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ORIGINAL RESEARCH PAPER

Domestic water consumption pattern and awareness of urban households

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ABSTRACT

BACKGROUND AND OBJECTIVES: Increased demand for water has put pressure on the water supply system, which has led to environmental issues such as water resource over-exploitation and ecosystem balance breaks. This study aimed to examine household water consumption trends and management practices and compare the efficacy of various water management interventions to reduce the Batticaloa district's water deficit.

METHODS: The primary data was collected through a questionnaire survey from 300 households belonging to the urban area in Batticaloa District in Manmunai Pattu, Sri Lanka. The data were analyzed using correlation and linear regression analyses. A flow rate study was designed to assess the individual flow rate for each household.

FINDINGS: The overall domestic water use is negatively correlated ($p \leq 0.01$) with the household head's age and education level and positively associated with income level. As the household size, age, education level, number of taps, and household income showed statistical significance ($p \leq 0.05$), the Linear regression model was statistically essential. Together, they accounted for 96.5% of the difference in per capita water consumption in the wet season. Moreover, most of the people are not aware of the cost of water per cubic meter and only 26.7% are aware of the cost and 88% of the respondents are more concerned about the quality of water and very few respondents (12%) are not concerned about the water quality.

CONCLUSION: The results indicate that more water is used by people with higher incomes in urban areas than people with lower incomes. The use of water depends on household members' living standards, family size, age, education level, and the number of taps present in the household. Also, most household members are not aware of the efficient use of water in the study area.

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INTRODUCTION

A crucial role in the place, operation, and creation of communities has been played by water. Water is critical and forms the foundation of a nation's social and economic growth (Singh and Turkiya, 2013). The United Nations has predicted that the world population will increase by another two billion (2×10^9) people by 2030 (Postel, 2000). The World Health Organization (WHO) characterized domestic water as the water utilized for domestic purposes, including drinking, washing, and food arrangement. Household water utilization is a huge part of the water use, and it differs as indicated by the expectations for everyday comforts of the buyers in metropolitan and provincial zones (Mohammed and Sanaullah, 2017). Giving sufficient and improved drinking water is progressively massive, particularly in nations with quickly developing populaces. Improved drinking water alludes to water sourced from a tap situated inside premises or yard/plot, a public standpipe, a cylinder well, a secured burrowed well or spring, and precipitation (UNICEF/WHO, 2015). The consumption of household water is determined by several variables, such as environment, seasonality, socio-economic and socio-demographic characteristics. In this analysis, only socio-demographic factors are taken into consideration. Many exploration ventures have zeroed in on featuring the momentum water lack and the private area's expanded use. Most research initiatives have concentrated on highlighting the current scarcity of water and the increased consumption by the residential sector. Nevertheless, when meeting household water demand as one of the main goals of various policy interventions and program recommendations on drought reduction or domestic water management strategies, a lack of domestic water usage studies is noted. This research examines the influence of household socio-economic conditions on different aspects of urban domestic water consumption in Manmunai Pattu, Sri Lanka in 2019.

MATERIALS AND METHODS

Data collection

A survey was conducted on household water consumption in the urban Batticaloa district, Sri Lanka (Fig.1). A Simple random sampling technique was followed to select households so that each household has an equal probability of being included in the sample. Also, more than half of the respondent households are currently not engaged in water conservation because of continuous access to water through their water source. A detailed questionnaire was prepared with over 40 questions. Socio-demographic characteristics of respondents, such as the age of the household head, education level, living standard of the family, average monthly income of Household and family size and domestic water use behavior at the household level such as the source of water supply, source of irrigation and source of drinking water were investigated. Furthermore, questions regarding each water end-use (e.g., bathing, hand washing, toilet flushing, dishwashing, cleaning, cooking, and watering the garden) were also included. The flow rate study was designed to form the knowledge obtained from the literature review, and it was discovered that the flow rate (tap

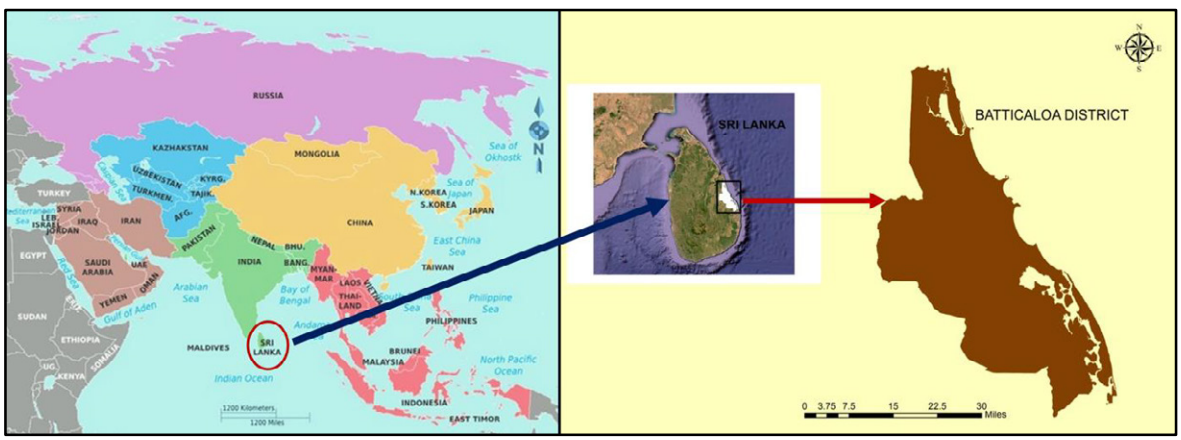

Fig. 1: Geographic location of the study area in urban Batticaloa area of Sri Lanka

and showerhead) could be estimated through a straightforward test. The test strategy depended on the Green Venture site: how to direct a stream rate test, 2007 (Green Venture, 2007). The test instruments incorporated a stopwatch (Mobile telephone), a holder with estimations as an afterthought, the most extreme estimation being 1.5 liters, and an adding machine. The principal techniques were as per the following: 1) The vacant holder was set under a tap or showerhead; the tap or the shower head was gone on to its most special stream rate. The stopwatch was begun simultaneously. When the water arrives at 1 liter, the watch was halted and the time was recorded; 2) The flow rate was calculated. For example, to fill one-liter container takes 5.8seconds, 5.8 sec= 0.1 min, the flow rate = 1 liter/ 0.1 minute= 10 liters/ minute; and 3) and this procedure was repeated twice obtain the average measurement.

Data analysis

The Statistical Kit for Social Sciences has integrated quantitative data on socio-demographic and water use characteristics (SPSS 25.0). To analyze the relationships between per capita intake of water and possible predictors, correlation and linear regressions were used. To evaluate the predictors of water use, a linear regression analysis was used. Each variable was entered in a sequence, and its value was assessed at the level of statistical significance.

RESULTS AND DISCUSSION

Demographic composition

The demographic composition of the sample households and the social status of farmers in the survey community is shown in Table 1. Around 30.7% of households' heads are aged between 56 to 65, and 28% are aged from 46 to 55 years while those aged

Table 1: Demographic composition

Age of the household head (years)	Number	Percentage	Education	Number	Percentage
Below 25	0	0	Primary	0	0
25-35	32	10.7	Intermediate	60	20.0
36-45	64	21.3	Advanced	144	48.0
46 -55	84	28.0	Higher	88	29.3
56-65	92	30.7	None	8	2.7
Above 66	28	9.3	Total	300	100.0
Total	300	100.0			
Ownership of the House			The living standard of the family		
Own	256	85.3	Poor	8	2.7
Rented	44	14.7	Medium	236	78.7
Total	300	100	Rich	56	18.7
			Total	300	100.0
Occupation of Household head			Average Monthly Income of Household		
Government	116	38.7	Below 10,000 LKR	0	0
Private/NGO	44	14.7	10,001-15,000 LKR	8	2.7
Business	28	9.3	15,001-20,000 LKR	8	2.7
Farmer	16	5.3	20,001-25,000 LKR	24	8.0
Day-wage labor	16	5.3	25,001-30,000 LKR	48	16.0
Others	80	26.7	30,001-40,000 LKR	44	14.7
Total	300	100.0	40,001-50,000 LKR	52	17.3
			Above 50,000 LKR	116	38.7
			Total	300	100.0
Family size					
2	8	2.7			
3	104	34.7			
4	108	36.0			
5	44	14.7			
6	24	8.0			
7	12	4.0			
Total	300	100			

*LKR (Sri Lankan Rupee), Around 1 LKR = 0.0054 US $

Table 2: Correlation between potential predictors – per-capita water usage

	Per-capita water usage	Correlation coefficient	Sig. (1-tailed)
Pearson Correlation	Family size	0.950	0.000
	Age	-0.944	0.000
	Education level	-0.873	0.000
	Number of taps	0.951	0.000
	Living standard	0.825	0.000
	Household income	0.968	0.000

36 -45 accounted for 16% of the total respondents. Regarding the household heads whose age between 25 -35 years and below 66 years were almost similar by having 8% and 7% respectively. However, there were no household heads observed below 25 aged groups. The survey showed that around half of the respondents (48%) had completed their advanced education level. In comparison, those who have received their higher education and intermediate level of education are 22% and 15% respectively. However, only 2% of them were uneducated, and there are no individuals who attained only primary education. Table 1 shows that 85.3% of household heads have their own house, while 14.7% of respondents reside in rented houses. In terms of living standards of the respondent's family, it was observed that a higher percentage (73.70%) of the family whose living standard is medium followed by wealthy families (18.7%). In comparison, the poor were accounted for 2.7%. The number of household size is one of the essential demographic characteristics of a household. According to household size, distribution of respondents shows that the majority (36 %) of the families had 3 to 6 members in their houses. In comparison, 14% of them had 5 members and those who have 6, 3, and 2 in 8%, 4%, and 2% respectively. According to the survey, the occupations of family heads found to be involved in the government sector (38.7%), other kinds of jobs (20%), private or Non-Governmental Organizations (NGOs) (14.7%), and the rest of them were engaged in business (9%), farming (5.3%) and daily labor work (5.3%).

Correlation between Demographic characteristics and water consumption pattern

Age of household member

Table 2 indicates that age is negatively correlated with total domestic water consumption and the correlation coefficient was -0.944 ($p<0.01$). The age of household members also influences the use of water. The behavior of water use can be very different among household members of different ages. It would be expected that households with children will use more water. Youngsters may use waterless wisely, such as taking more baths, laundering more often, whereas retired people maybe even more flourishing (Nauges and Thomas, 2000).

Living standards

Total domestic water intake is positively associated with living standards, $p<001$ (Table 2). This was supported by Syme *et al*. (2004) and Loh and Coghlan (2003), and the result is attributed to the use of modern appliances and a lack of knowledge of elders. In developing countries, people spend more money on products that use more water, such as dishwashers, washing machines, flushing toilets, and showers. As living standards rise, people also prefer to consume more meat, which requires more water in its processing. The number of people in residence (Hanke and Maré, 1982) is a variable that positively impacts household water consumption. The study population's total water usage was 12732.5 liters, and Per capita, water usage was 169.8 liters.

Income level

The correlation between water consumption and the income level of the survey community is shown in Table 2. It is shown that the total domestic water consumption is positively correlated with income level and the correlation coefficient was 0.968 ($p<0.01$). High water consumption may due to the high living standard of the survey community (Table 2), as a high level of income is associated with high living standards. This may mean a higher number of water-consuming appliances and a higher probability of high-water usage for watering large garden areas. Kennedy (2008) and Guhathakurta and Gober (2007) endorsed that increasing income results in corresponding water consumption

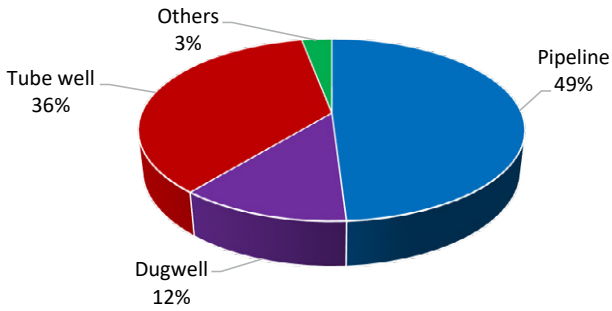

Fig 2: Different types of water supply

increment. Dalhuisen (2003) stated that though the water consumption is increased with income, it is not proportional. Usage of western-style bathtubs, dishwashers, and washing machines in high-income households also attribute to high-water consumption.

Education level

In a household, the level of education also affects water consumption. The overall domestic water intake was shown to be negatively correlated with the level of education, and the correlation coefficient was -0.873 (p<001) (Table 2). Educated people are more conscious about the increasing water scarcity, and they literate their younger generation to use water resources efficiently. The degree of education is positively associated with lower water use and higher water saving habits, which will minimize the household's overall water consumption (Millock and Nauges, 2010). Educational campaigns teach quick ways to save water and improve self-efficacy sensations. Collins et al. (2003), on the other hand, suggested that older people tend to use less water due to traditional patterns of water use (washing hands, showering, and sharing water between family members) and their unfamiliarity with water appliances.

Number of taps

The number of taps also influences the water consumption in a household. Table 2 shows that the total domestic water consumption is positively correlated with the number of taps and the correlation coefficient was 0.951 (p<0.01). It is proved from the results that there was a significant impact on water consumption due to the increased number of taps. Also, the increase in water consumption could be attributed to the pipe diameter and water flow rate (Englart and Jedlikowski, 2019).

Household size

Table 2 shows that household size is positively associated with overall domestic water use and the correlation coefficient was 0.95 (p<0.01). The amount of water used in a household determines the number of household members (Gaudin, 2006). Larger amounts of water are used for families with more family members. Arbus *et al*. (2004) found that, while this is not a proportional rise, water consumption increases with the household's size. Household size, however, was found to be an insignificant factor in the domestic level of water usage (Guhathakurta and Gober, 2007). A large household typically uses higher-frequency household appliances, resulting in higher water use than a small household. Many studies have shown a clear association between the age of the household leader and the net family size and the consumption of water (Arouna and Dabbert, 2010; Syme *et al*., 2004).

Water supply

Fig. 2 illustrates the different sources of the water supply of households. It was clear that around half of the households (49%) receive the pipeline water followed by tube well usage to a level of 36% while those who use water from dug well accounted for 12%. The lowest amount (3%) of respondents got water from other sources like lakes, rivers, and ponds. A similar result was reported by Tadesse *et al*. (2013) and Mahama *et al*. (2014). Several household characteristics strongly influence the choice of the water source. Local households seem to have adopted different practices for accessing

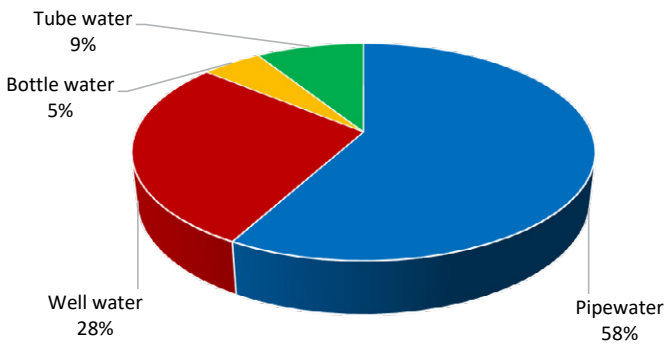

Fig 3: Different types of drinking water supply

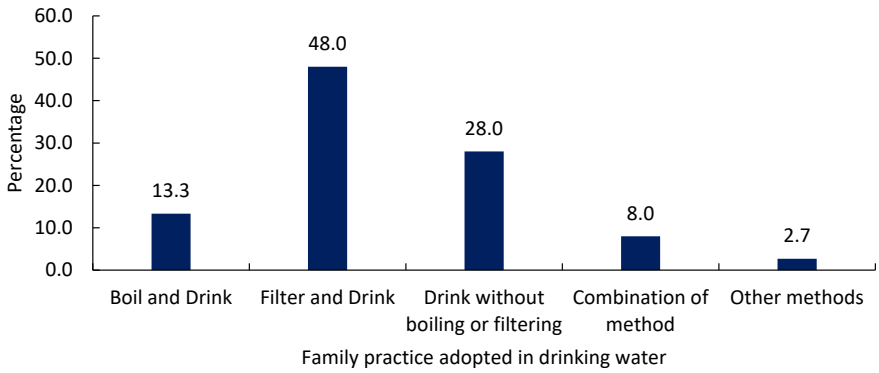

Fig. 4: Family practice adopted in the preparation of drinking water

alternative water sources rather than dug well alone to meet their diverse needs. Most households are dependent on private wells. But water sources and their uses changed significantly between the wet and dry seasons (Elliott *et al.*, 2017). The most common household water sources were taps and well (Casanova *et al.*, 2012).

Drinking water

Fig. 3 summarizes the percentage use of drinking water from a different source of water supply. Overall, the highest amount (58%) of drinking water was collected using the pipeline. Drinking water consumption from well water accounts for 28% of the total population. The tube well water and bottled water were the lowest water quantity, which is utilized for drinking purposes among the households for 9% and 5%. Piped water supply was the most common drinking-water source in urban areas. This parallels the Nketiah-Amponsah *et al*. (2009) observed that access to a pipeline drinking water source is higher than other types of drinking water sources. Bottled water consumption is low due to the high price. A study by Vásquez (2017) showed that bottled water consumption was positively linked to perceptions of health risk, household income, and education and market access. The probability of drinking bottled water has been adversely affected by household size.

The family practice adopted in the preparation of drinking water

Fig. 4 shows the family practice adopted in the preparation of drinking water. Most of the respondents (48%) were practicing filter and drinking methods, but 28% of the families were adopted to drinking the water without boiling or filtering. In terms of the boiling and drinking method, only about 13% of families used this method. However, only about 8% of respondents used the combination method, and 2.7% were using other methods when preparing the drinking water.

Boiling and filtering are the most common

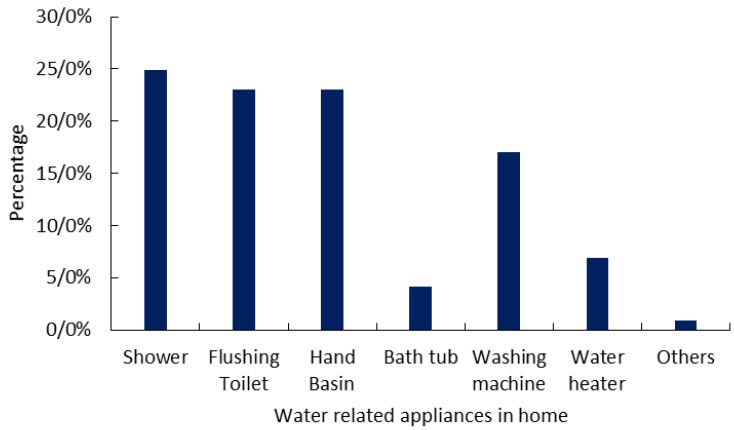

Fig. 5: usage of water-related appliances in the home

Table 3: Linear regression analysis

R	R Square	Adjusted R Square	Std. Error
0.982	0.965	0.962	23.8504

methods used in households for purifying water. Clasen *et al*. (2008) stated that boiling is a relatively expensive method, and Gilman and Skillicorn (1985) stated that boiling costs might be expensive for many low-income populations. Francis *et al*. (2015) observed the frequency of filtering water for children is higher than for adults. However, studies have shown that households do not regularly use Household Water Treatment when necessary and have potential health benefits (Brown and Clasen, 2012). Filtering was more common among user households than any form of treatment (Casanova *et al*., 2012).

Water-related appliances in the home

Fig. 5 illustrates the patterns of water use by households. It was clear that the highest amount (24.9%) of water has been used for showers for daily use by households while 23.0% of total water of household is used in toilet flushing and the same amount is used for personal hygiene, especially for hand washing. Nearly half of the proportion (17.1%) of water is utilized for washing machines. It was also found that small quantities needed for water heaters, bathtubs, and other needs using 6.9%, 4.1%, and 0.9% respectively.

Literature by Beal and Stewart (2011) argues that teenagers consume high volumes of water for showers. Shaban and Sharma (2007) found that bathing, washing dishes, washing clothes, and washing utensils are responsible for much higher water consumption in households. Modern lifestyle changes can increase water consumption when bathing and showering (Bello-Dambatta, 2014). Also, bathrooms and lifestyle changes contribute to the trend towards using significantly more water for showering (Shaban and Sharma, 2007).

Models Based on Linear Regression

Linear regression analysis was conducted to examine the potential predictors' effects on per capita water consumption in urban households. The model was statistically significant as household size, age, education level, number of taps and household income showed statistical significance ($p \leq 0.05$). Together they accounted for 96.5% of the variation in per capita water consumption in the wet season, R^2 = 0.965, F= 375.813.

Irrigation water management in households

Sources and methods of irrigation are shown in Table 4, A high percentage (88%) of people irrigate crops in their homes while a small percentage (12%) fail to irrigate. According to the results, the usage of well water for irrigation was found to be the highest, which is 66.7%, followed by pipeline (28.8%) and tube water (4.5%). This was supported

Table 4: Irrigation water management

Do you irrigate to crops in your home	Number	Percentage	Source of irrigation	Number	Percentage
Yes	264	88.0	Pipeline (National Water Supply and Drainage Board)	76	28.8
No	36	12.0	Well water	176	66.7
			Tube water	12	4.5
Total	300	100.0	Total	264	100.0
Irrigation time			Irrigation method		
Early morning	60	22.7	By hand (hose or bucket)	228	86.4
Late morning	8	3.0	Manual sprinkler	36	13.6
Evening	196	74.2			
Total	264	100.0	Total	264	100.0
Additional sources for irrigation water					
Rain barrel	12	4.5			
No	252	95.5			
Total	264	100.0			

Table 5: Awareness of water management

Awareness about the cost of water per cubic meter	Number	Percentage	The general belief about the current water rate	Number	Percentage
Aware	80	26.7	Too high	28	9.3
Not aware	220	73.3	Normal	248	82.7
Total	300	100.0	Do not know	24	8.0
			Total	300	100.0
Frequency of water supply (Pipeline)	Number	Percentage			
Regular	104	43.3			
Irregular	136	56.7			
Total	240	100.0			

by Das Bhowmik, *et al*. (2020). In terms of irrigation time, it was observed that the highest percentage (74.2%) of people irrigate in the evening followed by early morning irrigation (22.7%), and a noticeable low percentage (3%) was observed for late morning irrigation. This may be due to conserving the water by reducing evapotranspiration, as evapotranspiration is high in the day's hottest hours (Wonsook *et al.*, 2020). A significant amount (86.4%) of people irrigates by hand simultaneously, 13.6% irrigate by manual sprinkler method.

Awareness of water management at the domestic level

Awareness of respondents in regards to the water supply and conservation are shown in Table 5. According to the results, most people are not aware of the cost of water per cubic meter, and only 26.7% are aware of the cost. 82.7% of the total respondents believe that the current water rate is normal, while very few (9%) believe it is too high. This supports the results obtained for living standard and family income, as they are relatively high for most of the respondents (Table 1). The frequency of water supply results shows that more than half of the respondents face irregular water supply simultaneously, 43% face a regular supply of water.

Water management in households

Table 6 shows that 88% of the respondents are more concerned about the quality of water. However, very few respondents (12%) are not concerned about water quality. It can be seen that most of the people limit their water use because they think the amount of water in wells is low, 26.7% limit their water usage to reduce the electricity bill followed by 18.7% tend to conserve the water resource. To preserve the water, nearly a quarter (24%) of the respondents

Table 6: Linear regression analysis

Reasons for limited water use	Number	Percentage	Concern about the quality of water	Number	Percentage
Not sure well has enough water	136	45.3	Concerned	264	88.0
To keep the electrical bill down	80	26.7	Not concerned	36	12.0
Not sure the septic system can handle all wastewater	8	2.7			
To conserve water to protect the resource	56	18.7			
Others	20	6.7			
Total	300	100.0	Total	300	100.0
Actions were taken to conserve water	Number	Percentage	Measures are taken to avoid running or leaky toilets and other faucets	Number	Percentage
Take short showers	72	24.0	Never had the problem	116	38.7
Installed low-flow pumping fixtures	36	12.0	Repair running toilet immediately	116	38.7
Irrigating during early morning or evening	64	21.3	Call a plumber immediately	56	18.7
Installed water efficient irrigation system	12	4.0	Fix leaks within a week	12	4.0
Reduce irrigation land area	28	9.3			
Other	88	29.3			
Total	300	100.0	Total	300	100.0

Table 7: Different water usage

Usage	Percentage
Toilet usage	11.72
Bathing	45.02
Drinking	4.12
Clothes washing	15.06
Utensils cleaning	6.26
Cooking	2.84
Watering	11.42
House cleaning	3.04
Others	0.53

take short showers while a lesser amount of the survey population (4%) has installed a water efficient irrigation system. This may be due to the high cost of conservation devices Geller *et al*. (1983). According to the results shown for measures taken to avoid running or leaky toilets and other faucets, it is noticeable that most of the people (38.7%) repair the running toilet immediately and which is on par with respondents who never had any leakage problems. Despite this, very few (4%) fix leaks within a week. This may be due to the concern of people on the limited use of water for various reasons.

Total water usage and Cost of water per cubic meter

The study population's total water usage was 12.73 $m^{3,}$ and per capita water usage was 0.1698 m^3. And the monthly water consumption 381.98 m^3. According to Tables 7 and 8, households' total income is 2,703,410 LKR, and the total Bill usage is 65692.8 LKR. Therefore, the share of water usage cost in the overall income of families is 2.43%. Sadr *et al*. (2015) observed that a household's per capita water consumption was 183 litres/person/day. This is on par with the per capita water usage of the present study. Also, he found that the water used for bathing was

Table 8: Cost of water per cubic meter

No of Units	Usage Charge (LKR/Unit)	Monthly Service Charge (LKR)
0-5	12	50
6-10	16	65
11-15	20	70
16-20	40	80
21-25	58	100
26-30	88	200
31-40	105	400
41-50	120	650
51-75	130	1000
Over 75	140	1600

*unit, 1 unit = $1m^3$
(Waterboard.lk. 2021)

greater compared to other practices. A similar pattern was observed in the current study. The study in Indian urban areas showed that per capita water usage is negatively correlated with family size. However, the present study showed a positive correlation between water usage and family size (Sadr *et al*., 2015).

CONCLUSION

Increased demand for water has put pressure on the water supply system, which has led to environmental issues such as water resource over-exploitation and ecosystem balance breaks. This study showed that a high-income level and living standards increased total domestic water consumption. It was demonstrated that elder people use less water than younger people in general. Total domestic water consumption for household uses indicated that the highest amount of (72%) water has been used for showers and bath compared to toilet flushing, personal hygiene, and cloth washing. Family size and the number of taps in a household were found to be essential indicators in estimating household water consumption; it was shown that families with many members and a high number of taps have higher water consumption in general. The total domestic water consumption is negatively correlated ($p \leq 0.01$) with the household head's age and education level. However, positively correlated with income level. The Linear regression model was statistically significant as household size, age, education level, number of taps, and household income showed statistical significance ($p \leq 0.05$). Together, they accounted for 96.5% of the variation in per capita water consumption in the wet season. Moreover, most of the people are not aware of the cost of water per cubic meter and only 26.7% are aware of the cost and 88% of the respondents are more concerned about the quality of water and very few respondents (12%) are not concerned about the water quality. This study's findings concluded that the socio-economic condition of the households' impacts various aspects of domestic water consumption in urban Batticaloa in Manmunai Pattu, Sri Lanka. These findings would help manage the water demand and help reduce their consumption in urban areas.

AUTHOR CONTRIBUTIONS

A. Narmilan prepared the manuscript text, and manuscript edition, N. Puvanitha performed the experiments and literature review, G. Niroash analyzed and interpreted the data, M. Sugirtharan performed some of the remained experiments and R. Vassanthini performed the survey with urban households.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. The authors have also entirely witnessed the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy.

ABBREVIATIONS

%	Percentage
NGO	Non-Governmental Organization
LKR	Sri Lankan Rupee

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