Water supply provision characteristics in peri-urban area

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Abstract. Water infrastructure is a very important infrastructure in improving the quality of life. Given the importance of water infrastructure, the Government of Indonesia has set a target of 100\% access to drinking water by 2019. Despite the target set, there are many areas in which the condition of water infrastructure is below standard. In term of metropolitan area, the condition of water infrastructure in peri-urban is lower compared to urban area. To improve the condition of infrastructure in the peri-urban areas, it is important to know how the characteristics of infrastructure provision in the region are. The aim of this study is to identify the characteristics of water supply provision in peri-urban area. The analytical method used is descriptive and comparison analysis. The unit of analysis is city and regency level of metropolitan area in Indonesia. Degree of infrastructure provision is measured by coverage and consumption level. The results of the study indicate that the water supply coverage in peri-urban area is lower compared to core area, and water consumption is varied.

Keywords: water supply, per-urban area, metropolitan area

1. Introduction

Rapid urbanization process has an implication on urban population significantly and generates the growth of metropolitan area. Peri-urban area becomes the most active area of this urbanization process [1]. The population growth in the core city will greatly decline, while the population growth in its surrounding areas will rise [2]. Yet, this vast growth in these areas is still not accompanied with adequate services to all its inhabitants. These areas have the characteristics of being inadequately integrated into the city with regard to social and institutional issues as well as infrastructure services including water supply [3].

Some difficulties might hinder the process of development in this area particularly in providing the basic services. Smith, et al. (1998) argued that there are 4 aspects of difficulties on upgrading existing services in peri-urban area namely: (1) social aspect-uncertainty of land ownership and consequently a lack of security of land tenure; (2) technical aspect-the unplanned nature; (3) institutional aspect- local authorities may be unwilling to provide services to peri-urban areas, because any provision of services could be interpreted as acceptance of the legitimacy of the residents’ claims to land tenure; and (4) economic aspect-those living in peri-urban areas are frequently poor and the both of the residents and government may be unable or unwilling to invest money in improvements for services, especially if they have no security of tenure [4].
In view of that phenomena, it can be discussed that provision of public water infrastructure in peri-urban areas is still extremely limited [5]. People who dwell in peri-urban areas receive less far access to basic services including water service provision by formal system since public water supply system requires the residents to prove their legal security of tenure. On the other hand, a formal service provision system is obviously more rigid rather than the informal one in all aspects. It needs legal certainty, long-term and well planning, appropriate institutional aspect, sustainable funding sources, and has to meet technical requirements in order to ensure the continuity of the services.

Based on those backgrounds, this paper aims to explore the characteristics of water supply provision held by public water enterprise in peri-urban areas in Indonesia. Furthermore, we try to figure out whether there is some correlation between spatial variation among areas in a metropolitan area and public water supply delivery. We also try to discover the degree of water infrastructure services in peri-urban areas in Indonesia from two main indicators: service coverage and water consumption and compare them to the services received in the core area.

2. Overview: Metropolitan in Indonesia
The scope of this study is mainly focused on peri-urban areas in the context of metropolitan area in Indonesia. The term of metropolitan area has been defined in Indonesian Government Regulation Number 26/2008 as an urbanized area consisted of at least an urban area as well as a core area surrounded by sub-urban or peri-urban area(s) which has functional interrelation linked by integrated regional infrastructure network system with total population of at least 1,000,000 [6].

In Indonesia there are 14 metropolitan areas consisted of 14 core areas and 50 peri-urban areas based on Indonesia Government Regulation Number 13/2017 regarding the Amendment of Indonesian Government Regulation Number 26/2008 regarding National Spatial Plan specifically in the Attachment II [7]. Those areas spread all around Indonesia and 5 out of 14 metropolitans are located in Java Island. They are Jabodetabek, Bandung Raya, Kedungsepur, Gerbangkertosusila, and Kartamantul. Table 1 shows all of those 14 metropolitan areas along with its cities and regencies as well as its spatial variation. In this study, peri-urban area is determined as a city or regency that is not categorized as the core area. Each metropolitan has its own core area surrounded by several peri-urban areas as illustrated in Figure 1.

![Figure 1. Illustration of linkage of core and peri-urban areas in the context of metropolitan area.](image-url)
Table 1. Metropolitan in Indonesia.

| City/regency | Location              | Metropolitan area               |
|--------------|-----------------------|---------------------------------|
| Medan City   | Core                  | Mebidangro (off Java)           |
| Binjai City, Deli Serdang Regency, Karo Regency | Peri-urban | Java                            |
| Padang City  | Core                  | Palapa (off Java)               |
| Padang Panjang Regency, Padang Pariaman Regency | Peri-urban |                                |
| Palembang City | Core              | Patingraya Agung (off Java)     |
| Banyuasin Regency, Ogan Ilir Regency, Ogan Komering Ilir Regency | Peri-urban |                                |
| DKI Jakarta  | Core                  | Jabodetabek (Java)              |
| Tangerang City, Tangerang Regency, South Tangerang City, Depok City, Bogor City, Bogor Regency, Bekasi City, Bekasi Regency | Peri-urban |                                |
| Bandung City | Core                  | Bandung Raya                    |
| Cimahi City, Bandung Regency, West Bandung Regency, Sumedang Regency | Peri-urban | Java                            |
| Semarang City | Core              | Kedungsepur                     |
| Salatiga City, Kendal Regency, Semarang Regency, Demak Regency, Grobogan Regency | Peri-urban | (Java)                          |
| Yogyakarta City | Core          | Kartamantul (Java)              |
| Sleman Regency, Bantul Regency                  | Peri-urban |                                |
| Surabaya City | Core                  | Gerbangkertosusila (Java)       |
| Mojokerto City, Sidoarjo Regency, Gresik Regency, Lamongan Regency, Bangkalan Regency | Peri-urban |                                |
| Denpasar City | Core                  | Sarbagita (off Java)            |
| Badung Regency, Gianyar Regency, Tabanan Regency | Peri-urban | Java                            |
| Mataram City | Core                  | Mataram Raya (off Java)         |
| North Lombok Regency, East Lombok Regency, West Lombok Regency, Central Lombok Regency | Peri-urban | Java                            |
| Banjarmasin City | Core          | Banjarmasin and surrounding (off Java) |
| Banjarbaru City, Banjar Regency, Barito Kuala Regency, Tanah Laut Regency | Peri-urban |                                |
| Balikpapan City | Core              | Balikpapan and surrounding (off Java) |
| Tenggarong Regency, Samarinda City, Bontang City | Peri-urban |                                |
| Manado City  | Core                  | Manado-Bitung                   |
| Bitung City, North Minahasa Regency             | Peri-urban | (off Java)                      |
| Makassar City | Core                  | Maminasata (off Java)           |
| Maros Regency, Gowa Regency, Takalar Regency    | Peri-urban | Java                            |

Source: [7]

3. Methods

The research method is based on a quantitative approach using two main methods. Firstly, descriptive statistical analysis was used to describe the condition of water infrastructure service in the peri-urban area. Secondly, ANOVA (analysis of variance) was used to compare existing condition of water supply in peri-urban areas with the ideal standards of water provision as well as comparison of the water provision both in the core and peri-urban areas. With the combination of ANOVA and spatial analysis, some distinctions of water supply provision characteristics among metropolitan areas as well
as between spatial variations (core and peri-urban areas) can be differentiated and can be synthesized whether correlation between spatial variation and water supply provision characteristics exist.

The characteristics identified and analyzed are technical and financial aspect of water provision delivered by Local Water Enterprise commonly known as PDAM (*Perusahaan Daerah Air Minum*) and other public water supply. Most of those characteristics, such as service coverage, number of consumers, water sources, utilized water sources, distribution system, tariff, production cost, distribution cost, and non-revenue water (ratio of distributed water and water sold), are based on the data published in 2016 by Indonesia Association of Water Works Enterprise (Perpamsi). Another variable, that is water consumed, is derived variable from the main data gathered.

We focus our study on service coverage and water consumption. Service coverage is defined as number of consumers divided by total population and water consumption is safe water consumed per capita per day. Water consumption is calculated as a ratio of sold water and number of population served. Based on SDGs target, service coverage has to be 100%, and based on Regulation of the Minister of Public Works Number 14/PRT/M/2010 regarding Standard of Minimum Service, minimum water consumption is 60 liter/person/day.

4. Results and discussion

4.1. Results

Surface water takes the biggest portion of water source in peri-urban areas (96.56%), yet the enterprises have not utilized all of the resources for drinking water. Only 3.4% of surface water that has been utilized for drinking water. This means that surface water is ultimately potential of the raw water supply for public water enterprise even if it needs more treatment prior to be distributed to the consumers compared to others. Gravity and pumping system are used to distribute water to each consumer’s connection with the proportion of both system 31:69.

![Figure 2. Water source in peri-urban areas.](image)

Average tariff is Rp 4,041/m³ which is higher compared to average production cost, that is Rp 833/m³. The gap between production cost and tariff for consumers is allocated for other expenses, for instance maintenance cost, administration cost, investment, profit, and personnel expenditure. Water loss or non-revenue water (NRW) is still high, that is more than 30%.

Table 2. shows the output of the ANOVA analysis. The table also shows whether there is a statistically significant difference between the group means with 95% confidence intervals for the dependent variable (Spatial Variation) for each separate group (Core Area and Peri-urban Area), as
well as when all groups are combined (Total). It is interpreted that the significance value which is below 0.05, is categorized as statistically significant different between groups.

Using that statistic calculation, it can be seen that the distinction characteristics between groups of spatial variation showed by these explanatory variables: service coverage (.000), number of consumers (.000), potential water source (.020), potential water source from deep well (.005), potential water source from surface water (.045), total amount of utilized water source (.000), utilized water from deep well (.002), utilized water from surface water (.003), distributed water (.000), sold water (.000), tariff (.002), and distribution cost (.000). All of the variables have higher value in core area compared to peri-urban in average.

Table 2. Water supply provision characteristics based on its spatial variation in 2016.

| Variables                      | Spatial Variation | Mean  | Minimum | Maximum | F    | Sig. |
|--------------------------------|-------------------|-------|---------|---------|------|------|
| Service Coverage (%)           | Core Area         | 60.19 | 3       | 100     | 24.588 | .000*|
|                                | Peri-urban Area   | 28.40 | 2       | 90      |       |      |
|                                | Total             | 36.47 | 2       | 100     |       |      |
| Number of Consumers            | Core Area         | 199279.69 | 118 | 536984 | 34.890 | .000*|
|                                | Peri-urban Area   | 41296.77  | 3872 | 201467 |       |      |
|                                | Total             | 81419.41 | 118 | 536984 |       |      |
| Potential Water Source (l/sec) | Core Area         | 326042.47 | 450 | 3000000 | 5.757 | .020*|
|                                | Peri-urban Area   | 13880.34  | 187 | 380404 |       |      |
|                                | Total             | 93243.59 | 187 | 3000000 |       |      |
| Potential Water Source from Spring (l/sec) | Core Area | 519.17 | 67   | 1571  | .013 | .909 |
|                                | Peri-urban Area   | 584.07  | 12   | 7048  |       |      |
|                                | Total             | 572.27 | 12   | 7048  |       |      |
| Potential Water Source from Deep Well (l/sec) | Core Area | 568.33 | 148  | 1571  | 9.346 | .005*|
|                                | Peri-urban Area   | 165.80 | 3    | 840   |       |      |
|                                | Total             | 243.71 | 3    | 1571  |       |      |
| Potential Water Source from Lake (l/sec) | Core Area | 4799.20 | 90  | 21000 | 2.491 | .140 |
|                                | Peri-urban Area   | 182.22 | 0   | 400   |       |      |
|                                | Total             | 1831.14 | 0   | 21000 |       |      |
| Potential Water Source from Surface Water (l/sec) | Core Area | 324007.73 | 15 | 3000000 | 4.256 | .045*|
|                                | Peri-urban Area   | 17328.82 | 20 | 380404 |       |      |
|                                | Total             | 111210.12 | 15 | 3000000 |       |      |
| Total Amount                   | Core Area         | 4008.87 | 20  | 21000 | 15.835 | .000*|


| Variables                                      | Spatial Variation            | Mean     | Minimum | Maximum | F     | Sig.   |
|------------------------------------------------|-----------------------------|----------|---------|---------|-------|--------|
| of Utilized Water Source (l/sec)               | Peri-urban Area Total       | 723.45   | 57      | 4768    |       |        |
|                                                | Total                       | 1558.73  | 20      | 21000   | .321  | .575   |
| Utilized Water from Spring (l/sec)             | Core Area Peri-urban Area Total | 484.33   | 56      | 1571    | .321  | .575   |
|                                                | Core Area                   | 338.33   | 12      | 2861    |       |        |
|                                                | Peri-urban Area Total       | 364.88   | 12      | 2861    |       |        |
| Utilized Water from Deep Well (l/sec)          | Core Area Peri-urban Area Total | 514.14   | 50      | 1571    |      | 11.768 | .002* |
|                                                | Core Area                   | 130.56   | 3       | 522     |       |        |
|                                                | Peri-urban Area Total       | 214.47   | 3       | 1571    |       |        |
| Utilized Water from Lake (l/sec)               | Core Area Peri-urban Area Total | 4704.80  | 90      | 21000   | 1.804 | .209   |
|                                                | Core Area                   | 164.57   | 10      | 467     |       |        |
|                                                | Peri-urban Area Total       | 2056.33  | 10      | 21000   |       |        |
| Utilized Water from Surface Water (l/sec)      | Core Area Peri-urban Area Total | 2150.29  | 2       | 9229    | 9.989 | .003*  |
|                                                | Core Area                   | 571.28   | 13      | 4768    |       |        |
|                                                | Peri-urban Area Total       | 1051.85  | 2       | 9229    |       |        |
| Pump                                           | Core Area Peri-urban Area Total | 72.00    | 0       | 100     | .041  | .840   |
|                                                | Core Area                   | 69.81    | 0       | 100     |       |        |
|                                                | Peri-urban Area Total       | 70.30    | 0       | 100     |       |        |
| Gravity                                        | Core Area Peri-urban Area Total | 33.54    | 0       | 100     | .026  | .872   |
|                                                | Core Area                   | 31.73    | 0       | 100     |       |        |
|                                                | Peri-urban Area Total       | 32.14    | 0       | 100     |       |        |
| Distributed Water (m³/year)                    | Core Area Peri-urban Area Total | 106258172.29 | 42359  | 3.E+08  | 25.521 | .000*  |
|                                                | Core Area                   | 16793661.07 | 641142 | 2.E+08  |       |        |
|                                                | Peri-urban Area Total       | 38767400.67 | 42359  | 3.E+08  |       |        |
| Sold Water (m³/year)                           | Core Area Peri-urban Area Total | 75640869.31 | 23469  | 2.E+08  | 24.250 | .000*  |
|                                                | Core Area                   | 12426393.88 | 452446 | 1.E+08  |       |        |
|                                                | Peri-urban Area Total       | 27367997.16 | 23469  | 2.E+08  |       |        |
| Tariff (Rp/m³)                                 | Core Area Peri-urban Area Total | 5603.88  | 2864    | 9517    | 10.169 | .002*  |
|                                                | Core Area                   | 4041.25  | 1681    | 8208    |       |        |
|                                                | Peri-urban Area Total       | 4457.95  | 1681    | 9517    |       |        |
| Variables                     | Spatial Variation | Mean   | Minimum | Maximum | F     | Sig. |
|-------------------------------|-------------------|--------|---------|---------|-------|------|
| Production Cost (Rp/m³)       | Core Area         | 7466.60| 760     | 76097   | 1.598 | .213 |
|                               | Peri-urban Area   | 3207.91| 1       | 8928    |       |      |
|                               | Total             | 4567.06| 1       | 76097   |       |      |
| Distribution Cost (000Rp/tahun)| Core Area       | 43208543.50| 41       | 1.E+08  | 22.291 | .000*|
|                               | Peri-urban Area   | 8468178.34| 24020   | 67555746|       |      |
|                               | Total             | 18393996.96| 41       | 1.E+08  |       |      |
| Non-Revenue Water (%)         | Core Area         | 34.14  | 22      | 58      | .977  | .327 |
|                               | Peri-urban Area   | 31.02  | 12      | 63      |       |      |
|                               | Total             | 31.79  | 12      | 63      |       |      |
| Water Consumption (l/p/d)     | Core Area         | 210.38 | 136     | 282     | 3.031 | .087 |
|                               | Peri-urban Area   | 158.04 | 0       | 688     |       |      |
|                               | Total             | 169.98 | 0       | 688     |       |      |

Note: * there is significant difference between core and peri-urban area

Source: [8]

4.2. Discussion

The degree of water infrastructure service in this study, as mentioned before, is emphasized on two explanatory variables, namely service coverage and water consumption. According to the standard used, service coverage should achieve 100%, nevertheless average service coverage among cities/regencies is less than 40%. However, some cities have very good service coverage, such as Banjarmasin City, Samarinda City, and Salatiga City. The rest of population which is not served by public water supply uses individual or communal system or even served by private sector.

If we explore and separate the data based on location (Java vs off Java), spatial variation (core and peri-urban area), and metropolitan (14 areas), we can clearly see that there is a statistically significance difference between groups in each classification in term of service coverage. In the context of location, surprisingly metropolitan areas outside Java Island have shown better result (42.79%) than some of those in Java Island (29.07%). Metropolitan Balikpapan and its surrounding (79.33%) is in the first position among of all. Spatial variation phenomena still affect the provision of water supply and proves that peri-urban area is still less served (28.40%) than in its core (60.19%). National Water Supply System Development Supporting Agency (BPPSPAM) [8] in 2014 established service coverage indicator performance with its score in the scale of 1 (lowest) to 5 (highest). Service coverage in between 20%-40% is classified into low performance. Low service coverage in peri-urban areas indicates that there is some deficiency in the performance of management aspect by local water enterprise in delivering water provision.
Figure 3. Average of service coverage of public water supply provision in 2016.
Source: [8]

Figure 4. Average of water consumption from public water supply provision in 2016 (liter per capita per day).
Source: [8]

Second indicator in this study is water consumed per person in a day. This indicator is statistically tested in the term of 3 conditions, which are location (java versus off java), spatial variation (core and
peri-urban area), and metropolitan (14 areas). In contrast with service coverage, this indicator shows no relationship between water consumed by person a day with those 3 conditions. Water consumption in metropolitan area has exceeded the minimum standard of the needs of water consumption of 60 liters per person in a day. In total, the average water consumed reaches 169.98 l/p/d which is far beyond the minimum needs. Spatial variation does not contribute to the factor of water consumption even if the average of water consumption in Java Island and in the core area tends to be slightly more compared to those outside Java Island and in the peri-urban areas. People in Jabodetabek consume water 3 times more than the standard established while Kartamantul only consumes on the average of 1.5 times more than the standard, yet it still exceeds and fulfils the minimum standard. The fact that water consumption from public water supply in peri-urban is less than that in core area also reflect two things. First, public water supply service in peri-urban is limited. Second, water losses in core area are high. Water consumption in this study was calculated by dividing water distributed to the consumers and the number of consumers.

5. Conclusions
This study confirms the theory of a problem in limited public water service provision faced in peri-urban areas. Two main indicators show that peri-urban areas received less public water supply service compared to its core area. Service coverage as the first indicator in peri-urban areas is classified into low performance, since it only delivers 28.40% of inhabitants dwelled in this area and it indicates that public water supply provision in peri-urban areas should be intervened and it has to implement unusual business scheme in all aspects (technical, social, economic, and institutional) in order to achieve the 100% target of service coverage. Low density is a problem in extending public water supply provision in peri-urban area. Density influences cost of pipeline. In order to overcome the problem, government can implement various system in peri-urban, not only one system. Communal system based on the distribution of population can be an alternative. In place where the density and distribution of population is too low, individual system with control from government can be an alternative. On the contrary, water consumption as another indicator represents that the consumption is varied in all areas and there is no tendency of the lack of water consumption in peri-urban area since the average of water consumption has exceeded the minimum standard of 60 liters per person per day even though the average of water consumed in peri-urban area (159.40 l/p/d) is slightly less than those in the core area (209.62 l/p/d), yet it is far beyond the minimum standard established. The fact that water consumption from public water supply in peri-urban is less than that in core area also reflect that public water supply service in peri-urban is limited.

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