

Perspective of Population Growth and Clean Water Supply in Denpasar, Bali-Indonesia

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Abstract—Water is the basic need for better quality of life and becomes the sensitive issue in the urban area such as Denpasar City, the Capital of Bali province that very well known as the tourist destination in the world. Some experts predicted that Denpasar City will face the clean water crisis in 2019 and the government has made various controls to prevent the occurrence of this water crisis issues. The aim of this research is to get the perspective of clean water services in Denpasar City. The research conducted with descriptive qualitative design and supported by 52 subjects. The result showed that the average of clean water consumption is about 180 l / person / day and the total need for clean water in 2020 is 3,130,916 l / sec for 961,005 people with an annual population growth rate of 1.409%. From 2020 to 2024 Denpasar will not experience water shortages due to the availability of clean water resources is still excessive with water discharge is 240,044 l / sec in 2020 and 51,914 l / sec in 2024. However, the level of public satisfaction with clean water supply is in the low category with an average score of 139. The water is murky and the water discharge decreases during the peak hours. The government has to improve the quality of clean water services for better quality of life of the people.

Keywords—*perspective, clean water services, Denpasar City*

I. INTRODUCTION

Clean water is a natural resource used to meet daily needs such as consumption or in carrying out other daily activities. But over time, the increase in population is directly proportional to the need for water. But over time, the increase in population is directly proportional to the need for water. As the population in the western U.S steadily increase over the past century, conflicts over water allocation emerged, especially in place with large population centres and competing interest between domestic, agricultural and industrial [1]. Water crisis can occur in certain situations, for example in geological conditions where the process of groundwater travel takes thousands of years, so that if the extraction of ground water is carried out excessively, water will be lost [2]. If the availability of water is less compared to its needs, it will cause a crisis and water scarcity. The problem of water scarcity in urban areas of developing countries according to Khatri in her research is a major concern [3]. It is estimated that by 2050,

half of India's population will be living in urban areas and will face acute water problems. It was reported in 2002 that about 1.1 billion people still using water from unimproved sources, and two thirds of these people live in Asia. The number of people without improved water source in China alone is equal to the number of unserved in all of Africa. The quality of water that people receive is also questionable. In India, eighty-five percent of urban population has access to drinking water but only 20 percent available drinking water meets the health and quality standards set by the world health organization [3]. To avoid a water crisis, an appropriate clean water supply system is needed and in accordance with regional conditions.

From the technical aspect, the water supply system can be divided into 2 systems [4] there are the individual water supply system and the community/municipality water supply system. In the supply of clean water, water quality can also be assessed from sources of water used as raw water. There are several ways of taking water from this raw water system, including [5] free intake, broncaptering, dams and water pump.

Based on Bali Idep Selaras Alam Foundation's research, it's shown that there will be a clean water crisis hit Bali due to sea water intrusion through the underground because of excessive exploitation of ground water, polluted ground water, high conversion of green land, lack of surface water usage which is wasted to sea, and lack of water supply during the rainy season. In addition, the Bali Idep Selaras Alam Foundation also stated that some areas in Bali, especially in the southern part experienced a decline in groundwater levels of more than 50 meters less than 10 years and in 2012 Buyan Lake as the second largest source of freshwater supply in Bali decreased to 5 meters [6].

In other studies on water quality in Sanur by Triwulan et al in 2007, Bedugul area by Arthana in 2007, and on the south Badung beach by Sundra in 2011 found water in the area exceeded the I quality standard due to waste pollution and nearby wells with absorption of waste. In addition, the use of water in Bali also increased sharply due to the increasing number of tourist arrivals, as in 2016 there were 4,01 million foreign tourists and around 6 million domestic tourists who

lived in hotels or inns that needed water for bathing and other [7]. This will also affect population growth rate.

In a research by Sunarta et al about the development of water crisis in Bali Island in 2009 and 2013 has result that Bali has experienced a water deficit in 2009 and in 2013. The condition of Bali in 2009 showed that out of the 9 district/cities, five experienced a water deficit, whereas in 2013 it increased to 8 district/cities that have experienced a water deficit [8].

The Bali Central Statistics Agency in 2017 reported that the population density of Bali Island was 735 soul / km² with the population density of Denpasar City reaching 7,155 soul / km². Walk through survey showed that the water was brown and murky and the water discharge decreases during the peak hours. In addition, Denpasar PDAM-the regional company that supplies clean water stated that in 2014, the coverage of clean water services only reached 53.25% of the target or 45% of the total needs. This performance did not fit to the ideal number of the Millennium Development Goals (MDGs), which should be 78-80% to meet the satisfaction of customers. Haja [9] reported that the customer satisfaction of Denpasar PDAM from the aspect of complaints regarding the piping is low category, while satisfaction for aspects of water quality, water continuity, speed of installation of new connection installations in the medium category. In 2017, the water discharge of clean water reached 1094.47 l /sec, but in 2019, Denpasar will face the experience of clean water crisis, therefore, it needs the additional water sources [10]. To describe the perspective of clean water supply in Denpasar City, it is necessary to conduct research to determine population growth, clean water needs, availability of clean water and the level of community satisfaction with the supply of clean water in Denpasar that is distributed by the Denpasar City Government.

II. MATERIAL AND METHODS

A. Research Design

The research conducted with a descriptive- quantitative analysis design. Quantitative analysis was done for the population growth and clean water consumption figures that describe of the total needs of clean water. It is also analysis of a comparison of clean water sources and the needs to find out the remaining and percentage of clean water use. The descriptive analysis done to determine the consumer satisfaction. The secondary data refers to the report of the Statistic Bureau of Denpasar City and the primary data collected through the questionnaire with 52 subjects.

B. Research Location

The research conducted in Denpasar city, the capital of Bali – Indonesia, one of the Strategic areas with tourism industries and creative economics as the main pillar of economic growth.

III. RESULTS AND DISCUSSION

A. Population Analysis

1) *Number of population:* Number of populations described in Table I as below.

TABLE I. NUMBER OF POPULATIO ANALYSIS

No	Description	Method		
		Arithmetic	Logarithmic	Exponential
1	Population - 2015	880,600	880,600	880,600
2	Population - 2016	907,200	906,621	906,621
3	Population - 2017	920,500	919,918	919,918
4	Population - 2018	933,800	933,410	933,410
5	Population - 2019	947,100	947,100	947,100
6	Deviation Standard	25,583	25,569	25,569
7	Correlation	1,00	1,00	1,00

2) *Population growth:* Denpasar City divided into four sub-districts, South, East, West and North sub-districts. Projection of populations in each sub-district from 2015 to 2024 describes in Table II as below.

TABLE II. PROJECTION OF POPULATIONS IN EACH SUB-DISTRICT

No	Year	Number of Population					Total
		Sub-district Denpasar City					
		South	East	West	North		
		1,762%	1,156%	1,396%	1,322%		
1	2015	279,640	151,200	255,160	194,600	880,600	
2	2016	289,672	154,738	262,382	199,815	906,607	
3	2017	294,823	156,537	266,069	202,474	919,904	
4	2018	300,065	158,358	269,808	205,169	933,401	
5	2019	305,400	160,200	273,600	207,900	947,100	
6	2020	310,830	162,063	277,445	210,667	961,005	
7	2021	316,357	163,948	281,344	213,471	975,120	
8	2022	321,981	165,855	285,298	216,312	989,447	
9	2023	327,706	167,784	289,307	219,192	1,003,989	
10	2024	333,533	169,736	293,373	222,109	1,018,750	

Table II describes that the total population growth of Denpasar City in 2020 is 961,005 with an average population growth of about 1.409% and reaches the number of 1,018,750 in 2024. Khan stated that cities are future, the great migrations of people from rural to urban areas all over the world are proof of their power to attract and dazzle with their promise of a better life that happened population growth in the area [11]. Like population change from 1990 to 2000 at Tacoma 11,2%, Los Angeles 17,5%, San Diego 29,7 % and Las Vegas 52% [12].

B. Clean Water Consumption Figures

Clean water consumption was analysis by using the formula as below.

$$Rk = \frac{Qd}{Yn} \tag{1}$$

Where is: Rk: Clean water consumption figures by city category (lt / person / day)

Qd: Domestic water demand (lt / day)

Yn: Total population in the nth year (soul)

Refers to ..., Qd= 1,310 m³/month (based on the result of the questionnaire),

Yn = 242 persons (based on the respondent of the questionnaire)

$$Rk = \frac{1.310m^3 / month}{242persons} = 5,413m^3 / person month / = 0,180m^3 / person day / = 180 l / person / day$$

C. Data of Clean Water Needs

The need for clean water is the amount of water needed to serve the population which is divided into two classifications of water usage, namely domestic water demand and nondomestic water demand which is influenced by the clean water consumption rate. In meeting the needs of clean water, there is

a risk of water loss. So, to determine the total need for clean water also needs to be taken into account also the amount of water loss [13].

For the calculation of domestic water needs, nondomestic water needs, water loss and total need for clean water according to the Directorate General of Cipta Karya [14] can be calculated using the formula:

- Domestic water needs: $Q_D = Y_n \times R_k$ (2)
- Non-domestic water needs: $Q_n = Q_D \times m$ (3)
- Water loss: $Q_s = (Q_D + Q_n) \times 20\%$ (4)
- Total need for clean water: $Q_T = Q_D + Q_n + Q_s$ (5)

Explanation

Yn : Total population in the nth year (soul)

Rk : Clean water consumption figures by city category (lt / person / day)

m : Non-domestic percentage rate (%)

1) Domestic water demand: Based on the total number of population and the water consumption, the domestic water needs in each district of Denpasar City from 2015 to 2024 calculated as describes in Table III below.

TABLE III. DOMESTIK WATER NEEDS IN DENPASAR CITY

Year	Domestic Water Demand (m ³ /day)							
	Rk = 0,180 (m ³ /day)							
	South Denpasar		East Denpasar		West Denpasar		North Denpasar	
	Yn	Qd	Yn	Qd	Yn	Qd	Yn	Qd
2015	279.640	50.458	151.200	27.283	255.160	46.041	194.600	35.114
2016	289.672	52.269	154.738	27.921	262.382	47.344	199.815	36.055
2017	294.823	53.198	156.537	28.246	266.069	48.010	202.474	36.535
2018	300.065	54.144	158.358	28.574	269.808	46.684	205.169	37.021
2019	305.400	55.107	160.200	28.907	273.600	49.369	207.900	37.514
2020	310.830	56.086	162.063	29.243	277.445	50.062	210.667	38.013
2021	316.357	57.84	163.948	29.583	281.344	50.766	213.471	38.519
2022	321.981	58.099	165.855	29.927	285.298	51.479	216.312	39.032
2023	327.706	59.132	167.784	30.275	289.307	52.203	219.192	39.551
2024	333.533	60.183	169.736	30.627	293.373	52.936	222.109	40.078

Table III describes that domestic water needs in 2020 are 56.086 m³/day for South Denpasar district, 29.243 m³/day for East Denpasar district, 50.062 m³/day for West Denpasar district and 38.013 m³/day for North Denpasar. The domestic water needs will be reached at about 60.183 m³/day for South Denpasar district, 30.627 m³/day for East Denpasar district, 52.936 m³/day for West Denpasar district and 40.078 m³/day for North Denpasar district in 2024. As Suryadmaja reported that the Southern Badung area will need water to meet domestic water needs of 11.011.458,51 m³/year, an increase of 1,197% of the 2015 domestic water needs [15]. Van Schalkwyk also said that domestic water demand is considered to be a function of the value orientation of the community and

is tempered by metering and paying for water, moreover the actual volume of water used for domestic purpose is also affected by the number of people per tap, topography and water availability [16].

Data on domestic water demand is not only a data on clean water needs of a river. However, the amount of domestic water needs will affect the non-domestic water needs of an area.

2) Non-domestic water demand: Based on the domestic water needs, non-domestic water needs in each district of Denpasar City from 2015 to 2024 calculated as describes in Table IV below.

TABLE IV. NON-DOMESTIC WATER NEEDS IN DENPASAR CITY

Year	Non-Domestic Water Demand (m ³ /day)							
	m = 30%							
	South Denpasar		East Denpasar		West Denpasar		North Denpasar	
	<i>Q_D</i>	<i>Q_N</i>	<i>Q_D</i>	<i>Q_N</i>	<i>Q_D</i>	<i>Q_N</i>	<i>Q_D</i>	<i>Q_N</i>
2015	50.458	15.138	27.283	8.185	46.041	13.812	35.114	10.534
2016	52.269	15.681	27.921	8.376	47.344	14.203	36.055	10.816
2017	53.198	15.959	28.246	8.474	48.010	14.403	36.535	10.960
2018	54.144	16.243	28.574	8.572	48.684	14.605	37.021	11.106
2019	55.107	16.532	28.907	8.672	49.369	14.811	37.514	11.254
2020	56.086	16.826	29.243	8.773	50.062	15.019	38.013	11.404
2021	57.084	17.125	29.583	8.875	50.766	15.230	38.519	11.556
2022	58.099	17.430	29.927	8.978	51.479	15.444	39.032	11.709
2023	59.132	17.739	30.275	9.083	52.203	15.661	39.551	11.865
2024	60.183	18.055	30.627	9.188	52.936	15.881	40.078	12.023

Table IV describes that non-domestic water needs in 2020 are 16.826 m³/day for South Denpasar district, 8.773 m³/day for East Denpasar district, 15.019 m³/day for West Denpasar district and 11.404 m³/day for North Denpasar. The nondomestic water needs will be reached at about 18.005 m³/day for South Denpasar district, 9.188 m³/day for East Denpasar district, 15.881 m³/day for West Denpasar district and 12.023 m³/day for North Denpasar district in 2024. Suryadmaja in his research report that in 2020 the Southern Badung region experienced an increase in the number of non-domestic water needs by 1,197% from 2015 to 8.004.224,19 m³/year [15]. Hanlie conveyed the result of her evaluation in the South African region in her research related to statistical characterization and estimation of non-domestic water demands shows for the category Business Commercial, Industrial, Agricultural Holdings and Sport & Park Player have

similar median annual average daily demand (AADD) of between 1,5 and 1,7 kl/property/day. For Educational properties used substantially more water (4,7 kl/property/day), while Government & Institutional properties used substantially less water (0,7 kl/property/day). That showed if property size has the greatest impact on water demand for most category [17]. This also applies to area with high population mobility and population density.

To find out the total clean water needs, must know loss of water due to the clean water supply process besides the large of domestic and non-domestic water needs.

3) *Water loss*: Based on the non-domestic water needs, water loss in each district of Denpasar City from 2015 to 2024 calculated as describes in Table IV below.

TABLE V. CLEAN WATER NEEDS IN DENPASAR CITY

Year	Water Loss (m ³ /day)							
	% Max. Loss of water that is allowed = 20%							
	South Denpasar		East Denpasar		West Denpasar		North Denpasar	
	<i>Q_D + Q_N</i>	<i>Q_S</i>	<i>Q_D + Q_N</i>	<i>Q_S</i>	<i>Q_D + Q_N</i>	<i>Q_S</i>	<i>Q_D + Q_N</i>	<i>Q_S</i>
2015	65.596	13.119	35.467	7.093	59.854	11.971	45.648	9.130
2016	67.949	13.590	36.297	7.259	61.548	12.310	46.871	9.374
2017	69.157	13.831	36.719	7.344	62.413	12.483	47.495	9.499
2018	70.387	14.077	37.147	7.429	63.290	12.658	48.127	9.625
2019	71.639	14.328	37.579	7.516	64.179	12.836	48.768	9.754
2020	72.912	14.582	38.016	7.603	65.081	13.016	49.417	9.883
2021	74.209	14.842	38.458	7.692	65.996	13.199	50.075	10.015
2022	75.528	15.106	38.905	7.781	66.923	13.385	50.741	10.148
2023	76.871	15.374	39.358	7.872	67.864	13.573	51.416	10.283
2024	78.238	15.648	39.815	7.963	68.817	13.763	52.101	10.420

Table V describes that water loss in 2020 are 14.582 m³/day for South Denpasar district, 7.603 m³/day for East Denpasar district, 13.016 m³/day for West Denpasar district and 9.883 m³/day for North Denpasar. The water loss will be reached at about 15.648 m³/day for South Denpasar district, 7.963 m³/day for East Denpasar district, 13.763 m³/day for West Denpasar district and 10.420 m³/day for North Denpasar district in 2024. In his research, Suryadmaja reported that in 2020 Southern Badung was estimated to experience water loss

of 4.373.608,17 m³/year, an increase of 1,197% of the total water loss in 2015 [15]. Karadirek conveyed in his research if in other countries have water loss management to control the quality and quantity of their water. For example, Turkey have water loses max 43,6%, Latin American 40-55%, Brazil 39,1%, Italy 36 % and UK 20-23% of water needs. So, water losses from water distribution networks have become a crucial problem in many countries. Reduction of water losses

contributes directly to protection of water quality in water and public health [18].

After obtaining data on domestic water demand, nondomestic water demand and the amount of water loss that may occur, it can be calculated the total amount of clean water needs of an area.

4) *Total need for clean water:* Total water demand is the total water needs both domestic and non-domestic plus water loss. So, the clean water needs in each district of Denpasar City from 2015 to 2024 calculated as describes in Table VI below.

TABLE VI. CLEAN WATER NEEDS IN DENPASAR CITY

No	Year	Clean Water Needs m3/day				
		Sub-district				Total
		South	East	West	North	
1	2015	78,715	42,561	71,824	54,777	247,878
2	2016	81,539	43,557	73,857	56,245	255,199
3	2017	82,989	44,063	74,895	56,994	258,942
4	2018	84,465	44,576	75,948	57,753	262,741
5	2019	85,966	45,094	77,015	58,521	266,597
6	2020	87,495	45,619	78,097	59,300	270,511
7	2021	89,050	46,149	79,195	60,089	274,484
8	2022	90,634	46,686	80,308	60,889	278,517
9	2023	92,245	47,229	81,436	61,700	282,610
10	2024	93,885	47,778	82,581	62,521	286,766

Table VI describes that total clean water needs in 2020 is 270,511 m3/day and will reached at about 286,766 in 2024. Okello's research results show that if there is no decrease development on Lamu Island, the population is estimated to decrease by 50.000 by 2065. However, after projecting the population will reach 1,25 million in 2050, judging from the groundwater abstraction in 2009 of 0,06 m³ daily per capita while the results of the exponential population growth equation show an annual population growth rate of 0,003% resulting in daily demand per capita rising to 0,1 m³. Other results indicate the availability of freshwater will change due to population growth and is exacerbated by land used [19].

D. Clean Water resources

The availability of clean water is the main thing to guarantee the viability of survival that must be fulfilled by the government, both the central and regional governments. Increasing the availability of water in the future is the most important thing for human life for its survival. The existence of hydrological cycles and different regional conditions in each

region, the amount of water availability in each region will be different.

The United Nations World Report in 2015 also stated that water flows through the tree pillars of sustainable development, there are economic, social and environmental. Water resources, and the essential services they provide, are among the keys to achieving property reduction, inclusive growth, public health, food security, life of dignity for all and long-lasting harmony with Earth's essential ecosystem [20].

The perspective of clean water resources describes in Table VII as below.

TABLE VII. PERSPECTIVE OF CLEAN WATER RESOURCES

No	Year	Description			
		Clean water needs (a)	Clean water resources (b)	Remaining capacity (b-a)	Percentage
		(l/sec)	(l/sec)	(l/sec)	(%)
1	2015	2,868,958	1,170,960	-1,697,998	245,01
2	2016	2,953,687	1,170,960	-1,782,727	252,24
3	2017	2,997,008	1,170,960	-1,826,048	255,94
4	2018	3,040,980	2,870,960	-170,020	105,92
5	2019	3,085,612	3,370,960	285,348	91,54
6	2020	3,130,916	3,370,960	240,044	92,88
7	2021	3,176,900	3,370,960	194,060	94,24
8	2022	3,223,576	3,370,960	147,384	95,63
9	2023	3,270,955	3,370,960	100,005	97,03
10	2024	3,319,046	3,370,960	51,914	98,46

Table IV describes that the clean water resources in Denpasar City still meets the clean water needs in 2024. It means that the people in Denpasar City will not experience of clean water shortage. However, Sunarta never reported that Bali has experienced a water deficit in 2009 and in 2013. The total water supply in Bali in 2009 amounted to 4.71 billion m3/year and decreased to 3.57 billion m3/year in 2013, but the total water demand increased; in 2009 it amounted to 5.46 billion m3/year and in 2013 it amounted 6.23 billion m3/year. Thus, water crisis is determined by comparing the amount of supply and demand of water in a period [8].

E. Level Satisfaction on Clean Water Supply

Level of satisfaction measured by analyzing the result of the questionnaire with four of Likert scale: strongly agree (SA) with score of (4); agree (A) with score of (3); not agree (NA) with score of (2) and strongly not agree (SNA) with score of (1). There were 11 items of statement as indicators that subject not satisfied with clean water supply. Result of the analysis is describes in Table VIII bellow.

TABLE VIII. LEVEL OF SATISFACTION SCORE

N Subject	Item	SA	A	NA	SNA	Total Score	Average Score	Category
52	1	1	21	24	6	121	2.33	NA
52	2	0	1	42	9	96	1.85	NA
52	3	2	14	32	4	118	2.27	NA
52	4	31	15	3	3	178	3.42	NA
52	5	10	15	22	5	134	2.58	A
52	6	10	16	22	4	136	2.62	A
52	7	6	32	11	3	145	2.79	A
52	8	18	23	8	3	160	3.08	A
52	9	11	17	19	5	138	2.65	A
52	10	19	21	9	3	160	3.08	A
52	11	11	24	14	3	147	2.83	A
Total							29.48	
Average							2.68	A

Table V describes that the average score is 2.68~3, it means the subject agreed that the clean water supply is not satisfactory. It is in accordance with the result of walk through survey that the water was brown and murky and the water discharge decreases during the peak hours. Abebaw's research results show that better access to water source will increase satisfaction in terms of water quality and availability, but the effect of increasing water sources on user satisfaction is slightly lower for water availability than water quality [21]. So, to find out the optimal water supply needs to be seen from various aspects and adjusted to the standard of water supply. As China did, the region was able to provide clean water and repair damage quickly, precisely and properly. So that, the number of people who do not have a better water source in China is the same as the number of people not served throughout Africa [22].

IV. CONCLUSION

Base on the data analysis and discussions, there are some important points can be concluded as bellows.

- The total population of Denpasar City in 2020 was 961,005 with an average population growth of about 1.409%.
- The average number of clean water consumption in Denpasar is 180 l / person / day with the highest reaches of about 300 l / person / day, while the lowest is only 100 l / person / day.
- The total need of clean water in Denpasar City was 3,130,916 l / sec in 2020 and reached about 3,319,046 l / sec in 2024.
- Denpasar City still meets the clean water needs in 2024. It means that the people in Denpasar City will not experience of clean water shortage. There is still a remaining capacity of clean water sources, which is 240,044 l / sec in 2020 and 194,060 and 51,914 l / sec in 2024.

V. RECOMMENDATIONS

Continuous campaigns about water saving culture are important to increase people awareness of the water resources conservation and the environment, started from the early age of children.

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