Public complaints against the service level and access to clean water
	8	1,19	Public perceptions of water taps
	9	0,83	Level control of community participation in water quality
	10	0,64	Public knowledge about the effects of water quality on health

Table 3. Differences in index values sustainability between analysis with Monte Carlo and analysis of MDS

Dimension	Sustainability Index Value (%)		Differences
	MDS	*Monte Carlo*	
Ecologic	42,22	42,29	0,07
Economic	53,18	53,24	0,06
Legal and Institutional	35,22	36,02	0,80
Education	38,34	36,67	1,67
Social	52,20	52,32	0,12
Multi-Dimensions	40,15	41,05	0,90

Table 4. MDS analysis results for stress values and coefficient of determination (R2)

Parameter	Dimension					
	Ecologic	Economic	Legal and Institutional	Education	Social	Multi dimension
Stress	0,13	0,13	0,14	0,14	0,13	0,14
R^2	0,95	0,94	0,95	0,95	0,94	0,97

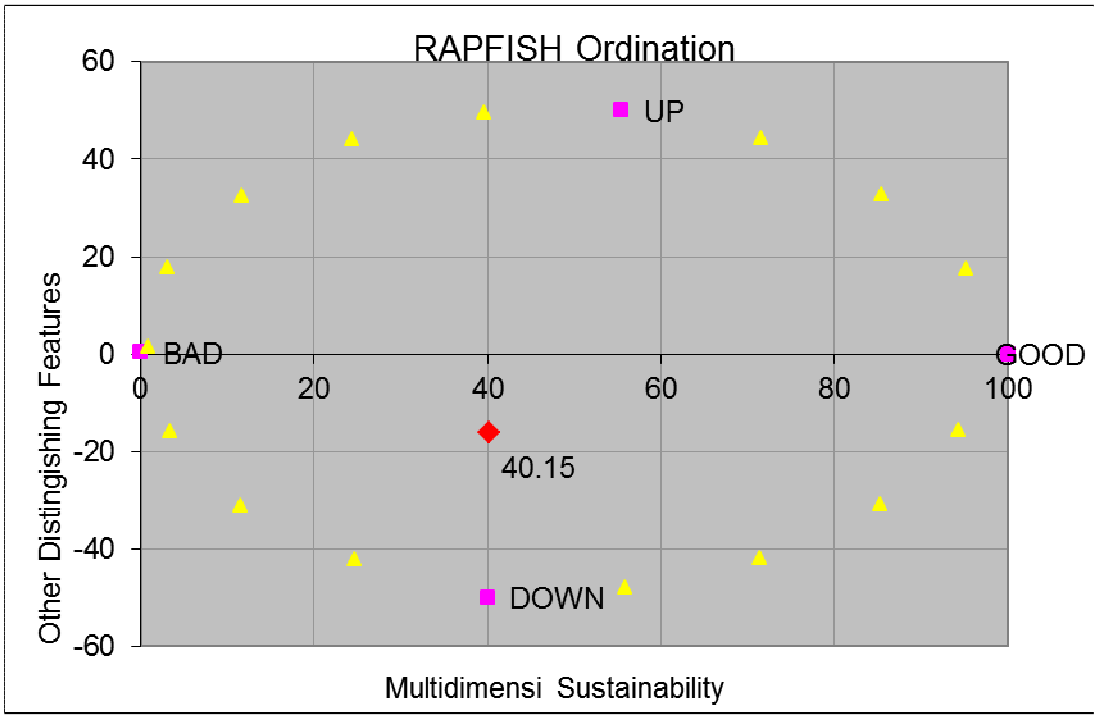

Figure 1. Bogor multidimensional index of sustainability in terms of the quality of raw water resources

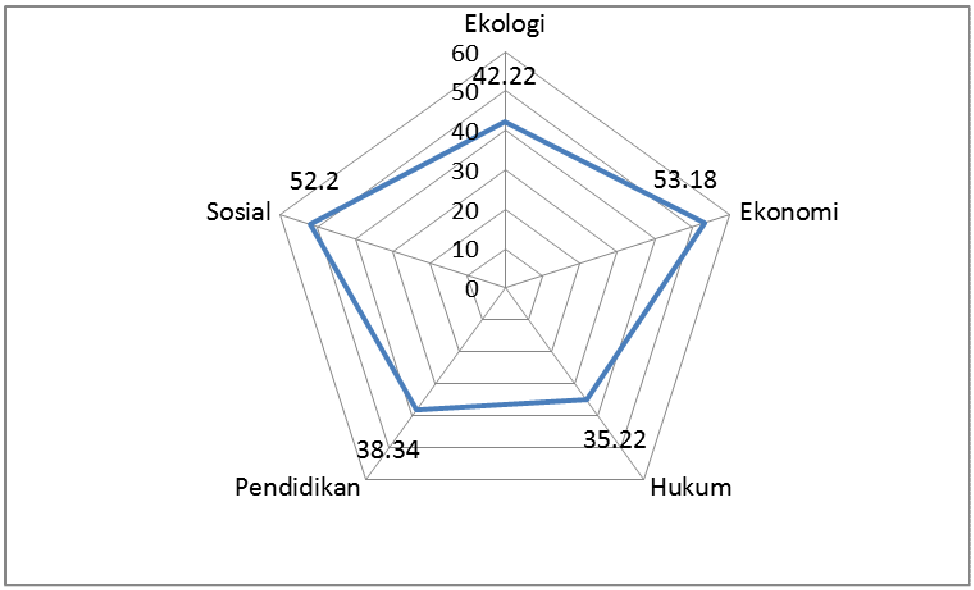

Figure 2. Kite diagram Bogor sustainability index value in terms of quality of the raw water resources