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ANALYSIS OF WATER DEMAND AND AVAILABILITY IN WAE MESE I WATER TREATMENT PLANT TO NUMBER OF CUSTOMERS IN 2030
(Case study: PERUMDA AIR MINUM WAE MBELILING)

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Abstract

Starting from bathing, washing, cooking to the elements of the human body, one of which also consists of water. The need for clean water is increasing along with population growth. In this study, an analysis of the need for and availability of clean water was carried out in the service area of the Wae Mese I Water Treatment Plant (WTP), which covers seven urban villages in the Komodo sub-district. Projected water demand is based on population growth from 2021 to 2030. Projected water availability is based on the production capacity of WTP Wae Mese I from 2021 to 2030. Based on projected water demand and availability, water balance and WTP production capacity are analyzed in 2030. Based on the results analysis, the population in 2030 will reach 45715 people and the total water demand in 2030 will be 62.06 liters/second. Meanwhile, the capacity of WTP Wae Mese I 40 liters/second has decreased to 33.81 liters/second in 2030. This results in a water deficit of 28.25 liters/second.

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1. Introduction

Water in human life has a very vital function. Human daily activities can never be separated from water. Starting from bathing, washing, cooking to the elements of the human body, one of which also consists of water. The water in question is clean water that does not contain chemical elements that can harm and interfere with the function of human organs. Given that clean water is an unlimited and sustainable need. Fulfillment of water needs is not only related to sufficient discharge but in terms of quality it meets applicable standards and must continuously be able to meet the community's needs within a certain period of time. The development of clean water infrastructure needs attention from the government, the private sector and also the community.

PERUMDA Wae Mbeliling is a business unit owned by the West Manggarai district government which is responsible for meeting the clean water needs of the community, which is also a form of government service to the community. PERUMDA's raw water sources for Wae Mbeliling drinking water come from the water of Wae Mowol, Wae Moto, Wae Mbaru, Wae Kaca, Wae Cumpe and surface water of the Wae Mese river. The five springs serve the people around the city of Labuan Bajo by gravity. Meanwhile, the surface water of the Wae Mese River is the source of raw water for the capital city of West Manggarai Regency, namely Labuan Bajo which covers seven villages in the Komodo District.

The surface water of the Wae Mese River is utilized by building the Wae Mese I Water Treatment Plant (WTP) and distributed by means of a pump. Wae Mese I WTP services cover the area of the Komodo sub-district, which includes seven sub-districts. WTP production capacity is 40 liters/second with a total service of 4,535 SR in 2021. Wae Mese I WTP production capacity is not yet sufficient for the community's water needs, it is proven that a system of distributing water twice a week is still implemented for several areas of clean water service. Therefore, it is necessary to assess the need for and availability of clean water, as an effort to improve clean water services.

In the next ten years, namely in 2030, the population will increase which will certainly affect the increase in the demand for clean water. The availability of existing water may not necessarily be able to balance the increasing demand for clean water, for this reason it is necessary to analyze the demand and availability of existing clean water for the next few years, namely until 2030. With this research, it is hoped that it can provide an alternative solution to the problem of clean water, especially for Wae Mese I WTP service area.

2. Materials and Methods

To make it easier to find out the order in which the Final Project work will be carried out, the author presents the work methodology in the following flowchart:

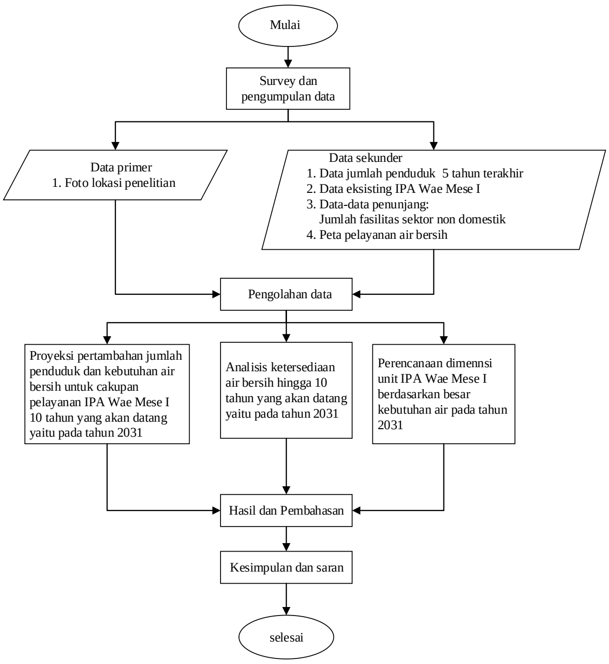

Fig.1 Flowchart

2.1 Research Significance

This study aims to determine the need for water in the service area of the Wae Mese I water treatment plant from 2021 - 2030. Water demand increases along with population growth, so population projections are made. Furthermore, domestic and non-domestic water needs are calculated based on the Planning Criteria for the Directorate General of Human Settlements, Public Works Service, 1996. From the results of the water demand an alysis, it is known that the production capacity of the Water Treatment Plant in 2030 is to meet the water needs of the community in the city of Labuan Bajo.

2.2 Study Area (if any)

Wae Mese I Drinking Water Treatment Installation serves the Labuan Bajo city area which includes 7 villages in Komodo District, District. West Manggarai, Prov. East Nusa Tenggara. The seven villages include the villages of Macang Tanggar, Batu Cermin, Labuan Bajo, Wae Kelambu, Nggorang, Golo Bilas and Gorontalo.

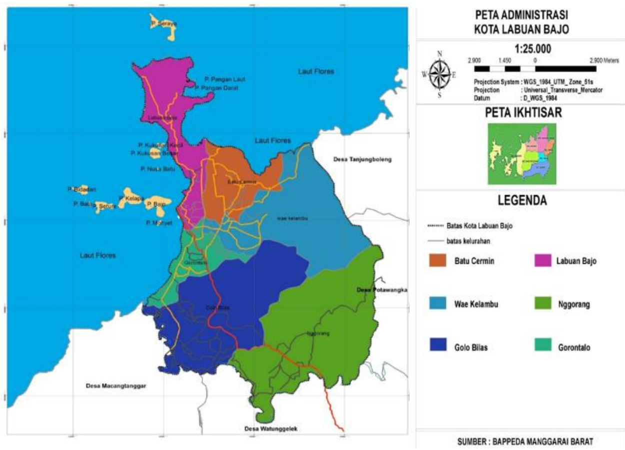

Fig.2 Labuan Bajo City Administration Map

2.3 Data

Sources of data used in this research are secondary data and primary data. The data are as follows:

1. Secondary Data

Data obtained from institutions related to research studies, in this case namely PERUMDA Wae Mbeliling Drinking Water. The secondary data is in the form of:

a. Data on population in the service area of Wae Mese I WTP for the last 5 years, namely 2016 – 2020.
b. Existing data for Wae Mese I WTP, in the form of water discharge data and WTP units.
c. Data supporting the number of facilities in the non-domestic sector, such as educational, health,
d. office, trade, public and recreational facilities, sports, and industry.
e. Image of map of the clean water service area of Wae Mese I WTP.

2. Primary Data

Data obtained by going down directly to the location/field. The primary data needed is field survey photos, Describe the data used, and how they were obtained.

2.4 Analysis Method

2.4.1. Analisys of Population Growth

- Geometric Method

$$Pn = Po(1 + r)^n \quad (1)$$

- Arithmetic method

$$Pn = Po(1 + rn) \quad (2)$$

- exponential method

$$Pn = P_0 \; x \; e^{rn} \quad (3)$$

Where:

Pn = population in year n projection (people)

Po = total population at the start of the projection

e = 2.7182818

r = average population increase (%)

n = projection period (years)

The basis for selecting population projections used is the calculation of the standard deviation. The standard deviation (Sd) is a statistical value that determines the distribution of the data in the sample, and how close the individual data points are to the average sample value. The standard deviation used is the smallest, because a small standard deviation value indicates that the data obtained from the projection is not much different from the original data (BPS, 2010).

$$SD = \sqrt{\frac{\sum(Yi-Yn)^2}{n}} \qquad (4)$$

Where:

SD = standard deviation

Yi = population projection data

Yn = average number of initial population

n = amount of data

2.4.2. Analysis of Clean Water Needs

- Domestic

Table 1. Clean Water Planning Criteria

Description	Cities Category Based on Total Population				
	>1.000.000 I	500.000 s/d 1.000.00 II	100.000 s/d 500.000 III	20.000 s/d 100.000 IV	< 20.000 IN
1. Consumption of house connection units (SR) (liters/person/day)	>150	150-120	90-120	80-120	60-80
2. Consumption of hydrant units (HU) (liters/person/day)	20-40	20-40	20-40	20-40	20-40
3. Non-domestic consumption					
a. Small business (liters/units/day)	800	800		600	
b. Big business (liters/units/day)	3000	3000		1500	
c. Large industry (liters/second/ha)	0,2-0,8	0,2-0,8		0,2-0,8	
d. tourism(liters/second/ha)	0,1-0,3	0,1-0,3		0,1-0,3	
4. Water loss(%)	20-30	20-30	20-30	20-30	20-30
5. Maximum daily factor	1,15	1,15	1,15	1,15	1,15
6. peak hour factor	1,5	1,5	1,5	1,5	1,5
7. Number of souls per SR (soul)	5	5	5	5	5
8. Number of souls per HU (people)	100	100	100	100	100
9. Residual pressure in distribution supply (meters)	10	10	10	10	10
10. Operating hours (hours)	24	24	24	24	24
11. Volume reservoir (% max day demand)	15-25	15-25	15-25	15-25	15-25
12. SR: HU	50 : 50 s/d 80 : 20	50 : 50 s/d 80 : 20	80 : 20	70 : 30	70 : 30
13. Service coverage(%)	90	90	90	90	70

Source: Planning Criteria for the Directorate General of Cipta Karya, Public Works Service, 1996

- Non Domestic

Table 2 City Non-Domestic Water Needs Categories I, II, III, IV

Sector	Mark	Unit
School	10	liters/person/day
Hospital	200	liters/bed/day
Public health center	2.000	Liters/unit/day
Mosque	3.000	Liters/unit/day
Office	10	Liter/employee/day
Market	12.000	Liters/hectare/day
Shop	500	Liters/unit/day
Hotel	150	liters/bed/day
Restaurant	100	Liter/seat/day
Military complex	60	liters/person/day
Industrial area	0,2-0,8	Liters/second/ha
Tourism area	0,1-0,3	Liters/second/ha

Source: Planning Criteria for the Directorate General of Cipta Karya, Public Works Service, 1996

2.4.3. Debit Analisys of WTP

To project the availability of the water discharge of the Wae Mese I Water Treatment Plant in the next ten years, namely in 2030, it is necessary to recapitulate the water discharge of the Water Treatment Plant for the last 5 years. Based on availability data for the last 5 years, namely 2016-2020, a linear regression formula can be used to project water availability for the next 10 years, namely in 2030.

$$Yn = a + (b.x) \qquad (5)$$

Yn = total water debit in the nth year

a, b = costing

x = period of time (year)

N = amount of data

3. Result and Discussion

3.1 Analysis of Population Growth

Total population is the main factor in the analysis of clean water demand in the study area. The population data used to calculate the average population growth is data on the population of 7 sub-districts in the Komodo sub-district, namely from 2016 - 2020. In planning this population projection, it is planned for the next 10 years, namely from 2021 - 2030.

The following is data on the population of the Komodo sub-district per village served by the Wae Mese WTP from 2016 – 2020.

Table 3 Data on the population in the Komodo District

No	Village	Year				
		2016	2017	2018	2019	2020
1	Golo Bilas	4196	4306	4389	4622	4906
2	Gorontalo	7464	7245	6983	7166	7292
3	Macang Tanggar	3039	3048	3016	3179	3079
4	Nggorang	1761	1845	1900	2018	2201
5	Wae Kelambu	5652	5855	6308	6704	7676
6	Batu Cermin	5322	5403	5569	5712	6024
7	Labuan Bajo	7360	7203	6848	6915	6154
	Amount	34794	34905	35013	36316	37332

Source: Komodo District in Figures 2017 – 2021

Then the population growth rate is calculated every year to get the average population growth.
An example of calculating the population growth rate for the Golo Bilas sub-district:

$$r_n = \frac{Pn-Po}{Po}\ x\ 100\ \% \qquad (1)$$

Information:

r_n = growth rate
P_n = population in year n
P_O = total population in the initial year

$$r_{2017} = \frac{P_{2017} - P_{2016}}{P_{2016}}\ x\ 100 = \ 2{,}62\ \%$$

$$r_{2017} = \frac{4306 - 4196}{4196}\ x\ 100 = \ 2{,}62\ \%$$

The following is a recapitulation of the population growth rate for each village.

Table 4 Population growth rate in Komodo District

Village	Year					
	2016	2017	2018	2019	2020	rate-rate(%)
Golo Bilas	-	2,62	1,93	5,31	6,14	4,00
Gorontalo	-	-2,93	-3,62	2,62	1,76	-0,54
Macang Tanggar	-	0,30	-1,05	5,40	-3,15	0,38
Nggorang	-	4,77	2,98	6,21	9,07	5,76
Wae Kelambu	-	3,59	7,74	6,28	14,50	8,03
Batu Cermin	-	1,52	3,07	2,57	5,46	3,16
Labuan Bajo	-	-2,13	-4,93	0,98	-11,01	-4,27

Source: Calculation Results, 2022

Based on the population growth rate in table 2, population projections are calculated using geometric, arithmetic and exponential methods. From the calculation of population projections using the three methods, the one with the smallest standard deviation is the arithmetic method. So the population projection for the planning year (2021-2030) uses the arithmetic method.

Population projection using the arithmetic method:

$$P_n = P_o(1 + rn)$$

Information:

r_n = growth rate

P_n = population in year n

P_o = total population in the initial year

An example of calculating the population projection for the Golo Bilas sub-district:

$$P_n = P_{2020}(1 + (4\% \, x(Year_n - 2020)$$

$$P_{10(2030)} = 4906\ (1 + 4\ \% \ x\ 10) = 6869\ people$$

The following is a recapitulation of population projections for 2021 – 2030

Village	Year									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Golo Bilas	5102	5299	5495	5691	5887	6084	6280	6476	6672	6869
Gorontalo	7252	7213	7173	7134	7094	7054	7015	6975	6936	6896
Macang Tanggar	3091	3102	3114	3125	3137	3149	3160	3172	3183	3195
Nggorang	2328	2454	2581	2708	2835	2961	3088	3215	3342	3468
Wae Kelambu	8292	8908	9524	10140	10756	11373	11989	12605	13221	13837
Batu Cermin	6214	6404	6594	6784	6975	7165	7355	7545	7735	7925
Labuan Bajo	5891	5628	5365	5102	4839	4577	4314	4051	3788	3525
Total	38170	39009	39847	40685	41524	42362	43200	44038	44877	45715

Source: Calculation Results, 2022

3.2 Analysis of Clean Water Needs

The standard for clean water needs is based on the Planning Criteria for the Directorate General of Cipta Karya, Public Works Service, 1996.

4.2.1 *Domestic Water Needs*

Domestic water needs include House Connection (SR) and Public Hydrants (HU).

Based on table 1 regarding clean water planning criteria, Komodo sub-district is included in the small town category (IV) with a population ranging from 20,000 – 100,000 people.

Table 5 Domestic Sector Service Coverage 2021 - 2030

No	Year	Total Population	Service Coverage		SR		HU	
			%	People	%	People	%	People
[a]	[b]	[c]	[d]	[and]	[f]	[g]	[h]	[i]
1	2021	38170	90	34353	70	24047	30	10306
2	2022	39009	90	35108	70	24575	30	10532
3	2023	39847	90	35862	70	25104	30	10759
4	2024	40685	90	36617	70	25632	30	10985
5	2025	41524	90	37371	70	26160	30	11211
6	2026	42362	90	38126	70	26688	30	11438
7	2027	43200	90	38880	70	27216	30	11664
8	2028	44038	90	39635	70	27744	30	11890
9	2029	44877	90	40389	70	28272	30	12117
10	2030	45715	90	41144	70	28801	30	12343

Source: Calculation Results, 2022

- Home Connection (SR)

Table 6 Water Needs for House Connections 2021 - 2030

No	Year	Number of Served Population (people)	Water Usage Standard (liters/person/day)	Total Water Needs (liters/second
[a]	[b]	[c]	[d]	[and]
1	2021	24047	100	27,83
2	2022	24575	100	28,44
3	2023	25104	100	29,06
4	2024	25632	100	29,67
5	2025	26160	100	30,28
6	2026	26688	100	30,89
7	2027	27216	100	31,50
8	2028	27744	100	32,11
9	2029	28272	100	32,72
10	2030	28801	100	33,33

Source: Calculation Results, 2022

$$SR = \frac{number\ of\ people\ x\ std.water\ usage\ (\frac{lIter}{person}/day)}{86400\ second}$$

$$SR_{2030} = \frac{28801\ person\ x\ 100\ (\frac{lIter}{person}/day)}{86400\ second} = 33{,}33 \text{ liter/second}$$

- Public Hydrant (HU)

Table 7 Water Needs for Public Hydrants 2021 - 2030

No	Year	Number of Served Population (people)	Water Usage Standard (liters/person/day)	Total Water Needs (liters/second)
[a]	[b]	[c]	[d]	[and]
1	2021	10306	30	3,58
2	2022	10532	30	3,66
3	2023	10759	30	3,74
4	2024	10985	30	3,81
5	2025	11211	30	3,89
6	2026	11438	30	3,97
7	2027	11664	30	4,05
8	2028	11890	30	4,13
9	2029	12117	30	4,21
10	2030	12343	30	4,29

Source: Calculation Results, 2022

$$SR = \frac{number\ of\ people\ x\ std.water\ usage\ (\frac{lIter}{person}/day)}{86400\ second}$$

$$SR_{2030} = \frac{12343\ person\ x\ 30\ (\frac{lIter}{person}/day)}{86400\ second} = 4{,}29 \text{ liter/second}$$

So the amount of domestic water demand is the amount of water needed for SR plus HU which is 37.62 liters/second.

4.2.2 *Non Domestic Water Needs*

The water demand for the non-domestic sector is calculated based on table 8 Planning Criteria for the Directorate General of Cipta Karya, 1996. The following is a recapitulation of domestic and non-domestic water needs for 2021-2030.

Table 7 Recapitulation of Domestic and Non-Domestic Water Needs 2021-2030

Facility	Water Requirement (liters/second)									
	Year									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic										
Home Connection (SR)	27,83	27,83	29,06	29,67	30,28	30,89	31,5	32,11	32,72	33,33
Hydrant Uum (HU)	3,58	3,66	3,74	3,81	3,89	3,97	4,05	4,13	4,21	4,29
Non Domestic										
Health	0,76	0,76	0,76	0,76	0,76	1,13	1,13	1,13	1,13	1,13
Education	1,74	1,78	1,82	1,85	1,89	1,93	1,97	2,01	2,04	2,08
worship	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36
Hotel	3,22	3,51	3,8	4,09	4,37	4,66	4,95	5,24	5,52	5,81
trade	1,17	1,2	1,22	1,24	1,27	1,29	1,31	1,34	1,36	1,38
Office	0,145	0,153	0,161	0,168	0,176	0,184	0,191	0,199	0,206	0,214
airport and seaport	1,45	1,64	1,82	2,01	2,19	2,18	2,56	2,75	2,94	3,12
Total (l/dtk)	40,26	40,89	42,741	43,958	45,186	46,594	48,021	49,269	50,49	51,71

Source: Calculation Results, 2022

Furthermore, it is calculated that water loss is 20% of the total water demand for the domestic and non-domestic sectors. Total water demand by adding up domestic and non-domestic water needs with water loss. From the total water demand, fluctuations in water use are calculated, namely the maximum daily water demand and peak hours. The maximum daily water demand is calculated by multiplying the maximum daily factor by the total water demand. Likewise, the peak hour water demand is calculated by multiplying the peak hour demand factor by the total water demand. The maximum daily factor and peak hour requirement can be seen in table 1 of clean water planning criteria (Directorate General of Human Settlement Planning Criteria for the Public Works Service, (1996).

Table 8 Water Loss and Total Water Needs 2021 - 2030

Year	Q Domestic and non-domestic	Water Loss (liters/second)	Total Water Needs (liters/second)
[a]	[b]	[c]	[d]
2021	40,26	8,05	48,31
2022	40,89	8,18	49,07
2023	42,74	8,55	51,29
2024	43,96	8,79	52,75
2025	45,19	9,04	54,22
2026	46,59	9,32	55,91
2027	48,02	9,60	57,63
2028	49,27	9,85	59,12
2029	50,49	10,10	60,58
2030	51,71	10,34	62,06

Source: Calculation Results, 2022

Table 9 Recapitulation of Projected Water Demand for 2021 – 2030

Year	Q Total (liters/second)	Maximum daily requirement (liters/second)	Peak Hour Water Requirement (liters/second)
2021	48,31	55,55	72,46
2022	49,07	56,43	73,61
2023	51,29	58,98	76,93
2024	52,75	60,66	79,12
2025	54,22	62,36	81,33
2026	55,91	64,30	83,87
2027	57,63	66,27	86,44
2028	59,12	67,99	88,68
2029	60,58	69,67	90,87
2030	62,06	71,37	93,09

Source: Calculation Results, 2022

3.3 Analysis of Water Availability

The availability of water in the Wae Mese 1 WTP was analyzed based on production discharge data for the last 5 years (2017 – 2021) using the linear regression method. Projected water availability until 2030, so that water balance can be calculated until 2030.

Table 10 Calculation of Production Capacity Projection

No	Year	Year (X)	Q position (Y)	X2	XY
1	2017	0	38,6	0	0
2	2018	1	38,3	1	38,3
3	2019	2	37,9	4	75,8
4	2020	3	37,4	9	112,2
5	2021	4	37,2	16	148,8
n		10	189,4	30	375,1

Source: Calculation Results, 2022

$$a = \frac{\sum Y . \sum X^2 - \sum X . \sum XY}{N . \sum X^2 - (\sum X)^2} = \frac{189{,}4\ x\ 30 - 10\ x\ 375{,}1}{5\ x\ 30 - (10)^2} = \frac{1931}{50}$$

$$= 38{,}6$$

$$b = \frac{N . \sum XY - \sum X . \sum Y}{N . \sum X^2 - (\sum X)^2} = \frac{5\ x\ 375{,}1 - 10 . 189{,}4}{5\ x 30 - (10)^2} = -0{,}37$$

$$Yn = a + (b . x)$$

$$Y_{2021} = 38{,}6 + \left(-0{,}37x\ (2021 - 2017)\right) = 37{,}2\ liter/second$$

$$Y_{2030} = 38{,}6 + \left(-0{,}37x\ (2030 - 2017)\right) = 33{,}81\ liter/second$$

Table 10 Water Balance Projections 2021 - 2030

Year	Q Production (QP) (liters/second)	Q Needs (QK) (liters/second)	QP - QK (Liters/second)
[a]	[b]	[c]	[d]
2021	37,20	48,31	-11,11
2022	36,77	49,07	-12,30
2023	36,40	51,29	-14,89
2024	36,03	52,75	-16,72
2025	35,66	54,22	-18,56
2026	35,29	55,91	-20,62
2027	34,92	57,63	-22,71
2028	34,55	59,12	-24,57
2029	34,18	60,58	-26,40
2030	33,81	62,06	-28,25

Source: Calculation Results, 2022

Based on the above calculations in the planning year, namely in 2030 there will be a water deficit of 28.25 liters/second.

4. Conclusion

Based onresults analysis, could the following conclusions are drawn:

Projection The number of residents in the service area of the Wae Mese I Water Treatment Plant (WTP) (7 sub-districts in the Komodo District) in 2030 will reach 45,715 people. The total water demand in 2030 is 62.06 liters/second.

The Wae Mese I WTP production capacity cannot meet the water demand in the service area from 2021 - 2030. The Wae Mese I WTP water production capacity (40 liters/second) has decreased in 2021 - 2030. In 2021 the production capacity is 37.20 liter/second and 33.81 liter/second in 2030. Based on the water balance analysis, namely the difference between demand and water availability, there will be a water deficit in 2021 of 11.11 liter/second and 28.25 liter/second in 2030.

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Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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