Water Supply Provision in Sarbagita Metropolitan Area

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Abstract. Sarbagita (Denpasar, Badung, Gianyar, and Tabanan) Metropolitan Area is one of seven metropolitan areas in Indonesia, located in the coastal region of Bali Island. Providing clean water in the coastal region is generally constrained by the limited sources of water. Besides, there is also disparity issue between the core and peri-urban area. The purpose of this study is to explore the conditions of water supply provision in Metropolitan Sarbagita in the context of coastal and peri-urban region. The methods of analysis used are descriptive and association analysis. The analysis shows that the location in the coastal area and peri-urban area does not affect the water supply provision for the case of daily safe water yet it does affect significantly in the specific context of drinking water source.

1. Introduction
Sarbagita (Denpasar, Badung, Gianyar, and Tabanan) Metropolitan Area is one of seven metropolitan areas in Indonesia. Some parts of Sarbagita are located in the coastal region of Bali Island. Water supply provision in coastal region is big issue because generally it is constrained by the limited sources of water in one side and high growth of built up area in another side. In the coastal area of Jiangsu, China, a high density of anthropogenic activities and land use changes affect the ecosystem services value and ecosystem functions [1]. In the case of Jiangsu up to 2020 there will be high probability that the coastline area will experience land transfer. The process of land transfer, mainly into built up are will affect the demand for water and also the availability of water source. Beside the issue of coastal region, in the case of Metropolitan Area there is also disparity issue between the core and peri-urban area. The case of Dammam Metropolitan Area the characteristics of new housing development are exclusiveness, low density, single housing type and poor connectivity with the surroundings [2]. Condition in Indonesia also shows the same result as in Dammam Metropolitan Area, where the development of new housing which is mainly in peri-urban area is characterized by exclusiveness, low density, and poor connection with public infrastructure. Generally, water supply provision in core area is better compared to peri-urban area. The purpose of this study is to explore the conditions of water supply provision in Metropolitan Sarbagita in the context of coastal and peri-urban region.

2. Methods
The method use in this research is association analysis by using crosstab. This kind of analysis was used because the research try to find the relationship between source of water and spatial characteristics (urban, peri-urban) as well as location (coastal, non-coastal). The relationship was analysed one by one. At the first step relationship between source of water and spatial characteristics was analysis, followed by analysis of source of water and location. Besides association analysis, in this research descriptive analysis was also used. Descriptive analysis was used to describe the condition of
water supply provision in Sarbagita Metropolitan Area. Data reduction techniques as a part of descriptive analysis were used.

3. Result and Discussion

3.1 Case Study Area

Sarbagita Metropolitan Area is one of seven metropolitan areas in Indonesia. It consists of Denpasar City, five districts in Badung Regency, two districts in Tabanan Regency, and four districts in Gianyar Regency as shown in Fig.1. One hundred and seventy sub districts spread over the area with 41 sub districts are located in coastal area and 25 of them are classified into peri-urban area (see Table 1.).

According to the Presidential Decree of Indonesia No.45/2011 regarding Spatial Plan of Sarbagita Metropolitan Area, there are seven core areas with Denpasar –Kuta Area is the main area and Mangupura Area, Jimbaran Area, Sukawati Area, Gianyar Area, Ubud Area, and Tabanan Area as its counter magnet. Other areas remained in Sarbagita Metropolitan Area (outside core area) are categorized as peri-urban areas.

Table 1. Number of villages in Sarbagita Metropolitan Area based on spatial variation and location

| Number of Sub Districts | Coastal Area | Non-Coastal Area |
|-------------------------|--------------|------------------|
| Core Area               | 16           | 59               |
| Peri-urban Area         | 25           | 70               |

Fig. 1. Sarbagita Metropolitan Area
3.2 Water Provision in Sarbagita Metropolitan Area

Water used by households in Sarbagita Metropolitan Area is distinguished based on the source and its use. Drinking water could be acquired from bottled water, piped water with water meter, well pump, well and wellspring. 42.9% villages acquire drinking water mostly from the piped water with water meter from local water enterprise as known as PDAM (Perusahaan Daerah Air Minum) followed respectively by bottled water (23.5%), well pump (19.4%), and wellspring (11.8%). Based on the data gathered from Central Bureau of Statistics, Indonesia (2014), traditional well is still used by households with only 2.4% of villages mostly fulfill their needs of drinking water from this type of water source (see Fig.2.a.).

Drinking water is acquired whether from piped water with water meter, well pump, well, wellspring, and groundwater. The same main water source as for drinking water, piped water with water meter provided by PDAM also takes the biggest percentage (66.5%) among the water sources of daily safe water followed by well pump (27.1%). As illustrated in Fig.2.b., wellspring is scarcely used for daily safe water source shown by only 0.6% village uses this type of water source for fulfilling its daily safe water.

PDAM has been widely delivering the needs of drinking water and daily safe water provision and has reached the service coverage in more than 65% villages in this metropolitan area. Each city/regency in Sarbagita Metropolitan Area has its own PDAM that covers its own area. In accordance with the data from BPPSPAM (2014), service coverage of PDAM Tabanan Regency shows the best performance among other PDAM(s) in this metropolitan area, that is 89.8%. Coverage of other PDAMs were also good (Badung Regency: 81.6% and Gianyar Regency: 69.9%), except PDAM Denpasar City (43.3%).

The Chi-Square test is used to determine whether both of location and spatial variation affect or does not affect the water supply provision in Sarbagita Metropolitan Area. If it does affect then we would be able to know in which part it differs according to the information from those following Crosstabs presented. On the basis of the results of Chi-Square test and Crosstab presented in Table 2, 3, 4, 5, 6, 7, 8 and 9, the following interpretations are made.

3.3 Water Provision based on Spatial Variation

The results of Chi Square test reveal that at a confidence level of 95%, there is correlation between water provision and spatial variation in the context of drinking water source (see Table 2.). Nevertheless, it does not show the same result for the test performed on the context of daily safe water source; correlation cannot be found between these two variables (see Table 3.). Some of the reasons of these results can be explained by Crosstabs presented in Table 4 and Table 5 as follows.
Table 2. Chi-Square test of drinking water sources and spatial variation in Sarbagita Metropolitan Area

| Pearson Chi-Square | Value     | Df | Asymp. Sig. (2-sided) |
|--------------------|-----------|----|-----------------------|
|                    | 16.690a   | 4  | .002                  |

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 1.76.

Table 3. Chi-Square test of daily safe water sources and spatial variation in Sarbagita Metropolitan Area

| Pearson Chi-Square | Value     | df | Asymp. Sig. (2-sided) |
|--------------------|-----------|----|-----------------------|
|                    | 4.440a    | 4  | .350                  |

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .44.

Correlation between these two variables in the context of drinking water source can be based on two reasons. First of all, as we can see in Table 4., the use of bottled water for drinking is more common in the core area rather than in the peri-urban area. On the contrary, well pump and wellspring are widely used in the peri-urban area due to its typology of geographical condition of the peri-urban of Sarbagita Metropolitan Area that is still characterized by natural condition, so that many villages are still located near to wellspring and water depth in the well is still adequate to be utilized.

In contrast to previous findings, significant differences of water sources used between core and peri-urban area in the context of daily safe water cannot be found distinctly as shown in Table 5. However, piped water with water meter in these two cases (drinking water and daily safe water) is still the main source

Table 4. Crosstab of drinking water sources and spatial variation in Sarbagita Metropolitan Area

| Bottled Water | Piped Water with Water Meter | Well Pump | Well | Wellspring | Total |
|---------------|------------------------------|-----------|------|------------|-------|
| Spatial Variation | Core Area                    | 27 (36.0%) | 31 (41.3%) | 12 (16.0%) | 2 (2.7%) | 3 (4.0%) | 75 (100.0%) |
| Peri-urban Area | 13 (13.7%)                  | 42 (44.2%) | 21 (22.1%) | 2 (2.1%)  | 17 (17.9%) | 95 (100.0%) |

Table 5. Crosstab of daily safe water sources and spatial variation in Sarbagita Metropolitan Area

| Piped Water with Water Meter | Well Pump | Well | Wellspring | Ground Water | Total |
|-------------------------------|-----------|------|------------|--------------|-------|
| Spatial Variation | Core Area | 52 (69.3%) | 21 (28.0%) | 2 (2.7%)  | 0 (0.0%) | 75 (100%) |
| Peri-urban Area               | 61 (64.2%) | 25 (26.3%) | 4 (4.2%)  | 1 (1.1%)  | 4 (4.2%) | 95 (100%) |

3.4 Water Provision in Sarbagita Metropolitan Area
The same method analysis is also applied to identify correlation between variables of water provision and location. In this term, location is differed based on coastal and non-coastal area. In the context of drinking water source, location considerably affects the types of source used for drinking water shown by the statistical result of Chi-Square test presented in Table 6. Conversely, as described in Table 7., we can assume that no correlation can be found between these two variables in the context of daily safe water in this metropolitan area.
Table 6. Chi-Square test of drinking water sources and location in Sarbagita Metropolitan Area

|                      | Value     | df | Asymp. Sig. (2-sided) |
|----------------------|-----------|----|-----------------------|
| Pearson Chi-Square   | 33.748a   | 4  | .000                  |

a. 3 cells (30.0%) have expected count less than 5. The minimum expected count is .94.

Table 7. Chi-Square test of daily safe water sources and location in Sarbagita Metropolitan Area

|                      | Value     | df | Asymp. Sig. (2-sided) |
|----------------------|-----------|----|-----------------------|
| Pearson Chi-Square   | 9.917a    | 4  | .042                  |

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .24.

Correlation that occurs between variables of water provision and location in the case of drinking water source can be seen by the pattern of water source mostly used by villages in coastal area (see Table 8.). Villages in the coastal area mostly acquire drinking water from bottled water where piped water with water meter from PDAM is rarely found for drinking water source in these villages. In comparison to the coastal area, villages in non-coastal area mostly used piped water with water meter from PDAM (51.5%) followed by the source from well pump (20.8%) for their drinking water needs.

Even though it is clearly known that for drinking water, there is noticeable difference use of water source between coastal and non-coastal area, yet that matter does not apply in the case of daily safe water. As the matter of fact, there is no major distinction of the use of water source for daily safe water which is described in Table 9. Piped water with water meter followed by well pump is the most widely used water source for daily basis both in coastal and non-coastal area.

Table 8. Crosstab of drinking water sources and location in Sarbagita Metropolitan Area

|                      | Bottled Water | Piped Water with Water Meter | Well Pump | Well | Wellspring | Total |
|----------------------|---------------|------------------------------|-----------|------|------------|-------|
| Location             | Coastal Area  | 22 (55.0%)                  | 6 (15.0%) | 6 (15.0%) | 0 (.0%)     | 6 (15.0%) | 40 (100.0%) |
|                      | Non-Coastal Area | 18 (13.8%)                | 67 (51.5%) | 27 (20.8%) | 4 (3.1%)     | 14 (10.8%) | 130 (100.0%) |

Table 9. Crosstab of daily safe water sources and location in Sarbagita Metropolitan Area

|                      | Piped Water with Water Meter | Well Pump | Well | Wellspring | Ground Water | Total |
|----------------------|------------------------------|-----------|------|------------|--------------|-------|
| Location             | Coastal Area                 | 21 (52.5%) | 18 (45.0%) | 0 (.0%) | 1 (2.5%)     | 40 (100.0%) |
|                      | Non-Coastal Area             | 92 (70.8%) | 28 (21.5%) | 6 (4.6%) | 1 (.8%) | 3 (2.3%) | 130 (100.0%) |

3.5 Water Provision in the Coastal and Peri-urban of Sarbagita Metropolitan Area

Turning into more specific case of water provision in the coastal and peri-urban of Sarbagita Metropolitan area, as illustrated in Fig. 3, it can be known that from 25 villages located exactly in the coastal area and classified into peri-urban area, bottled water (37.5%) is the main source for these villages to fulfill their needs of drinking water. From this is also concluded that piped water with water meter from PDAM is the least option for drinking water (16.7%).

As comparison, this piped water with water meter (54.2%) is reversely being the main water source for daily safe water in these villages followed by well pump (41.7%). These matters indicate that drinking water is more vulnerable and cannot be acquire carelessly in the coastal area due to the fact that its geographical condition affects scarcity of drinking water as freshwater aquifers are not available at suitable depths and surface water is highly saline. Households’ choice of water source is complex and seasonally dependent (Islam, et al., 2013)
4. Conclusions
In general, piped water with water meter provided from PDAM is the main water source in Sarbagita Metropolitan Area for both of drinking water and daily safe water with the best performance of service coverage is presented by PDAM Tabanan Regency (89.8%) and the least performs by PDAM Denpasar City (43.3%). To sum up briefly, the findings show that there is noticeable correlation between variables of water supply provision and location (coastal and non-coastal area) as well as spatial variation (core and peri-urban area) in the context water source specifically for drinking water. Bottled water is being the main source for households located in coastal and peri-urban villages whereas piped water with water meter is rarely used for drinking water (least option).

In sharp contrast, this kind of water source (piped water with water meter) is widely used both in core and peri-urban area and even in coastal and non-coastal area if only it is used for daily safe water. From these results, it can be concluded that drinking water especially in coastal area is needed to be prioritized in the context of drinking water supply provision due to its geographical condition that affects to its high salinity. Therefore, some policies, strategies, and programs in providing adequate service of drinking water in coastal area should be formulated and implemented.

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