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Groundwater Sustainability in Bandung, Indonesia

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Keywords: groundwater sustainability, Bandung, Echizen Ono, Nagaokakyo

Ⅰ. Introduction and background of the study

Groundwater has a function as a water source for industry, household, and farming in the areas, and it is exploited through deep well extraction. Moreover Bandung city in West Java Province, Indonesia has one of the most dynamic groundwater systems in Indonesia. Even though it is not recommended as a sustainable function, shallow well extraction has an important role in social life and individual economic activity. Furthermore, industrial activities have some important roles to create job demand, supply goods and increase income for local government revenue.

Extraction of groundwater in Bandung started in 1893 in Hoofdienschool (around Tegalega) since then the use of groundwater has increase until 1950. At the early 1970 the industries activities started to use groundwater until recent (Salahudin et all 2011). Based on Statistical Board, 2.394.875 in 2010 are not all provided by Water Supply Enterprise. Ironically, the need of clean water is still 75% depend on groundwater, it is caused by limited water supply from Enterprise and also from others resource than groundwater. Water supply which are managed by the enterprise came from city from the river of 222,6 liters / sec. the spring of 175,6 liters / sec. Whereas from the ground water through 24 bore holes are estimated at 161,8 liters / sec. In 2000 known that domestic purpose used 7510 liter/sec and industries 3462 liter/sec and in 2005 increase 10.405 liter/sec and 4252 liter/sec (Salahudin et all 2011)

Nagaokakyo and Echizen Ono Cities in Japan are interesting case for lesson learned studied in groundwater management in all aspects such as in institutional, stakeholder relations, vision, and merging groundwater and surface water. Integrated management will be more effective than fragmented management as applied in Bandung. Currently, the interest of using lessons learned and best practices is analyzing multi-aspect studies that are based on comparisons. According to (Marlin PMP, 2008) a lesson learned process is one that crosses functional edges and allows an organization or any other objects to learn from both its mistakes and its successes.

Ⅱ. Review of previous works

Recent studies have researched mostly technical aspect of hydrogeology such as Soetrisno (1996) that divide Bandung Basin aquifer into two systems : shallow aquifers (40 m below the surface) and deep aquifers (around more than 40 m to 250 m below the surface). Abidin, H.Z, et all, 2006 that observed land subsidence in several locations in the Bandung Basin that was caused by excessive groundwater extraction. In addition Hutasoit (2009) observe that groundwater drawdown has found in several locations such as Bandung City, Bandung Regency, Kabupaten Bandung, Bandung Barat, Garut, Subang, and Sumedang. Moreover Sumawijaya and Suherman (2009) observe that the high increasing number of population are not balanced with the water supply company. That problem caused the citizen use groundwater for their daily life and some others observed about groundwater from

integrated aspect of engineering, society and policy. A previous study was done by Kataoka and Kutsuma (2008), in Bandung City using groundwater data from 1970 until 2005 and focusing more on groundwater management (Figure I.1). Based on their finding, this current research paper will use the year 1998 as a baseline of groundwater data because it was the beginning of economic growth after the monetary crisis in Asia.

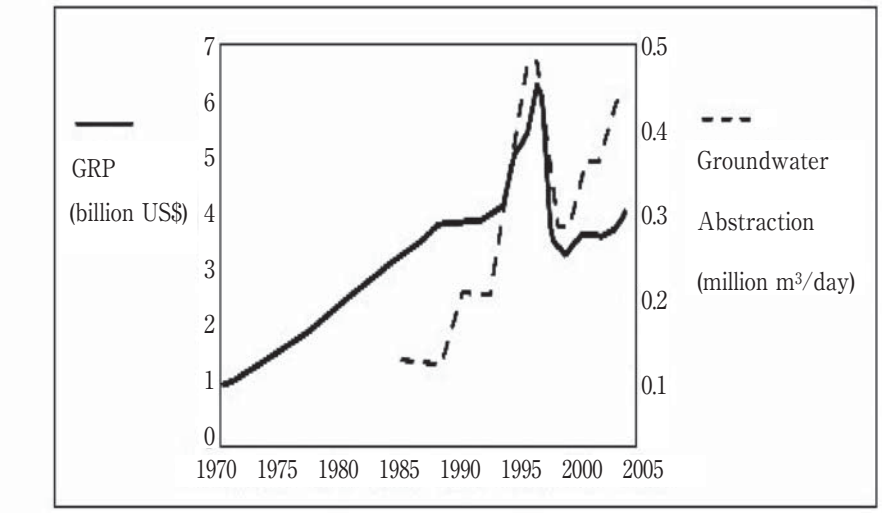

Figure 1. Time courses of Groundwater abstractions and GRP In Bandung (Kataoka and Kutsuma, 2008)

Ⅲ. Methods/Rationale

Currently, there are many studies about groundwater in Bandung City that mostly in hydrology and hydrogeology aspect. That examine engineering aspect of goundwater such as water table, pollution, subsidence, and etc. There is still rare research that compares the groundwater sustainability evaluation according to, interviews and groundwater sustainability index.

Based on Boyce and Neale, 2006, in-depth interviewing is a qualitative research method that engages to perform intensive individual interviews with a small number of respondents to explore their viewpoints on a particular case. In this research, in-depth interview was used to get detailed information from government and the community who have relation to groundwater. This interview survey is implemented to get information about groundwater policy implementation on national, provincial government level and community regarding groundwater sustainability. Moreover, it is expected to interview 10 respondents in Bandung and 4 respondents in Echizen Ono and Nagaokakyo city.

Groundwater Sustainability Index is used for guidance the interview. The guidance for reducing uncertainty in evaluation groundwater policy is using an index like Groundwater Sustainability Infrastructure Index by Vishnu, 2011. This index aproach is able to view the progress of sustainability level from the view point of technical, management, and participation. So interesting to try is used to assess the groundwater sustainability in case study area. This procedure helps analysts to focus on groundwater and others influenced component. Introduce by Vishnu Sangam S, Saroj K. C, and Futaba K in 2011, divided index into five main Component; there are Groundwater monitoring, Public Participation, Knowledge Generation and dessemination, Institutional Responsibility, and Regulatory Intervention.

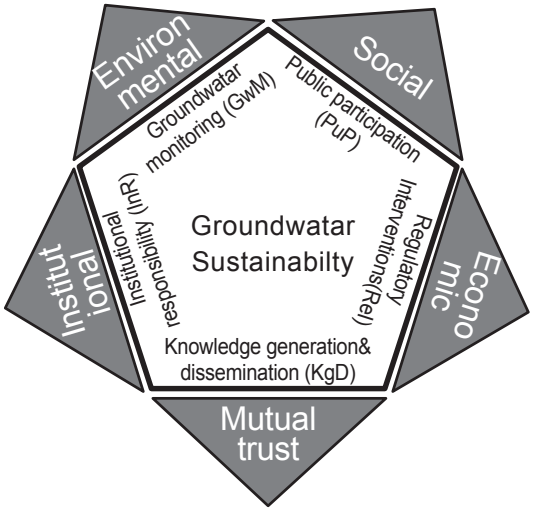

Figure 2. Groundwater Sustainability Infrastructure Index 5 Component (Vishnu et al, 2011)

This method tries to describe the Groundwater Sustainability Infrastructure Index in Bandung by using an index approach and inserting the components into the radial diagram visualization (Figure 3)

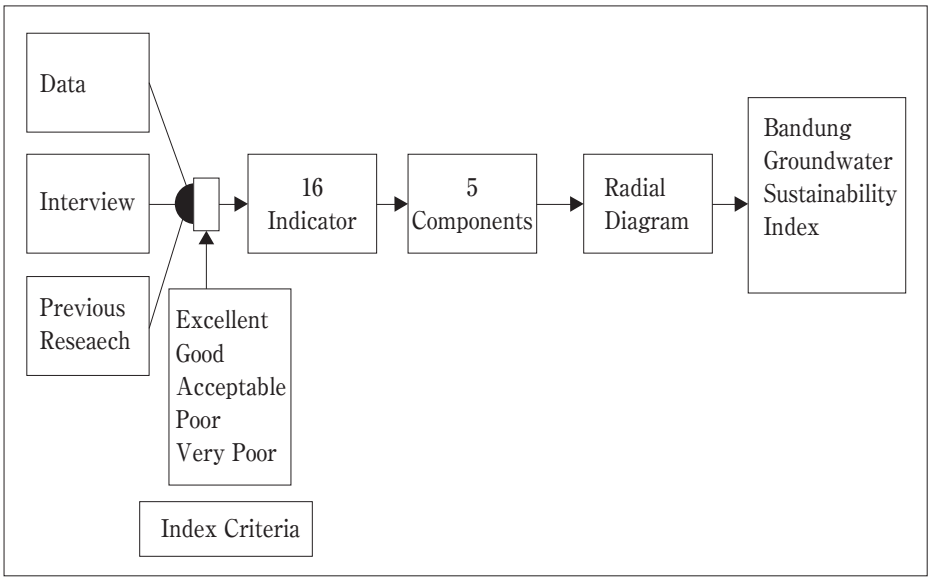

Figure 3. Flow Chart of analysis Groundwater Sustainability Infrastructure Index (Author, 2011)

This index flow is the result of the author adjustment with supporting from the groundwater trend data, in-depth interviews and previous research. It is given to sixteen indicators, and then narrowed down to five component scores. Meanwhile it is plotted in the radial diagram that shows the picture of groundwater sustainability infrastructure index (GSII) in Bandung.

Table 1. Qualitative Value of Indicator (Author, 2011)

	Indicator	Excellent (100)	Good (75)	Acceptable (50)	Poor (25)	Very Poor (0)
Groundwater monitoring	1.1. Groundwater level	Very Stable	Stable	No problem	Unstable	Very Unstable
	1.2. Groundwater extraction	No Extraction	Very Small Extraction	Small Extraction	High Extraction	Very High Extraction
	1.3. Groundwater quality	Very Safe for Drinking	Safe for Drinking	Normal	High Polluted	Very High Polluted
	1.4. Land Subsidence	No Subsidence	Very small Subsidence	Small Subsidence	High Subsidence	Very High Subsidence
Know ledge Generation and Dessemination	2.1. Knowledge generation	Very High Knowledge	High Knowledge	Middle Knowledge	Low Knowledge	Very Low Knowledge
	2.2. Knowledge date storage	Very Good Date Storage	Good Date Storage	Middle Date Storage	Low Date Storage	Very Low Date Storage
	2.3. Provision for dissemination	Very Good Socialization	Good Socialization	Middle Socialization	Low Socialization	Very Low Socialization
Regulatory intervention	3.1. Groundwater Right	Very Good Right	Good Right	Normal Right	Worst Right	Very Worst Right
	3.2. Groundwater Licensing	Very Good Tax/ Subsidy	Good Tax/Subsidy	Middle Tax/Subsidy	Low Tax/Subsidy	Very Low Tax/ Subsidy
	3.3. Economic Instrument	Very Good Instrument	Good Instrument	Middle Instrument	Low Instrument	Very Low Instrument
Public Participation	4.1. Awareness	Very High Awareness	High Awareness	Middle Awareness	Low Awareness	Very Low Awareness
	4.2. Interest to participate	Very High Interest	High Interest	Middle Interest	Low Interest	Very Low Interest
	4.3. Availability of mechanism	Very Good Mechanism	Good Mechanism	Middle Mechanism	Low Mechanism	Very Low Mechanism
Institutional Responsibility	5.1. Availability of authority	Very Good Authority	Good Authority	Middle Authority	Low Authority	Very Low Authority
	5.2. Legal framework	Very Good Framework	Good Framework	Middle Framework	Low Framework	Very Low Framework
	5.3. Institutional Capacity	Very Good Institutional	Good Institutional	Middle Institutional	Low Institutional	Very Low Institutional

The main questions that are asked for inteview are Groundwater level, Groundwater extraction, Groundwater quality, Land Subsidence, Knowledge generation, Knowledge/data CSM, Provision, Groundwater Right, Groundwater Licensing, Economic Instrument, Awareness, Interest to participate, Availability of mechanism, Availability of authority, Legal framework and Institutional Capacity. Those question are adopted from 16 indicators by Vishnu et al, 2011 and modify by the authors for the qualitative value of indicators (0, 25, 50, 75, and 100 (Table 1) and also the explanation value of component Very Poor, Poor, Acceptable, Good, and Excellent (Table 2)

Table 2. Value Component Explanation (Author, 2011)

Component	Excellent	Good	Acceptable	Poor	Very Poor
1. Groundwater Monitoring	The existence of data that provide more detailed, integrated each other. No groundwater problem is found	The existence of data that provide more detailed, integrated each other, but still found some groundwater problem	The existence of data that gives a general overview, some still fragmented, and found groundwater problems	The existence of data but is still fragmented data that cannot give a real general groundwater conditions	No date concerning on groundwater that cannot provide groundwater view
2. Knowledge Generation and Dessemination	The existence of formal and non formal education to inform the concept of groundwater sustainability, high contribution of government and lowest contribution of NGO	The existence of formal and non formal education to inform the consept of groundwater sustainability, equal contribution from both government and NGO	No formal education, but exist the informal education to socialize even in small scale. High contribution of NGO and lower from government	No formal education but exist the informal socializing to inform the concept of groundwater sustainability, although only done by NGOs	No formal and non formal education to inform the consept of groundwater sustainability
3. Regulatory Interventions	The existence of regulations to manage water in detail and there are no obstacles in implementation	The existence of regulations to manage water in detail and there are few obstacle in implementation	The existence of regulations to manage water in general and few in detail, and still few problem found in implementation	The existence of regulations to manage water in general and few in detail, and many problems were found in implementation	No regulation to manage water even though only in general

The analyzes is discussion on the barriers to groundwater policy implementation in Bandung by using the depth interview result and groundwater trends from the previous analysis. Furthermore, to know the value of groundwater sustainability in Bandung conducted by using a groundwater sustainability index approach by Vishnu et all 2011. Through this GSII, it is expected to know the real condition that needs to be improved in Bandung. Components and indicators that are used for the index are based influence factors. Finally at the last part of this research, conclusion based on groundwater sustainability index, will be giving a briefly understanding on groundwater policy implementation in Bandung. Moreover, several recommendations will be given to improve the effectiveness of groundwater policy in Bandung City.

Ⅳ. Groundwater use and its implication on the environment

Based on interviews result and literature review in Bandung, the Groundwater Sustainability Infrastructure Index can be obtained as Acceptable (Table 3 and Figure 4).

Table 3. Result of Groundwater Sustainability Index (Author, 2011)

Groundwater Sustainability Indicator Score Base on Figure Ⅱ.13		Groundwater Sustainabilty Component Score Base on Indicator Average		
Indicator	Indicator Index	Component	Component Index	GS Ⅱ
1.1. Groundwater level	Poor (25)	1. Groundwater Monitoring	Poor (18, 75)	Acceptable (32, 05)
1.2. Groundwater extraction	Poor (0)			
1.3. Groundwater quality	Poor (25)			
1.4. Land Subsidence	Poor (25)			
2.1. Knowledge generation	Poor (25)	2. Knowledge generation and dissemination	Acceptable (33, 3)	
2.2. Knowledge/date CSM	Poor (50)			
2.3. Provision	Poor (25)			
3.1. Groundwater Right	Good (75)	3. Regulatory Interventions	Acceptable (41, 6)	
3.2. Groundwater Licensing	Acceptable (25)			
3.3. Economic Instrument	Poor (25)			
4.1. Awareness	Poor (25)	4. Public Participation	Poor (25)	
4.2. Interest to participate	Poor (25)			
4.3. Availability of mechanism	Poor (25)			
5.1. Availability of authonity	Acceptable (50)	5. Institutional responsibilty	Acceptable (41, 6)	
5.2. Legal framework	Poor (25)			
5.3. Institutional Capacity	Acceptable (50)			

However, if it is observed separately each component will give different scores. Regulatory Intervention and Institutional Responsibility Component score indicate is This is caused by the establishment of laws that increasingly focus for water and groundwater. Although up to now still sometimes overlap with each other. Other components other than the two above are still showing score Poor.

Even though the establishment some Act and Regulation concerning groundwater but the score result are poor. This happens because of weak implementation of punishment and reward at groundwater monitoring. The other notes is for Knowledge generation and dissemination Component and Public Participation that both had scored Poor. Rather different with Groundwater monitoring that has some regulation and guidance concerning, this Component is a new point of view in

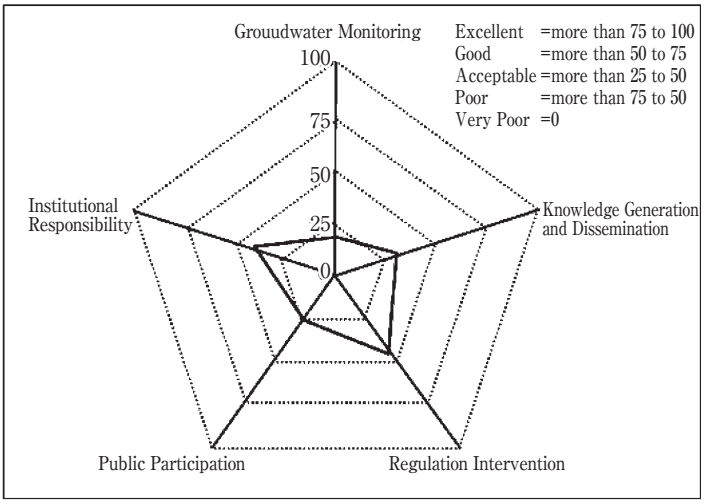

Figure 4. Bandung Groundwater Sustainability Infrastructure Index (Author, 2011)

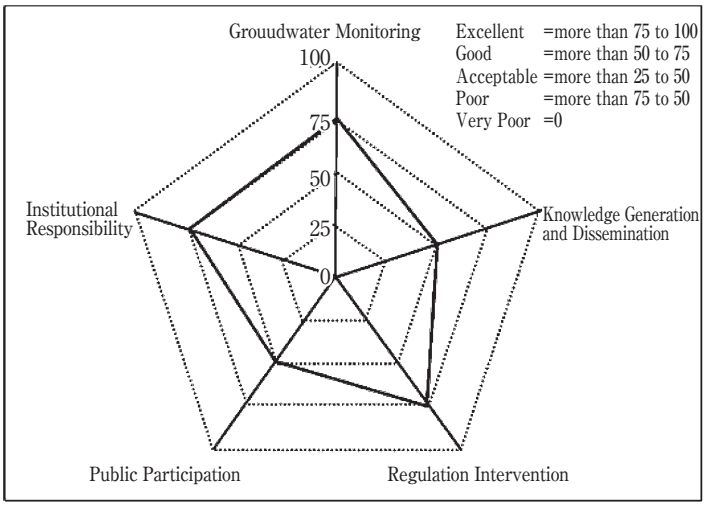

Figure 5. Nagaokakyo Groundwater Sustainability Infrastructure Index (Author, 2011)

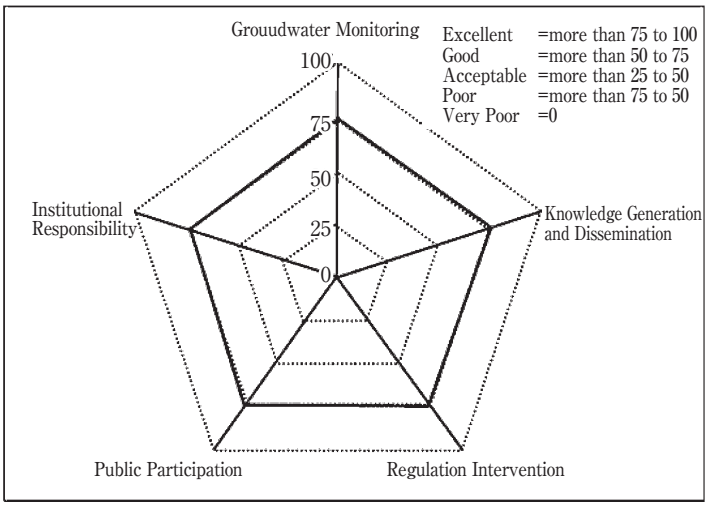

Figure 6. Echizen Ono Groundwater Sustainability Infrastructure Index (Author, 2011)

Bandung groundwater management that usually focus on the technical approach. Using participation and public knowledge will improve individual understanding to make action for groundwater sustainability. Meanwhile, for Groundwater Monitoring, and public participation in are in the second rank, while the knowledge is in the lowest component that need improvement for getting Groundwater Sustainability goal.

According to Nagaokakyo and Echizen Ono Index (Figure 5 and Figure 6). Existence regulation and applying it comprehensively is precise actions to achieve good performance on groundwater policy. Moreover Law enforcement and application of strict regulation are the best practices that that can learn from Japan. Then enriched by additional regulations that explain more detail and technical will make better guidance to perform in local context such as groundwater extraction permit and groundwater conservation allocation.

Ⅴ. Discussion and Conclusion

Policy regulations that are applied related to water resources especially on groundwater in Bandung City are proper enough. According to those details above, It is shown from in-depth interview result that groundwater regulation that are issued is good and appropriate with Bandung condition. They are some project priority that government should be equal such as economic, environment, and social. Considering of economic development, Bandung government tries to attract more investors to build economic activity. Considering of this, environmental issues of groundwater are not being a priority aspect in case of development planning. In fact Groundwater management planning is separate from Regional Planning Agency because until now Regulation for underground planning does not exist. Accordingly, the main difficulty in groundwater policy implementation is integrated planning with others agencies. In terms of groundwater management, several agencies have various programs, but not in line with each other.

According to its tasks and functions the provincial office of energy and mineral resources has a major role in coordinating. However, there are some weaknesses of the implementation. One of them is that decentralization on this autonomy era makes bias in the role of provincial and local. Based on regulations issued, some regulation that are not directly mention groundwater such as Autonomy Act, but it is made negative impact to the implementation.

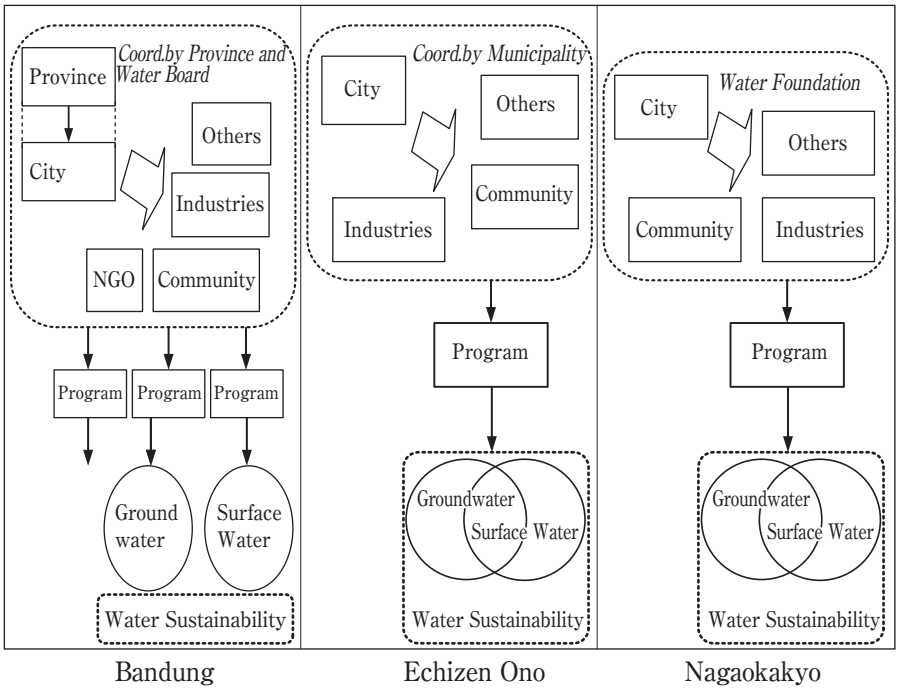

Figure 7. Groundwater Management Comparison

The standard of Groundwater Sustainability in Bandung is explained by adopting Groundwater Sustainability Index (GSII). In this study the index scores is using qualitative research approach with score value is author adjustment. In the next research it will be meaningful to further explanation on the score value into quantitative research with more detail survey data for the five components.

Bandung Case is interesting to additional research by using another lesson learn study with nearly the same scale such as Tokyo and Osaka. In this recent research does

not discuss briefly on subsidence due to over extraction like these two cities, but more in drawing the application of groundwater sustainability concept. Moreover, in Bandung subsidence problems has not reached to critical stage, but it

would better anticipate as done in Tokyo and Osaka for Bandung future development.

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