Water Demand Of Gambung Water Supply System, Bandung Regency, West Java

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Abstract—Water demand keeps increasing in Bandung Regency, particularly in Soreang, Katapang, Margahayu, and Margaasih districts that would be referred to as Gambung Drinking Water Supply System (DWSS) in this paper. The service coverage of Gambung DWSS supplied by Tirta Raharja Regional Water Supply Enterprise (PDAM) is only 6.85%, including Soreang and Katapang districts. On the other hand, the service has not reached Margahayu and Margaasih at all. This research aims to predict the water demand of DWSS Gambung in 2040, comprising two phases of planning. The method includes projecting population in the study area to the year of 2030 and 2040, analyzing population density in the residential areas, as well as assessing the water usage and its fluctuation in the existing service area. The projection of service coverage is up to 70% in the year of 2030 and 97% in the year of 2040, with an estimated water demand of 216 L/second and 352 L/second, respectively.

Index Terms—water consumption, water demand, drinking water supply system

1 INTRODUCTION

A safe, reliable, affordable, and easily accessible water supply is essential for good health [1]. Due to population growth, the climate change factor has developed a huge gap between the supply and demand of water [2]. In this situation, efforts should be made to optimize water consumption and prevent possible conflicts or quarrels in dominating water resources in the future [3]. In Indonesia, according to the Legislation No. 32 of 2004 on Regional Government, PDAM (Regional Water Supply Enterprise) has the responsibility to manage the piped water supply. One of the goals of efficient water supply management is to provide a stable supply of drinking water as required by consumers [4]. Without the supply of drinking water, any sanitary convenience that must be part of manufacturing service buildings cannot be operated, meals to employees cannot be served, and in many cases, drinking water is used in technological manufacturing processes [5]. In order to increase coverage of drinking water services in Bandung Region, PDAM Tirta Raharja has planned the development of Drinking Water Supply System (DWWS) in the Gambung area, which consists of 4 districts, namely Soreang, Katapang, Margahayu, and Margaasih, as shown in **Fig. 1**. Currently, PDAM has only supplied Soreang and Katapang districts as listed in **Table 1**.

TABLE 1
Gambung DWWS Coverage

District	Connection	Population served	Service Coverage (%)
Soreang	5,774	21,221	17.82
Katapang	3,857	14,100	10.84
Total	**9,631**	**35,320**	**28.66**

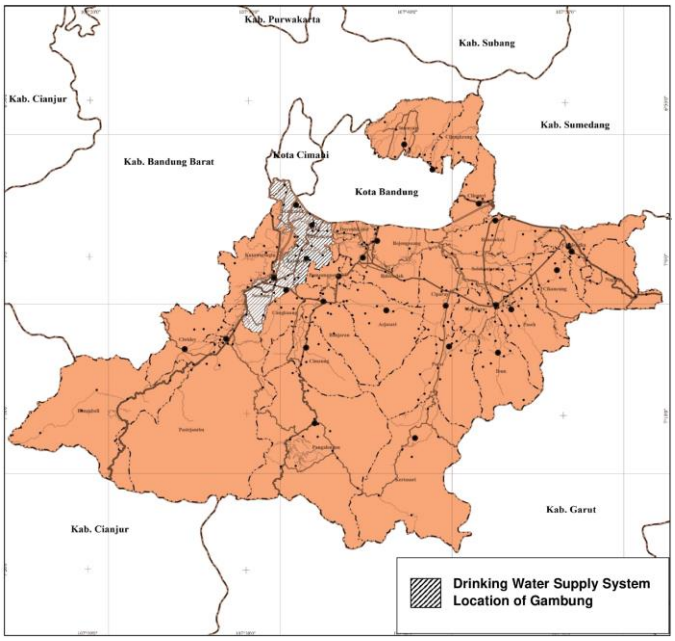

Fig. 1. Gambung DWWS Area, Bandung Regency
(Source: Bandung Regency Spatial and Regional Planning, 2016–2036)

In 2018, the total population supplied by PDAM in the existing area is around 35,320 people. This number is very small compared to the total population in the planning area of Gambung DWSS of 538,964 people. The percentage of service coverage is only 6.85%. Prediction of water demand in urban areas is key importance for water supply management. Water demand prediction is essential in any short or long-term management plans [4, 6]. Indonesia has a target of "100.0.100" that must be achieved. It implies 100% of safe access to drinking water, 0% of poor settlements, and 100% of solid waste handling coverage [7]. Water demand of the Gambung DWSS planning area has been set to be projected until 2040, therefore the population growth until 2040 was taken into account. Population projection is increasingly utilized as a tool for understanding and modeling the economic, social, and environmental futures of sparsely populated areas [8].

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2 METHODOLOGY

2.1 Data Source

The data on the annual water usage and water distributed every hour for a week were derived from PDAM. Administrative and land use maps were gathered from the RTRW (Spatial and Regional Planning) of Bandung Regency. Population data is sourced from BPS (Central Bureau of Statistics) of Bandung Regency.

2.2 Data Analysis

1. Population Projection

The population projection until 2040 was calculated using the number of population for the last 10 years. The geometric method was employed using the following equation [9]:

$$P_T = P_L [(1+r)^Z] \qquad (1)$$

where P_T is the population in the target year, P_L is the population in the launch year, *r* is the average geometric rate of change, and *z* is the number of years in the projection horizon.

2. Water Demand Calculation

This planning uses models based on Unit Water Consumption. It relies on the usage of water per inhabitant, per customer, per employee, or other units of industrial output. The demand is estimated by multiplying this water usage unit by the number of users served in the future [10]. The scheme of planning stages is illustrated in **Fig. 2**.

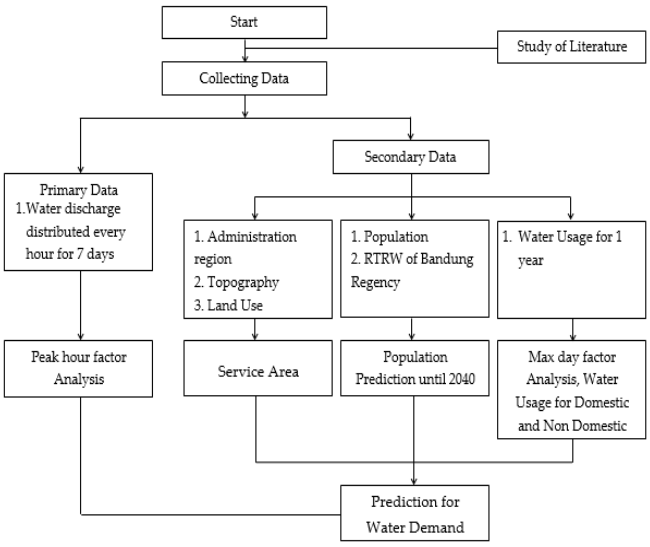

Fig. 2. Planning Stages

3 RESULTS AND DISCUSSION

3.1 Evaluation of the Existing Coverage Area

On the contrary with Margahayu and Margaasih, Soreang District and Katapang District have been supplied by PDAM. Water consumption in Soreang and Katapang can be seen in **Table 2**.

TABLE 2
Water Consumption in 2018

District	Connection	Population Served	Water Usage	
			L/sec	L/person/day
Soreang	5,774	21,221	31.93	130
Katapang	3,857	14,100	22.02	135
Total	**9,631**	**35,320**	**53,95**	**133**

Based on the data of water usage in Soreang and Katapang, the unit of water consumption is expressed as per person per day. The water consumption for Soreang and Katapang districts is 130 L/person/day and 135 L/person/day, respectively. Due to the small difference in water usage, the average water consumption of 133 L/person/day was used as the water supply amount in the planned area of Gambung DWSS.

3.2 Population Projections

The projection of the regional population of Gambung DWSS was conducted using the geometric method. This method assumes that a population will be increased by a similar rate with the base period over a given increment of time in the future [9]. The population growth in the Gambung DWSS planning area has been fairly constant for the last 10 years, and it is assumed that the pattern would remain the same for the foreseeable future. The population projection results of the planning area are represented in **Table 3**.

TABLE 3
Population Projection until 2040

District	Population (People)	r	Total Population (People)	
	2018		2030	2040
Soreang	119,112	1.52	142,723	165,936
Katapang	130,012	1.56	156,527	182,709
Margahayu	133,171	1.57	160,489	187,488
Margaasih	156,669	1.56	188,650	220,234
Total	**538,964**	**1.55**	**648,388**	**756,367**

Table 3 denotes that the value of *r*—the rate of population growth—is yielded by the analysis of data from BPS and RT-RW. On the basis of the average population growth rate of 1.55, there will be an increase of 108,000 people in each interval of 10 years.

3.3 Population Density

The population density is the ratio of population to the settlements area. Its value can be derived from the population projection, and it does not always correlate with overpopulation. The population density refers to the quantitative aspect, while overpopulation is more of a qualitative nature [11]. The carrying capacity of the area to support the lives of its inhabitants was used as the reference for the population density. The existing land use of the study area is depicted in **Fig. 3**, whereas its planned designation until the year of 2036 is portrayed in **Fig. 4**. As illustrated in both graphs, there will be a quite massive change in land use during the next 20 years. Agricuture is still dominant in **Fig. 3**,

while **Fig. 4** signifies the domination of residential area in the center, with agricultural lands concentrated in the south and north regions.

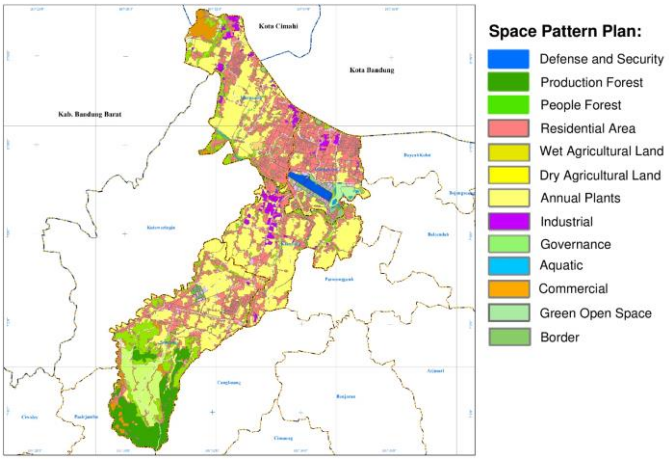

Fig. 3. Existing Map for Land Use
(Source: Bandung Regency Spatial and Regional Planning 2016–2036)

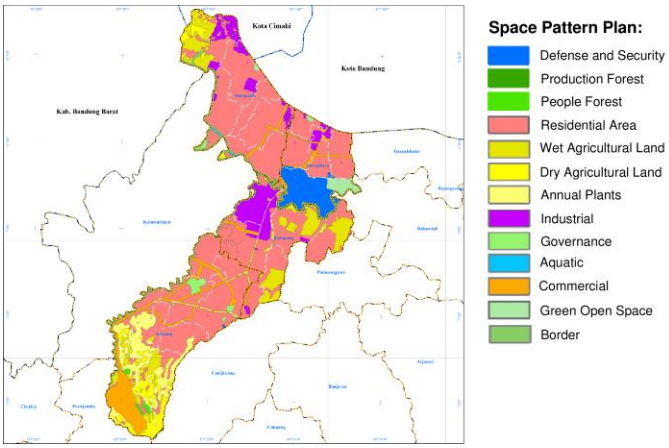

Fig. 4. Planned Map for Land Use
(Source: Bandung Regency Spatial and Regional Planning 2016–2036)

The number of population density until 2040 is shown in **Table 4**. In 2018, its value in Gambung DWSS is categorized as high population density. In this range, vertical residences can be an alternative to meet housing needs. In 2030 and 2040, the population density is considered a medium category where urban development can be balanced with the population growth.

TABLE 4
Population Density until 2040

District	Population Density (people/Ha)		
	2018	2030	2040
Soreang	198	115	134
Katapang	298	180	211
Margahayu	210	307	359
Margaasih	219	147	172
Total	**226**	**166**	**193**

3.4 Service Percentage

The service percentage in Gambung DWSS is still extremely low. To reach the target of 100% of safe access to drinking water, phasing the improvement of service coverage is necessary for the development of the water supply system to make the planning process easier [4, 6]. Firstly, the calculation of service percentage in 2030 and 2040 was carried out. The percentage value was obtained from the assumption of supplying the existing service coverage proportionally to the population density in 2030 and 2040, as listed in **Table 5**.

TABLE 5
Percentages of Service Planning in Gambung DWSS

District	2030		2040	
	Service Coverage	Served Population	Service Coverage	Served Population
Soreang	67%	95,351	90%	149,385
Katapang	77%	122,866	100%	182,117
Margahayu	74%	118,112	99%	184,854
Margaasih	63%	118,721	98%	215,350
DWSS	**70%**	**455,051**	**97%**	**731,707**

The existing service percentage in 2018 and the calculated population density in 2030 were employed on service planning in the year 2030. Likewise, the predicted service percentage in 2030 and the projected population density in 2040 were used in the service planning of the year 2040. The service priority is sorted based on the population density in each region (high to low). According to **Table 4**, the percentages of Gambung DWSS service in 2030 and 2040 are 70% and 97%, respectively. It would not reach 100% in 2040 [7], but at least the prediction is close.

3.5 Water Demand

Water demand consists of domestic purposes for households and non-domestic use for public facilities and infrastructures [12]. Following the phasing of service planning and the identification of water demand per person per day, the domestic water consumption in each district was calculated until 2040. The amount of domestic water consumption in 2040 will be 322 L/s, increased by 5 folds from its usage in 2018. The detailed data for each district is tallied in **Table 6**.

TABLE 6
Water Consumption for Domestic Purposes per District

District	2018	2030	2040
	(L/s)	(L/s)	(L/s)
Soreang	32	44	71
Katapang	22	55	82
Margahayu	0	49	78
Margaasih	0	49	91
Total	**54**	**197**	**322**

The non-domestic water consumption is usually planned in the range of 20%–25% of the total domestic water consumption [12]. In the existing supplied districts of Soreang and

Katapang, the percentage of non-domestic consumption is 9.5%. The predictions of its value in 2030 and 2040 are arranged in **Table 7**.

TABLE 7
Water Consumption for Non-Domestic Purposes per District

District	2018	2030	2040
	(L/s)	(L/s)	(L/s)
Soreang	3	4	7
Katapang	2	5	8
Margahayu	0	5	7
Margaasih	0	5	9
Total	**5**	**19**	**31**

The total water demand in Gambung DWSS was obtained from the sum up of domestic and non-domestic consumption in each region. The results are shown below in **Table 8**.

TABLE 8
Water Demand per District in Gambung DWSS

District	2018	2030	2040
	(L/s)	(L/s)	(L/s)
Soreang	35	48	78
Katapang	24	60	90
Margahayu	0	54	85
Margaasih	0	54	99
Total	**59**	**216**	**352**

The total water demand in Gambung DWSS in 2040 will be 352 L/s. This value serves as the reference for planning the production capacity of Gambung WTP, which should be designed larger than the total water required to accommodate potential sudden increases in water demand. Thus, a production capacity of 375 L/s is recommended for designing Gambung WTP.

3.6 Distribution Plan

Based on the topography, the Gambung DWSS planning area is a flat ground in general. A higher altitude of the land surface is only found in the northern part of Margaasih District and the southern part of Soreang District that are mostly used for agricultural function. The entire region is located at an elevation of 700 meters above sea level. The planned reservoir is placed in Sadu Village, Soreang, at an elevation of 850 meters above sea level. The primary distribution pipeline will traverse the arterial roads along Soreang, Katapang District, and Margahayu District. In Margaasih, the pipeline will pass through the collector roads. The distribution plan for the whole planning area can be seen in **Table 9**, and the pipeline plan is depicted in **Fig. 5**.

TABLE 9
Distribution of Water Demand per Village in 2040

Village	Water Demand (L/second)
Soreang	
Sadu	8
Sukajadi	4
Sukanagara	3
Panyirapan	5
Karamatmulya	5
Soreang	15
Pamekaran	10
Parungserab	6
Sekarwangi	5
Cingcin	17
Total	**78**
Katapang	
Gandasari	12
Katapang	12
Cilampeni	15
Village	**Water Demand (L/second)**
Pangauban	12
Banyusari	6
Sankanhurip	21
Sukamukti	12
Total	**90**
Margahayu	
Sulaeman	2
Sukamenak	21
Sayati	23
Margahayu Selatan	25
Margahayu Tengah	14
Total	**85**
Margaasih	
Nanjung	11
Mekarrahayu	25
Rahayu	18
Cigondewah Hilir	8
Margaasih	19
Lagadar	18
Total	**99**
Grand Total	**352**

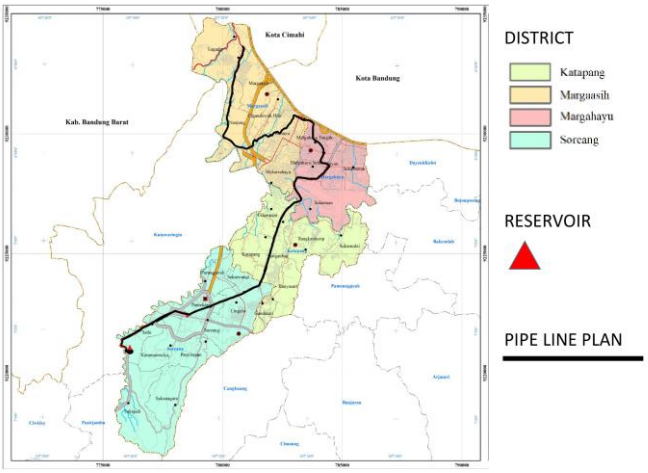

Fig. 5. Planning of Reservoir and Pipeline

4 CONCLUSION

The population projection using the geometric method resulted in 756,367 people by 2040. The analysis of water supply percentage in Gambung DWWS yielded a service coverage of 97% that provides 731,707 residents. This service percentage leads to the total daily water consumption of 352 L/sec. Hence, a total production capacity of at least 375 L/sec is suggested for planning the WTP in Gambung to accommodate the total water demand (including peak season).

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