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WATER SCARCITY IN THE DEPOK AREA

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ABSTRACT: When the development of a city is very fast, the city can experience environmental imbalance if the needs of the population are not met, especially clean water facilities. Depok City is a city that has grown very fast, and only has a piped water channel to 20% of the community, so 80% of people depend on groundwater. This will cause a disaster in terms of water scarcity. Through the calculation method of water balance, analyzed based on the number and density of the population, the type and area of land use will result in the total water needs of the people of Depok city to be balanced by the water supply through the pipeline network of Depok City. According to the water balance of Depok city for 2010–2027, until 2017, Depok City has been experiencing depletion of water supply from PDAM Tirta Asasta, and will then experience increased supply in year 2022 because PDAM Tirta Asasta will increase its production capacity to be 2,285 L/sec with addition of supply from IPA Legong, Citayam, Duren Seribu, and Cinere up to a total of 3,475 L/sec. However, the condition of this supply will not last long, and will again revert to depletion in 2027, caused by the need for clean water in Depok City increasing without a simultaneous increase in the production capacity of clean water by PDAM Tirta Asasta.

Keywords: Depok City, Water Balance, PDAM, Population, Land use

1. INTRODUCTION

Natural resources, especially water resources, are becoming increasingly difficult to obtain. According to Soemarwoto (1991), one of the causes is the growing population relying on the same natural resources [1]. The availability of water resources is also affected by seasonal changes and rainfall. In the last decade, changes in the seasonal rainfall have had a strong impact in Indonesia , especially in Java. According to Badan Meteorologi, Klimatologi dan Geofisika (BMKG) data in most areas in West Java during the period 1971–2000 and 2001–2010, the beginning of the dry season arrive earlier and last longer period (40 days). In the future, parts of Indonesia, especially those located south of the equator, may have longer dry seasons and shorter rainy seasons with higher rainfall (Moediarta and Stalker, 2007) [2].

The water crisis, especially the inability to meet water needs most of the time, and the massive excess in the rainy season, will trigger an increased risk of disasters related to water, weather, and climate. In the Jabodetabek area, the problem of population growth and limited clean water-supply infrastructure . Depok city is a metropolitan suburb of DKI Jakarta that accommodates the burden of a population that increases every year. The increase in population, will have an impact on the decrease of carrying capacity, the emergence of accessibility and traffic burden problems, and the high use of groundwater will make a high water-loss, and will cause problems with solid waste management and environmental sanitation. Based on data obtained from Statistics Indonesia 2015, Depok City has a high level of groundwater use, which has reached 44.94%. Excessive groundwater use is one of the results of population growth that can cause some adverse impacts without significant offsets, including land subsidence, flood hazards, and other ecological hazards (Fig. 1) (Russo, 2004)[3].

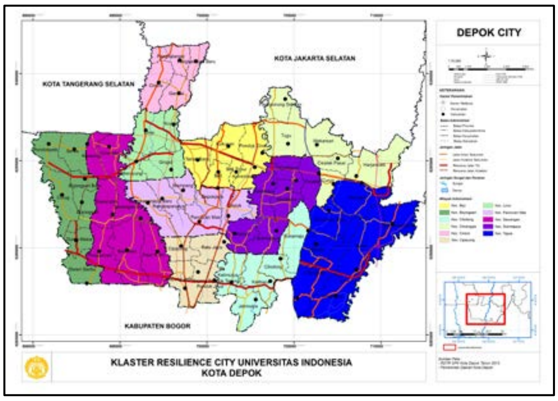

Fig. 1. Area of Depok City.

The water balance is a quantitative picture of the availability condition of water associated with the conditions of need in a region. It is one of the most important tools, and can be used in the development of a region. The water balance will be very useful in ensuring the sustainability of the carrying capacity and the environmental capacity of the area from the perspective of water availability. The deficit water balance condition is a crucial factor that must be addressed in order to ensure the availability of water, so as to meet the need for clean water to support existing life, as well as social and economic activities. By knowing the condition of the water balance of a development area (Fig. 2), the results of water balance analysis can be used to prepare mitigation efforts so as to eliminate or reduce the growth constraints on development and existing activities, especially when faced with water scarcity issues. This issue of water scarcity has begun to occur and be experienced by many areas in Indonesia as a result of environmental damage, pollution, or hydrological disturbance accompanied by increasing water demands by various entities.

Data collection is done through a literature study, primary data compilation and supporting data, review, and analysis of existing water balance components, surveys and field measurements, followed by simulation models to obtain quality data. The data obtained are further processed, analyzed, and synthesized to obtain the water balance condition. The results of this water balance arrangement are expected to give an idea of the level of water security 20 years into the future.

The calculation and projection analysis of the quantity of water requirements, which will be determined by the number of population to be served, the types of socio-economic activities available, the water requirements for urban support activities such as water for firefighting purposes, and garden watering, in the Depok city.

2. WATER SENSITIVITIES CITY

Drought is caused by decreasing rainfall. The decrease in rainfall has resulted in a decrease in the amount of water availability so that soil moisture has also decreased significantly below the normal average. Wilhite and Glantz (1985) divides the drought into four facets: meteorological, hydrological, agricultural, and socioeconomic drought [4].

Water Sensitivities City (WSC) is the result of negotiations between a number of experts and researchers, who have related visions to achieve a sustainable urban environment that has the character of a tough, livable, productive and sustainable city (Johnstone, 1997)[5]. The WSC interacts directly with the urban hydrological cycle by maintaining water security to ensure social and economic well-being through the efficient use of water resources from a diversity of available water resources. It also acts to improve and protect the quality of rivers and wetlands, reduce risks and damage caused by puddles and floods, and create available public spaces and the existence of water recycling systems, water management strategies and systems that contribute to biodiversity, carbon sequestration, and the reduction of heat island effects on urban areas.

The use of urban water pipelines greatly affects water availability for people, as well as network behavior. Although the supply of clean water is sufficient for the demand, the intermittent distribution will lead to an imbalance between the users by reducing the water supply to the high nodes and increasing the supply to the lower nodes. The effect on the short-term behavior of network-piping is much higher, with a difference higher than 200% under ordinary continuous distribution conditions (Fontanazza et al., 2007) [6].

The distribution of intermittent pipelines has an enormous impact on people and networks. Users change their water supply patterns with higher peaks (connected with local reservoir filling) and large periods with very low output, and they can also receive higher or lower water volumes depending on their height and position on the network (Fontanazza et al., 2007) [6].

The sustainable management plan should focus on continuous improvement in stakeholder engagement and infrastructure in the developing regions, and water reclamation and reuse in developed areas. Reuse of water will reduce stress during periods of drought, although costs and risks of technology adoption are still a barrier both in developing and developed countries. Improving the productivity of crop water can benefit all water user sectors discussed in this article by reducing competition between the agricultural sector and urban and environmental users (Russo et al., 2014) [7].

3. METHODS

The spatial pattern of water scarcity in Depok City is based on the water balance, in which population and land use variables, the population water requirement in each sub-district, and the water requirement in the area of each land use are factors. The determination of population water needs is based on Table 1:

Table 1. Indicators and variables.

No.	Indicator	Variables	Sample	Unit
1	Water Availability	Water resources and water supply facilities.	Water resources and water supply facilities per sub-district.	m^3/year/capita
2	Water Consumption Level	Population in sub-district area.	Perusahaan Air Minum (PAM) customers and non-costumers per sub-district in Depok.	l/capita/day
3	Water Continuity	Discharge.	Water resources and water supply facilities per sub-district.	m3/sec
4	Land use	Land use in sub-district area.	Open space, settlement, public facilities, and industry per sub-district.	Km^2

The continuity referred to in this research is the continuity of piped water for PAM customers and, additionally, to piping for residents who are not PAM customers. Continuity other than piping includes groundwater and river water. Continuity is reviewed by flowing water over 12 hours or drainage of fewer than 12 hours. Determination of scores for continuity of drainage of each source of clean water is taken from the middle value of 10 and from the maximum value of 20, so the determination of the score is as follows:

- If drainage of water <6 hours, it will be given a score of 5.
- If water drainage takes 6–12 hours, it will be scored 10.
- If water drainage takes 12–24 hours, it will be scored 15.
- If water drainage takes 24 hours, will be scored 20.

After that, the value of the water source continuity indicator can be calculated using the following equation:

$$\frac{(\%NPAM\ x\ KAT) + KAS + (\%NPAM\ x\ KPAM)}{3}$$

where % NPAM is the percentage of the population not subscribed to PAM; KAT is the continuity scores on groundwater sources; KAS is the continuity scores on river water sources; % PAM is the percentage of people who subscribe to PAM; and KPAM is the continuity scores on piped water sources / PAM.

4. RESULTS

4.1. Population

According to data from Statistics Indonesia 2016, the population in Depok City is 2,106,100 people. The number of males is 1,061,889, and the number of females is 1,044,211. The largest population is in the Cimanggis sub-district, with a population of 293,132 (148,301 males and 144,831 females). While the smallest population is in the Limo sub-district with a population of 106,545 inhabitants (53,963 males and 52,582 females). Males make up 50.41% of the total population of Depok City, and females make up 49.59%. Data describing the total population of Depok City are presented in Table 2 below:

Table 2. Population and Density in Depok City.

No.	Sub-District	Male	Female	Total	Area (km^2)	Density (people/km^2)
1	Sawangan	76,254	73,441	149,695	25.90	5,780
2	Bojongsari	61,392	59,426	120,818	17.79	6,791
3	Pancoran Mas	128,384	126,632	255,016	18.21	14,004
4	Cipayung	78,785	76,173	154,958	11.63	13,324
5	Sukmajaya	139,707	141,711	281,418	18.04	15,600
6	Cilodong	76,545	74,896	151,441	16.09	9,412
7	Cimanggis	148,301	144,831	293,132	21.22	13,814
8	Tapos	131,705	130,218	261,923	32.33	8,102
9	Beji	101,824	99,152	200,976	14.30	14,054
10	Limo	53,963	52,582	106,545	12.32	8,648
11	Cinere	65,029	65,149	130,178	10.47	12,433
	Total	1,061,889	1,044,211	2,106,100	198.30	10,621

Source: Statistics Depok in 2016 [8]

Sukmajaya sub-district has the highest population density with a density of 15,600 people/ km^2, of which the total area of 5.780 km^2. Then the sub-district with the smallest density is Sawangan with the number of 5,780 people/km^2 with an area of 25.9 km^2. Depok city itself has a population density of 10,621 people/km^2 (Fig. 2).

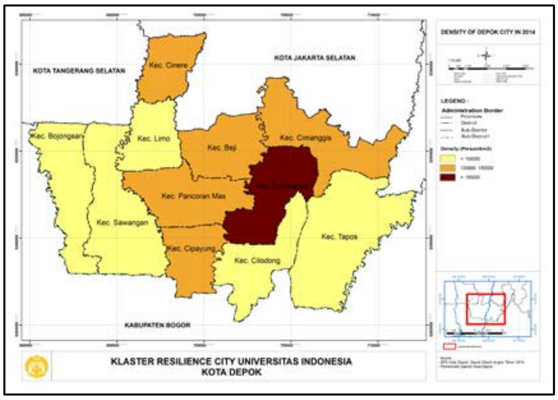

Fig. 2. Population density of Depok.

4.2. Water Pipeline Services in the Depok Area

As part of this study a study related to the use of the piped water network was also conducted. This was done to understand the coverage area of the piped network and service quality of PDAM in Depok City. The following is the result of data collection in the form of home connection and percentage coverage of the PDAM Tirta Asasta service in Depok City (Table 3).

Table 3. Percentage Area of PDAM Depok City

Sub-district	Amount of HC	People/ residence	Number of PDAM Services	Popula-tion	Percentage Area PAM (%)	Percentage Area non-PAM (%)
Sawangan	1,915	3.61	6913	144,528	5%	95%
Bojongsari	1,247	3.59	4477	116,650	4%	96%
Pancoran Mas	6,518	3.52	22943	246,228	9%	91%
Cipayung	-	3.66	0	149,612	0%	100%
Sukmajaya	26,661	3.48	92780	271,735	34%	66%
Cilodong	3,232	3.54	11441	146,220	8%	92%
Cimanggis	6,579	3.37	22171	283,025	8%	92%
Tapos	2,967	3.37	9999	252,897	4%	96%
Beji	2,565	3.33	8541	194,044	4%	96%
Limo	1,055	3.58	3777	102,872	4%	96%
Cinere	-	3.48	0	125,697	0%	100%

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4.3. Land Use in Depok

With a total area of 198.30 km^2, Depok City has a variety of land uses in different sub-districts (Fig. 3 and Table 4):

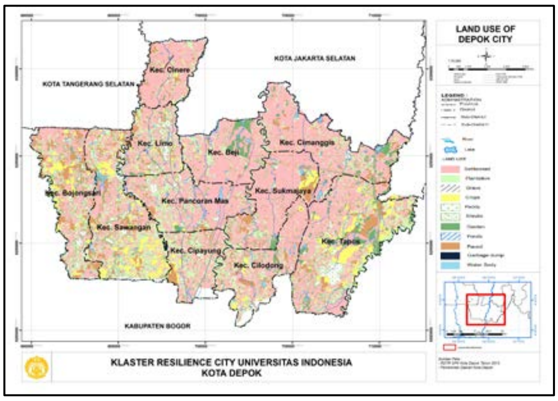

Fig. 3. Land use in Depok.

4.4. Climate

The climate of Depok City consists of three climatic regions, i.e. the north has lower rainfall (Cinere and Limo), and rainfall increases towards the south (Sukmajaya, Cilodong, Tapos) (Fig. 4).

Table 4. Land use in Sub-districts.

No	Sub-district	Area (km^2)	Hectares	Land use (hectares)			
				Settlement	Industrial and Trading	Civil Facility	Open Space
1	Sawangan	29.29	2928.93	695.00	0.00	728.43	1505.50
2	Bojongsari	19.79	1979.00	1137.70	0.00	206.40	635.40
3	Pancoran Mas	21.22	2122.00	1733.50	60.50	101.66	1929.02
4	Cipayung	11.63	1163.00	584.37	0.00	4.34	238.94
5	Sukmajaya	18.04	1804.00	963.54	385.08	85.18	190.40
6	Cilodong	16.08	1608.00	1149.00	233.40	0.00	129.80
7	Cimanggis	21.22	2122.00	1290.30	0.00	418.81	265.80
8	Tapos	32.33	3233.00	1736.82	0.00	1349.18	147.00
9	Beji	14.3	1430.00	807.50	0.00	217.30	441.00
10	Limo	15.33	1533.00	1243.20	0.00	80.90	209.60
11	Cinere	11.041	1104.10	882.10	0.00	111.30	102.75

Source: (BPS Depok, 2016) [8].

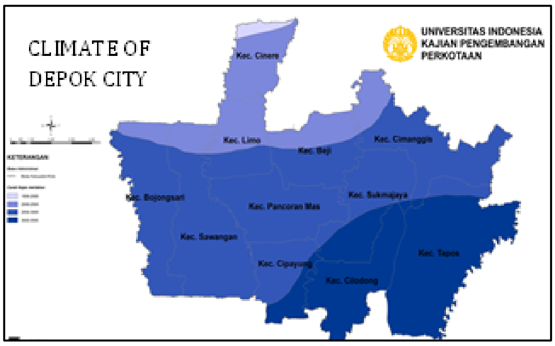

Fig. 4. Climate of Depok.

4.5. Water Balance

The water balance in Depok City is based on the PDAM piped water usage and the PDAM Tirta Asasta water supply development plan.

The water balance is prepared by assuming the increase will occur at the level of domestic and non-domestic water consumption, the target of piped water/piped service coverage, and the decrease in non-revenue water. In addition, the increase of the PDAM Tirta Asasta production capacity is adjusted to its target with PDAM Tirta Asasta.

Based on the calculation of the water balance carried out by looking at the conditions in 2010, the existing state in 2017, and estimations up to 2027, there are components of population, coverage of water services, domestic and non-domestic water needs, the amount of water supply there is a significant water deficit in Depok City, reaching an average of 700 liters/sec (Table 5). If this is not accompanied by improvement efforts, there will be water scarcity that will impact the lives of city dwellers.

Table 5. Water balance in Depok City.

Nb	Parameters	Unit	Year					
			2010	2015	2016	2017	2022	2027
1	Total population	Person	1,755,610	2,106,100	2,179,810	2,106,102	2,180,447	2,257,417
2	Target coverage of clean water service / drinking piping	%	63	63	63	65	84.15	100
3	Maximum limit of groundwater capture	%	40	35	30	20	15	0
4	Total population served	Person	1,106,034	1,326,843	1,373,280	1,368,966	1,834,846	2,257,417
5	Domestic clean water consumption	L/person/day	60	60	60	61.43	75	80

6	Domestic water demand	L/sec	768	921	954	973	1593	2090
7	Non-domestic demand	L/sec	253	304	315	321	526	690
8	*Non-revenue water* (nrw)	%	35	35	35	31.87	25	20
9	Total clean water demand	L/sec	1,379	1,654	1,712	1,707	2,648	3,336
10	Total raw water requirement	L/sec	1,448	1,737	1,798	1,792	2,780	3,503
11	Total of production capa-city PDAM Tirta Tsasta	L/sec	1,095	1,095	1,095	1,095	2285	2,285
A	supply IPA Legong		0	0	0	0	670	670
B	Supply IPA Citayam		0	0	0	0	120	120
C	Supply IPA Duren Seribu (Angke)		0	0	0	0	100	100
D	Supply IPA Cinere/Pesanggrahan		0	0	0	0	300	300
12	Water deficit (raw water & clean water)	L/sec	-353.04	-642.13	-702.92	-697.45	694.66	-27.76

Source: (Ali et al., 2017) [9].

5. CONCLUSIONS

The water balance of Depok City in 2010–2027 was described in 2017. Depok City is depleting the supply of clean water from PDAM Tirta Asasta, then it will be supplied by 2022 because PDAM Tirta Asasta will increase its production capacity to 2,285 L/sec with the addition of supplies from IPA Legong, Citayam, Duren Seribu, and Cinere up to a total of 3,475 L/sec. However, the condition of this supplementation will not last long, and will return to depletion in 2027, caused by the growing need for clean water in Depok City, and no parallel increase in the production capacity of clean water by PDAM Tirta Asasta.

6. REFERENCES

[1] Soemarwoto, O. Ekologi Lingkungan Hidup dan Pembangunan Cetakan ke 5. 1991, Bandung: Penerbitan Djambatan.

[2] Moediarta R, and Stalker, P., Sisi lain perubahan iklim: Mengapa Indonesia harus beradaptasi untuk melindungi rakyat miskinya. 2007. UNDP Indonesia.20p.

[3] Russo, S. J., Pfau, M. L, Peripheral and Central Mechanisms of Stress Resilience. ELSEVIER. Neurobiol Stress. 2015 Jan; 1: 66–79. Published online 2014 Sep 30. doi: 10.1016/j.ynstr.2014.09.004

[4] Wilhite, D.A and Glantz, M.H., Understanding the drought phenomenon: the role of definitions. 1985, Water International, 10, 111-120.

[5] Johnstone, P., Adamowicz, R., de Haan, F. J., Ferguson, B., and Wong, T. Water Sensitive City. 2012.

[6] Fontanazza, C. M., Freni, G., Analysis of Intermittent Supply Systems in Water Scarcity Conditions and Evaluation of the Resource Distribution Equity Indices. WIT Transactions on Ecology and the Environment, Vol. 103, 2007 WIT Press www.witpress.com, ISSN 1743–3541 (online) doi: 10.2495/WRM070591.

[7] Russo, T., Alfredo, K., and Fisher, J. Sustainable Water Management in Urban, Agricultural, and Natural Systems. Water, Vol. 6, 2014, pp. 3934–3956; doi:10.3390/w6123934.

[8] BPS,Kota Depok Dalam Angka 2016. BPS Kota Depok.

[9] Ali, F., Indra, T. L., and Sukisno, Optimalisasi Infrastruktur Sungai Terhadap Kebutuhan Air Baku Kota Depok. 2017, Laporan Kemajuan. Hibah PUPT DIKTI.