ELSEVIER

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 17 (2013) 666 – 674

Procedia
Environmental Sciences

The 3rd International Conference on Sustainable Future for Human Security
SUSTAIN 2012

Challenge in integrating clean water infrastructure provision in Jabodetabek Metropolitan Area

Sri Maryati[a,]*

[a]*Research Group for Urban and Regional System Infrastructure, School of Architecture, Planning, and Policy Development, Institute of Technology Bandung, Jalan Ganesha No. 10, Bandung 40132, Indonesia*

Abstract

Development of suburbs in Jabodetabek Metropolitan Area, triggered by land development in certain areas by developer, is characterized by disintegration of infrastructure provision. Disintegration of infrastructure provision causes uneven infrastructure services received by community and higher unit cost. This paper aims to identify the possibility of integrating infrastructure provision in Jabodetabek Metropolitan Area and provide recommendations to integrate infrastructure provision in the region. Through searching of secondary data and results of previous studies, an analysis to determine the extent of possible integration of infrastructure in the region is carried out. Based on the results of analysis, it is known that integration is possible in term of water availability and number of population. Attentions have to be given to density and institution in order to realize integration.

Keywords: Clean water; infrastructure; metropolitan area

1. Introduction

Jakarta Metropolitan Area (JMA) is the largest metropolitan area in Indonesia, which consists of DKI Jakarta Province and other cities (kota) and regencies (kabupaten) in the surrounding of Jakarta. The cities and regencies in the surrounding of Jakarta are Kota Bogor, Kabupaten Bogor, Kota Depok, Kota Tangerang, Kota Tangerang Selatan, KabupatenTangerang, Kota Bekasi and Kabupaten Bekasi. In this

* Corresponding author. Tel.: +62-22-2504735; fax: +62-22-2509171.
*E-mail address:*smaryati@pl.itb.ac.id.

doi:10.1016/j.proenv.2013.02.083

metropolitan area, Jakarta is the core area, while Bogor, Depok, Tangerang, and Bekasi (Bodetabek) are suburbs which support the development of Jakarta as the city's core.The total area of JMA is 5897 km2 and total population in 2009 was 24.6 million and 68.6% of whom live in Bodetabek. Compared to the data in 2000, the proportion of population living in Bodetabek in 2006 increase. In 2000, proportion of population living in Bodetabek was 57%. The map of JMA is shown in Fig 1.

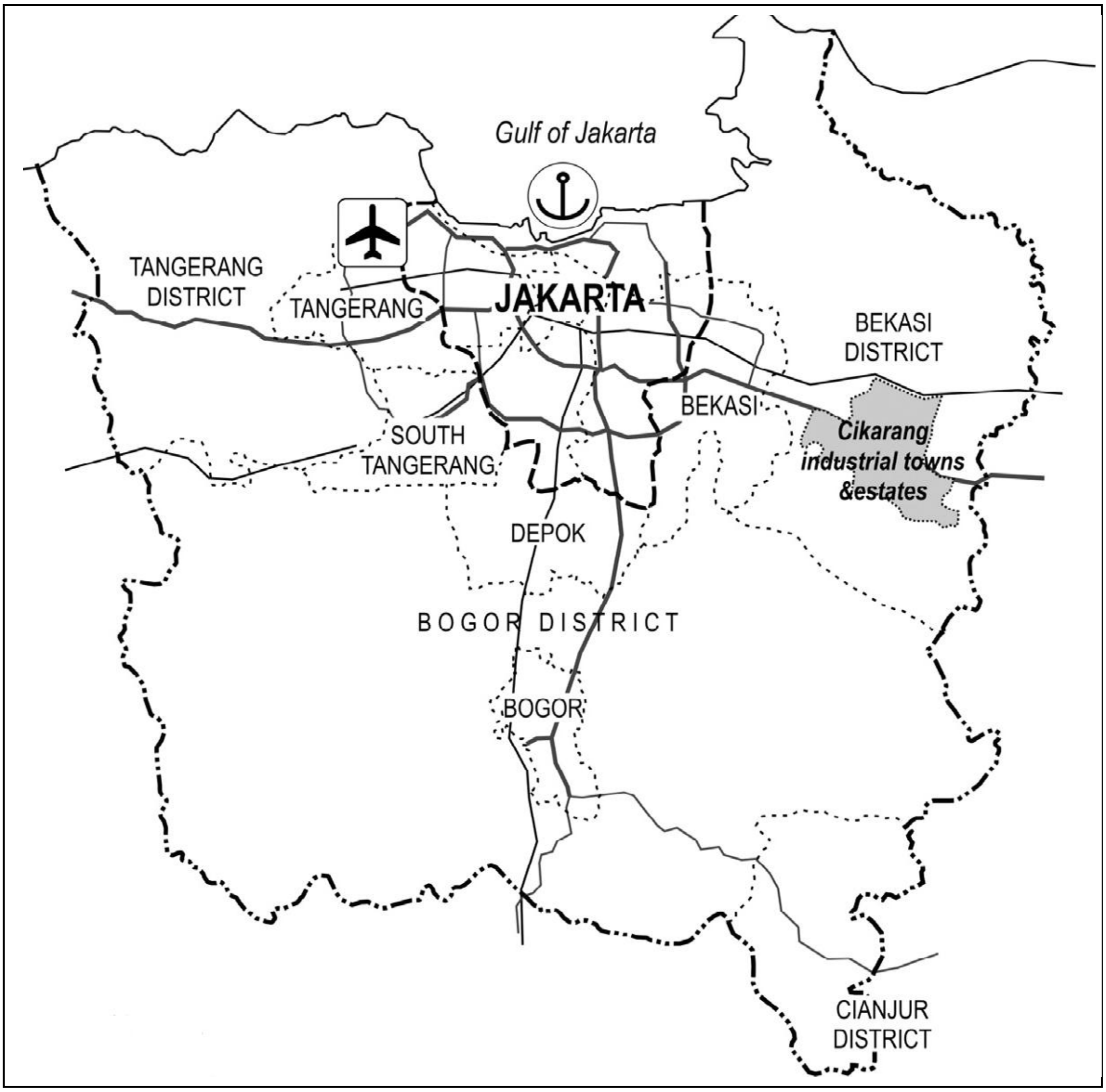

Fig. 1. map of Jabodetabek Metropolitan Area [1]

The growth of suburbs cannot be separated from the role of developer. Nevertheless, in the development of new areas, price and availability of land was the primary consideration of the developer, while the availability of infrastructure was not an important thing [2]. The developer tends to provide infrastructure independently, ignoring the existing public infrastructure. As a result infrastructure provision in the suburbs is not integrated. New formal settlement generally has their own infrastructure system. Another problem in JMA was unavailibility of infrastructure in informal settlement. For those facing the problem of unavailibility of infrastructure, they have to strive for their own infrastructure.

The aim of this paper is to identify the possibility of integrating infrastructure provision in JMA, especially in the suburbs and provide recommendations in an effort to provide infrastructure in the region. This paper will focus on clean water infrastructure. Integrated provision of infrastructure is associated with optimal scale and density, because integration will lead to higher costs if the region is very scattered and has low density. The questions in this paper are 1) what is the requirement for optimal provision of water infrastructure?, 2) how are the condition of settlements and water infrastructure in JMA?, 3) how are the recommendations for addressing the issue of infrastructure provision in JMA.

To answer these questions, the data from previous studies were used. Furthermore, we revisit studies related to water supply cost and optimum scale of water infrastructure provision and trying to find the optimal scale and density of water infrastructure. Next we compare the existing condition and the results of previous studies related to optimal scale and density. We also consider the requirement of integration, such as availability of water sources and income level of community. The next session of this paper explains the cost study and optimal scale of water supply provision. This part gives conceptual framework for integration of infrastructure. After that, we give an overview of water supply provision in JMA. Finally, we discuss about the possibility for integrating infrastructure.

2. Water Supply Cost and Optimal Scale of Water Infrastructure Provision

Water supply infrastructure has high capital cost. For infrastructure with high capital cost generally economies of scale exist. If economies of scale exist, the unit cost of infrastructure provision tends to decrease with the increasing of scale. In economies of scale concept, there is one point called optimal scale. At this point, the cost of infrastructure provision is the most efficient. After this point the unit cost of infrastructure provision will increase with the increasing of scale. Small scale infrastructure has higher unit cost compared to the bigger one up to optimal point. Integrating infrastructure in order to enlarge the scale is one reason to decrease the unit cost of provision.

The existence of economies of scale and optimal scale is determined by cost function. Recent studies related to cost function usually used neo-classical cost function approach (see for example Kim and Lee [3], Mizutani and Urakami [4], and Maryati et al [5]). In neo-classical cost function, cost was defined as a function of quantity, price of input factors, and technological factors. In water supply system, quantity is usually expressed as volume of production or volume of distribution. Price of input factors consists of wage, electricity cost, and chemical cost. Technological factors are technologies used in water production and distribution. Neo-classical cost function can be expressed as Equation (1).

$$C = f(Q, I, T) \tag{1}$$

where C is cost, Q is quantity, I is price of input factors, T is technological factor. Previous studies suggested that neo-classical cost function can be extended by considering environmental condition. It is because water supply cost is not only influenced by quantity, price of input factors, and technological factor, but also by variation in environmental conditions [3],[4],[5].

Some studies identified optimal scale of water supply provision. Since the condition of independent variables of cost function is different across country or region and also time, the optimal scale of provision is time and location specific. Study in Indonesia found that optimal scale of production system was 767,514 people [8]. The study used neo-classical cost function approach as explained in Equation 1.

Quantity was measured from production volume; input factor price and technological factor were assumed the same across the study area. Environmental condition was also considered in the study. Study in Indonesia [5] showed that water production system was influenced by topography and water quality. Based on neo-classical cost function, the cost function for production system in the study was defined as Equation (2).

$$C = f(Q, S, P) \tag{2}$$

where C is cost, Q is quantity (production volume), S is water quality and P is topography. Cost consists of chemicals cost, energy cost, raw water retribution, land rent, wage, maintenance cost, and depreciation. Water quality was measured from the source of water for the system. It was because, in Indonesia, source of water influenced the type of treatment. The source of water could be divided into well, spring and surface water. Topography was measured through the type of transmission system, which could be divided into pumping and gravity system. Water quality and topography, furthermore, were expressed as dummy variables. The form of function used was linear function and the result of parameter estimation could be expressed as Equation (3).

$$C = -2.0 \times 10^7 + 219.4\,Q + 4.1 \times 10^7\,SD + 1.6 \times 10^8\,Pump \tag{3}$$

where C is cost, Q is quantity (production volume), SD is dummy variable for well and Pump is dummy variable for pumping system. Optimal scale in the study was observed graphically from the graph of unit cost and production volume. Unit cost was total cost divided by volume of production. Optimal scale of production for pumping system was on 50 million m3/yr. By using water consumption standard as many as 120 l/person/day and assuming 25% of water loss, the number could serve 767,514 population.

Efficient provision of infrastructure was not only influenced by size, but also density. Study conducted by Wenban-Smith [6] stated that density was as important as size. Back to the concept of economies scale and optimal sacle, at the optimal point, the cost is lower for higher density region compared to the lower one. Furthermore, at certain point where density is too low, it is not efficient to provide infrastructure in the big scale. The provision of public infrastructure system in general is not normally justified if the density is lower than 2,590 people per km2 [7].

3. Water Supply Provision in Jabodetabek Metropolitan Area

Provision of water supply in JMA can be divided into three types. The first classification is provision by public water supply company (Perusahaan Daerah Air Minum, PDAM) or cooperation between PDAM and private sector; the second classification is provision by developers of formal housing or industrial estate in the form of communal system; and then, the third one is provision by individual. The third classification is for those who are not served by PDAM or developers.

Based on Directory of Perpamsi, 2010 [9], there were 7 public water supply companies operated in JMA. They were PDAM Kota Bogor, PDAM Kabupaten Bogor, PDAM Kota Tangerang, PDAM Kabupaten Tangerang, PDAM Kota Bekasi, PDAM Kabupaten Bekasi and PAM Jaya, which covered provision for DKI Jakarta. PAM Jaya formed concession with two private parties to serve population in DKI Jakarta. The coverage of public water supply in Bodetabek area was from 3% to 58.47%. Table 1 shows the coverage of each public water supply in Bodetabek area.

Table 1. Number of customers and coverage of PDAMs in Bodetabek

Water Supply Company	Customers	Coverage (%)
PDAM Kota Bogor	94,995	58.47
PDAM Kabupaten Bogor	126,540	15.35
PDAM Kota Tangerang	17,586	22
PDAM KabupatenTangerang	103,420	49.49
PDAM Kota Bekasi	12,289	3
PDAM KabupatenBekasi	147,761	20.27

PDAMs use spring, surface water, dam and well as the water sources. The main source of water in JMA is surface water. Mainly, water is distributed to the customers by pipeline, connecting source of water to individual household or public hydrant. In some region, water is distributed by truck (known as "mobil tanki air" in Bahasa). The truck distributes water from water source to the so called water terminal ("terminal air" in Bahasa). From the water terminal, water is used by a group of customers. Public hydrant and water terminal are allocated for low income customer. Non-PDAM customer can also buy water from PDAM and the water is distributed by truck. One of the big problems in PDAM is water loss. Water loss in PDAM in JMA ranging from 10.41% to 33.87% [9]; the lowest figure belongs to Kabupaten Tangerang and the greatest figure belongs to Kota Bogor. Water source, volume of production and water loss are shown in Table 2 [9].

Table 2. Water source, volume of production and water loss

Water Supply Company	Water Source (l/s)	Production Volume (m3/yr)	Water Loss (%)
PDAM Kota Bogor	SW: 1,114; S: 336	n.a.	33.87
PDAM Kabupaten Bogor	SW: 1,062; S: 694; W: 82	56,635,542	33.41
PDAM Kota Tangerang	SW: 328	9,901,496	16.14
PDAM KabupatenTangerang	SW: 52,348	136,134,538	10.41
PDAM Kota Bekasi	D: 275	8,722,209	19.91
PDAM KabupatenBekasi	SW: 1,517	n.a.	n.a.

Note: SW: surface water, S: spring, W: well, D: Dam

The development of JMA is characterized by intensive development of new town and industrial estate in the suburbs. New towns are built especially for middle and high income groups. The reasons for middle and high-income groups moving to the new towns, among others, are to avoid congestion, air pollution and space constraints in the city center and to expect more reliable security, better infrastructure and living environment [10]. There are 22 new towns in JMA [11]. The locations of new towns are spread in Jakarta, Kota Tangerang Selatan, Kota Tangerang, Kota Bekasi, Kabupaten Tangerang, Kabupaten Bekasi and Kabupaten Bogor. The majority of new towns are located in Kabupaten Tangerang, which is 7 out of 22 new towns. The areas of new towns are varied between 375 ha to 30,000 ha. The smallest one is Summarecon Serpong and the largest one is Bukit Jonggol Asri. Bukit Jonggol Asri has not yet been operated. Bumi Serpong Damai and Jababeka are also big new towns, with the total area of 6,000 ha and 5,600 ha, respectively. In a new town, infrastructure is usually provided by the new town's developer. The service of such infrastructure is limited only for population in the new town. The new towns and industrial estates usually have their own water treatment plant (WTP) and use various sources of water. In Kabupaten Bekasi, new towns and industrial estates use water from Tarum Canal and Cikarang River and also groundwater to fulfill their needs. There is no significant problem for water supply provision in new towns. Nevertheless, new towns and industrial estates in JMA were built by different developers, so there is no connection between infrastructure in the new towns with existing public infrastructures and infrastructures in other new towns. Furthermore, new towns have their own institutions to manage their infrastructures. Table 3 shows sources, numbers of WTP and volumes of production of water supply provision by industrial estates in Kabupaten Bekasi [12].

Table 3. Source, number of WTP, and volume of production of water supply provision in industrial estate in Kabupaten Bekasi

Industrial Estate	Source	Number of WTP (unit)	Volume of Production (m3/day)
Jababeka	Tarum Canal	2	66,528
EJIP	Tarum Canal, Cikarang River	1	18,000
LippoCikarang	Cikarang River	1	40,608
BIIE (Hyundai)	Cikarang River	1	13.000
MM 2100	Tarum canal	2	12.000
Deltamas	Ground water, Tarum Canal	1	5,184

For people who live in small-scale formal housings or informal housings and not connected to public water supply, they fulfill their needs by using nearest water source; it is usually an individual well or water bought from vendors. There are many private developers who build small scale formal housings. Usually, developer of small scale formal housing does not provide water supply infrastructure. The developer usually provides well or deep well individually only for its customers. Connecting to the coverage of public water supply and small amount of people who are served by communal system, the proportion of people using individual system is big.

The distribution of water source is not equal across the region. Some regions have very good water sources, in term of quantity and quality; however, the others do not have. If they have to meet their needs of water individually, the people who live in bad condition of water will face water crisis problem. The income distribution and willingness to pay among the population are also varied. For people from low income group, providing infrastructure by themselves is very difficult. It is because the high capital cost of infrastructure. As a consequence, they have to buy water from vendors. Buying water from vendors, in fact, is more expensive compared to operationalization of individual system; but they have no choice. Water supply system and institution for managing system are shown in Table 4.

Table 4. Institution of water supply provision in JMA

System	Institution
Public Water Supply	PDAM or PDAM-Private Company
Communal System	Developer of New Town, Formal Housing, or Industrial Estate
Individual System	Individual Household

4. Integrating Water Supply Provision in Jabodetabek Area

There are two main reasons for the importance of integration of water supply provision. The first reason is uneven distribution of water source and the second reason is uneven distribution of income. Uneven distribution of water can cause water crisis for those living in scarce region. Uneven distribution of income prevents low income people from the access to clean water.

Public provision of water infrastructure enables people living in water-scarce area to get water from other areas. Availability of raw water from the rivers only in JMA is 61.32 m3/s, whereas the demand is 45.3 m3/s [13]. These two figures show that availability of water in JMA can meet the needs.

GDP per capita in 2010 in JMA was varied, ranging from IDR 4.8 million in Kota Bogor to IDR 296 million in DKI Jakarta. If we assume that 5% of household income was allocated for clean water and 1 household consisted of 5 people, it means that budget for it ranges from 0.1 million to 6.1 million per month. For some people, their income cannot cover the cost to get clean water; but, if water infrastructure can be integrated, cross-subsidy among customers can be realized.

Although there are many benefits of public provision, there are some points which have to be considered in integration of water infrastructure in JMA. According to part 2 in this paper, the most important things to be considered are size, represented by potential number of customers or number of population, and density. Number of customers and density in JMA are shown in Table 5 (adapted from Waluyo [11]).

Table 5. Number of population and density in JMA

Region	Number of Population 2009	Population Density 2010 (people/km2)
Jakarta Selatan	1,894,889	13,003
Jakarta Timur	2,195,300	11,675
Jakarta Pusat	814,086	16,914
Jakarta Barat	1,635,678	12,627
Jakarta Utara	1,201,983	8,196
Kabupaten Bogor	4,477,344	1,681
Kota Bekasi	1,890,171	8,980
Kota Depok	1,736,565	8,670
Kota Tangerang	1,525,534	9,271
Kota Tangerang Selatan	1,108,943	7,534
Kota Bogor	946,204	7,985
Kabupaten Bekasi	2,630,401	2,065
Kabupaten Tangerang	2,565,279	2,673

Regarding the size, when we notice the number of customers of public water supply system in Table 1, which ranges from 12,289 customers or 61,445 people to 147,761 customers or 591,044 people (assuming 1 customer consists of 5 people) and the result of optimal scale in Indonesia which is about 767,514 people, it can be concluded that public water supply in Bodetabek area has not reached the optimal scale. If we assume that all of populations living in Jabodetabek are potential customers, it can be concluded that integration is possible according to the number of customers or populations. According to the figure of optimal scale, there should be 32 water supply authorities in Jabodetabek.

The problem arises when density is considered. The population density in JMA is uneven and tends to decline by increasing distance from Jakarta. Based on Table 5 and the figure of density to justify public infrastructure, which is 2,590 people per km2, only Kabupaten Bogor and Kabupaten Bekasi cannot meet the figure. Although in average, the density in Kabupaten Tangerang can reach the requirement density, the density in some districts (kecamatan) is below the figure.

Another important thing to be considered in integration of infrastructure in JMA is institution aspect. The management of infrastructure, especially in new towns and industrial estates, is done by developers individually. Nevertheless, according to Hudalah and Firman [1], in 2006 a Memorandum of Understanding (MoU) was signed by seven industrial estates in Bekasi, witnessed by the Department of Public Works, the Government of the West Java Province, the Government of Kabupaten Bekasi, PT Jasa Marga and other developers in Cikarang-Bekasi. The industrial estates, when signing the MoU, agreed to cooperate and form a special economic zone named ZONI (Zona Internasional or International Zone). Through ZONI, the industrial estates in Cikarang can coordinate better with the government to create an integrated plan, including plan for infrastructure. Meanwhile, the MoU is focused on development of transportation infrastructure. ZONI can be a good start for integration of infrastructure. Such kind of unity should be extended to include other regions and other infrastructure.

5. Concluding Remarks

Integration of water supply provision in Jabodetabek area is possible according to water availability and number of population. For density, only Kabupaten Bogor, Kabupaten Bekasi, and some districts in Kabupaten Tangerang do not meet the density requirements for public infrastructure. Institution aspect is also an important factor to be noticed in infrastructure integration. A good start has been executed through the formation of ZONI in Cikarang-Bekasi.

Integration of infrastructure can be started from the existing infrastructure and then extended to the nearby areas. For Kabupaten Bogor, Kabupaten Bekasi and Kabupaten Tangerang, the integration can be done after the density reaches the requirement figure. Some technical aspects, which are not discussed in this paper, such as the diameter of pipe, location of water treatment and pressure, have to be considered in order to get good result of integration. For institution aspect, MoU and unity of developers and local governments for providing integrated infrastructure are needed.

Acknowledgements

This article is part of national priority research MP3EI 2012 funded by Ministry of Education and Culture, Republic of Indonesia (248/SP2H/PL/Dit.Litabmas/V/2012) and research scheme for research group funded by Institute of Technology Bandung (SAPPK.PN-6-14-2012). The author would like to thank Dr. Heru Purboyo Hidayat Putro, the principal researcher of national priority research MP3EI 2012 for valuable suggestions.

References

[1] Hudalah D, Firman, T. Beyond property: industrial estates and post-suburban transformation in Jakarta Metropolitan Area. *Cities* 2012;29:40-8.

[2] Winarso H (2002) in Hudalah D, Winarso H, Woltjer J. *Peri-urbanisation in East Asia: a new challenge in planning*. IDPR. 2007: 29(4):503-19

[3] Kim E, Lee H. Spatial integration of urban water services and economies of scale. *Review of Urban and Regional Development Studies* 1998;10(1):3-18.

[4] Mizutani F, Urakami T. Identifying network density and scale economies for Japanese water supply organizations. *Regional Science* 2001;80:211-30.

[5] Maryati S, Notodarmojo S, Chatib B, Widiarto. Environmental condition and cost of water production and distribution. *Proceeding the 1st International Conference on Sustainable Infrastructure and Built Environment in Developing Countries*, Bandung 2009; 2-3 November.

[6] Wenban-Smith H. *Urban infrastructure: density matters, not just size.* Research papers in Environmental and Spatial Analysis, Department of Geography and Environment, London School of Economics 2006;104.

[7] Rainer G. *Understanding infrastructure: a guide for architects and planners*, New York: John Wiley & Sons; 1990

[8] Maryati S. Optimal scale of water supply provision in Indonesia. *The 3rd International Seminar on Tropical Eco-settlement*, Jakarta 2012; 30 October-2 Nov

[9] Perpamsi. *Perpamsi Directory* 2010

[10] Firman T. The continuity and change in mega-urbanization in Indonesia: a survey of Jakarta-Bandung Region (JBR) development. *Habitat International* 2009;33:327-39

[11]Waluyo NP. *Identifikasi peran kota baru dalam dekonsentrasi perkotaan wilayah Metropolitan Jabodetabek* (studi kasus Kabupaten Bekasi). Final Project at City and Regional Planning Study Program, School of Architecture, Planning, and Policy Development, Institute of Technology Bandung, 2012.

[12] Double Degree Program, Magister of Regional and Urban Planning, Institute of Technology Bandung. *Public infrastructure performance in the surrounding of industrial zone in Bekasi*. Report of Planning Studio 2010

[13]Wibowo H, Setiawan F, Subehi L. Study of investment on clean water services at Jabodetabek based on physical characteristics. In: Kobayashi K, Surjono, Ari IRD, editors. *Water supply management system and social capital*, Malang: University Brawijaya Press, 2012, p.215-22