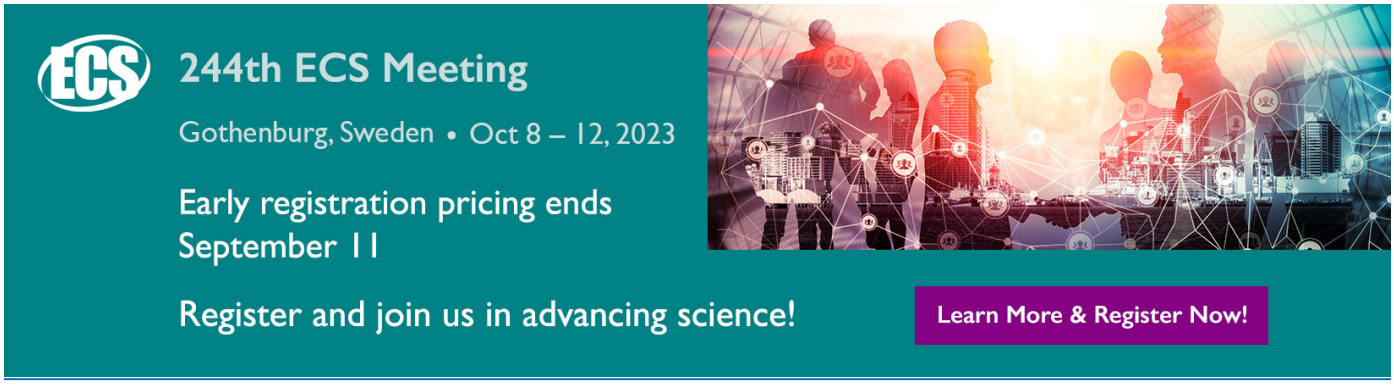
Assessment of groundwater utilization in the Bandung-Soreang groundwater basin based on non-domestic water demand planning standards



Assessment of groundwater utilization in the Bandung-Soreang groundwater basin based on non-domestic water demand planning standards

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Abstract. The need for water in various human activities increases with population, agriculture, and industry. The utilization of surface water is a priority to meet water demands. However, if access to surface water cannot be fulfilled, then the fulfillment of water demands will shift to groundwater. The research was conducted by calculating the standard of water demands for industrial activities based on the ministry of public works and housing standards. The first calculation is carried out by calculating water demand through the industrial land area in the research location and multiplied by the standard of water demand for non-domestic water demands. The second standard water demand calculation is the equivalent percentage of domestic water demands as non-domestic water demands. The first calculation method explains that West Bandung Regency had exceeded the maximum value of the standard water demands. In the second calculation method, Cimahi City, Sumedang Regency, and West Bandung Regency had exceeded the maximum value of water demand standards. Further research is needed regarding the collecting data of distribution and volume of groundwater utilization by unregistered wells. It is to explain actual groundwater utilization for domestic and non-domestic in Bandung-Soreang Groundwater Basin. So that water resources management can be carried out comprehensively.

keywords: groundwater, Bandung-Soreang groundwater basin, water utilization

1. Introduction

Water resource management (WRM) plans, develops, and manages water resources across all users regarding their quantity and quality. On the other hand, integrated water resource management (IWRM) is the coordinated approach of the higher than water, land, and other connected resources [1]. The Bandung Raya metropolitan area is an urban unit formed agglomeration of economic, community social, built-up land, and population located in 5 regencies/cities. Namely Bandung city, Cimahi city, part of Bandung Regency, part of West Bandung regency, and part of Sumedang regency [2].

The water resource is a necessity for the livelihood of society and used for the prosperity of the people. Water resources need to be managed in harmony with social, environmental, and economic

functions. That is to create integration between regions, sectors, and generations to meet water demands. The above efforts are for facing the imbalance between decreasing water availability and increasing demand [3].

The Bandung Raya is predicted to experience a clean water crisis in the next few years. The high population growth due to the high rate of migration and urbanization and the rapid growth of economic activity has led to increased demand for clean water. On the other hand, the capacity for clean water is also decreasing due to excessive exploitation of water resources by households, industrial activities, and other economic activities. This condition is exacerbated by the rapid development carried out in the catchment area [4].

The increasing demand for raw water has led to uncontrolled groundwater pumping in the Citarum Watershed, especially in the urban and industrial Bandung-Soreang groundwater basin areas. This condition is exacerbated by changes in land use in the upstream area, which causes a decrease in groundwater recharge capacity. The Impact is a decrease in the groundwater level, triggering a groundwater crisis and land subsidence [5].

Groundwater is one type of water source that humans commonly use in many activities. Groundwater use around the globe has grown exponentially from 100 km3/yr in the 1950s to over 1000 km3/year in the 21st century [6]. An estimated 2 billion people use groundwater for their basic water needs. Groundwater and surface water pollution from home and industrial waste and agricultural activities are becoming more of a problem [7]. Increasing groundwater utilization to meet demand is common due to population, industrial, and economic growth [8].

The above background can be an informed problem: whether groundwater use is by the applicable standards in the Bandung - Soreang groundwater basin. Therefore, this study aimed to determine groundwater consumption patterns in the industry by assessing the volume of water consumed by the industry in the Bandung - Soreang groundwater basin, whether by the applicable standards.

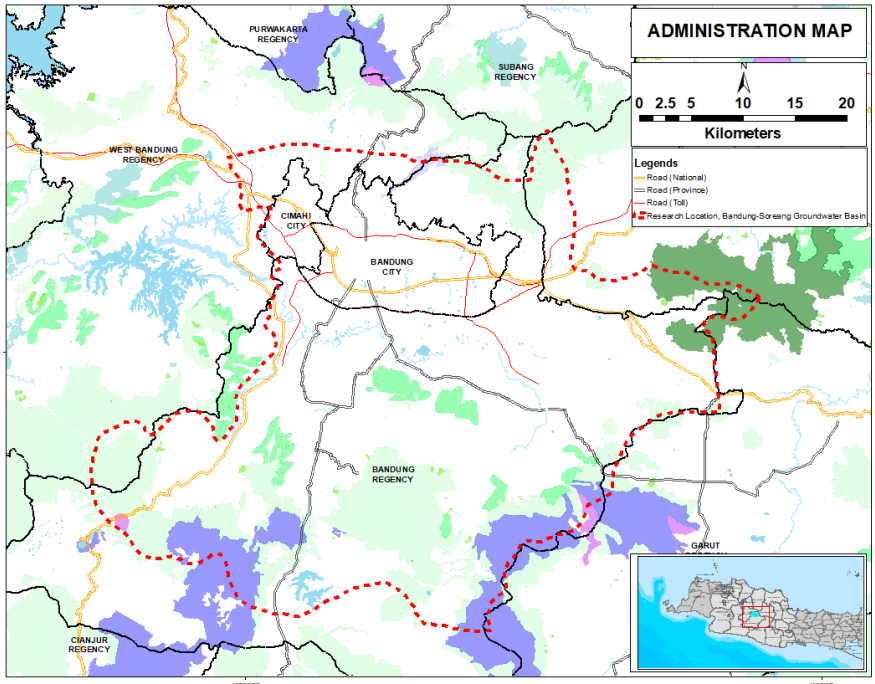

Figure 1. Research Location (Bandung - Soreang Groundwater Basin)

2. Material & Methods

Bandung - Soreang Groundwater Basin is located in West Java Province, covering five administrative areas: Bandung City, Cimahi City, Bandung Regency, West Bandung Regency, and Sumedang Regency (Figure 1 and Table 1). The analysis is carried out in research locations, spreading the five administrative areas that intersect with Bandung - Soreang Groundwater Basin and overlaps with the Upper Watershed of the Citarum River Basin. The data used in this analysis are obtained from various agencies and water requirements design standards. These data include:

1. Groundwater users.
2. Industrial land area.
3. Water demands standards for industrial activities.

Table 1. Five Administrative areas in Bandung-Soreang Groundwater Basin

Regencies/Cities	Area (km^2)	No. Subdistrict	No. Urban Village	Population
Bandung City	168	30	151	2,503,708
Cimahi City	41	3	15	607,811
Bandung Regency	1,757	31	280	3,717,291
West Bandung Regency	1,336	16	165	1,683,711
Sumedang Regency	206	26	283	1,149,906

Sources:[3]

In planning a water supply system, it is necessary to know the water demand and use. Water demands are influenced by population size, season, climate, habits, and lifestyle of the community, available plumbing facilities, and industrial activities. Water demand is the amount of water required for basic needs / a unit of water consumption divided into domestic and non-domestic water demands. Non-Domestic water is water used for supporting activities in settlements other than for domestic water demands. The standard of non-domestic water supply is determined by offices, health, industrial, commercial, public, and others.

The more non-domestic facilities in an area, the more water demands to support these non-domestic activities. The city development plan and activities have to be known to predict the non-domestic water demand. The water demand can predict based on a population where non-domestic consumers can be calculated following domestic water supply standards. Thus it is necessary to know the type and number of facilities that will come. What are the types and number of current facilities? Those are needed to calculate the approximate/ development of type and number of facilities in the future. The research was conducted by analyzing the suitability of the reported groundwater use with two water requirements standards of the Ministry of Public Works and Housing [9]. Water demands can be calculated using the Clean Water Planning Criteria in particular areas/cities/ regencies based on their total population. Non-domestic water demands are calculated based on the cities category based on total population (Table 2).

Non-domestic water demands are calculated using the amount of domestic water demand in an area, using equations (1), (2), (3) [10].

Number of Household = Total Population: 5 Family member / Household (1)

Domestic Water demands = Number of Household x 100 liters/sec/household (2)

Non-Domestic Water demands = Total Domestic Water demands x 15% (3)

2.1 Collecting data on groundwater users and population data at the research location

Groundwater user data is obtained from the Department of Energy and Mineral Resources of West Java Province. In this data, a list of users is received along with the address of the company. The groundwater user data is used as primary data for water demand analysis carried out through the clean water planning criteria of the ministry of public works and housing, while the calculation of water demands is carried out in industries registered with the Department of Energy and Mineral Resources of West Java Province which use groundwater as meeting clean water demands in industrial activities.

Table 2. Clean Water Planning Criteria

Description	Cities category based on total population				
	>1,000,000	**500,000 - 1,000,000**	**100,000 - 500,000**	**20,000 - 100,000**	**<20,000**
	Metropolitan	**Big Cities**	**Medium Cities**	**Small Cities**	**Village**
Household unit's consumption	>150	150 - 120	90 - 120	80 - 120	60 - 80
Public Hidrant unit's consumption	20 - 40	20 - 40	20 - 40	20 - 40	20 - 40
Non-Domestic unit's consumption					
a. Small commerce (liter/unit/day)	600 - 900	600 - 900		600	
b. Big commerce (liter/unit/day)	1,000 – 5,000	1,000 – 5,000		1,500	
c. Industries (liter/second/ha)	0.2 – 0.8	0.2 – 0.8		0.2 – 0.8	
d. Tourism (liter/second/ha)	0.1 – 0.3	0.1 – 0.3		0.1 – 0.3	
Water loss (%)	20 - 30	20 - 30	20 - 30	20 - 30	20 - 30
Maximum day factor	1.15 – 1.25 *daily	1.15 – 1.25 *daily	1.15 – 1.25 *daily	1.15 – 1.25 *daily	1.15 – 1.25 *daily
Peak hour factor	1.75 – 2.0 *daily max	1.75 – 2.0 *daily max	1.75 – 2.0 *daily max	1.75 *daily max	1.75 *daily max
Population per Household	5	5	5	5	5
Population per Hidrant	100	100	100	100	100
Residual pressure at the downstream distribution network (meter)	10	10	10	10	10
Operational hour	24	24	24	24	24
Reservoir volume (% Max Day Demand)	15 - 25	15 - 25	15 - 25	15 - 25	15- 25
Household : Hidrant	50 : 50 to 80 : 20	50 : 50 to 80 : 20	80 : 20	70 : 30	70 : 30
Service Coverage (%)	90	90	90	90	70

Source: [9]

2.2 Calculation of industrial land area using geospatial mapping

Geospatial mapping identifies the location and position of an object or event below, on, or above the earth's surface expressed in a particular coordinate system. Geospatial mapping in this study uses groundwater user data to determine the industrial land area at Bandung - Soreang Groundwater Basin. The industrial area calculation is carried out using ArcGIS for all industries in the research area. And the industrial distribution pattern can be seen at Bandung - Soreang Groundwater Basin.

2.3 Assessment groundwater consumption at Bandung – Soreang Groundwater Basin

The assessment is carried out on the standard of non-domestic water demands with the realization of water taking in non-domestic activities monitored based on monthly reports at the ESDM office of West Java province. The analysis is carried out regarding the suitability of groundwater consumption data to consumption standards for water demands based on an industrial area and based on the percentage of domestic water consumption.

3. Result and Discussion

3.1 Reported Groundwater Utilization

Population data is obtained from the Central Statistics Agency of West Java Province. The total population in Bandung - Soreang groundwater basin area is used as a divisor category of water demand. The water demand standard is based on the population in each regency/city. Therefore, the category is generating the expected value of consumption units for non-domestic in a particular area. The Groundwater user reported at the Department of Energy and Energy Resources of West Java Province in 2020 is described in Table 3 and a graph comparing reported groundwater consumption to total population in figure 2.

In West Bandung and Sumedang districts, only a few sub-districts are included in the Bandung-Soreang Groundwater Basin area. Therefore the population data used is the population for areas included in the study area only. Thus, in comparing the reported groundwater consumption and the population in the Bandung-Soreang Groundwater Basin area. It can be seen that the total population in an area does not describe the amount of groundwater consumption.

Table 3. Reported Groundwater Consumption

Regency/ City	Number of the industry using groundwater user	Reported Groundwater Consumption	
		(m^3/year)	(litre/ sec)
Bandung City	713	10,775,326	341.68
Bandung Regency	308	8,023,293	254.42
Cimahi City	155	6,029,660	191.20
Sumedang Regency	91	4,982,360	157.99
West Bandung Regency	88	6,907,627	219.04

Source: [8]

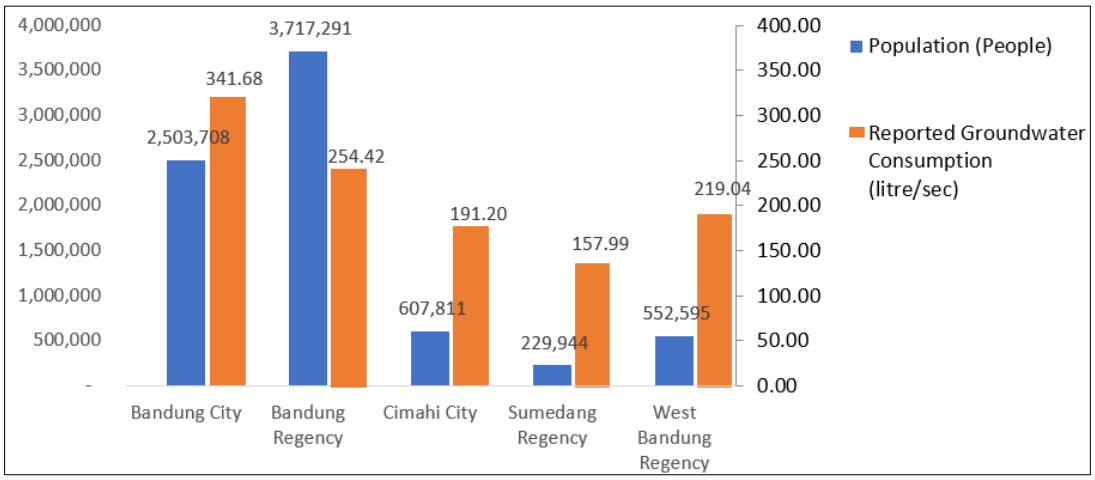

Figure 2. Population comparison of each area with the pattern of reported groundwater consumption in the Bandung-Soreang Groundwater Basin.

3.2 Analysis of water demands based on an industrial land area

Non-domestic water demands based on clean water planning criteria, especially for industry, could be calculated based on the industrial land. Population data (Table 4) is needed to determine the water demands of non-domestic, especially industrial. Based on the population size, it is known that four areas are Metropolitan categories, and 1 area is a Big City category.

Table 4. Non Domestic Water Demand based on population

Regency/ City	Population 2020	Regency/ City Category	Non-Domestic Unit's Water Demand (Industry)
Bandung Regency	3,831,505	Metropolitan	0.2 – 0.8 liter/second/Ha
Sumedang Regency	1,154,428	Metropolitan	0.2 – 0.8 liter/second/Ha
West Bandung Regency	1,714,982	Metropolitan	0.2 – 0.8 liter/second/Ha
Bandung City	2,510,103	Metropolitan	0.2 – 0.8 liter/second/Ha
Cimahi City	620,393	Big City	0.2 – 0.8 liter/second/Ha

3.2.1 Geospatial Mapping

Based on the geospatial map, it is known that industrial activities are Bandung City, Cimahi City, Bandung Regency, West Bandung Regency, and Sumedang Regency. Data of groundwater for industrial collected from Department of Energy and Mineral Resources of West Java Province. That data for mapping of industrial distribution. Mapping is carried out to determine land in each industrial company that uses groundwater as a water source for industrial activity. The area coverage and mapping of industries at the research location are shown in Table 5 and Figure 3.

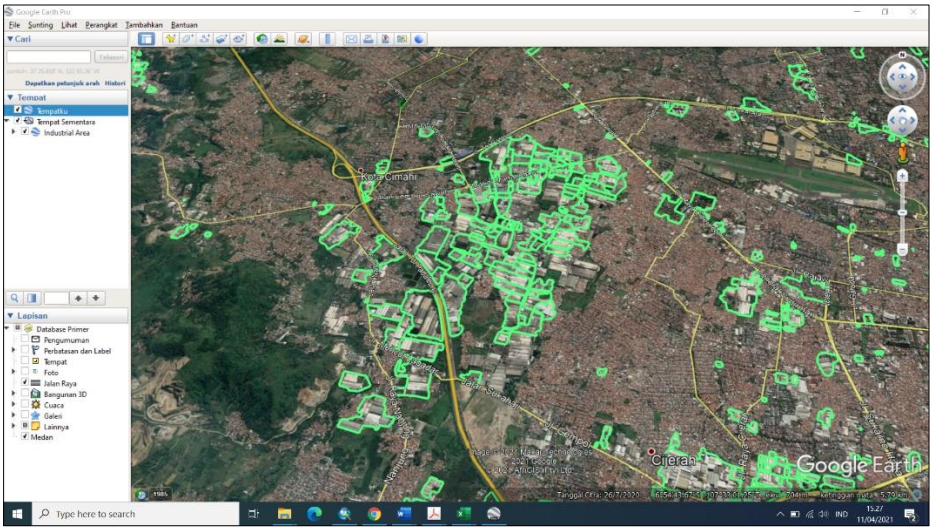

Figure 3. Geospatial mapping of Industrial areas in Bandung – Soreang Groundwater Basin.

Table 5. Industrial Area Coverage in Bandung-Soreang Groundwater Basin.

Regencies/ Cities	Industry	Coverage Area (Ha)
Bandung City	713	922.34
Bandung Regency	308	805.71
Cimahi City	155	283.72
Sumedang Regency	91	471.82
West Bandung Regency	88	165.45

3.2.2. Industrial Water Demand Based on Area Coverage of Industrial Area

In the clean water planning criteria, industrial water demand are industrial area coverage multiplied by water demand. Industries' standard water demand ranges from 0.2 – 0.8 liters/second/ha (Table 2). The analysis results are explained in Table 6, then juxtaposed with the population data of each administrative area in the research area (Figure 4 and Figure 5).

Table 6. Industrial Water Demand based on Clean Water Planning Criteria

Regencies/ Cities	Industry	Area coverage (Ha)	Industrial Water Demand (0.2 – 0.8 Liter/Sec)		
Bandung City	713	922.34	184.47	-	737.87
Bandung Regency	308	805.71	161.14	-	644.57
Cimahi City	155	283.72	56.74	-	226.98
Sumedang Regency	91	471.82	94.36	-	377.45
West Bandung Regency	88	165.45	33.09	-	132.36
Total	1,355	2,649.04	529.81	-	2,119.23

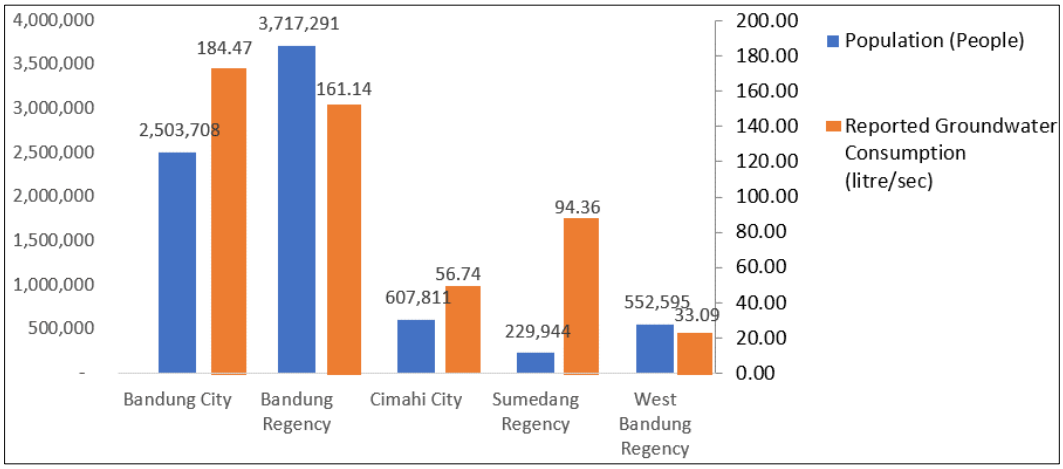

Figure 4. Industrial water demand based on Clean Water Planning Criteria (0,2 liter/sec/ha)

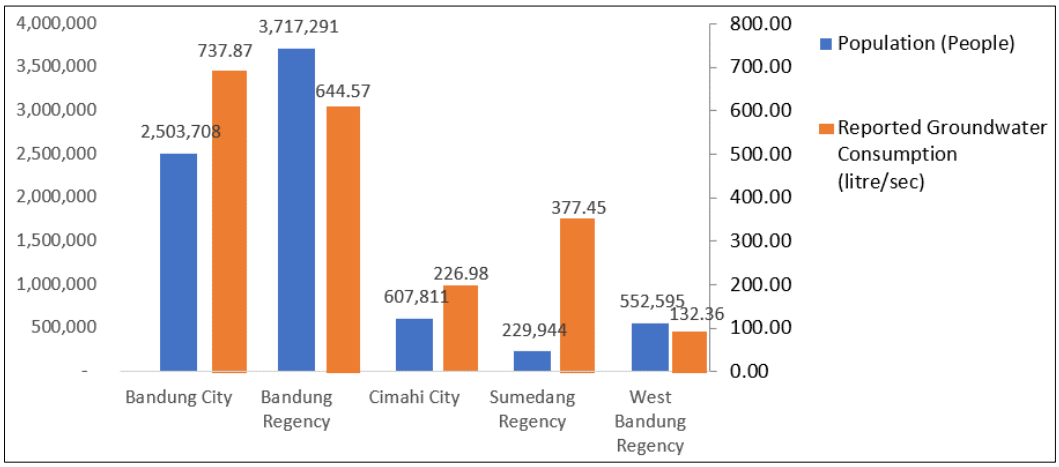

Figure 5. Industrial water demand based on Clean Water Planning Criteria (0,8 liter/sec/ha)

3.3 Industrial Water Demand Calculation Base on Domestic Water Demand

Industrial water demand can also be calculated by using 15% equivalent to domestic water demand. Domestic water demand is estimated using the population in a particular area. The area's water demand equivalent to 1 liter/sec can give up to 100 households with five family members each household. Based on domestic water demand, water demand for industrial in Bandung-Soreang Groundwater Basin is shown in Table 7 and Figure 6.

Table 7. Industrial Water Demand based on 15% equivalent domestic water demand.

Regency/ City	Population	Industrial Water Demand (litre/sec)
Bandung City	2,503,708	751.11
Bandung Regency	3,717,291	1,115.18
Cimahi City	607,811	182.34
Sumedang Regency	229,944	68.98
West Bandung Regency	552,595	165.77

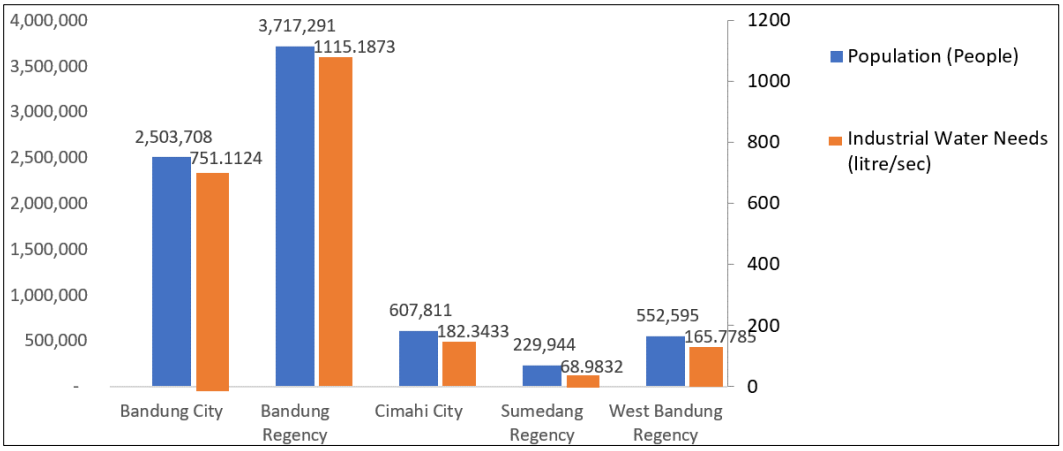

Figure 6. Industrial water demand based on domestic water demands equivalent in the administrative area

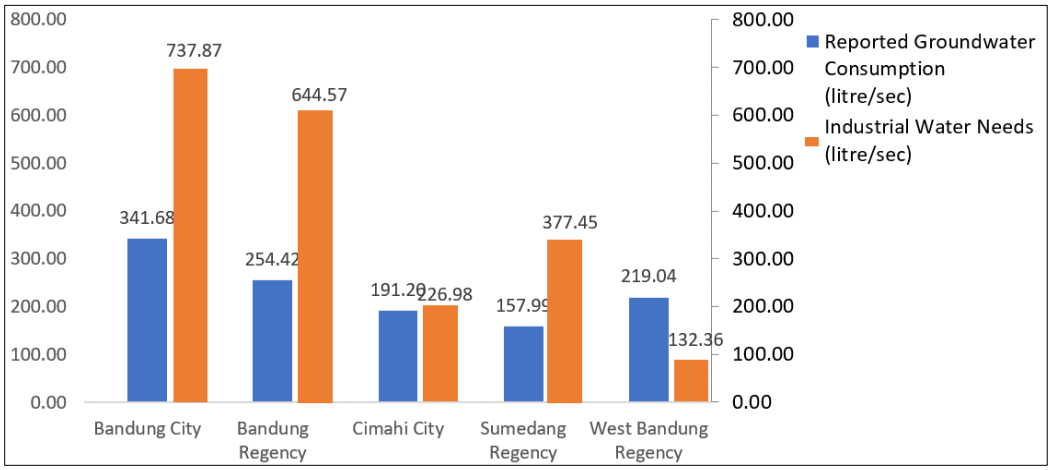

Figure 7. Comparison of reported industrial groundwater consumption with clean water planning criteria.

3.4 Assessment of the suitability of groundwater consumption with water demand standards

Two types of water demand analysis for non-domestic activities, especially industrial needs, provide an overview of the water consumption pattern in research locations. These two calculations were later compared to reported groundwater users at the Department of Energy and Energy Resources of West Java Province to assess the suitability of consumption patterns.

The suitability assessment will explain whether the consumption pattern in the Bandung-Soreang Groundwater Basin is still within the permissible threshold or has exceeded the provisions based on the standard. The graphic in figure 7 and figure 8 provides an overview of consumption patterns compared to the two non-domestic water demand standards.

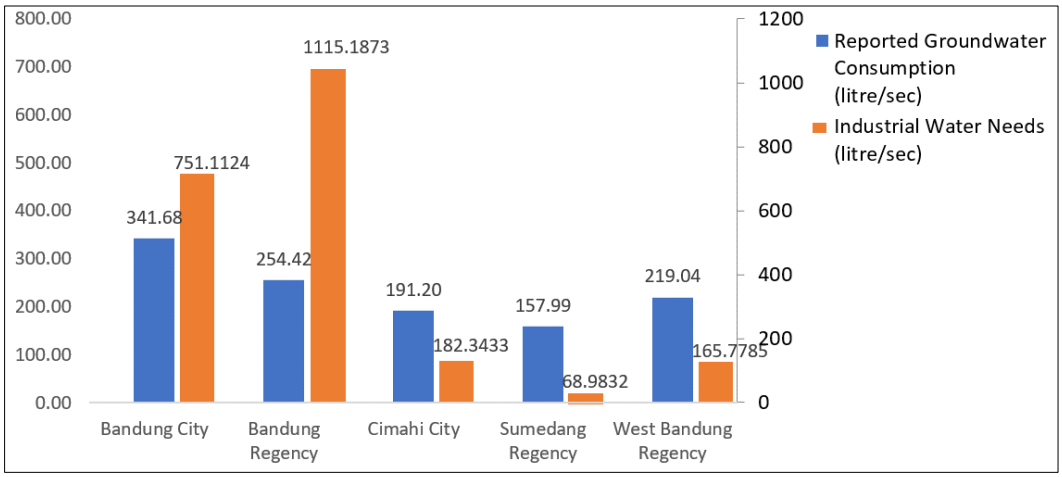

Figure 8. Comparison of reported industrial groundwater consumption with 15% percentage domestic water demand as non-domestic water demand.

4. Conclusion

The industrial distribution in Bandung - Soreang Groundwater Basin is spread over five regencies/cities. The most significant distribution point is Bandung city with 713 industries, Bandung district with 308 industries, Cimahi City with 155 industries, Sumedang Regency with 91 industries, and West Bandung Regency with 88 Industry. Thus, the entire industry spread across Bandung – Soreang Groundwater Basin that using groundwater to fulfilling their water demands is 1355 industries.

Population comparison of each area with the pattern of reported groundwater consumption in the Bandung-Soreang Groundwater Basin explains no relationship between industrial needs and population size in each administrative area. Later on, the water demand analysis was carried out with two types of analysis for industrial activities. It explained that West Bandung Regency had exceeded the maximum value of the water demands standard in the first calculation methods. In the second calculation method, Cimahi City, Sumedang Regency, and West Bandung Regency have exceeded the maximum value of water demand standards. Further research is needed regarding the collecting data of distribution and volume of groundwater utilization by unregistered wells to explain how much domestic and non-domestic groundwater utilization in the Bandung-Soreang Groundwater Basin so that water resources management can be carried out comprehensively.

Acknowledgements

Gratitude is due to the Department of Energy and Mineral Resources of West Java Province for providing groundwater user data.

References

[1] Weerasinghe, I 2020 Water Resource Management. In TORUS 3 – Toward an Open Resource Using Services D Laffly p 177-186
[2] West Java Provincial Regulation number 12 2014 Management of the development of metropolitan areas and growth centers in West Java Province Bandung
[3] Pribadi K N and Oktavia P 2007 Integrated Water Resources Management Through the Development of Sustainable Development Policies in the Bandung Basin, *Journal of Urban and Regional Planning* v 18 p 1-32.
[4] Laws of the republic Indonesia number 17 2019 Water Resources. Republic of Indonesia. Jakarta.
[5] Seizarwati W Rengganis H Wardhana Y A W Ahmad R D Syahidah M and Muthiya A 2020 Groundwater Model Prototype to Support SWMS in Citarum Watershed Internal Report of the Center for Hydrology and Water Environment Directorate of Water Resources Engineering Bandung

[6] Misi A Gumindoga W Hoko Z 2018 An Assessment of Groundwater Potential and Vulnerability in The Upper Manyame Sub-Catchment of Zimbabwe, Physics and Chemistry of the Earth (Elsevier) vol 105 p 72 – 83
[7] Morris B L Lawrence A R L Chilton P J C Adams B Calow R C Klinck B A 2003 Groundwater and its Susceptibility to Degradation: a Global Assessment of the Problem and Options for Management United Nations Environment Programme Nairobi Kenya
[8] Taufiq A Hosono T Ide K Kagabu M Iskandar I Effendi A Hutasoit L Shimada J 2018, Impact of excessive groundwater pumping on rejuvenation processes in the Bandung basin (Indonesia) as determined by hydrogeochemistry and modeling TT *Hydrogeology Journal* vol 26 p 1263–1279
[9] Ministry of public works and housing 2018 Planning of Transmission And Distribution Clean Water Pipelines Jakarta p 3-10
[10] Ministry of public works and housing 2015 Strategic Plan of Directorate of Water Supply System Development Jakarta p 118