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Modeling of Clean Water Needs Analysis Based on Dynamic Systems in Lubuk Sikaping District

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ABSTRACT

Water is the source of life because water is not only needed by humans but also by nature to maintain a stable ecosystem. Humans and other creatures depend on water to grow and develop. The water needs of every livingthing are different and are influenced by the availability of water itself. The utilization of water as a whole in aspects of life becomes more valuable in terms of quantity and quality. The higher the cost of living for each person, the greater the need for water. This study aims to determine the projection of clean water needs in Lubuk Sikaping District from 2023 to 2043 based on population, find out the projection of clean water needs dynamically using powers studio 10 software, and find out whether the availability of clean water is sufficient for the next 20 years. The method used for the planned population projection of the next 20 years uses arithmetic methods. The results obtained in this study the need for clean water increases for the next 20 years, amounting to 125,563 liters/second. The results of water availability in Lubuk Sikaping District are still sufficient for the next 20 years. And based on the same installed capacity each year the availability of water is to be the same or constant every year.

Keywords: *Water; Clean Water Needs; Water Availability, Powersim Studio 10.*

INTRODUCTION

Water is the most influential thing in the life of living things because if there is no water it will adversely affect the condition of the body and interfere with the growth and development of these living things [1]. This is because most of the constituent components of living things are water [2]. All living things on earth such as humans, animals, and plants need water for survival. If there is excessive water loss, it will be very fatal to living things [3]. Along with the increase in population that increases from year to year, the need for clean water will increase, and competition to obtain clean water for various purposes will increase [4]. The development of an area will result in a continuous increase in clean water along with the rate of population growth [5]. The demand for clean water cannot be avoided, but it must be predicted and planned for the best possible use [6].

Lubuk Sikaping is a sub-district as well as the capital of Pasaman Regency, West Sumatra. Lubuk Sikaping District in 2023 figures geographically has an area of 346,50 km2, the north is bordered by Panti District, the south is bordered by Bonjol and Tigo Nagari Districts, the west is bordered by West Pasaman Regency, and the east is bordered by South Mapat Tunggul District. Lubuk Sikaping has 13 Nagari and 32 Jorong. In 2022, the population of Lubuk Sikaping is 52.132 people. Lubuk Sikaping District experiences an increase in

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population every year so in the next few years the population will be more rapid [7]. The number of populations will certainly affect the increase in the number of clean water needs [8]. Based on data [9], the PDAM Tirta Dharma Lubuk Sikaping unit is the unit with the largest number of subscriptions in Pasaman Regency. Pasaman Regency has eight PDAM service zones and the Regional Drinking Water Company (PDAM) Tirta Dharma Lubuk Sikaping unit is in zone III which uses water sources and pipelines originating from Bulakan Spring, Pigiary Source, Head of City IPA, Jambak Source, Piudang Source, Sungai Landai IPA and Koto Tangah IPA. Therefore, in this area, most people use PDAM services to get clean water to meet their daily needs.

However, this area has PDAM that experiences problems every time, especially if there is heavy rainfall, the PDAM water will die and the water produced is turbid dirty muddy. Lubuk Sikaping sub-district was recently hit by a flash flood on December 3, 2023, which caused the condition of the clean water management section, namely the intake building, the flow of transmission pipes to be severely damaged and the water produced is still experiencing problems and adversely affecting the community. The existence of water resource problems can have socioeconomic and environmental impacts on humans, so an integrated optimization model is needed to estimate the impact [10]. The government has made various efforts in handling water resources through PDAMs, improving services, and meeting community needs for clean water. The application of effective clean water management is a driving factor for the progress of an area, allowing it to develop into a resilient environment.

METHODS

The research conducted used a quantitative research descriptive approach. The quantitative descriptive research method is a method that aims to create an objective picture or description using numbers, starting from data collection, interpretation (interpretation) of data, and appearance and results [11]. The type of quantitative descriptive research is a study to determine the clean water needs of Lubuk Sikaping District and the availability of clean water. The data collected for this study are as follows:

1. Map of Lubuk Sikaping District
2. Population data of Lubuk Sikaping sub-district obtained from the Central Bureau of Statistics
3. PDAM customer data
4. Clean water demand data
5. Clean water availability data
6. Data on the number of non-domestic facilities in Lubuk Sikaping District
7. Other supporting data deemed necessary for research

The stages of data analysis in research are as follows:

1. Calculate population projections
   To estimate the population in the future or 2043, population projections are carried out. Projections of the population in the future can be predicted based on the planned population growth rate that is relatively increasing each year [12]. Methods used to calculate population projections include:
   a. Geometric Methods
      Formula used:

$$Pn = Po\ (1 + i)^n$$

      With:
      Pn = Number of inhabitants in the nth year
      Po = Number of inhabitants at the beginning of the year

i = Population growth ratio rate
n = Period in one year

b. Arithmetic Method
Formula used:

$$Pn = Po \{1 + (i.n)\}$$

With:
Pn = Number of inhabitants in the nth year
Po = Number of inhabitants at the beginning of the year
i = Population growth ratio rate
n = Period in one year

c. Exponential Method
Formula used:

$$Pn = Po.e^{(in)}$$

With:
Pn = Number of inhabitants in the nth year
Po = Number of inhabitants at the beginning of the year
e = Natural logarithm number equal to (2.7182818)
i = Population growth ratio rate
n = Period in years

Of the three methods above, you must choose one of the methods to use in the next calculation, which is to calculate the population projection until the planned year [13]. The selection of the method is with the following considerations:
- The coefficient (r) must be either 1 or -1 or close to both.
- Standard deviation (SD) must be the smallest because a small standard deviation value indicates that the data obtained is not much different from the original data.

2. Calculate clean water needs analysis
   a. Domestic water needs
   b. Non-domestic water needs
   c. Total clean water needs
   d. Water loss

3. After analyzing population projections and clean water needs, the data is then entered into Powersim Studio 10 Software [14].
   a. Stock flow diagram (SFD) creation
      SFD can be formulated after CLD and input-output diagrams. SFD is a dynamically created model. SFD consists of items previously described, this SFD uses level, constant, auxiliary, rate, etc.
   b. Data input
      The required data will be inputted into the model, and the items used in the model have their respective values.
   c. Simulation phase using timetable and time graph
      The completed model will be simulated on the timetable and time graph. The results of model simulations projected in the next 20 years will be published in tables and graphs.
   d. Model testing /Validation test
      The validation test is carried out with an error rate test. The data is tested by comparing values obtained from Microsoft Excel and data from PowerSim.

The research was conducted in Lubuk Sikaping District, Pasaman Regency, West Sumatra Province. Lubuk Sikaping District is located in Pasaman Regency and is the most populated

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area. Astronomically Lubuk Sikaping District is located between 100°02' east longitude, and between 00°17' to 00°03' south latitude. Lubuk Sikaping has an area of 346.50 km2. next. The boundaries of Lubuk Sikaping include:

- North: Panti District
- South: Bonjol and Tigo Nagari sub-districts
- West: West Pasaman Regency
- East: Mapat Tunggul District

Lubuk Sikaping District consists of 13 Nagari namely Tanjung Beringin, Jambak, Durian Tinggi, Pauah, Aia Manggih, and Sundata, Tanjung Beringin Selatan, Tanjung Beringin Utara, Aia Manggih Barat, Aia Manggih Selatan, Aia Manggih Utara, Sundata Selatan, Sundata Utara. The map of Lubuk Sikaping sub-district can be seen in Figure 1.

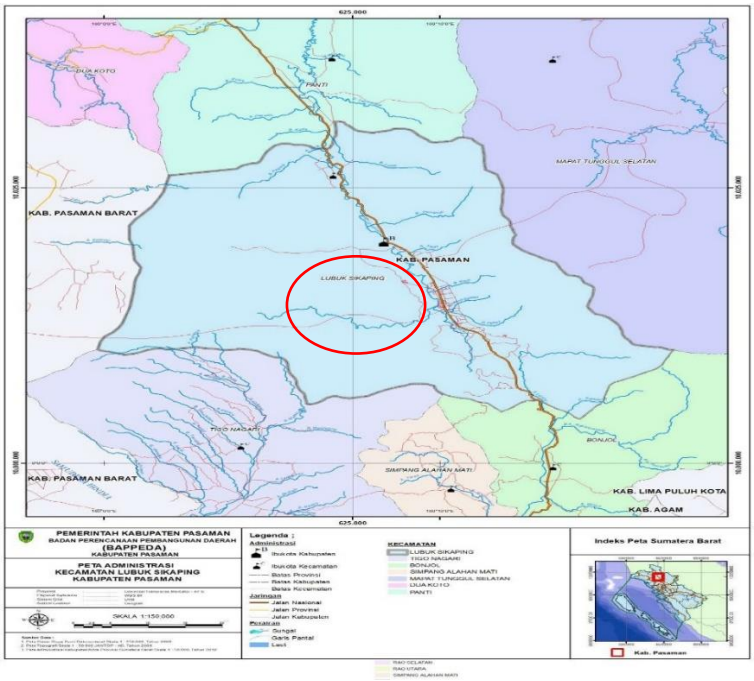

Figure 1. Map of Research Location

RESULTS AND DISCUSSION

From the results of data analysis on Microsoft Excel, the results of predicting clean water need in 2043 using arithmetic methods, in 2043 the population in Lubuk Sikaping District has grown to 90.668 people, while in 2023 it will be 53.967 people. Thus, it can be seen that the average growth is 3,52% per year.

Table 1. Percentage of population growth in Lubuk Sikaping District in 2018 – 2022

Year	Nth Year	r (%)	Statistical Count	The Calculation Result		
				Geometric	Arithmetic	Exponential
2018	0	3,52%	45.578	45.578	45578	45578
2019	1	3,52%	45.712	47.182	47182	47211
2020	2	3,52%	51.092	48.843	48787	48902
2021	3	3,52%	51.600	50.562	50391	50654
2022	4	3,52%	52.132	52.342	51995	52468
Standard Deviation				2674,041	2536,693	2723,911
Correlation Coefficient				0,910106	0,913747	0,910039

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Based on the results of the data obtained in the table above, it can be seen that the standard deviation with the smallest value and the correlation coefficient closest to number 1 is a projection using the arithmetic method, then for the projection of the population of Lubuk Sikaping District is determined using the arithmetic method.

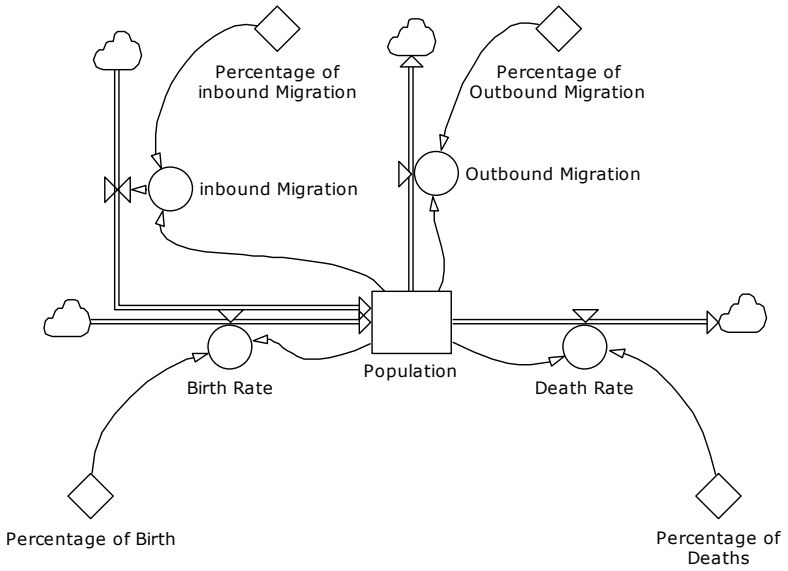

Figure 2. Stock Flow Diagram Population Projections

The results of population growth obtained from Powersim software are almost the same as the results obtained from Excel, namely population growth every year has increased that in 2023 the population is 53.524 people and has increased until 2043 which is 90.679 people. The following graph of population projections each year can be seen in the figure below.

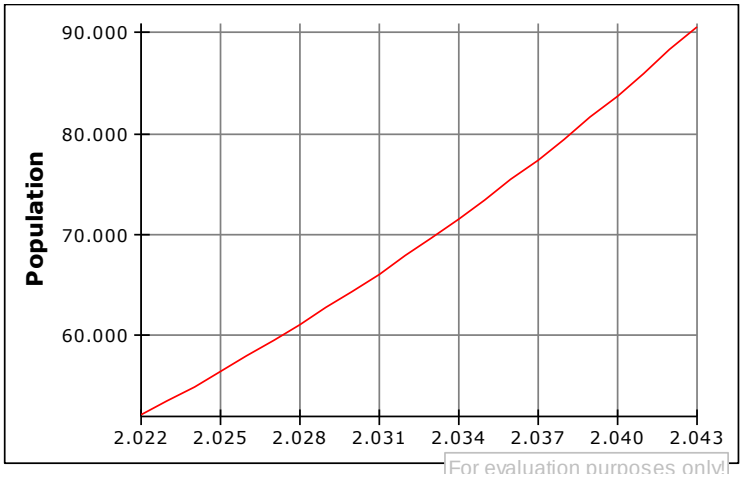

Figure 3. Population Projection Graph

The increase in population will directly cause the need for clean water to increase because various human activities require water both domestic activities (household needs and toilets) and non-domestic activities such as commercial activities, water needs for various sectors, namely those related to education, health, worship, and water needs for other activities [15].

For the results of the prediction of domestic clean water needs in 2043, with service level coverage of 90% of residents in the small city category, namely 120 liters/person/day clean water needs of the Lubuk Sikaping sub-district service area of 113.34 liters/second. Domestic clean water demand in 2023 will be obtained at 67,46 liters/second. The results of the prediction of domestic water demand using powerim software in 2043 are 113,35 liters/second.

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Projection of non-domestic clean water needs in Lubuk Sikaping District using the arithmetic method. Non-domestic facilities consist of educational facilities, health facilities, and worship facilities. Based on the results of the Microsoft Excel project, it is obtained that in 2043 there will be an increase in clean water demand compared to 2023. The projection of educational facilities in 2023 is that the number of students will increase to students in 2043. The projection of 211 beds in 2023 will increase to 355 beds in hospitals by 2043. The projection of Pribadatan facilities amounting to 58 mosques and 128 mosques increased to 62 mosques and 138 mosques.

For a recapitulation of the prediction of non-domestic clean water needs in Lubuk Sikaping District in 2023-2043 using the Planning Criteria of the Directorate General of Copyright, the Pu Office (1996). Based on the projected clean water demand in 2023-2043, it is known that there will be an increase in clean water demand in 2043 compared to 2023. The projected water demand for educational facilities in 2023 is 1,665 liters/pupil / second to 2,797 liters/pupil / second in 2043, as well as health facilities which are 0,535 liters / second to 0,891 liters / second, and worship facilities are 4,977 liters/unit / second to 5,347 liters/unit/second.

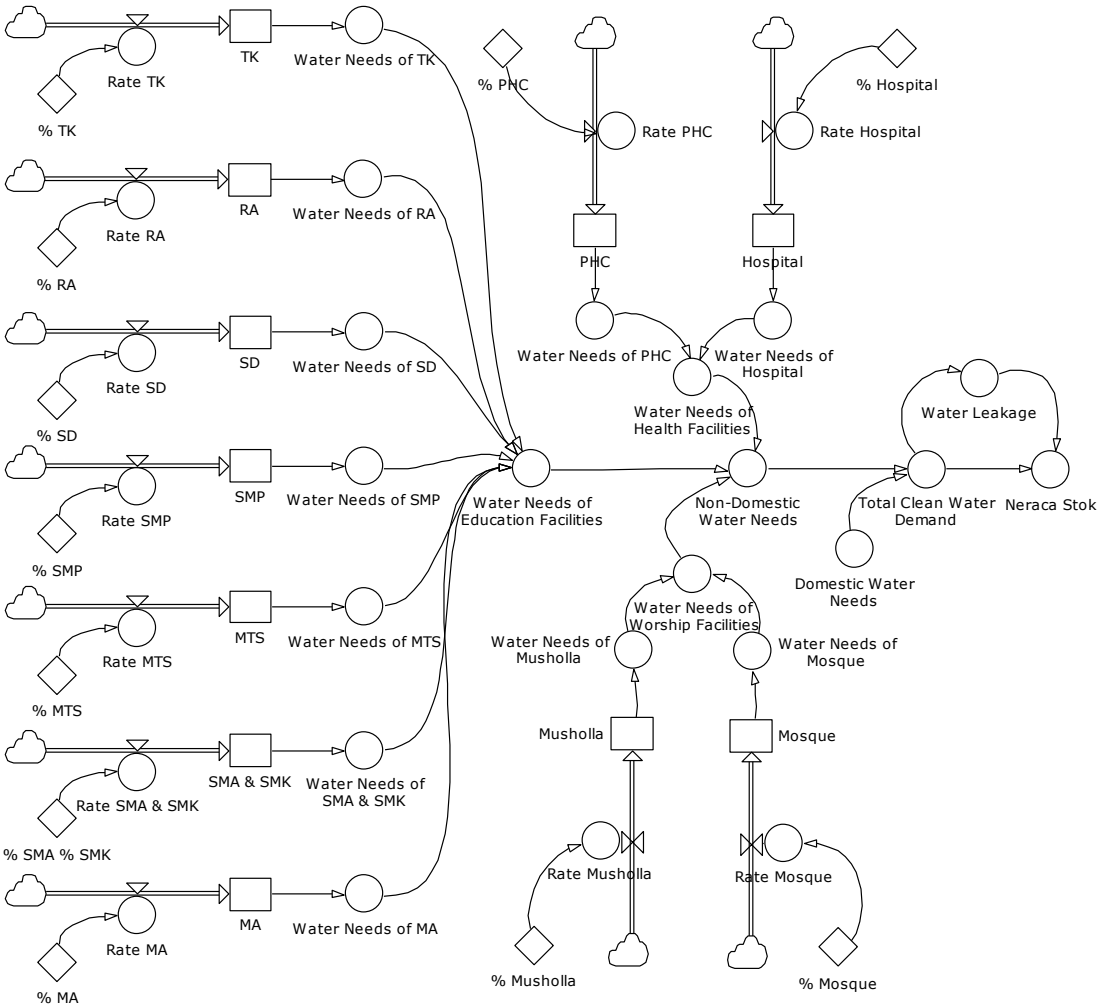

Figure 4. Stock Flow Diagram of Clean Water Requirements

The projection of total clean water demand in Lubuk Sikaping District in 2023-2043 is obtained from the sum of the projected results of domestic water demand and non-domestic water needs. Based on the projected total clean water demand in 2023-2043, it is known that the projected total clean water demand in 2023 is 74,637 liters / second and there is an increase in 2043 to

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122,376 liters / second. A water loss of 24,48 liters/second was obtained from the total water needs. The total requirement obtained from Powersim Studio 10 is 125,563 liters/second. As shown in Table 2 below

Table 2. Projected total clean water demand of Lubuk Sikaping District until 2043

year	Population	Domestic Water Needs (Ltr/Sec)	Non-Domestic Water Needs (Ltr/Sec)	Total Clean Water Demand (Ltr/Sec)
2.022	52.132	65,165	7,034	72,199
2.023	53.524	66,906	7,281	74,186
2.024	54.954	68,693	7,528	76,220
2.025	56.422	70,527	7,774	78,302
2.026	57.929	72,411	8,021	80,432
2.027	59.476	74,345	8,267	82,613
2.028	61.065	76,331	8,514	84,845
2.029	62.696	78,370	8,761	87,131
2.030	64.370	80,463	9,007	89,470
2.031	66.090	82,612	9,254	91,866
2.032	67.855	84,819	9,501	94,319
2.033	69.667	87,084	9,747	96,832
2.034	71.528	89,410	9,994	99,404
2.035	73.439	91,799	10,241	102,039
2.036	75.400	94,250	10,487	104,738
2.037	77.414	96,768	10,734	107,502
2.038	79.482	99,353	10,980	110,333
2.039	81.605	102,006	11,227	113,233
2.040	83.785	104,731	11,474	116,205
2.041	86.023	107,528	11,720	119,249
2.042	88.320	110,400	11,967	122,367
2.043	90.679	113,349	12,214	125,563

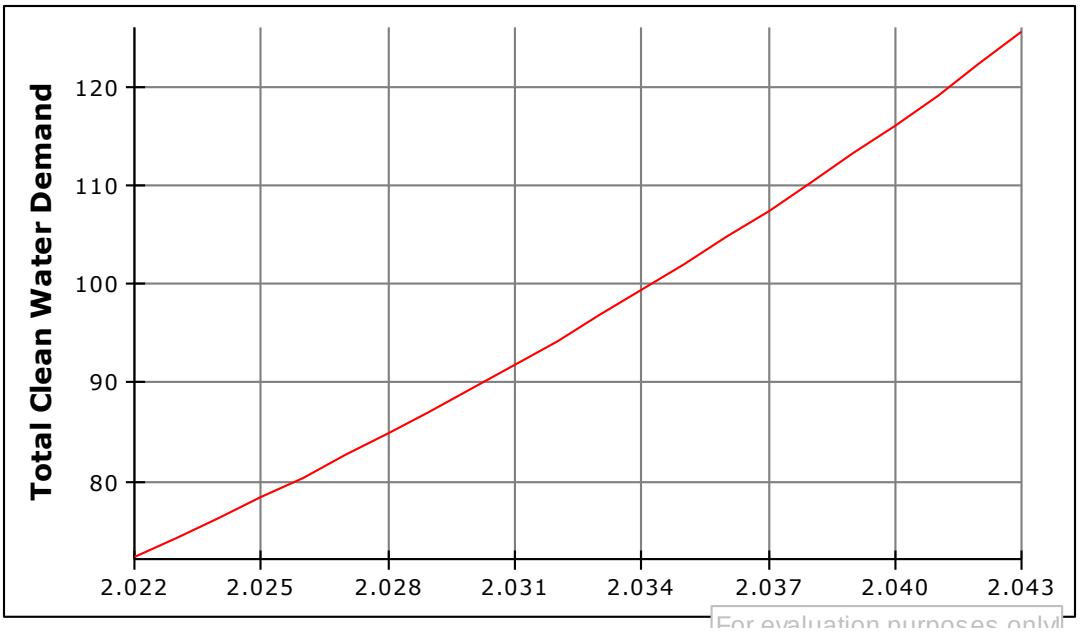

Figure 5. Graph of Total Clean Water Needs

Based on the figure in the graph above, it can be seen that the total demand for clean water has increased from 2022 to 2043.

The projection of the number of active customers of PDAM Tirta Dharma in Lubuk Sikaping District in 2043 using the arithmetic method obtained that in 2043 the number of active customers in Lubuk Sikaping District will grow to 13.066 customers, while in 2023 there will be 8.599 customers.

The projected clean water needs of PDAM Tirta Dharma's active customers in 2023, with a 90% service level coverage method, PDAM's active customers' clean water needs are 10,526 liters/second. The need for clean water for PDAM Tirta Dharma's active customers will increase in 2043. This can be seen based on the projected clean water needs of PDAM active customers

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in 2043, with a service coverage method of 90% of the population, the clean water needs of PDAM active customers are 16,333 liters/second. The following is an overview of dynamic models for water needs based on PDAM customers.

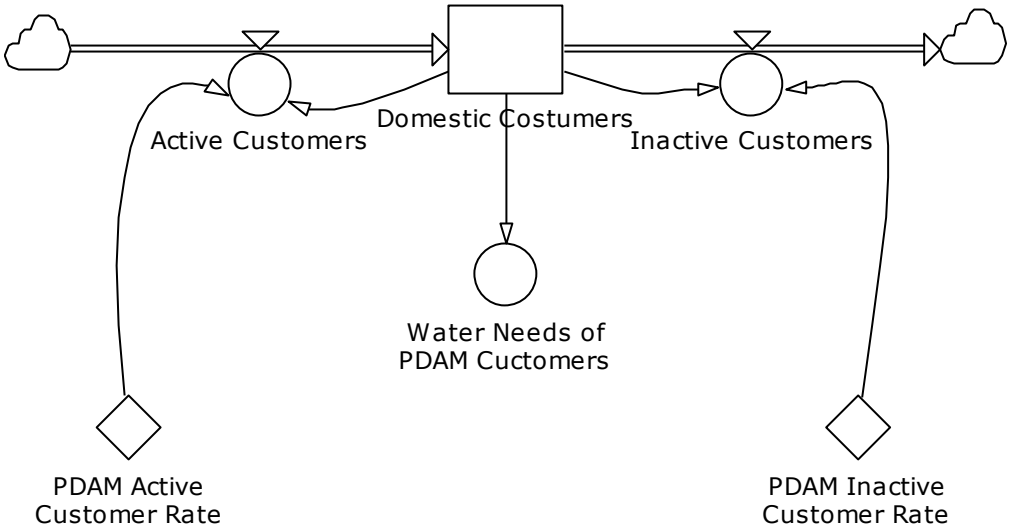

Figure 6. Stock Flow Diagram Clean water needs of PDAM customers

Table 3. Projected total clean water needs of PDAM Lubuk Sikaping District customers until 2043

year	Domestic Costumers	Water Needs of PDAM Cuctomers (Ltr/Sec)
2.022	8.421	10,526
2.023	8.599	10,749
2.024	8.781	10,976
2.025	8.966	11,208
2.026	9.156	11,445
2.027	9.350	11,687
2.028	9.547	11,934
2.029	9.749	12,186
2.030	9.955	12,444
2.031	10.166	12,707
2.032	10.380	12,976
2.033	10.600	13,250
2.034	10.824	13,530
2.035	11.053	13,816
2.036	11.286	14,108
2.037	11.525	14,406
2.038	11.769	14,711
2.039	12.017	15,022
2.040	12.272	15,339
2.041	12.531	15,664
2.042	12.796	15,995
2.043	13.066	16,333

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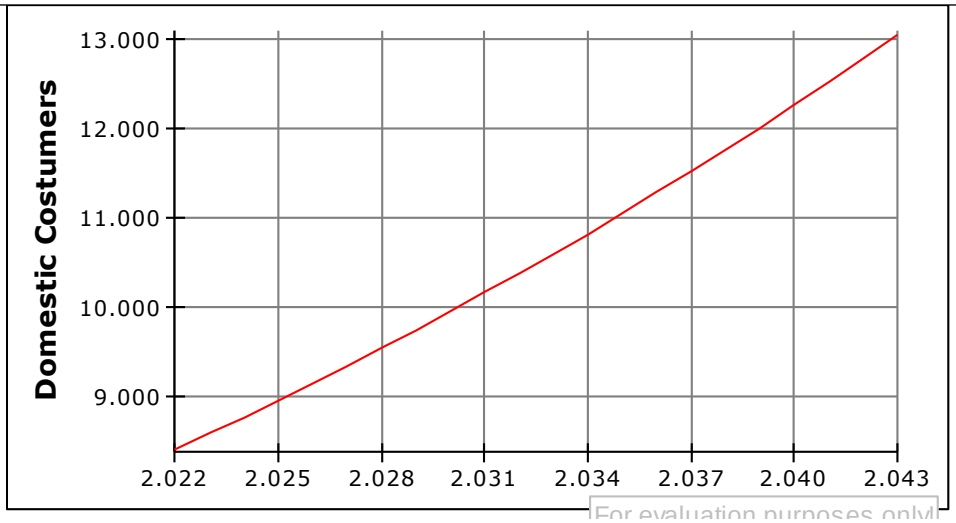

Figure 6. PDAM customer's clean water needs graph

Based on the data on the projected clean water needs of Lubuk Sikaping District, an adequate source of clean water is needed. Clean water sources used to meet the needs of Lubuk Sikaping District are obtained from surface water, springs.

CONCLUSION

Based on the analysis of data processing and the discussion that has been described, conclusions can be drawn as follows:

1. The predicted results of clean water demand in Lubuk Sikaping District from 2023 to 2043 have increased, from 74,637 liters / second to 122,376 liters/second. This happens because the population is also increasing every year, which is 90.668 people in 2043.
2. The results of predicting clean water needs using dynamic models in Powersim software also increased in 2043, amounting to 125,563 liters/second. This is because the population will increase by 90.769 people in 2043.
3. From the analysis of the data obtained the availability of water in Lubuk Sikaping District is still sufficient for the next 20 years. And based on the same installed capacity each year the availability of water is to be the same or constant every year.

REFERENCES

[1] Z. Fynnisa, M. Irwansyah, M. Hasanah, Z. Siregar, and R. Aprilia, "ANALISIS KEBUTUHAN AIR BERSIH PDAM TIRTA KUALO DI KECAMATAN DATUK BANDAR," *Menara: Jurnal Teknik Sipil*, vol. 19, no. 1, pp. 1–8, 2024, doi: 10.21009/jmenara.v19i1.36029.

[2] A. Setiawan, "ANALISIS KEBUTUHAN AIR BERSIH DI WILAYAH KECAMATAN MADURAN KABUPATEN LAMONGAN," *DEARSIP: Journal of Architecture and Civil*, vol. 3, no. 02, pp. 118–126, 2023, doi: 10.52166/dearsip.v3i02.5215.

[3] R. K. Wardahani, A. Pamudjianto, F. Desembardi, A. Rusdi, and M. Dwangga, "ANALISIS KEBUTUHAN AIR BERSIH DI KAMPUNG LILINTA DISTRIK MISOOL BARAT," *Jurnal Ilmiah Teknik Sipil (JIMATS)*, vol. 3, no. 01, pp. 53–64, 2024.

[4] A. Sofyan, K. S. Kusumahadi, S. S. U. Atmoko, Y. R. Tjamin, and T. M. Setia, "KEBUTUHAN AIR BERSIH BERBASIS PIPA PERUSAHAAN DAERAH AIR

MINUM (PDAM) DI KECAMATAN TEBET," *J Teknol*, vol. 14, no. 2, pp. 233–240, 2022, doi: 10.24853/jurtek.14.2.233-240.

[5] D. Jaya and P. G. Tamelan, "Kajian Ketersediaan dan Kebutuhan Air Bersih di Desa Compang Tenda Kabupaten Manggarai Timur: Study of clean water availability and demand in Compang Tenda Village, Manggarai Timur Regency," *Batakarang*, vol. 3, no. 1, pp. 19–23, 2022.

[6] N. Nurfatimah, "ANALISIS KEBUTUHAN AIR BERSIH DI KECAMATAN CAKRANEGARA KOTA MATARAM," *Teknosains: Media Informasi Sains dan Teknologi*, vol. 17, no. 1, 2023, doi: 10.24252/teknosains.v17i1.35310.

[7] Badan Pusat Statistik, *Kecamatan Lubuk Sikaping Dalam Angka 2023*, BPS Kabupaten Pasaman, 2023.

[8] A. F. Yadi, I. Suprayogi, M. Fauzi, and B. Bochari, "Analisa Kebutuhan Air Bersih Berdasarkan Rencana Tata Ruang Wilayah (RTRW) Kota Pekanbaru Tahun 2038," *SAINSTEK*, vol. 10, no. 2, pp. 131–137, 2022.

[9] Badan Pusat Statistik, Badan Pusat Statistik Kabupaten Pasaman, BPS Kabupaten Pasaman, 2021.

[10] R. N. Setiawan and T. Nh, "Prediksi Kebutuhan Air Bersih Desa Pinggirpapas Kecamatan Kalianget Kabupaten Sumenep Madura Pada Tahun 2029," *vol*, vol. 4, pp. 25–31, 2020, doi: 10.29405/jgel.v4i1.4261.

[11] R. D. H. Yusuf, "Analisa Kebutuhan Air Bersih Domestik Dan Non Domestik (Studi Kasus Pengolahan Air Kelurahan Kalumata)," *DINTEK*, vol. 13, no. 1, pp. 39–48, 2020.

[12] S. Simanjuntak, E. O. Zai, and M. H. Tampubolon, "Analisa Kebutuhan Air Bersih Di Kota Medan Sumatera Utara," *Jurnal Visi Eksakta*, vol. 2, no. 1, pp. 119–128, 2021.

[13] E. T. Asmorowati and D. Sarasanty, "Model Prediksi Kebutuhan Air Berbasis Sistem Dinamik di Kabupaten Mojokerto," *Dinamika Lingkungan Indonesia*, vol. 8, no. 2, pp. 91–99, 2021.

[14] B. Susetyo and G. F. Laxmi, "Model dinamis pengelolaan air bersih terpadu di Kota Bogor," *Krea-TIF: Jurnal Teknik Informatika*, vol. 5, no. 1, 2017, doi: 10.32832/kreatif.v5i1.763.

[15] I. Idwan and A. Asrasal, "Analisis Kebutuhan Air Bersih Desa Barangka Kabupaten Buton," *Jurnal Pendidikan Tambusai*, vol. 8, no. 1, pp. 2191–2197, 2024.