Spatiotemporal Characteristics of the Domestic Water Consumption Patterns and Related Issues in Sri Lanka

G.N. Kaushalya, V.P.I.S. Wijeratne, L. Manawadu

Department of Geography, University of Colombo, Cumarathunga Munidasa Mawatha, Colombo 03.

DOI: 10.29322/IJSRP.10.08.2020.p10492
http://dx.doi.org/10.29322/IJSRP.10.08.2020.p10492

Abstract- Water is essential for all sorts of growth and development of humankind, animal, and plant. One of the most important uses of water is for domestic purpose and it is the third-largest water consumer from total water consumption in the world. This study mainly explored the spatiotemporal patterns of domestic water consumption and related issues in semi-urban and rural areas. Primary data collection mainly conducted with a hundred (N=100) sample household questionnaires and sample households were selected based on main drinking water sources (groundwater and tap water) using a stratified random sampling method. Correlation, Kernel density, nearest neighbor analysis, and interpolation techniques were used to fulfill the main research objective of the study. All analyses carried out using ArcGIS 10.1 and Excel 2013 software. The study found 392 randomly distributed domestic groundwater wells for daily activities. In the wet season, most households (65%) using the groundwater for their daily purposes but in the dry season, most of them (51%) use the government water supply. The daily average water consumption of the study area is 119.44L per person per capita per day. Bathing, toilet, cloth washing, and cooking and washing dishes were identified as the higher water consumption activities around the study area. The amounts of water consumption by each activity were 31.54%, 24.2%, 23.66%, and 10.33% respectively. However, water consumption patterns can be changed due to income, the number of household members, age, and distance. Also, the Uneven distribution of drinking water sources, spatial and time-related issues, insufficient water storage facilities, water scarcity, poor water management were identified as major issues related to domestic water consumption in the study area. Finally, it is hoped that the results of the study would benefit the policy and planning executives in the study area in optimizing the existing water resources for sustainable development.

Keywords: Domestic Water Consumption, Spatiotemporal variability, ArcGIS 10.1, Water Supply

I. INTRODUCTION

Water plays a significant role in human life and it became a basic necessity for economic growth and better living standards. Apart from the rapid population growth, expansion in urbanization, industrialization, rising demand and falling supplies due to overexploitation and anthropogenic impacts remain some of the major challenges in the drinking water sector. Moreover, Water is essential for the growth and development of all species of humans, animals, and plants. The Earth's hydrosphere contains about 1.36 billion kilometers of water and 75 percent of the earth's surface is covered with water containing 97 percent salt and 3 percent freshwater. Only 1 percent of freshwater is available for human consumption (Ali and Tarfa, 2012).

One of the most important uses of water is for domestic purpose and it is the third-largest water consumer from total water consumption in the world after industry and agriculture. The World Health Organization (WHO) defines “domestic water as the water used for all domestic purposes, including drinking, bathing, and food preparation”. Domestic water consumption can be partition into two types: indoor water use activities and outdoor water use activities. Indoor water use activities include drinking, cooking, hygiene (bathing, laundry, and cleaning), and outdoor water use includes car washing, kitchen gardens, livestock water, and yard cleaning (Al-Ahmady et al, 2011). Domestic Water varies according to the living conditions and daily activities of consumers in urban and rural areas (Mohommad and Sanaullah, 2017). The United Nations organization has predicted that the world population will increase by another two billion by 2030 (Postel, 2000). Furthermore, with urbanization because of the influx of people into urban centers and urban areas, more water is likely demanded domestic purposes in those areas. Although increasing water demand is understood relative to the gradually increasing population, it is very difficult to quantify the increasing water demand due to the change in living conditions. And also, several studies have done globally have shown

various factors were significantly connected with determining the amount of domestic water use. Such as the number of household members, level of maintenance of water supply system, education, and age of household head, income, distance to the water source, type of water source, etc. (Keshavarzi & et al, 2006: Fan et al, 2013).

According to the world health organization (WHO), the minimum per capita daily water consumption is 150 Liters. At present, per capita, daily water consumption in many parts of Sri Lanka is less than 100 Liters (Singh & Turkiya, 2013). Also, about 42 percent of the world's population will not be able to meet their basic water needs by the year 2050. Water scarcity affects more than 1.1 billion people globally. It was estimated that one-fifth of the world's population lives in areas where there is no enough water to meet-all demands (Shan and et al, 2015). A further one of the world's population does not have access to clean drinking water. This will have a direct impact on developing countries like Sri Lanka (Hewagamage, 2016). Population growth, business activity, urban development, water pollution, climate change, and drought have led to increasing water shortages in many parts of the world. (Shan & et al. 2015). Therefore, water shortage is a common and prevalent issue in different countries, especially in developing countries.

At present, a significant increase in the domestic water consumption sector can be seen also in Sri Lanka with population growth and urbanization. Sri Lanka has been always fortunate in having abundant freshwater reserves. But the increasing population, overexploitation of surface water, and groundwater over the few decades have resulted in water scarcity in any region of the country. Therefore significance changes and patterns can be identified in the domestic water consumption sector in Sri Lanka as well.

Recent decades have seen many research-based on household water consumption all over the world. But the few analyses have done in Sri Lanka. However, the most recent researchers have done for the identification of activity based on household water consumption. Various studies from the whole world have been studied on household water consumption patterns. These studies have shown that domestic water consumption in households varies considerably according to the living standard of the different areas. Per capita, water use was found to be 83.17 liters per person per day in Bangladesh with a positive correlation with socio-economic factors such as income, household size, use of water pipes, quality of the houses, and e.c.t. (Al Amin et. al., 2011). Singth and Turkiya (2013) study household domestic water consumption patterns in rural semi-arid village India were per capita water consumption stands at an average of 117 Liters. Per capita was found to be as high as 203 Liters per person per day in Harbin China with a correlation with some factors such as climate changes (dry and wet seasons), use equipment in water consumption, etc. (Tingyi Lu, 2007). Oyasanmi, (2018) has identified the patterns of household water consumption in different areas of the Koji State in Lokoja Metropolis as well as sources of water supply in the area.

In many studies that have been done in this regard have been studied on the water usage by different domestic water consumption sector. Oyasanmi, (2018) has identified the water used for washing clothes and bathing accounted for the largest quantity of household water consumption per day with 53 percent and 25 percent respectively of total daily water consumption. In India, Shaban and Sharma (2007) studied domestic water consumption patterns in seven major cities. This study was found out that at the household level, bathing is the highest amount of water consumption with about 28 percent of total domestic water consumption. Toilets 20 percent, washing clothes 18.6 percent and washing utensil 16.3 percent. In Bauchi metropolis, the pattern of domestic water consumption at the household level is bathing which accounts for 45 percent of total domestic water consumption. Flushing toilet (15%) and Muslim prayer (10%) have become the second and third largest water consumption (Istifanus, 2017).

Some studies have also attempted to study the water sources used for domestic water consumption. Oyasanmi, (2018) has identified a total of 30 percent of households depended on wells located in their land or neighboring houses. Also, in this study, the analysis revealed that per capita water consumption varied within different locations in the study area. Mohammad and Sanaullah (2017) studies about the sources of water for domestic consumption and private tube wells (48.5%) and public hand pumps and neighbors (19.2%) have become the main water source for their daily activities. According to the results of the correlation analysis in this study indicated that water consumption was significantly correlated with household size, the age of household head, household income, availability of tap water, time to collect water, bathing time per month, and groundwater table.

Barreto, (1999) has surveyed the water profile of residential consumption, end uses of water and frequency, and mean flow rates in a sample of households located on the west side of the city of Sao Paulo. According to the results of this study, the consumption for each weekday of monitoring, Friday as the higher water consumption. The point

of water consumption that showed greater use was the shower with 13.9%.

However, considering some of the research that has been done, it showed that they have studied the various issues related to domestic water consumption. In most of the studies, urban areas were chosen as their research study area. But in this study, both semi-urban and rural areas were chosen as the study area. This researches also studied the changes in household water consumption between several administrative zones. However, the focus of this study was to identify the changes in household water consumption in a selected small administrative region. Furthermore, while the above studies focus on statistical analytical methods for data analysis, this study has focused both statistical and spatial analyses. Also, in contrast to those studies, this study focuses to identify the problems related to water consumption. In this way, it can be identified that there are some differences between the above-discussed studies and the current study.

The primary aim of the research investigation was to identify the spatiotemporal patterns of domestic water consumption and related problems in Dompe GN Division, Gampaha District. To achieve the overall objectives, specific objectives formulated as; [1] identify the main water sources and their distribution patterns in the study area, [2] access the spatiotemporal patterns of domestic water consumption in the study area, [3] examine the problems in related with water consumption in the study area.

II. METHODOLOGY

Study area

In the study, Dompe GN Division was selected as a study area, Situated in Gampaha district,Western Province. Dompe GN Division extending 1.287Km² small area of Gampaha District located in the western part of Sri Lanka. It was located at the Latitude 6° 57' 31" N - 6° 56' 35" N of equator and Longitude 80° 4' 11" E - 80° 2' 57" E (Figure 1). Dompe GN Division Located at the wet Zone in Sri Lanka. The area lies at an altitude of 50 feet above mean sea level and it belongs to the Kelani River Basin. According to the secondary data were obtained from the Census and statistics department of Sri Lanka, groundwater sources (Shallow wells) became their main water resource for Drinking water.

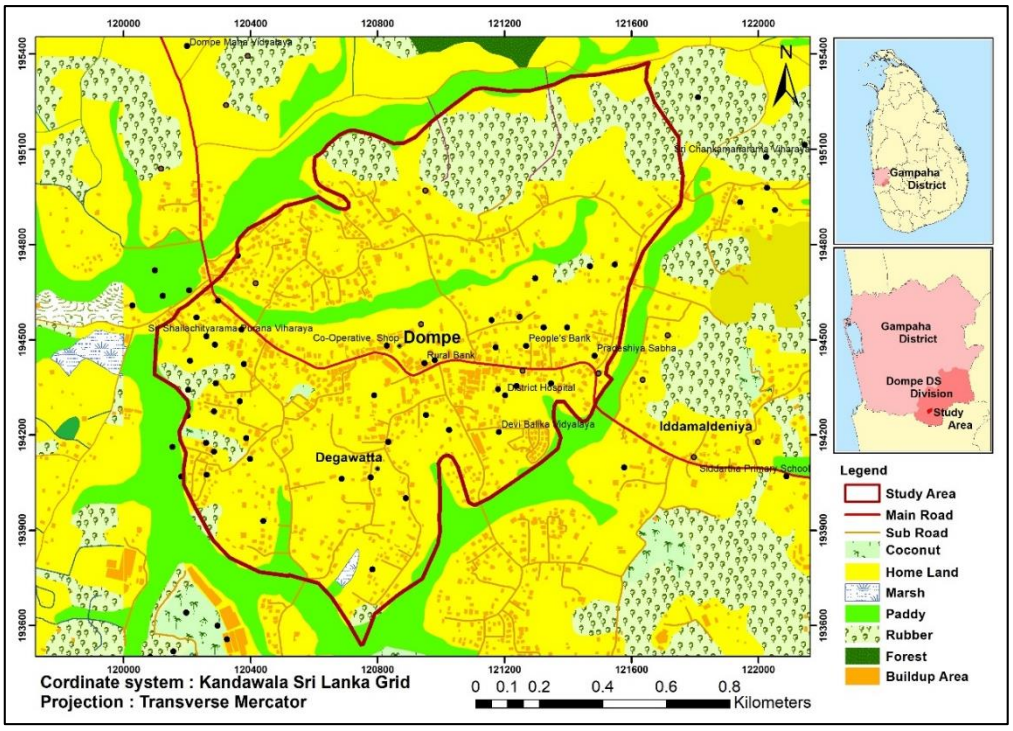


Figure 1: Study Area Map.

Data and Methods

Primary data were collected from July 2019 to January 2020 and mainly covered dry and wet seasons for data collection. Data collection mainly conducted by hundred (N=100) sample household questionnaire and households selected based on main drinking water source (groundwater and tap water) using stratified random sampling method to collect data on quality of water, duration of water

usage, amount of water usage, type of water storage and water availability. Also, this survey obtained information on socio-economic and demographic factors such as income, number of household members, the age of household head, time to collect water, and the capacity of the container in which water is stored. A GPS survey carried out to identify the spatial locations of groundwater sources as well. Additionally, Semi-structured interviews also conducted in this research to identify the opinions of the people about domestic water issues and randomly selected ten officers and village leaders who are living in the study area.

Secondary data collection was also an important part of this study. Relevant secondary data were collected from the National Water Supply and Drainage Board, Department of Census and Statistics, and through the research papers and some useful literature.

Data Analysis

i. Spatial Distribution Pattern of Water Resources

Spatial Distribution of the domestic water resources was identified using spatial analysis tools in ArcGIS10.3. Average Nearest Neighbor Analysis was used to examine the distribution pattern of the water resources over the study area. The spatial density of the water resources was identified using Kernel Density Method and this analysis mainly estimated the density of water resources an entire dimensional study area, based on the known locations of discrete events. The density was calculated based on the centroid of each grid and Kernel function has used to interpolate the values over the study area.

ii. Characteristics and Pattern of Domestic Water Consumption

Indoor water consumption includes water used for bathing, toilet, cooking, drinking, washing, etc. were calculated to identify the characteristics of domestic water consumption. Daily basis per capita water consumption was calculated by each activity using the following equations (Equation 1 to 4). Concentric ring buffers were created from the main road and daily water consumption values were extracted to each ring to identify the pattern of the water resource distribution in the study area. Also, correlation analysis was used to assess the pattern of domestic water consumption and household income, the number of household members, age, and distance were used as major factors.

Equation 1:

*Daily water consumption for Bathing = Time for each use * Tap use frequency * Tap flow rate*

Equation 2:

*Daily water consumption for toilet = Toilet cistern volume/ Bucket volume * Number of flushes per day*

Equation 3

*Daily water consumption for cooking = Time of each use * Tap use frequency * Tap flow rate*

Equation 4

*Daily water consumption for washing clothes = (Time for tap use * Tap flow rate) or*

*(Washing machine water use = machine water consumption * number of uses)*

iii. Problems and Challenges of Domestic Water Use

Problem tree analysis was used to identify the existing problems and challenges based upon information on questionnaire survey and interviews. Also formulated the core problems, direct and indirect problems related to the domestic water consumption in the study area, and constructed a tree showing these relationships.

III. RESULTS AND DISCUSSION

Main water resources and their distribution patterns

The study survey found 392 domestic groundwater wells for daily activities and the Nearest Neighbor Analysis showed their random distribution patterns over the study area (Figure 2). The highest spatial density of the groundwater well in the study area is 2.968 and the lowest is 0.495 (Figure 3). Therefore, it can be identified that the groundwater wells of the study area have distributed unevenly. The ratio between groundwater resources and households in the study area can be identified as a 1: 2.34. Higher density areas scattered in the Western and Northwestern regions in the study area.

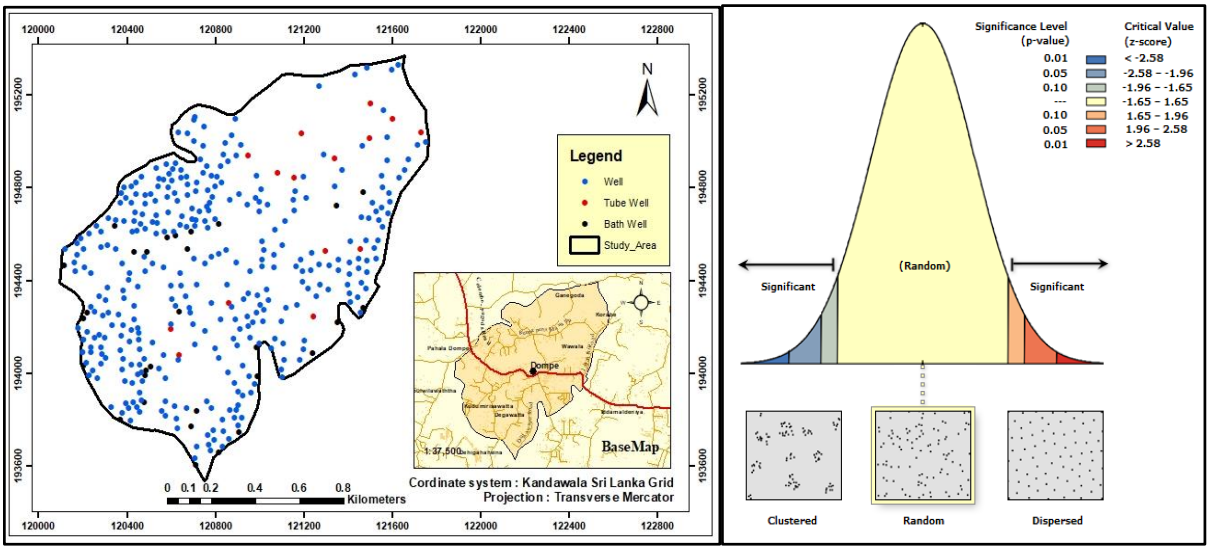


Figure 2: (a) Spatial Distribution of Groundwater Wells in the Study Area; (b) Spatial Distribution Pattern of the Groundwater Wells (Using Nearest Neighbor Analysis)

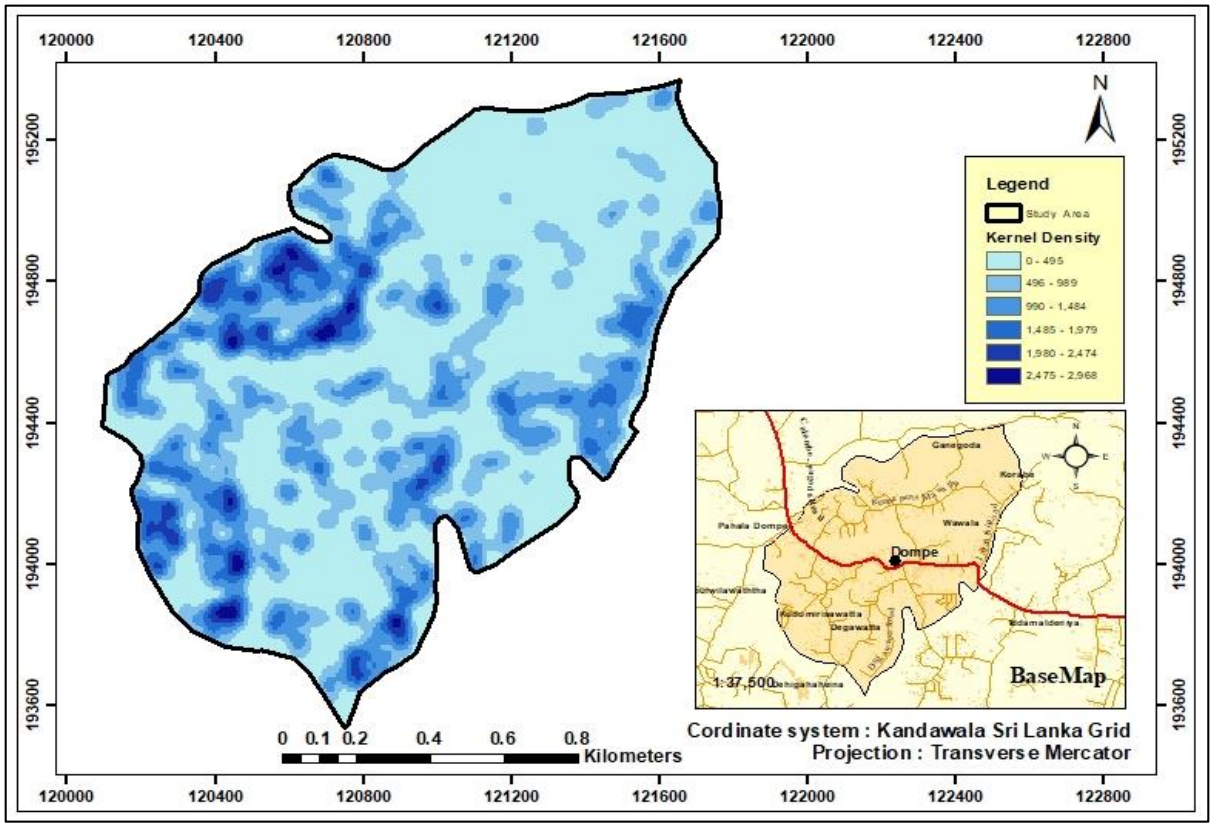


Figure 3: Spatial Density Map of Groundwater wells.

In the wet season, most households (65 percent) using groundwater resources for their daily activities. Such as shallow wells, deep wells, tube wells, etc. Furthermore, 35 percent of households using the government water supply for their daily activities. But in the dry season, most of them (51 percent) used the government water supply for their daily activities (Table 1).

Table 1: Characteristics of Spatial Distribution of Groundwater Well

Water Source	Total Number of Wells	Percentage	Spatial Density
Shallow and Deep Wells	348	88.78	0.3795
Tube Wells	30	7.65	0.0327
Bath Wells	14	3.57	0.0153
Total	**392**	**100**	**0.4272**

Characteristics and Spatial Distribution Pattern of Domestic water Consumption

The daily average water consumption of the study area is 119.44L per person per capita per day. The minimum per capita daily water consumption is 84.10 Liters and the maximum per capita daily water consumption is 173.80 Liters (Table 2). There is a big difference between daily domestic water consumption in the area and different influencing factors can be identified, such as the number of household members, age, occupation, income, etc. About 10 percent of households per capita daily water consumption exceeds 150 Liters and 83 percent of household per capita water consumption exceeds 100 Liters. But, about 17 percent of households have a per capita water consumption of fewer than 100 Liters. The average total water consumption of the household in the study area is 438.87L. Also, the minimum daily water consumption of a household can be identified as 130.90 Liters and the maximum as 890.80 Liters.

Table 2: Average water Consumption and Total water consumption per Household

Characteristics	Water Consumption per person per capita per day (Lpcd)	Total water consumption per Household per capita per day (Liters)
Mean	**119.44**	**438.87**
Standard Deviation	20.17	148.42
Minimum	84.1	130.9
Maximum	173.8	890.8

But when focusing on the special distribution of average water consumption per capita per day, it is possible to identify the differences in its distribution within the study area. The daily average water consumption of the area clearly shown that moving away from the main road, which depicts a lower value to higher value of domestic water consumption can be observed in the rural areas of the study area (Figure 4).

Water is used for various indoor purposes such as drinking, bathing, cloth washing, toilet, cooking, domestic cleaning, etc. and outdoor activities such as garden watering, washing vehicle, livestock, etc. The pattern was bathing which consumes 31 percent of total domestic water use at the domestic level, Flushing toilet (24 percent), washing cloth (23 percent), cooking (10 percent), Drinking (2 percent) watering garden (3 percent) and so on. Bathing became the highest water usage activity in the study area. Figure 5 shown total daily water consumption by activity in the study area.

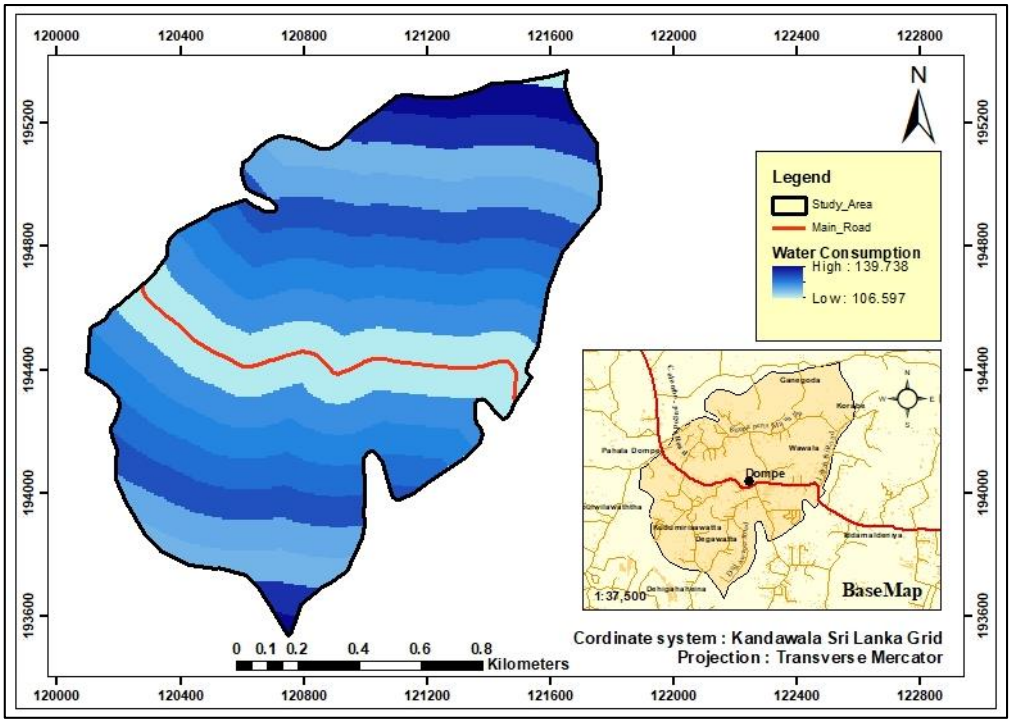
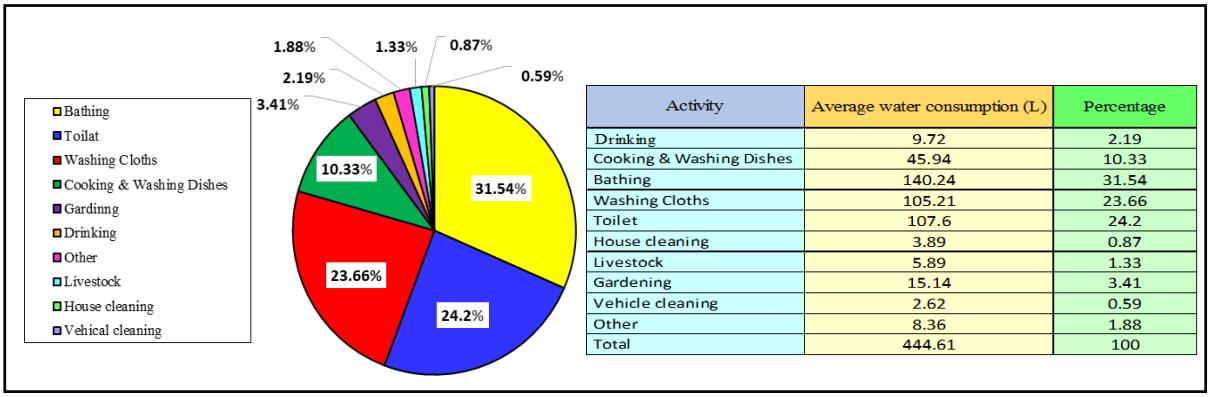


Figure 4: The Spatial Variability of Daily Average Water Consumption with Distance



Activity	Average water consumption (L)	Percentage
Drinking	9.72	2.19
Cooking & Washing Dishes	45.94	10.33
Bathing	140.24	31.54
Washing Cloths	105.21	23.66
Toilet	107.6	24.2
House cleaning	3.89	0.87
Livestock	5.89	1.33
Gardening	15.14	3.41
Vehicle cleaning	2.62	0.59
Other	8.36	1.88
Total	444.61	100

Figure 5: Total Daily Domestic Water Consumption by Each activity

Furthermore, several factors can be identified that affected domestic water consumption in the study area, and different influencing factors were analyzed. Monthly household income, the level of education of the head of household, the number of family members, and the capacity of the water storage tank have shown a positive significant correlation with daily domestic water consumption in the study area (Table 3). Pearson correlation analysis statistics show that the range of coefficients is weak correlations (0.1-0.3), low correlation (0.3-0.5) a significant correlation (0.5-0.8) and high correlation (0.8-1.0). Among those factors, the number of household members (R^2 - 0.90949) and the capacity of the water storage tank (R^2 - 0.83573) were found out, have a high positive significant correlation with daily domestic water consumption. However, it was also found that factors such as time spent at home and the age of the household head have a negative correlation with daily domestic water consumption.

Table 3: Factors Influencing Domestic Water Consumption

Factor	Correlation coefficient
capacity of the tank	0.83573
number of family members	0.90949
household income	0.28051
age of the head of the household	-0.10656
level of education of the head of household	0.22175
time spent at home	-0.23336

Also, a questionnaire survey was consulted on their ideas on some of the existing domestic water consumption patterns in households. Accordingly, 73 percent of households said that water consumption has increased as the number of household members has increased. 38 percent of households was agreed that as the number of member's increases, the amount of water used for members was limited. About 56 percent of households agreed that water consumption increased as household income increase. With the decrement of water at the source during the dry season, 84 percent agreed that water consumption has limited.

Problems/Challenges of Domestic Water Consumption

A problem tree was created to identify the problems related to domestic water consumption in the study area. That focused on identifying the key problems related to domestic water consumption (Figure 6). Accordingly, six major issues of domestic water consumption were identified in the study area. Such as uneven distribution of domestic water resources, Spatial and Time-related problems, water-storing problems, Water scarcity, Water Management issues, Other Problems related to domestic water consumption.

The government water supply and groundwater resources can be identified as the main domestic water sources in the study area and as a result, many problems related to water supply and groundwater wells in the study area can be identified. About 37 percent of households have government water supply as their primary water source in the study area. Duration of water supply was only at night, limiting water supply for a very short period and inadequate water speed is the main problem that can be identified in this connection. Problems can be identified concerning the water supply for a short period.

About 63 percent of households in the study area utilize the groundwater wells as their primary water source. Problems such as water scarcity during dry seasons, fluctuation of groundwater levels, drying of groundwater source, groundwater sources are not constructed to a proper standard, deterioration of groundwater quality, inability to construct a groundwater source due to rock layers, and insufficiency of groundwater source can be identified concerning the use of groundwater wells. Furthermore, it can be seen that a few people in the study area do not have a permanent water source for their daily activities. This was due to the poor quality of groundwater, the high cost of constructing groundwater well, and the lack of groundwater access.

With the gradual urbanization, pollution of surface water sources, as well as groundwater sources due to garbage accumulation, is a major problem that can be identified in the present in the study area. It is also possible to identify the accumulation of water in the marshlands of the study area with the flood conditions during the rainy season. At the same time, the water from the nearby groundwater sources can be seen to be inappropriate for human consumption. The high cost of re-cleaning these water sources and the inability to use the water from those water sources for a short period were led to problems related to domestic water consumption.

Also, the lack of tanks with high water capacity to store enough water for the consumption in households is a problem for some families in the study area. This is due to their inability to purchase tanks with higher water capacity. Furthermore, drying up water sources during the dry season is one of the major problems that can be identified in many parts of the study area. Along with this, people living in low altitude areas for alternative water sources (bath wells, tube wells, and government water supply). But the peoples in high altitude areas suffer from lack of water for their daily activities.

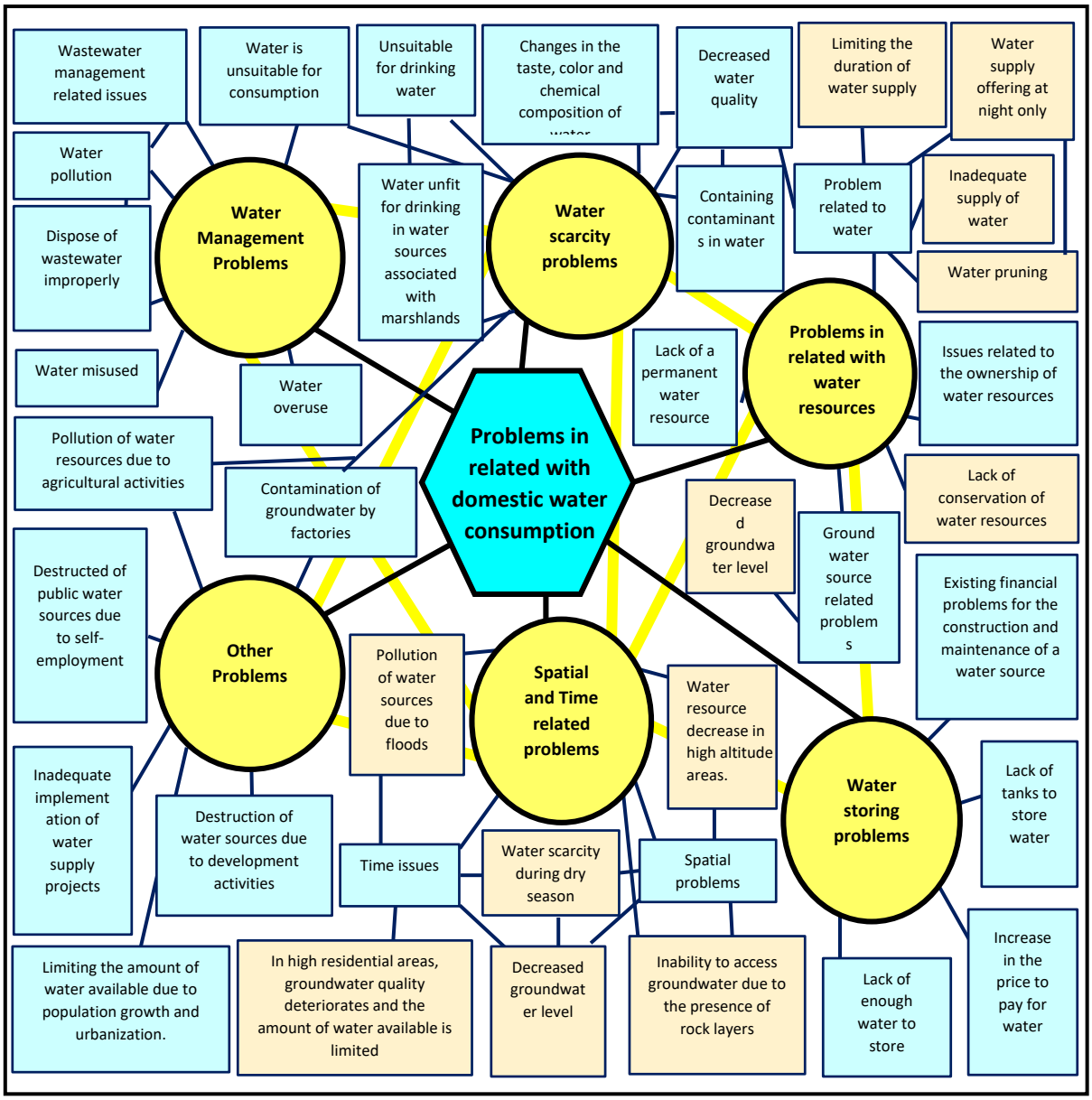


Figure 6: Problems/Challenges of Domestic Water Use

Water management related issues such as water overuse and water misuse can also be identified in the study area. The daily water consumption of the household increased as the number of members in the household increases. In comparison, the amount of water available from the water source has not changed which has led to problems in domestic water consumption. Also, the problems related to the disposal of wastewater can be identified in the area. This shows that several interrelated problems of domestic water consumption can be identified in the study area.

IV. CONCLUSION

In the wet season, most households (65 percent) using groundwater resources for their daily activities. Such as shallow wells, deep wells, tube wells, etc. Furthermore, 35 percent of households using the government water supply for their daily activities. But in the dry season, most of them (51 percent) used the government water supply for their daily activities. The study found 392 domestic groundwater wells for drinking and other domestic use. Distribution pattern of groundwater wells identified as Random distribution. The distribution density of the groundwater wells is 0.4272. Also, the ratio between groundwater resources and households in the study area can be identified as 1: 2.34. Higher groundwater resource density can be identified in the western and northwestern regions in the study area. The results of this study revealed that the daily average water consumption of the study area is 119.44L per person per capita per day. About 10 percent of households per capita daily water consumption exceeds 150 Liters and 83 percent of

household per capita water consumption exceeds 100 Liters. But, about 17 percent of households have a per capita water consumption of fewer than 100 Liters. Near the main road, the daily average water consumption per person per capita per day was found to be lower than compared to other areas.

Bathing (31 percent) is the highest water usage activity in the study area. Toilet (24 percent) and Washing clothes (23 percent) are the second and third largest water consumers from total domestic water consumption. Furthermore, several factors can be identified that affected domestic water consumption in the study area. According to the correlation analysis can identify the household income, the level of education of the head of the household, the number of family members, and the capacity of the tank have a positive significant correlation with daily domestic water consumption in the study area.

Accordingly, six major issues related to domestic water consumption were identified in the study area. Such as problems related to the uneven spatial distribution of domestic water resources, spatial and time-related problems, water-storing problems, water scarcity, water management issues, other problems related to domestic water consumption, etc. It was also found that these problems are interrelated with each other.

REFERENCE

Amin, M.AL., Mohmud, K., Hosen, S., Islam, M.A. (2011) Domestic water consumption patterns in a village in Bangladesh; Available at online: http://iebconferences.info/356.pdf (07.02.19)

Al-Ahmady, K.K., (2011) Calculating and Modeling of an Indoor water consumption factors in Mosul City, Iraq.
Available at online: https://www.researchgate.net/publi cation/324115649_Calculating_and_Modeling_of_an_Indoor_Water_Consumption_Factor_in_Mosul_City_Iraq(21.02.19)

Ali, M. and Tarfa, A.B., (2012) State of water supply and consumption in urban areas at household level. A case study of East Wollaga Zone Ethopia; Available at online: https://www.semanticscholar.org/paper/State-of-Water-Supply-and-Consumption-in-Urban-at-A-Ali-Terfa/aa64f72f9324b1e6a82af8dfff642742fb4ba2eb (20.04.19)

Barreto, D., (1999) Residential water profile and internal end uses
Available at online: https://www.google.com/url?sa=t&source=web&rct=j&url=http://www.irbnet.de/daten/iconda/CIB11789.pdf&ved=2ahUKEwiK4LrS 4DrAhVJfisKHX9IBcYQFjAAegQIBRAB&usg=AOvVaw2K_3FlV_yuli-RXwAv0s6i (08.03.19)

Delina, P. J. E., and Dasinaa, S. (2016) Consumer Perception and Factors Influencing in Adapting of Bottled Water Consumption in Batticaloa District, Sri Lanka; Available at online: https://www.eajournals.org/journals/interna tional-journal-of-interdiscipli nary-research-methods-ijirm/vol-4issue1april2017/consumerpercept ionfactorsinfluencing-adapting-bottled-waterconsumption-batticaloa-district-sri-lanka (2019.06.10)

Istifanus, V. (2017) Pattern of Domestic Water Use in Bauchi Metropolis; Available at online: https://www.iiste.org (21.02.19)

Jensen, P.K., Van Der Hoek, W., Konradsen, F., Jehangir, W.A. (1998) Domestic use of irrigation water in Punjab
Available at online: https://www.google.lk/search?q=domestic+use+of+irrigation+watar+in+panjab&oq=domestic+use+of+irrigation+water+in+panjab&aqs=chrome..69i57j33.5673j1j7&client=ms-android-samsung&sourceid=chrome-mobile&ie=UTF-8 (11.03.19)

Jethoo, A.S. and Pooniya, M.P. (2011) water consumption pattern of Jaipur city, India; Available at online: www.ijesd.org/show-30-362-1.html (21.02.2019)

Jorge, C., Vieira, P., Rebelo, M., Coves, D. (2015) Assessment of water use efficiency in the household using cluster analysis; Available at online: http://www.sciencedirect.com/science/article/pil/s18 7770581502615 6-2015 (09.02.19)

Keshavarzi, A.R., Sharifzadeh, M., Haghighi, A.A.K., Amin, S.,Keshtkar, SH., Bamdad, A. (2006) Rurl domestic water consumption behavior: A case study in Ramjerd area, Fars province, I.R. Iran; Available at online: https://www.sciencedirect.com/science/article/abs/pii/S004313540 6000406 ?via %3Dihub (11.03.19)

Lu, T. (2007) Research of domestic water consumption's field study in Harbin, China.; Available at online: https://www.switchurbanwater.eu/outputs/pdfs/w31GenPHDResear ch of domestic_water_consumptionfield_study_in_Harbin_China.pdf&veb (2019.02.15)

Mamade, A., Loureiro, D., Covas, D., Coelho, S.T., Amado, C. (2013) Spatial and temporal forecasting of water consumption at the DMA level using extensive measurements; Available at online: https://www.sciencedirect.com/science/article/pii/s1 877058140012 09 (21.02.19)

Mohammed, A.H. and Sanaullah, P. (2017) An Empirical Analysis of Domestic water Sources,Consumption and Associated Factors in Kandahar City, Afghanisthan; Available at online: https://www.researchgate.net/publication/316512250_An_Empirical_Analysis_of_Domestic_Water_Sources_Consumption_and_Associated_Factors_in_Kandhar_City_Afghanistan (2019.06.14)

Oyesanmi, O. (2018) An Assessment of Domestic Water Consumption Pattern in Lokoja Metropolis, Koji State.; Available at online: http://www.reserchgate.net/pubblication/328496453 (12.03.19)

Postel, S.L., (2000) Entering an Era of water scarcity: The challenges Ahead; Available at online: https://esajournals.onlinelibrary.wiley.com/doi/10.1890/1051-0761%282000%29010%5B0941%3AEAEOWS%5D2.0.CO%3B2

Shaban, A. and Sharma, (2007) Water consumption patterns in Domestic household in major cities of India
Available at online:https://www.researchgate.net/publication/262127354_Water_Consumption_Patterns_in_Domestic_Households_in_Major_Cities (21.03.20)

Shan, Y., Yang, L., Perren, K., and Zhang, Y., (2015) Household water consumption: Insight from a survey in Greece and Poland; Available at online: https://www.researchgate.net/publication/281467055_Household_Water_Consumption_Insight_from_a_Survey_in_Greece_and_Poland

Singh, O.and Turkiya, S. (2013) A survey of household domestic water consumption patterns in rural semi-ared village, India; Available at online: https://www.reserchgate.net/publication/242656039(12.02.19)

Thomas, T. (1998) Definition of water security (personnel communication) Trivandrum planning Meeting, August

Voigt, T.N.V. and Mohajeri, S. (2013) Water Demand Management, water end use measurements and water consumption patterns in Tehran households.; Available at online: https://www.goole.lk/url?sa=t&source=web&rct=j&url (21.02.19)

WHO, (2013) the right to water, WHO Geneva

AUTHORS

First Author –Ms. G.N. Kaushalya, Department of Geography, University of Colombo, (BA), gnnipuni011@gmail.com.

Second Author – Mrs. V. P. I. S. Wijeratne, Department of Geography, University of Colombo, (M.Sc.), sandamali@geo.cmb.ac.lk.

Third Author – Senior Professor Lasantha Manawadu, Department of Geography, University of Colombo, (PhD), lasan@geo.cmb.ac.lk.

Correspondence Author – G.N. Kaushalya, gnnipuni011@gmail.com, +94763869985

.