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Comparison of Domestic Water Consumption Pattern in Attaragoda (Rural) and Dangedara East (Urban) GN Divisions in Galle, Sri Lanka

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***Abstract**—Domestic water consumption is one of the most critical sectors of water usage and accounts for the third-highest water portion of global water consumption. This domestic water usage can be categorized in four ways: consumptive use, hygienic use, amenity use, and productive use. Due to rapid urbanization, Sri Lanka has a higher water consumption in the domestic sector. Galle is the fourth largest municipality in Sri Lanka in terms of population size. The current study identified water consumption patterns of selected urban and rural Grama Niladhari Divisions (GNDs) in Galle, Sri Lanka. Attaragoda GND (rural area) and Dangedara East GND (urban area) were selected as the study population. Data was collected through a questionnaire survey. A stratified random sampling technique was applied to distribute questionnaires among 177 and 213 Attaragoda and Dangedara East residents, respectively, during August-November (2021). It was identified that urban residents use only pipe-born water for domestic uses while rural households utilize not only pipe-born water but also groundwater. The rural area had a higher mean total water consumption (72 Liters/Capita/Day) than the urban area (62.4 Liters/Capita/Day). Mean total water consumption differed significantly between rural and urban areas ($p<0.05$). The activity that utilized the most water was washing clothes, followed by bathing and kitchen washing in both regions. There were significant differences in total water consumption for kitchen washing purposes, bathing and sanitary purposes, gardening purposes, animal husbandry purposes, clothes washing, and other washing purposes between rural and urban areas ($p<0.05$). Water consumption for kitchen washing and bathing was slightly greater in urban areas than in rural areas. It can be attributed to modern lifestyles, such as having more convenient cooking wares, flushing toilets, and shower facilities among urban residents. Washing clothes, gardening, animal husbandry, and other washing activities increased water consumption in rural areas. Households in urban areas that depend entirely on pipe-born water had a higher monthly domestic water consumption cost (Rs.612.70) than rural areas where residents utilize groundwater and pipe water. Most urban residents have switched to pipe-born water sources due to the contamination of water sources with urbanization and garbage accumulation. Most rural residents believe tap water is undrinkable due to its flavor. According to the results, households in an urban area use only pipe water for their domestic purposes, and rural households use pipe born water as well as groundwater for their domestic purposes. Laundry is the most significant water-intensive activity in both study regions.*

***Keywords**— Domestic water consumption, Pipe born water, Groundwater, Urban, Rural.*

I. INTRODUCTION

Water is a major requirement of humans and other living organisms (Bhatti and Nasu, 2010). Water demand means the amount of water requested by the users that is provided freely in unlimited quantities. Water consumption is the actual consumption of water for various tasks. Typically, water demand is higher than water consumption (Samuel, 1986). Population growth and urbanization have become significant problems for the increasing water demand. People use water for various activities, including industrial, domestic, agricultural, etc. World Health Organization (WHO) stated that “100 liters of water (per day) are required to meet an individual’s basic needs optimally” (Howard et al., 2003).

The term "domestic water demand" often describes the amount of water required for various residential purposes (Bhatti and Nasu, 2010). Domestic water demand depends on econometric factors such as knowledge, types of houses, water source accessibility, economic class, water quality, climate and hydrology, water price, and water policy (Bhatti and Nasu, 2010; Klein et al., 2008).

Domestic water consumption is regarded as the third-largest water consumption method in the world. Due to rapid urbanization, Sri Lanka also shows higher water consumption in the domestic sector. However, urbanization and the destruction of natural sources directly cause the reduction of available water sources. It also causes significant changes in domestic water consumption in urban and rural areas in Sri Lanka (Kaushalya et al., 2020). Mainly, household water uses can be divided into indoor and outdoor services. Toilets, showerheads, and washers are the three most water-intensive indoor activities, accounting for 26.7 percent, 16.8 percent, and 21.7 percent of total indoor water consumption, respectively (Lee et al., 2011). WHO stated that domestic water is “used for all usual domestic purposes including consumption, bathing, and food preparation” (Howard et al., 2003). This domestic water use can be categorized in four ways. They are consumption (drinking and cooking), hygiene (including basic needs for personal and domestic cleanliness), amenity use (for instance, car washing and lawn watering), and productive use (animal watering, construction, and small-scale horticulture).

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According to the demand theory, when the price of a good is increased, its demand decreases (Froukh, 2001). When a water price is established, calculating a per-unit cost for each home and source becomes quite simple. Even if it is free, collecting water from non-piped sources usually includes fees for transporting water from a distance (Cheruiyot, 2016). The amount of water used in the household will almost certainly increase as the family grows (Keshavarzi et al., 2006). The most crucial point in determining water use has been determined to be the household size. (Cheruiyot, 2016).

Water scarcity is widely recognized as a significant challenge to global sustainability and, if poorly managed, to international peace and progress (Hamdy et al., 1995). Growing water shortage issues affect most of the 17 SDGs, directly or indirectly (Brooks, 2007). Water supplies are under significant stress due to demographic, economic, and social factors, environmental degradation, climate change effects, and technological advancements. Water usage is estimated to rise across all sectors by 2030, with the world facing a 40% global water scarcity. Water withdrawals are expected to grow by 50% in developing nations and 18% in developed states by 2025. While approximately 1.8 billion people live in places with acute water scarcity, satisfying water demands for various purposes will be challenging (Yannopoulos et al., 2019). With current technology, reducing water pollution or increasing the balance between supply and demand for water quality is crucial for resolving regional water shortage challenges (Jia et al., 2020). Water is increasingly seen as a limited resource (Groot and Nijkamp, 2001). Different tasks can be done to reduce water waste. For example, reuse water in the washing machine, toilet with flushing interception, economy shower heads, etc. Also, the users can store the rainwater in tanks and use it later for gardening, car washing, etc. (Terpstra, 1999).

In many places of the world, water scarcity remains a significant issue (Tzanakakis et al., 2020). In the next 30 years, the global population will reach 10 billion, with developing countries accounting for a large percentage of this increase. More than half of the world's population is living in urban areas now, especially in densely populated cities; by 2050, more than two-thirds of the population will live in urban areas. Therefore, water scarcity and a gap in the amount of water available become a vast problem in the future (Maldonado-Devis et al., 2021). The increasing population and development activities such as rapid urbanization, industrialization, and agricultural operations place immense pressure on existing water sources. As a result, the existing per capita water availability of 2400 m^3 will be reduced to 1800 m^3 by 2025 (Amarasinghe et al., 2008).

Sri Lanka is not considered a water-scarce nation in general. With population expansion and urbanization, Sri Lanka is seeing a significant increase in domestic water usage (Kaushalya et al., 2020). The present drinking water supply coverage in Sri Lanka is expected to be 78 %, according to the 2009 draft Drinking Water Policy for Sri Lanka. Piped water service is available to 35% of 12 the population. Dug wells, tube wells, springs, and rainwater collection are used by the remaining 43% of the population (Ariyananda, 2010). Assessing domestic water demand functions is still difficult in developing countries since relevant data is not always accessible (Nauges and Berg, 2009). Some of the main reasons include not using metered water usage connections, differences in the conditions of water sources from family to household, and the absence of properly designed household surveys (Mu et al.,1990).

According to the Asian Development Bank (ADB), Sri Lanka's household and urban water insecurity is worse than other Asian countries (ADB, 2013; Arfanuzzaman and Rahman,2017; Otaki et al., 2022). The National Water Supply and Drainage Board (NWSDB) is the only organization in Sri Lanka to provide drinking water and maintain quality. NWSDB supplies this water primarily to municipalities and their suburbs (NWSDB, 2011; Shayan et al., 2020). Rural areas receive significantly less water supply.

Galle is a major city in the Southern province of Sri Lanka. It comprises 19 divisional secretariats (DS); 12 DS have community-managed water supply schemes. According to UDA (2019), Galle is the fourth largest municipality in Sri Lanka in terms of population size. In Galle, 93,118 people are living at present, which will be around 600,000 in 2030 (UDA, 2019). About 19.8% of the population has access to piped water. However, Galle's groundwater poses health risks due to insufficient wastewater treatment (Otaki et al., 2022). Therefore, the available volume of water may be reduced soon. Therefore, this study was conducted to compare the domestic water consumption in Galle's urban and rural GNDs.

II. METHODOLOGY

2.1 Study Area, Study Population, and Sampling Strategy

The present study was conducted in rural and urban areas in Galle, Southern province of Sri Lanka. 142/A Attaragoda Grama Niladari Division (GND) was selected as a rural area, while 97/D Dangedara East GND was selected as an urban area (Figure 1 and Figure 2). 142/A Attaragoda GND extends 62 hectares, and 97–D Dangedara East GND extends 49 hectares. A pilot study was conducted in June 2021 to identify the most suitable sampling sites and suitable sampling strategies. Only the permanent households residing in the GND were included from each GN division for the study.

During the data collection period, residents who did not reside in their homes for an extended time and were not permanent residents in the selected GNDs were omitted. The sample size for the questionnaire distribution was calculated according to the following formula (Pouragha et al., 2020).

$$Sample\ size = \frac{\frac{Z^2 \rho(1-\rho)}{e^2}}{1 + \left(\frac{Z^2 * \rho(1-\rho)}{e^2 N}\right)}$$

Where,
n = Sample size
N = population size
p = Population proportion (0.5)
e = Margin of error (5%)
z = z-score value for the confidence level (1.96)

The calculated sample size for 142/A Attaragoda GND and 97/D Dangedara East GND were 177 and 213, respectively. 142/A Attaragoda GN division had 14 sub-roads, whereas 97-D Dangedara East GN division had 18. The sample size was proportionally established by randomly selecting residences along each road. Each sub-road in 142/A Attaragoda and 97-D Dangedara East GN divisions was assigned an equal number of homes (Figure 3). The number of households was calculated using the formula below. Then, a random sample procedure was used to choose families. Both sides of the road from each GND were considered when selecting residents.

$$\text{Number of household select from each sub road} = \left(\frac{\text{Number of household in each sub road}}{\text{Total number of Household within GN division}} \right) * \text{Sample size}$$

2.2 Data collection

The questionnaire survey collected monthly domestic water usage data from selected residents in the two areas mentioned above from August to November 2021. Before the investigation, an informed written agreement was collected from each residence along each route using the sampling technique described above. The entire survey was performed in Sinhala language. It required approximately 15 to 20 minutes to complete the questionnaire. GPS points of each selected household were collected using a GPS receiver.

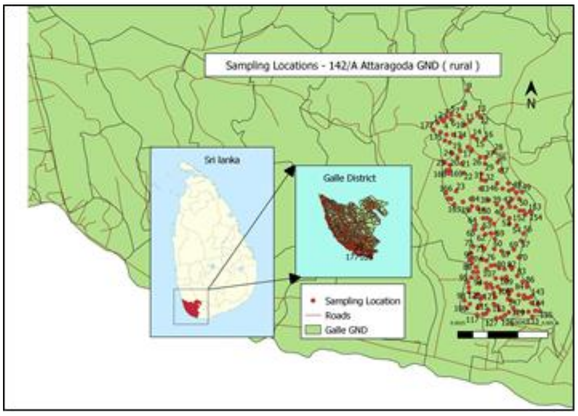

Fig. 1: 142/A Attaragoda GND

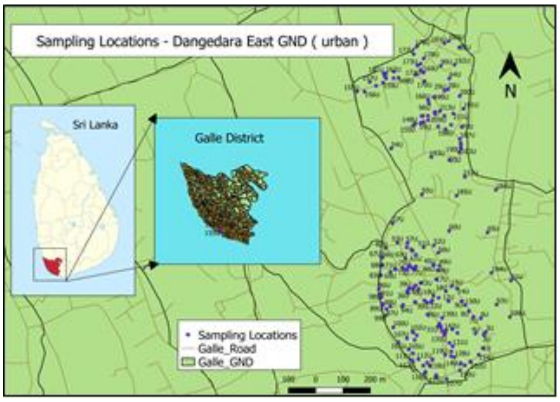

Fig. 2: 97-D Dangedara East GND

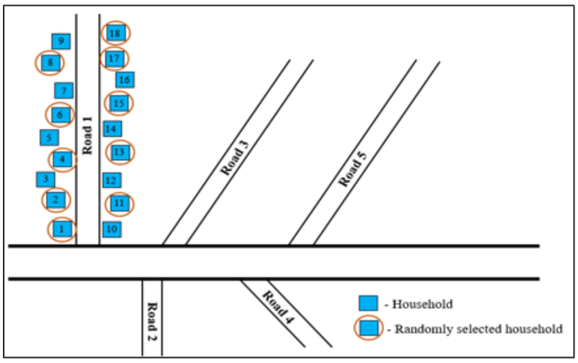

Fig. 3: Household selection strategy

Population data were collected from open discussions with Grama Niladari using Grama Niladhari Division Statistics, Galle (2020) in both GN divisions. Ethical approval was gained from the Ethics Review Committee of Humanities and Social Sciences, Faculty of Graduate Studies, University of Sri Jayewardenepura (Certificate No: ERC-HSS/FGS/2022/05/01).

2.3 Data processing and analysis

2.3.1 Calculation of domestic water usage in Liters per Capita per Day (LPCD)

The LPCD was calculated separately for rural and urban areas using the following equation (Kumpel et al., 2017).

$$LPCD=V / (D*N*P$$

Where,

V = Volume of water used for domestic purposes
D = Average number of days in a month (30)
N = Number of households sharing the tap (1)
P = Number of people in the household

2.3.2 Statistical analysis

Daily water usage was calculated for each domestic activity. The collected data were analyzed descriptively using Minitab 17 and Microsoft Excel 2013 to determine the significant difference between the two areas. Since the data were normally distributed, a two-sample t-test was used for further analysis.

III. RESULTS AND DISCUSSION

3.2 Analysis of Water Consumption Categories

3.2.1 Water source

Urban and rural households use tap and well water as their sources. According to the questionnaire survey, Figure 4 compares water sources used for drinking and other purposes (Bathing and sanitary, kitchen washing, clothes washing, vehicle washing, gardening purposes, animal husbandry practices, etc.) in rural and urban areas.

Households in an urban area used only tap water for their domestic purposes. Rural households used tap water as well as groundwater for their domestic purposes. When considering water for drinking, the highest number of rural households (88.7%) used well water, and the rest (11.3%) used tap water as the water source. Regarding other domestic proposes, 83.1% of households used well water, and 16.9% used tap water as the water source.

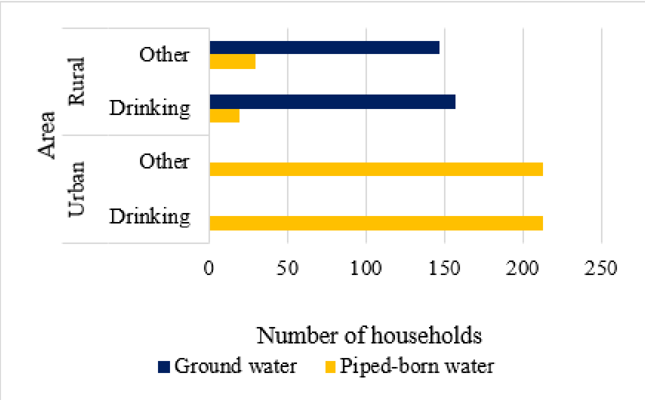

Fig. 4: Water source used for consumption in both study areas.

The National Water Supply and Drainage Board (NWSDB) is mainly responsible for water supply throughout Sri Lanka and plans to provide 140 LPCD in urban areas and 110 LPCD in rural areas (Department of Census and Statistics Sri Lanka, 2012). Figure 5 defines the tap water supply and groundwater as the principal domestic water sources in the two study areas. In an urban area, their primary water source is piped-born water. However, the main water sources in the rural area are groundwater and tap water. Other than primary water sources, some households meet their water demands using both. According to Panabokke and Perera (2005), about 80% of the rural domestic water supply needs are completed from groundwater-utilizing dug and tube wells in Sri Lanka. Most urban residents switch to tap water sources due to groundwater and surface water contamination caused by gradual urbanization and garbage accumulation (Kaushalya et al., 2020). A significant portion of the urban water requirement of the country is treated and distributed by the NWSDB (Panabokke and Perera, 2005). The majority of rural residents in the research area choose groundwater for drinking. The reason is that they dislike the flavor of tap water for their consumption.

3.2.2 Mean total water consumption Liters Per Capita per Day (LPCD) in both study areas.

Figure 5 shows the mean total water consumption difference between rural and urban areas.

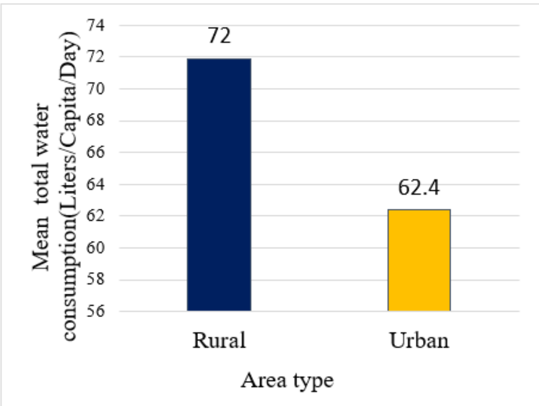

Fig. 5: Comparison of mean total water consumption in study areas

Total water consumption for domestic needs is significantly different from rural to urban. (p = 0.000). The rural area had a higher mean total water consumption than the urban area.

This may be due to several reasons, including gardening is essential for rural households in developing countries. Home gardening directly makes an impact on water consumption. Watering gardens accounted for the majority of outdoor water use. It uses more than half the water outside (Fan, 2013). In addition, animal husbandry practices were recorded as higher in rural areas when compared to urban ones. Therefore, water consumption also increases in the rural area (Keshavarzi et al., 2006).

3.2.3 Comparison of per capita water consumption between urban and rural area

Fig 6 shows the mean water consumption for each domestic purpose between rural and urban areas.

There were significant differences in total water consumption for kitchen washing purposes (p = 0.000), bathing and sanitary purposes (p = 0.003), gardening purposes (p = 0.000), animal husbandry purposes (p = 0.003), clothes washing (p = 0.000) and another washing purpose (p = 0.000) between rural and urban areas. There were no significant differences in water consumption in drinking and vehicle washing among rural and urban areas (p >0.05). Clothes washing consumed the highest water consumption, followed by water used in bathing and kitchen washing. Water consumption in urban areas for kitchen washing and bathing was slightly higher than in rural areas. Rural water consumption was higher for clothes washing, gardening, animal husbandry, and other purposes.

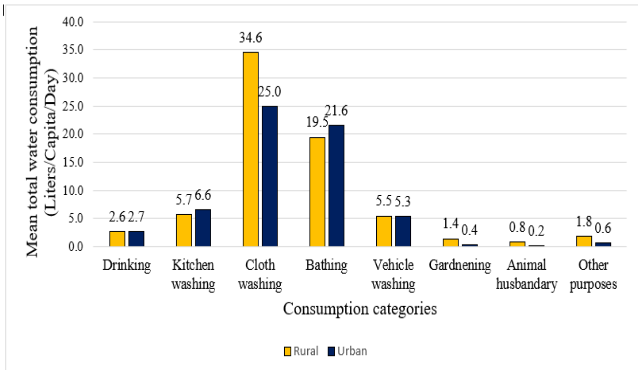

Fig. 6: Comparison of per capita water consumption for urban and rural areas

Based on the results, in a rural area, there is a higher amount of other water used for clothes washing and other purposes (ex, a fish tank) than in an urban area. The reason is that most rural household maintain their fish tanks as a hobby. Rural people also wash their clothes by hand, and urban households use modern washing machines (Otaki et al., 2022). According to Figure 7, a metropolitan area shows higher water consumption for bathing and kitchen washing. The reason is that it is in an urban area where residents have more modern lifestyles, such as more convenient cookware, flushing toilets, and shower facilities (Otaki et al., 2022).

3.2.4 Comparison of cost for domestic water consumption between two areas

There was a significant difference in paid domestic water consumption costs between study areas (p = 0.000). Figure 7. shows the mean monthly fee paid for domestic purposes in both regions.

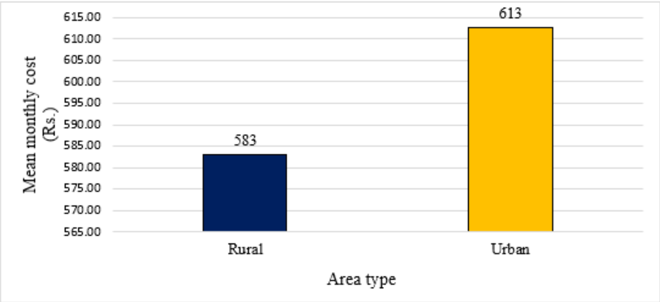

Fig. 7: Mean monthly cost for domestic water consumption in rural and urban areas.

According to the results in Figure 8, expenses for domestic needs vary from rural to urban. Urban people spend more on prices than rural. Most rural people depend on groundwater sources for their household needs other than tap water, and urban people rely entirely on tap water sources.

IV. CONCLUSION

Households in urban areas used only tap water for domestic purposes, and rural households used tap water and groundwater for domestic purposes. Laundry is the most water-intensive activity in both study regions. Rural areas have more domestic water consumption (by LPCD) than urban ones. Collecting rainwater could be an effective method for lowering the amount of groundwater and municipal tap water used for gardening in residential areas.

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