Regional Case Study

Identification of the Influence of Socio, Demographic, and Economic Factors on Domestic Water Consumption Patterns (A Case Study: Bandar Lampung City, Indonesia)

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Abstract

Urban water management efforts are essential in encouraging the fulfillment of the SDGs targets. One action that can be done is to approach the calculation of the actual water consumption value. This research conducted a survey of domestic water consumption in Bandar Lampung City to obtain comprehensive information. Bandar Lampung City was chosen because it is one of the cities on the island of Sumatra with a high economic growth rate. Lampung Province is the top 3 province in Sumatera Island with the higher Gross Domestic Product Growth on 2022, with Bandar Lampung as its capital city. Furthermore, water consumption patterns were analyzed for various activities, socio demographic conditions, and the community's economy. The results showed that of the 404 samples, the average water usage was 195.08 liters/person/day, with the dominant activities in use including bathing (66.84 liters/person/day), flushing the toilet (35.71 liters/person) / day), and ablution (29.74 liters/person/day). Furthermore, the variable number of family members in one house and income level have significant different on total domestic water consumption. The results obtained in this study are expected to assist in making decisions regarding urban water management plans.

Keywords: Water consumption; Bandar Lampung; consumption patterns; urban water management; SDGs

1. Introduction

Clean water is a fundamental community need that needs to be met, as stated in point six of the 2030 Sustainable Development Goals (S.D.G.s) (UNDP, 2021; Amala et al., 2023). Along with increasing population growth, urbanization, industrialization, and living standards, the need for clean water will inevitably increase (J.A.S. & P.M.P., 2011; Simukonda et al., 2018). On the other hand, in 2017, 29% of the global population (2.2 billion people) faced water scarcity which caused a water supply deficit that reached a critical level in various countries, one of which was Indonesia (WHO World Health Organization, UNICEF, 2019; Hasan & Ridwan, 2021). It is even predicted that by 2050, the number of people with inadequate access to clean water will increase to more than 5 billion, or around 1.5 times more than the data in 2018 (D.W. Indonesia, 2021). Therefore, it is necessary to manage water as an aspect of essential ecosystem services to minimize the potential for water scarcity disasters to occur and support sustainable development.

Several approaches in urban water management efforts have been carried out, including using the actual urban water consumption/urban water demand approach (Alharsha et al., 2022) in big cities in various countries such as the United States (Gursel et al. ., 2020), Australia (Nouri et al., 2018; Horne, 2020), China (Fan et al., 2017; Zhuo et al., 2019), Japan (Ohno et al., 2018); (Otaki et al., 2016), UK (Surendran & Tota-Maharaj, 2018; Vieux et al., 2017), and India (Kumar et al., 2021); (Basu et al., 2017). All of these studies show that essential ecosystem services related to water in a city tend to increase along with the increase in per capita income of an area as well as the availability of water and the type of water source (urban water resources/urban water supply) (A. Ester South, 2018). Furthermore, the factors influencing water consumption are very flexible and specific between study locations because community habits heavily influence it (Marinoski et al., 2014). In national regulations, the use of clean water is dominant in household activities such as bathing, cooking, washing, and watering plants that are routinely carried out (Kusumo, 2016). Therefore, the effort to comprehensively determine the availability and consumption of urban water is a crucial factor in dealing with the problem of water scarcity for implementing sustainable urban development.

Domestic water consumption in each country and region has different needs and variations in its use. Based on previous research in Batticaloa District, Sri Lanka, the use of clean water is strongly influenced by the economic level of the community, and the average respondent's family members ignore the efficiency of using clean water (A. Narmilan et al., 2022). Then in drought-prone areas in India, identifying determinant factors such as household size, frequency of needs fulfillment, sociodemographics and economics are used to understand the unevenness of the water used (Mrittika et al., 2017). Meanwhile, research in China in the area of The Wei River Basin (Fan, Liangxin et al., 2013) revealed that cleaning the house is the factor that consumes the cleanest water as a comparison also in studies of several regions in Indonesia, in South Tangerang City (Alfrida E. Suoth et al., 2018), Kab. Gunungkidul (Evi & Slamet, 2019) reveals that domestic water consumption requires the most water, namely bathing and toilet activities, reaching 30% of total domestic water consumption. Therefore, it can be concluded that different regional conditions, as well as socio, demographic and economic factors, need to be considered in determining an area's water use level.

Currently, information related to urban water consumption in Indonesia is minimal and focuses on cities on Java Island (Hasbiah & Kurniasih, 2019; Ali et al., 2018) and Bali Island (Mohan, 2021) with the aim of research to solve water crisis problems what happened. This problem of water security can be prevented if the potential availability of water and the determinant factors that affect water consumption in a city can be known in advance (Azizah et al., 2022). This information will be the basis for the government's sustainable urban water management policies. The island of Sumatra, one of the largest islands in Indonesia, is currently experiencing very rapid development, one of which is due to the construction of massive toll road infrastructure (Trans Sumatra Toll Road) (Saraswati et al., 2022). The Trans Sumatra Toll Road on the eastern side of Sumatra Island can potentially increase economic income from the big cities of the provinces it passes through, such as Lampung, South Sumatra, Jambi, Riau, North Sumatra and Aceh (Berawi et al., 2015). It certainly has the potential to affect essential services, especially water in the eastern part of Sumatra. Therefore, this study will comprehensively analyse water consumption in Bandar Lampung, a big city on the east side of Sumatra Island (Urban Water Supply and Demand).

2. Methods

2.1 Study Location

Lampung is one of the provinces experiencing a water crisis due to seasonal changes. When the long dry season hit parts of Lampung, it took much work for residents to get water to meet their daily needs (Sulistyorin et al., 2020). Changes in the earth's surface temperature make Lampung vulnerable to increased rainfall and decreased rainfall, so the chances of experiencing drought and even a water crisis are getting bigger (Sulistyo et al., 2020). In 2016, Bandar Lampung also experienced an increase in

temperature as BMKG data for Bandar Lampung City (2016) shows that during this period 2013-2018, there was an increase in temperature (1.2°C) in Bandar Lampung City (Tampubolon et al., 2018). On the other hand, the population growth rate of Bandar Lampung City tends to increase from year to year (Central Bureau of Statistics, 2022). Bandar Lampung is located in southern Sumatra. The position of this city is at an altitude of 700 m above sea level and geographically located at 50°20'-50°30' South Latitude and 105°28'-105°37' East Longitude (Figure 1) with the area of Bandar Lampung City, namely 197.22 km2 consisting of 20 Districts with a population of 1,617,118 people (Sinia & Susilo, 2021). The primary sources of water used by the people of Bandar Lampung City to meet various daily needs come from groundwater/wells (70.45%) and piped water from local government drinking water company (Perumda Air Minum Way Rilau) (21.21%) and bottled drinking water (8.33%) (Ria, 2021).
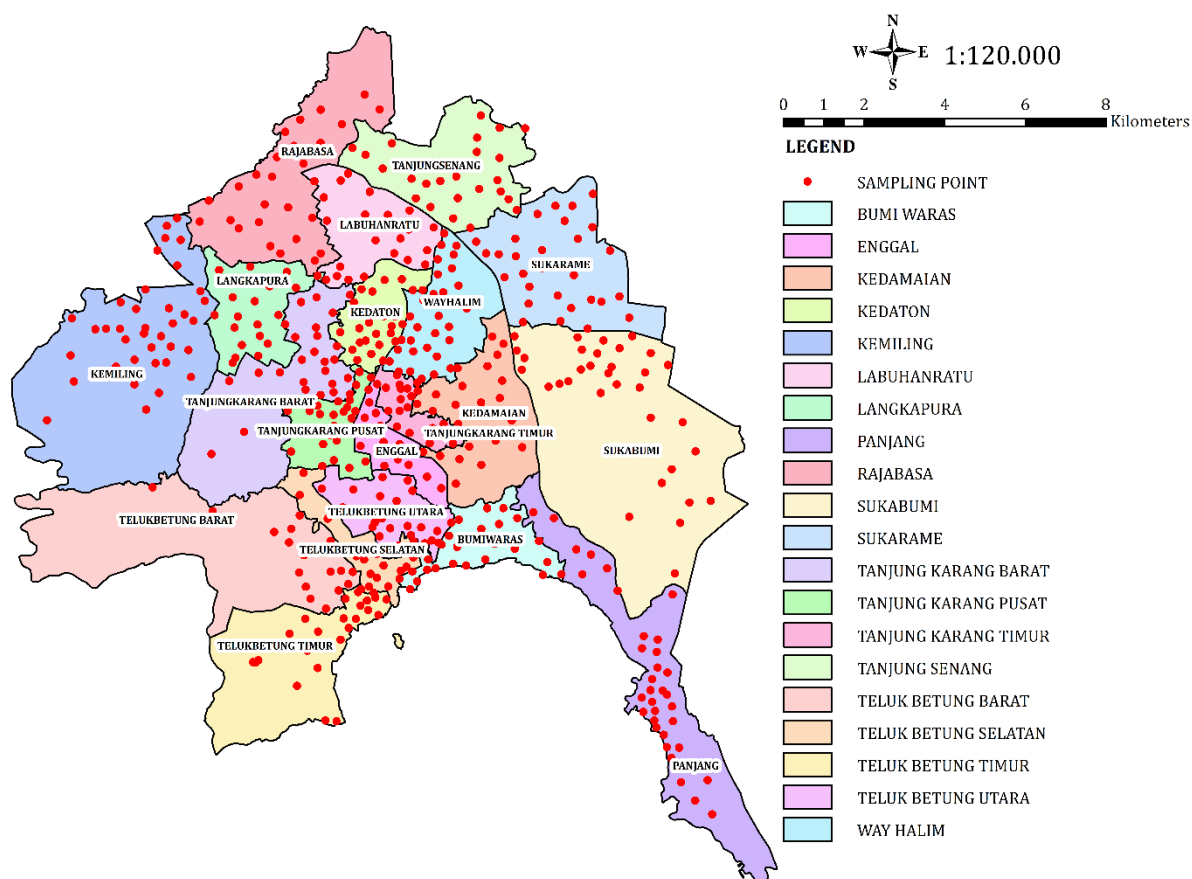

Figure 1. Sampling point location in Bandar Lampung, Lampung Province, Indonesia

2.2   Data Collection and Analysis

In this study, a questionnaire related to domestic water consumption was designed with as many as 67 questions in the form of multiple choice questions equipped with attached information regarding the types of toiletries, types of glasses based on their volume, types of buckets based on their volume and the type of faucet used (**Supporting Information – Appendix 1**). A survey related to domestic water consumption was carried out comprehensively at the household level to collect information related to sociodemographic characteristics (water sources, number of residents in one house, age, sex, and education level) and community economic characteristics (income and employment levels). This survey includes statements about the frequency, duration of water use, and volume of water consumption for daily activities, including bathing, washing hands, flushing toilets, washing clothes, washing dishes, cooking, watering plants, and washing vehicles. These various daily activities were selected from several previous references related to domestic water consumption studies (Mrittika et al., 2017).

The total sample of respondents in this study was 500 randomly selected and stratified based on the proportion per sub-district in Bandar Lampung City (stratified random sampling). This sampling was conducted in September - October 2022 by conducting a preliminary survey beforehand to test the validity and reliability of the questionnaires used in this study (the test was carried out on 50 sample respondents (Dyah, 2018)). The results of the validity and reliability tests show that the questionnaire used is valid and reliable if the Pearson Product Moment validity test value is more than 0.3 and the Cronbach Alpha reliability value is more than 0.6. There were a total of 27 questions, validity testing using the Pearson product-moment correlation showed that of the 27 questions tested, 26 questions were declared valid, and 1 question was declared invalid. Then the reliability test results calculated using the Cronbach Alpha equation are > 0.6 for each type of activity, and all activities are declared reliable so that the questionnaire can be used. The results of validity and reliability test were summarized on **Supporting Information – Appendix 2**. The survey was conducted at each sample location/household for an average of 10 minutes. The survey was conducted by 12 surveyors consisting of students. Due to the unavailability of a water meter during data collection, the students (i.e., 12 final years students from Department of Environmental Engineering, Institut Teknologi Sumatera) were trained to measure water duration and flow rate using a calibrated clock and measuring cup for each water consumption activity. With this approach, the amount of water consumption can be calculated for each use as a function of frequency and water flow rate.

The data that has been collected is then processed using Microsoft Excel and R Studio software. Furthermore, statistical parameter analysis was carried out, which included (maximum value, minimum value, average value, quartiles, median, cumulative frequency, correlation coefficient, and reliability coefficient of 404 samples. The samples analyzed were 404, where the value of this sample was the result of cleaning outliers from a total of 500 data. Boxplot methods was using to justify the outliers, samples which have higher/lower value than the maximum/minimum values from the boxplot method were taking out from the calculation (i.e., outlier data). Furthermore, the data cleaned from the boxplot followed by normality assessment (**Supporting Information – Appendix 3**) were processed using the ANOVA method to determine the significance of several sociodemographic and economic factors

3.   Result and Discussion

3.1   Socio Demographic and Economic Characteristics Of The Study Location Respondents

Data collected from a survey in the Bandar Lampung City on 404 respondents shows that the most used water source is the non piping system category, with 302 inhabitants. The most dominant sex found at the time of the study was the category of female respondents, with 288 samples. The age of the respondents who were found varied, and the age range of 25-54 years with 247 people was the most dominant one found. High school education background is the highest population with 190 people. Occupations in other categories include homemakers, freelancers, and students being the highest population with 227 people. The income range of Rp 1,250,000 - Rp 3,000,000 is the most dominant income for respondents, with 217 people. Furthermore, the most dominant density in one household is 4-6 people, with a sample population of 259 people (**Figure 2**). The socio, demographic and economic characteristics of the total respondents in Bandar Lampung are summarized in **Figure 2**. Regarding the water source variable used by the respondents, the dominant respondent used the classification of non piping system water sources (well water) as many 302 respondents. It was also influenced by the new connected to city piping system distribution installation covering 16.9% of Bandar Lampung City.
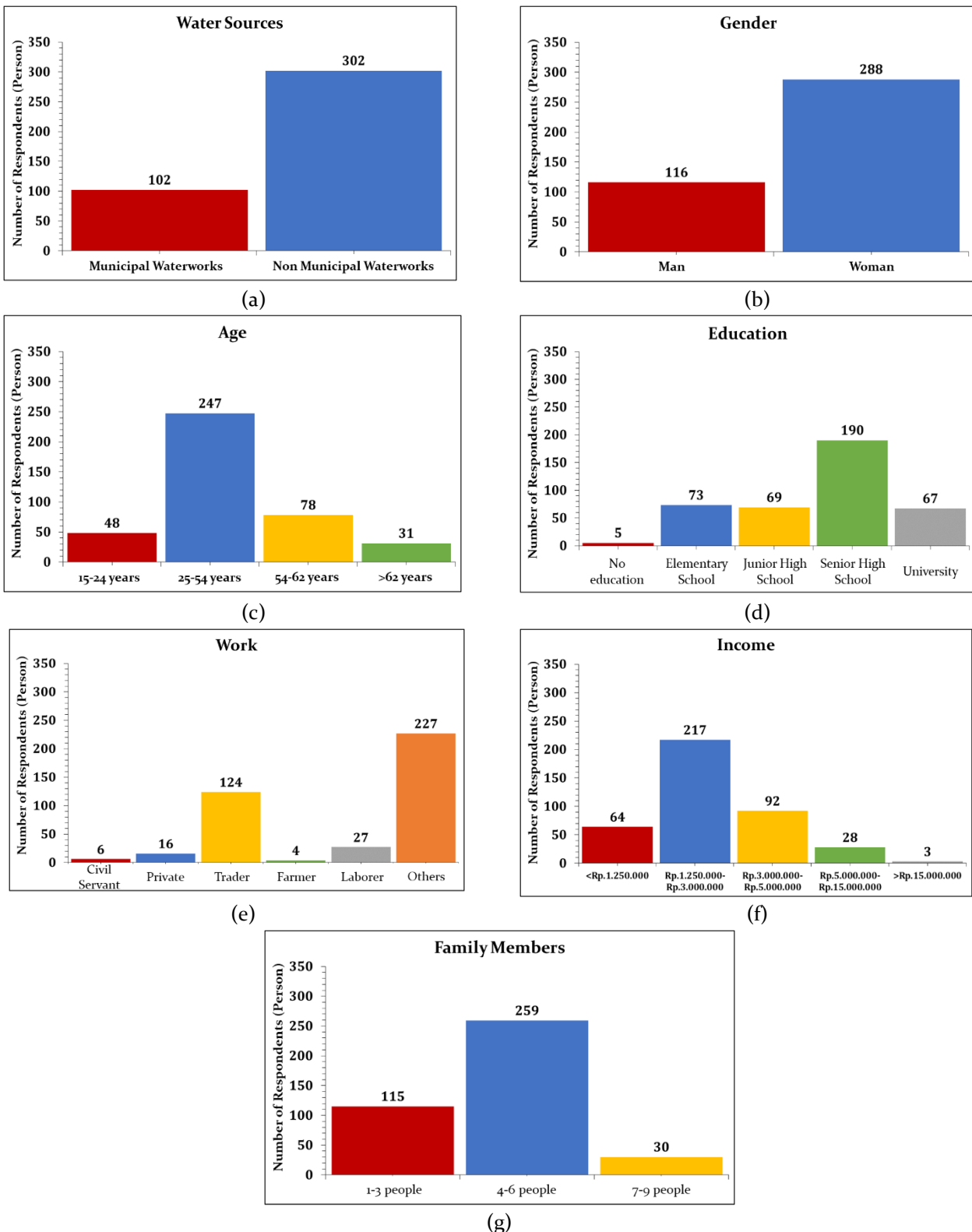
Figure 2. Sociodemographic and economic characteristics of respondents in Bandar Lampung City (total sample of respondents N = 404 people)

3.2. Value of Domestic Water Consumption
a. Value of Domestic Water Consumption

The total value of domestic water consumption (litres/person/day) in Bandar Lampung City is around 195.08 litres/person/day. With an average value of water consumption for several daily household

activities, including drinking (1.80 litres/person/day), bathing (66.84 litres/person/day), flushing the toilet (35.71 litres/person) /day), performing ablution (29.74 litres/person/day), washing hands (15.04 litres/person/day), brushing teeth (5.85 litres/person/day), cooking (4.74 litres/person) /day), washing dishes (20.34 litres/person/day), washing clothes (9.15 litres/person/day), washing vehicles (3.15 litres/person/day), watering plants (1.74 litres/person/day), and cleaning the floor of the house (1.37 litres/person/day) (Table 1). Therefore, it can be seen that the three domestic activities that consume the most water sequentially from the highest to the lowest are bathing (34.2% of total domestic water consumption) and flushing toilets (18.3% of total domestic water consumption), domestic and ablution (15.2% of total domestic water consumption).

Table 1. Survey results on average consumption of domestic clean water with standards (liters/person/day)

Activity	Average consumption ± Standard deviation	The Indonesian Standard		
		SNI 03-7065-2005	Department of Health	Department of Settlements and Regional Infrastructure
Drink	1.80 ± 0.50	1.4	2	2-5
Bathe	66.84 ± 24.43	20	20	4-80
Flushing Toilets	35.21 ± 14.02	5	-	20-60
Ablution	29.74 ± 14.37	-	15	12-50
Washing hands	15.04 ± 8.87	-	-	-
Brushing teeth	5.85 ± 2.86	-	-	1-2
Cooking	4.74 ± 3.99	-	-	10-30
Wash dishes	20.34 ± 13.98	30	-	5-20
Washing clothes	9.15 ± 6.01	100 (Manuals) 60 (Machine)	13	30-70
Vehicle Washing	3.15 ± 3.16	15	22,5	10-30
Water plants	1.74 ± 2.42	20	11	5-15
Cleaning the floor	1.37 ± 1.08	16	32	-
Average	195.08 ± 44.62	268.4	150	140-400

The average total domestic water consumption of the people of Bandar Lampung City is 195.08 litres/person/day. This result is still relatively high compared to the water demand standards in several reference standards, primarily based on the city typology in which Bandar Lampung is a metropolitan city (Sinatra et al., 2020). Based on the standards of the Department of Settlement and Regional Infrastructure 2002, Bandar Lampung has at least a domestic water consumption rate of between 150 - 210 litres/person/day. In determining the total value of domestic water consumption, some variables are used as activity patterns in domestic water use. In this case, it is divided into two parts, namely private water consumption and shared water consumption. Variables included in the personal water consumption section include bathing, flushing the toilet, drinking, ablution, washing hands, and brushing teeth. In comparison, shared water consumption is the use of one family's water, namely cooking, washing dishes, washing clothes, washing vehicles, watering plants, and cleaning floors. Water usage is discussed in more detail in the following sections:

1) Personal water consumption

   a) Bath

Domestic water consumption for bathing activities is 66.41 litres/person/day, which is relatively high compared to the Ministry of Settlement and Regional Infrastructure (4-80 litres/person/day). Even with SNI 03-7065:2005, the difference is enormous, which stipulates that the need for bathing water is 20

litres/person/day. Some of the things that cause this big difference are the frequency of people bathing in a day with a different amount. The climate also influences it. As time increases, the air temperature increases, so the frequency of people bathing will increase (Pratiwi et al., 2022).

b) Flushing toilets

The community uses two types of toilets to fulfill their need to flush the toilet, namely squatting and sitting toilets. These two types of toilets have different water requirements; for squat toilets, water consumption uses a dipper, while for seated toilets, you can directly press the flush button. With an average water consumption for flushing toilets of 35.66 litres/person/day, the people of Bandar Lampung City tend to have the same frequency of defecation and urination which has an impact on water consumption for flushing toilets. The frequency of bowel movements is around 1-2 times a day and for urination, 3-5 times a day.

c) Drink

The need for drinking activities for Bandar Lampung City's population is around 1.83 litres/person/day. The need for drinking is by the existing standards, namely 2 litres/person/day. The pattern of community activities in drinking activities is insignificant, so the results are close to standard.

d) Ablution

Ablution activity is one variable that becomes an additional option because Indonesia has a majority Muslim population. Hence, the ablution variable is crucial in water consumption (Solikhin, 2016). It includes the Bandar Lampung City, with a majority Muslim population, so domestic water consumption for ablution activities is 31.78 litres/per person/per day. If you look at the existing standards, this figure is above the standard were based on the Ministry of Health, the standard figure for ablution is 20 litres/person/day. However, the 2005 Indonesian Nasional Standard does not regulate the standard for the need for ablution activities. The cause of this high number is that many people need to be made aware of opening the faucet when doing ablution, and the times for ablution are very diverse. People feel a surplus of water and need to pay more attention to the correct procedures for ablution (Ariesman, 2018). It causes wasteful use of water when performing ablution. One solution to saving water for ablution is to regulate water flow with sensors that adjust to body posture (Panjaitan et al., 2021).

e) Washing hands

The type of community work is very influential in this activity. The amount of consumption of washing hands by the people of Bandar Lampung City is 15.66 litres/per person/day. With most people working as traders, the frequency of hand washing is increasing due to their work which tends to make their hands always dirty (Fauzy, 2017). The transition period after the Covid-19 pandemic also made many people pay more attention to cleanliness with PHBS (Clean and Healthy Living Behavior), so many people did not only wash their hands but also used soap (Prasetya, 2022).

f) Brushing teeth

Tooth brushing activity is one variable with a domestic water consumption value of 5.93 litres/per person/day. The water here is used for gargling when brushing your teeth, which the community commonly does in two ways. Some rinse their mouths using water directly from the tap, and some use media such as a dipper or glass. In general, this community's behaviour determines the amount of water used. For example, when using a faucet, some people do not turn the faucet off, making water consumption even greater. One solution is to turn off the tap while rinsing (Rohendi & Nur, 2018).

2) Consume water together

a) Cooking

Water consumption for cooking activities in Bandar Lampung City is 5.02 litres/person/day. Cooking is one of the household's main activities, significantly impacting water consumption. However, the level of water consumption for cooking can also be affected by the season, where during the dry season, the use of water for cooking tends to be lower (Setiawan et al., 2020). Apart from that, the number of family members also affects the level of water consumption (Sinia & Susilo, 2021).

b) Wash dishes

Washing dishes is something that must be done in the household. In the Bandar Lampung City community, water consumption for this activity is 21.22 litres/person/day. This value is significant compared to existing standards; the minimum standard is 2.2 litres/person/day, and a maximum of 25 litres/person/day. It is influenced by the frequency of people washing daily and the type of work, especially rice sellers who tend to wash dishes more often. In addition, the volume of media used to wash dishes will affect the total water used. Making it a habit to eat clean is an effort to save water, whereas washing dishes requires less water (Ariesman, 2018). As already stated, the amount of water used is quite a lot, so it can be used to use dishwashing waste containing zinc for plants (Rosadi et al., 2021).

c) Washing clothes

In washing clothes, people are generally divided into two: those who wash using a washing machine and those who use their hands using tubs or buckets. In existing conditions, using a washing machine results in more efficient water consumption than using a tub or bucket. On average, water consumption for washing clothes for the people of Bandar Lampung City is 9.30 litres/person/day. Washing machines with front-loading models are also more efficient than top-loading models (Sharpe & Swistock, 2008). In general, the 2-tube washing machine has the most models in society (CLASP, 2020). Even though washing machines are more economical than washing by hand, saving steps must be taken by increasing public awareness of environmental issues related to patterns and methods of washing clothes (Panuju et al., 2022).

d) Vehicle Washing

Based on calculations, the average consumption value for washing vehicles for the people of Bandar Lampung City is 4.19 litres/person/day. If you look at the standard water requirement, this figure is still far below 22.5 litres/person/day. In the existing conditions, most people have at least one motorbike, which is usually washed once a week. The number of vehicles is closely related to the water consumption for washing vehicles. It shows that the level of water consumption for washing vehicles is minimal because people do not wash their vehicles every day, and there are still many people who do not have cars, so the need for water to wash vehicles is getting smaller. Of course, the more vehicles, the more water is needed (Astuti et al., 2018).

e) Water plants

Watering these plants consumes at least 3.20 litres of water/per person/day. This figure is below the standard, requiring at least 11 litres/person/day. To save water used for watering plants, you can use grey water. There is no requirement for water quality in watering plants, so water used for bathing or washing clothes and dishes can be used to water plants (Handayani, 2013). Water consumption in the community is not too high because the season also affects the amount of water needed, the research was conducted in the rainy season, so there was no need to do watering (Gunawan & Sari, 2018).

f) Cleaning the floor

The calculation results of floor cleaning activities require around 1.46 litres/person/day. This figure is very far below the standard requirement of 16-31 litres/person/day. The reason for the low need for water to clean floors is that many people's houses need to be tiled, so they do not need to be cleaned using water; just using a broom is enough. However, some people who pay attention to the cleanliness of their homes, by cleaning the floors, not only use water but use floor cleaning liquid so that they need to rinse several times, which results in an increasing amount of water being used (Desfitri et al., 2022).

3.3. Variations in the Socio, Demographic and Economic Conditions of the Study Location Respondents

The average domestic use of clean water based on socio-demographic and economic conditions at the study locations shows that the average amount of consumption in the classification of water sources is the same as 195 litres/person/day. Gender experiences different variations in the value of consumption, where the average consumption is female, which is dominant at 197 litres/person/day. The age with the

most use, with an average total consumption of 195 litres/person/day, is 25-54 years. Higher education is the last classification, with the highest average consumption of 201 litres/person/day. Other occupations, including homemakers, freelancers, etc., are the most dominant in average water consumption, amounting to 200 litres/person/day. Income with an average classification of Rp. 3,000,000-5,000,000 has an average water consumption of 200 litres/person/day. Family members of 1-3 people are the most dominant in average water consumption, with 203 litres/person/day (**Figure 3**).

The analysis results show no significant differences (p-value > α, p-value = 0.99 and α= 0.05) between the various water sources used in influencing total domestic water consumption. In the gender variable, female respondents are more dominant than male respondents. It is due to the survey being conducted on weekdays affecting more interactions with female respondents who incidentally are housewives. In the gender variable, there is no significant difference (p-value > α, p-value = 0.18 and α= 0.05) in gender variation on total domestic water consumption. Regarding age characteristics, the dominant classification of respondents was 25-54 years old. This category is included in the group of workers of productive age (Bappenas, 2018). Besides that, education is one of the variables in the social aspect that is considered capable of influencing water consumption. The level of education will be directly proportional to the mindset of using water (Setianingsih & Suprayogi, 2020). Domestic water consumption by age to total water consumption shows that age do not have significantly differences (p-value > α, p-value = 0.88 and α = 0.05). Furthermore, education in this case also does not have significant differences in variations in domestic water use (p-value > α, p-value = 0.18 and α = 0.05). This value shows no correlation between recent education and total domestic water consumption. Communities with low or high levels of education will have a similar mindset to save or use water according to the availability of resources (Setianingsih & Suprayogi, 2020).

In the type of work, respondents with other types of work were dominant, with homemakers consuming more water than others. Due to several factors, including the demands of their work in managing the house, the water demand is high. The variation in the type of work does not show a significant difference in the average amount of domestic water consumption (p-value > α, p-value = 0.07 and α = 0.05). Unlike the case with domestic water consumption variables based on variations in income, which shows that the respondents' income has a significant different on total domestic water consumption per capita (p-value < α, p-value = 0.01 and α = 0.05). Dominant income belongs to respondents with an income of Rp. 1,250,000-Rp. 3,000,000 or are included in the Regional Minimum Wage category of Bandar Lampung City, based on the decision of the Governor of Lampung, the minimum wage for Bandar Lampung City in 2023. The same thing also happens to the number of family members, where the family number have significant differences on total domestic water consumption (p-value < α, p-value = 0.003 and α = 0.05). These results indicate the effect of variation in the number of family members. In this study, the number of dominant families ranged from 4-6 people in one family. Based on Central Bureau of Statistics, the average family member in Lampung Province is four people in one family (Central Bureau of Statistics, 2016). The results regarding real demand domestic water and sociodemographic-economic conditions in Bandar Lampung would help the city government to develop urban water management, especially this research could be the basis data for the development of master plan for the drinking water supply system.
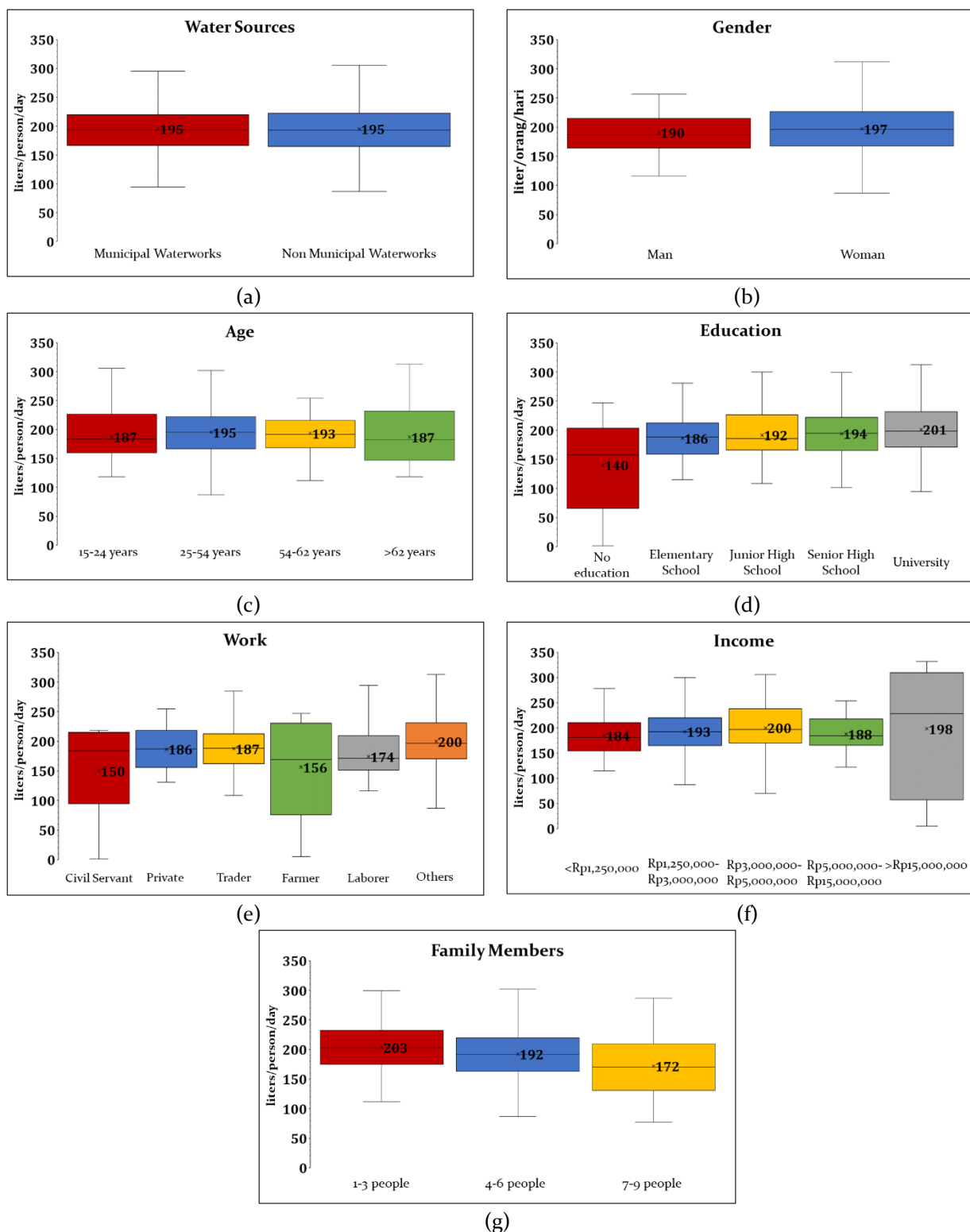
(a)

(b)

(c)

(d)

(e)

(f)

(g)

Figure 3. Variation of sociodemographic and economic conditions on the total amount of domestic water consumption in Bandar Lampung City (total sample of respondents N = 404 people)

4.   Conclusion

The use of water for domestic needs from a survey of 404 respondents was 195.08 liters/person/day. Daily domestic water consumption in Bandar Lampung is used for household primary and secondary household needs. The most dominant use of water lies in bathing, flushing toilets, and performing ablutions. These three activities contribute around 67.5% of the average daily water use for

domestic household needs. The results of ANOVA show that the socio, demographic and economic factors that significantly influence total domestic water consumption are factors related to the number of family members and the income level of the respondents. The results obtained in this study are expected to assist in making decisions regarding urban water management plans.

Acknowledgement

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