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Prediction Analysis of Domestic and Non-Domestic Water Needs in Serang City, Banten

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Abstract

Water needs are divided into domestic and non-domestic needs, where household water consumption is one of the biggest contributors to the water crisis in urban areas. High water consumption in residential areas is due to population growth, so an awareness is needed to protect water resources. One of the efforts to maintain water resources in an area is to prepare predictions of future water needs. The method used is a dynamic system. The results show that the domestic sector still dominates water use in the Serang area even though the population growth rate is starting to slow down. Water use in the domestic sector reached 30,314,023,800 liters in 2020. The non-domestic sector experienced an increase in water demand, but the rate was still predictable, especially in terms of livestock and agriculture. The use of water in the non-domestic sector in 2020 reached 726,572,026 liters. The number of domestic needs is still high even though the number of population growth has decreased, while from a non-domestic side the increase in the number of livestock in the Serang area is still within reasonable limits because in general the growth in the number of livestock is controlled by the relevant agencies. Domestic water demand in Serang City in 2020 is 30,314,023,800 liters per year or 83,052,120 liters per day. The planning for the construction of a dual reservoir with reference to the criteria of the Directorate General of Cipta Karya is 15% -25% of the daily requirement. From this information, the reservoir volume that can be made is around 12,347,818 liters – 20,763,030 liters

Keywords: Dual reservoir, water needs, domestic, non-domestic

Introduction

Water resources are non-renewable resources that require humans to act wisely in their use. Domestic water use is still very difficult to manage, but on the other hand, household water use is the biggest contributor to the water crisis. The impact of human consumption on global water resources can be mapped using the water footprint. The water footprint concept is proposed and defined as “a measure of human deprivation of freshwater resources”. The water

footprint is an indicator of water use which includes water consumption and pollution; they can also be applied to expand water resource evaluation systems and provide water use information for decision making. The environmental crisis occurs because of the excessive use of natural resources. Utilization of natural resources that does not pay attention to sustainable elements. Excessive consumption patterns of natural resources can lead to a natural resource crisis [1].

In analyzing a complex system, working with real conditions is very risky and costly, therefore a model is needed that can represent the condition of the existing system. Behavior and complexity in a system can be described through system dynamics [2]. Prediction of water demand can be prepared using a model, one of which is a dynamic model [3]. Prediction of accurate water demand is very necessary in the water resources management system so that a policy can be determined for efficiency and allocation of water demand [4]. Walker, et. al (2015) predicting domestic water consumption using an artificial neural network statistical method. The built model is able to predict a number of water consumption but still has difficulty accurately predicting consumption at peak usage [5]

Suheri, et.al (2019) made a prediction model for clean water needs based on the population in the Sentul City urban area [6]. The model made only uses the population variable using the Stella 9.0.1 software tool. Water demand prediction models are useful for urban planning in infrastructure and technology investment and policy reform on water demand [4].

This study aims to predict future water needs with the influence of changes in population, the effect of increasing the number of industries and facilities both commercial and non-commercial using a dynamic system so that it can be used as a basis for making water resources management decisions.

The need for clean water is the amount of water needed to meet water needs in daily activities such as bathing, washing, cooking, watering plants and so on. Sources of clean water for daily living needs in general must meet quantity and quality standards [7].

Water needs are divided into domestic and non-domestic water needs. Categories of clean water needs for purposes can be seen in Table 1 below.

Table 1. *Domestic Water Demand*

No	Description	Category				
		Metro	Big	Currently	Small	Village
1	Consumption of house connection (SR) lt/org/hr	190	170	150	130	30
2	General Hydrant Connection (HU) lt/hr/org	30	30	30	30	30
3	Water loss	20-30	20-30	20-30	20-30	20-30
4	Number of souls / SR	5	5	6	6	10
5	Number of souls / HU	100	100	100	100-200	200
6	Reservoir volume (%) max day demand	20	20	20	20	20
7	HC : GH	50:50 80:20	50:50 80:20	80:20	70:30	70:30

Description HC = House connection, GH = General Hydrant. Source: Director General of Human Settlements, 2007

Materials and Methods

A system is composed of several complex elements and interact with each other so that solving problems in a system requires a simplification of the problem by way of systems thinking. System dynamics, which was first introduced by Joy Forester in 1950 at MIT, is a method for describing the problems of a system [8]. System dynamics can describe the behavior and complexity of the system over time [2]. The stages in the dynamic system approach include: needs analysis, problem formulation, system identification, system modeling and model validation [9].

This research was conducted in Serang City. The secondary data used is sourced from the Central Statistics Agency of Serang City from 2016 to 2020. The water needs referred to in this study are the water needs used to support all human water needs both in domestic and non-domestic activities and the water needs of various sectors. Based on SNI No. 19-6728.1-2002, water needs are divided into (1) domestic water needs; (2) non-domestic water needs; (3) the need for industrial water; (4) the need for health facilities; (5) tourism needs; (6) agricultural, fishery and animal husbandry needs.

Domestic water needs are calculated from the number of rural residents and the number of urban residents. Where the standard water requirement for urban residents is 120 l/day/person and village residents is 60 l/day/person. The standard used to calculate water demand is based on SNI No. 19-6728.1-2002 (National Standardization Agency, 2002). Domestic water demand (in l/year) for one year is calculated using the following equation:

$$Q\ (city) = \Sigma\ population\ x\ 365\ x\ \frac{120\ \frac{l}{day}}{people}\ (1)$$

$$Q\ (village) = \Sigma\ population\ x\ 365\ x\ \frac{60\ \frac{l}{day}}{people}\ (2)$$

Q(city) and Q(village) are the water demand in m^3/year.

Irrigation water needs are calculated during the rice planting season in rice fields with technical, semi-technical and non-technical irrigation. The amount of irrigation water needs using the equation:

$$A = irrigated\ rice\ field\ x\ 0.001\ \ m^3/sec/ha\ x\ 3600\ x\ 24\ x\ 120\frac{day}{season}\ (3)$$

Farm water needs

$$QL = \ 365\ x\left\{q\left(^{c}/_{b}\right)x\ P\ \right\}\ (4)$$

Where :
QL= Water requirement for cattle (m^3 / year), q(c/b) = Water requirement for cattle/buffalo (l/head/day),
P(c/b) = Number of cows or buffalo (tails),
q(s/q) = Water requirement for sheep/goats (l/head/day),
P(s/q) = Number of sheep/goats (tails),
q(pi) = Water requirement for pigs (l/head/day),
P(pi) = Number of pigs (head), q(po) = Water requirement for poultry (l/head/day),
P(po) = Number of birds (tails).

This research was conducted at Taman Argo Subur Housing, Cisoka, Tangerang Regency. In determining the required water discharge, it is necessary to analyze population

growth by analyzing population growth projections for the next 20 years in accordance with the planning in this study using linear analysis with equation [6] :

$$Pt = a + bX \quad (5)$$

Where :
P_t : Total population of the area under investigation in year t.
X : The value taken from the independent variable
a,b: Constant

Domestic water needs are the needs of clean water for residents for the benefit of daily life. Broader than just food and drink consumed by mouth, clean water is needed for various purposes which are currently a basic need, such as bathing and washing or various other forms of environmental hygiene [7] . There are many uses of domestic water, such as for washing clothes, washing household appliances, washing cars and two-wheeled vehicles, bathing, washing face, brushing teeth, defecating, cooking, drinking, washing floors, washing oneself (ablution), washing feet, washing hands, watering house plants, watering livestock and pets (not for livestock purposes), water for aquariums (must be changed every few days) and other necessities [8] . The standard used to calculate water demand is based on SNI No. 19-6728.1-2002 (National Standardization Agency, 2002). Domestic water demand (in l/year) for one year is calculated using the following equation [9] :

$$Q(\text{City}) = \sum \text{Population} \times 365 \times 120 \ \frac{\frac{l}{day}}{\text{people}} \quad (6)$$

$$Q(\text{Village}) = \sum \text{Population} \times 365 \times 60 \ \frac{l}{day}\Big/_{\text{people}} \quad (7)$$

Q (City) and Q (village) is the water requirement in m^3 / year

EPANET (Environment Protection Agency Network) is a computer program (model) that performs hydraulic simulations and behavior of water quality in a drinking water distribution pipe network (pressure pipe). A drinking water distribution network consists of pipes, nodes (branches), pumps, water tanks or reservoirs and valves. EPANET is a program that is widely used to model drinking water distribution and piping systems. This system can predict movement, water demand and piping systems. Researchers and consultants use EPANET to design and measure new water infrastructure, improve existing old infrastructure, operate tanks and pumps, reservoirs, valves, energy efficiency, water quality and prepare for emergencies [10] .

The output generated from the EPANET program includes the flow rate in the pipe (lt/sec), water pressure from each point/node/junction which can be used as an analysis in determining the operation of installations, pumps and reservoirs. The use of pumps in piped flow is very important to maintain the required flow rate. A pump is a device that can move liquids, gases or sometimes slurries, by mechanical action, usually converted from electrical energy to hydraulic energy [11] .

Results

Serang city is geofreely located between 5099' - 6022' south latitude and 106007' 106025' east longitude. Serang City has a total area of $\pm$ 266.71 Km ^{2} and consists of 6 (six) sub-districts, namely Serang District, Kasemen District, Taktakan District, Cipocok Jaya District, Curug District, and Walantaka District.

Since the formation of Serang City in 2007, this area has been growing with a fairly high population growth. The population of Serang City in the period 2010 to 2020 can be seen in Table 2.

Table 2. *Residents of Serang City*

Year	Amount (soul)	Growth (%)
2010	580,802	
2011	593,601	2.20%
2012	606,302	2.14%
2013	618,802	2.06%
2014	631,102	1.99%
2015	643,205	1.92%
2016	655,004	1.83%
2017	666,600	1.77%
2018	677,804	1.68%
2019	688,603	1.59%
2020	692,101	0.51%

On average during the observation year population growth reached 1.77 %. Population growth in 2020 is only 0.51 %. Based on the population in 2020, the water needs in Serang City can be calculated as follows:

$$Q\ (\text{city}) = \Sigma\ \text{population x } 365 \text{ x } \frac{120\ \frac{\text{l}}{\text{day}}}{\text{people}}$$

$$Q\ (\text{city}) = 692.101 \text{ x } 365 \text{ x } \frac{120\ \frac{\text{l}}{\text{day}}}{\text{people}}$$

$$Q\ (\text{city}) = 30.314.023.800 \text{ liter}$$

By using a geometric series, it can be estimated that the domestic water demand for 2030 or ten years from the latest population data owned by the City of Serang. Based on the results of calculations in 2030 it is estimated that the population of Serang City is 840,952 people. Thus, the amount of domestic water needs of Serang City in 2030 is 36,833,680,225 liters.

Furthermore, the calculation of non-domestic water needs is indicated by the water demand from rice fields and livestock. In 2019-2020 the rice harvested area in Serang City can be seen in Table 3 below.

Table 3. *Rice Harvest Area Per District (Ha)*

Subdistrict	2019	2020
Curug	905.00	1,550.90
Walantaka	2,797.00	2,749.90
Cipocok Jaya	965.00	1,189.40
Serang	597.00	666.10
Tatakan	1,166.00	1,266.40
Kasemen	7,560.00	7,418.90
Total	**13,990.00**	**14,841.60**

Based on the 2019-2020 data above, the water demand for rice fields in Serang City in 2020 is 153,877,708 m3 ^{per} season or if in 1 year there are 3 planting seasons, the water need for 1 year is 461,633,126 liters. .

The livestock sector in Serang City is dominated by Goats and Sheep, which account for more than 50% of the total livestock in the city (Table 4).

Table 4. *Number of Livestock for the 2019-2020 Period*

No	Type of livestock	2019	2020
1	Beef cattle	76	80
2	Dairy cows	132	76
3	Buffalo	4,564	4,126
4	Horse	26	54
5	Goat	58,657	57,672
6	Sheep	45,630	46,412
	Total	109,085	109,220

Based on SNI 19-6728-1-2002, water needs for livestock can be seen in Table 5 below.

Table 5. *Water Needs for Livestock (l/day)*

No	Type of Livestock	Water Consumption
1	Cow / Buffalo	40
2	Sheep / Goat	5
3	Pig	6
4	Poultry	0.6

By using the amount of water needed for various livestock, it can be calculated that livestock water needs in 2020 are 725,860 liters per day or 264,938,900 liters per year (Figure 1).

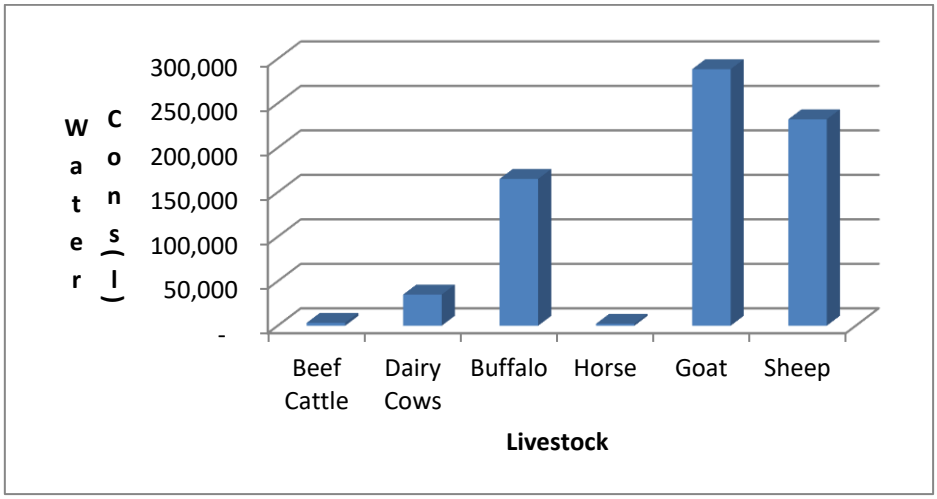

Figure 1. *Water Needs for Livestock (2020)*

Thus, the total water demand in Serang City based on domestic and non-domestic needs in 2020 is 31,040,595,826 liters.

Prediction of domestic water demand in 2030 of 36,833,680,225 liters still shows the dominance of the urban population in utilizing water for their needs. Compared to population growth which is on average 1.77%, the livestock animal growth rate which reached 6.1% in

2020 is still not close to the domestic water needs, this is due to the increasing population every year, although the growth is no longer as large as the early days of the formation of the city of Serang.

Prediction of water demand in the future is expected to help the city government to maintain and prepare for water availability. The availability of surface water and ground water is provided by rain. Rainfall data is used to estimate surplus and deficit conditions so that dual reservoirs can be built that can accommodate rainwater and groundwater or those from PAM.

The average rainfall in Serang City during the period 2010-2018 can be seen in Table 4 below.

Table 4. *Average Rainfall 2010-2018 (mm)*

Bulan	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	322	243	302	424	377	363	126	321	142
February	195	91	181	212	212	241	272	351	178
March	166	205	91	224	103	194	229	114	222
April	72	107	184	76	72	131	88	94	154
May	113	85	98	261	113	39	143	143	70
June	177	38	36	60	65	83	93	101	197
July	208	79	16	244	233	5	135	107	3
August	118	0	0	122	10	12	87	18	0
September	328	32	7	35	22	0	160	48	30
October	186	71	128	84	21	29	165	112	88
November	148	79	51	149	155	54	138	154	117
December	109	112	95	381	139	155	179	242	168
Rata2	178.5	95.2	99.1	189.3	126.8	108.8	151.3	150.4	114.1

Source: *BMKG station class I, Serang*

Based on Table 4 above, it can be seen that the city of Serang has a dry month between June and September, while in other months it has sufficient rainfall.

With reference to the domestic water demand in Serang City in 2020, which is 30,314,023,800 liters per year or 83,052,120 liters per day, the dual reservoir development planning with reference to the criteria of the Directorate General of Human Settlements is 15%-25% of daily needs. Thus the reservoir volume that can be made is 12,347,818 liters – 20,763,030 liters. [16]

The dual reservoir design can be seen in Figure 2.

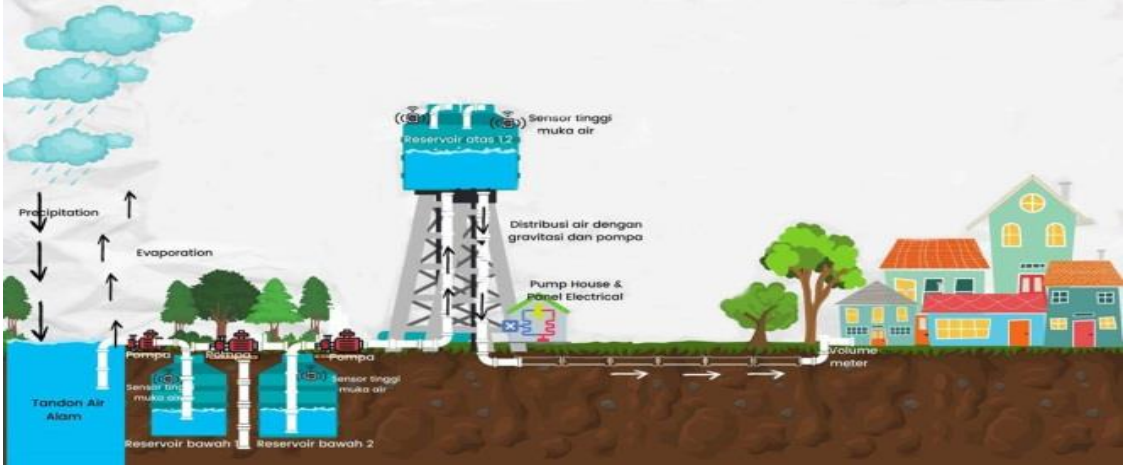

Figure 2. *Placement of Dual Reservoir*

The results of this study are in line with the research of Asmorowati and Sarasanty (2021) which calculates water demand based on each sector and makes predictions of needs using dynamic systems. Current water demand calculations are used to predict future water needs [5]. Astuti et al (2018) investigated domestic and non-domestic water needs to analyze community water needs. The results of his research show that people in the Gunungkidul area utilize water efficiently and in accordance with SNI rules [6]. Rudyanto, et.al (2018) utilize a dynamic system to calculate water demand and create a water balance model. His research provides a water balance model to meet the water needs of the community in the research location [2].

Research by Biantoro, et.al (2022) uses a water level sensor to help predict the occurrence of floods where the experimental results show a low error rate [18]. Domestic hot water consumption for housing plays an important role in research, especially in terms of technical, social, climatic and economic factors. Fargallo, et. al (2022) developed a model to predict the water demand for housing in the south-central region of Chile. The resulting model can be used to predict domestic hot water consumption in the future [19]. Oyeleke's research (2019) predicts domestic water consumption for an affordable price. In his research predicting the supply and supply of water in the future [20].

Conclusion

In 2020, water demand in Serang City is dominated by domestic use, where the total water demand reaches 30,314,023 liters per year. Meanwhile, on the other hand, non-domestic water demand, which is represented by the needs of the livestock and rice fields sector, is 726,572,026 liters per year.

These results indicate that the domestic sector still dominates the water demand in urban areas. Prediction results using geometric series show that in 2030 domestic water needs will reach 36,833,680,225 liters per year. The number of domestic needs is still high even though the number of population growth has decreased, while from a non-domestic side the increase in the number of livestock in the Serang area is still within reasonable limits because in general the growth in the number of livestock is controlled by the relevant agencies.

References

B. I. Amalia and A. Sugiri, “Ketersediaan Air Bersih dan Perubahan Iklim: Studi Krisi Air di Kedungkarang Kabupaten Demak,” J. Tek. PWK, vol. 3, no. 2, pp. 295–302, 2014.

A. Rudyanto, L. M. Limantara, U. Andawayanti, and E. Suhartanto, “Model of water balance based on the system dynamics,” Int. J. Civ. Eng. Technol., vol. 9, no. 12, pp. 267–276, 2018.

H. Malaka, M. Yanuar, J. Purwanto, and A. Zein, “Analisis Sistem Dinamik Neraca Air Di Pulau Tidore,” J. Air Indones., vol. 8, no. 2, pp. 125–136, 2018.

C. Zhai, H. Zhang, and X. Zhang, “Application of System Dynamics in the Forecasting Water Resources Demand in Tianjin Polytechnic University.,” Int. Conf. Artif. Intell. Comput. Intell., pp. 273–276, 2009.

D. Walker, E. Creaco, L. Vamvakeridou-lyroudia, R. Farmani, Z. Kapelan, and D. Savi, “Forecasting Domestic Water Consumption from Smart Meter Readings using Statistical Methods and Artificial Neural Networks,” vol. 119, pp. 1419–1428, 2015.

A. Suheri, C. Kusmana, M. Y. J. Purwanto, and Y. Setiawan, “Model Prediksi Kebutuhan Air Bersih Berdasarkan Jumlah Penduduk di Kawasan Perkotaan Sentul City,” J. Tek. Sipil

dan Lingkung., vol. 4, no. 3, pp. 207–218, 2019.
Asmadi, Khayan, and H. S. Kasjono, Teknologi Pengolahan Air Minum, Cet. 1. Yogyakarta: Gosyen Publishing, 2011.
J. D. Sterman, "System Dynamics: System Thingking and Modelling for A Complex World," ESD Intern. Symp., no. October, pp. 1–29, 2014.
A. Susanto, "Model dinamik penyediaan air baku melalui pendekatan water sensitive city di das ciliwung hulu (kasus desa bendungan, kecamatan ciawi, kabupaten bogor)," pp. 1–13, 2011.
R. Angellina and A. U. Farahdiba, "Analisis Kebutuhan Air Bersih Berdasarkan Jumlah Penduduk Di Desa Gedangkulut Kab. Gresik Melalui Pendekatan Sistem Dinamis," UPN JAwa Timur, vol. 2, no. 1, pp. 103–109, 2021.
H. T. Risky Yohanes Rottie Tiny Mananoma, "Pengembangan Sistem Penyediaan Air Bersih," Sipil Statik, vol. 5, no. 4, pp. 225–235, 2015.
R. Triatmadja, "Kebutuhan Air Domestic," in Teknik Penyediaan Air Minum Perpipaan, Yogyakarta: Gadjah Mada University Press, 2016, pp. 7–8.
E. T. Asmorowati and D. Sarasanty, "Model Prediksi Kebutuhan Air Berbasis Sistem Dinamik di Kabupaten Mojokerto," Din. Lingkung. Indones., vol. 8, no. 2, p. 91, 2021.
EPA, "Water Research," EPA.gov, 2020. [Online]. Available: https://www.epa.gov/water-research/epanet.
A. W. Biantoro, B. Darmono, and H. Pranoto, "Performance Analysis of DN1750 and DN1800 Electric Submersible Pump for Production Optimization on the Oil Well," Int. J. Adv. Technol. Mech. Mechatronics Mater., vol. 3, no. 1, pp. 39–52, 2022.
Chandra Afriade Siregar; Dudung Mulyadi; Agung Wahyudi Biantoro; Heri Sismoro; Yanti Irawati, "Automation and Control System on Water Level of Reservoir based on Microcontroller and Blynk," 2020 14th Int. Conf. Telecommun. Syst. Serv. Appl. (TSSA, 2020.
F. A. Astuti, A. Sungkowo, and W. A. D. Kristanto, "Analisis Kebutuhan Air Domestik dan Non Domestik di Kabupaten Gunungkidul," J. Sains &Teknologi Lingkung., vol. 10, no. 2, pp. 139–146, 2018.
A. W. Biantoro, S. I. Wahyudi, M. F. Niam, and A. G. Mahardika, "Analysis of Ciliwung river flood debit and city flood anticipation using floods early detection system (FEDS)," IOP Conf. Ser. Earth Environ. Sci., vol. 955, no. 1, 2022.
A. P. Fargallo, B. B. Huertas, and S. C. Espinoza, "Domestic hot water consumption prediction models suited for dwellings in central-southern parts of Chile," J. Build. Eng., vol. 49, no. October 2021, pp. 1–13, 2022.
B. . Oyeleke, A. . Ayinla, and E. . Olorunaiye, "Predicting Domestic Water Consumption under Price Affordability Predicting Domestic Water Consumption under Price Affordability," Int. Conf. Sci. Eng. Enviromental Technol., vol. 4, no. 11, pp. 89–96, 2019.