# Identifying Current Trends in Source Selection of Household Water Use in Pohaddaramulla, Kalutara

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**Abstract—** Sri Lankan Drinking Water Supply Policy is committed for the sustainable use of drinking water, while addressing reliability and safety of the resource. . In this research, trends in the selection of water sources for household use in Pohaddaramulla area are addressed. Tube wells, open wells, and mains supply from the National Water Supply and Drainage Board (NWS&DB) are the main water sources used in the area. However, some areas are not covered by the NWS&DB services as yet. Various trends in selecting water sources by the consumers are found. Ground water sources are used while using the mains supply. Data collected through a questionnaire, rainfall data, evapotranspiration data, runoff calculations, and various other sources were used to analyse the current trends and identify their sustainability. Several types of trends are found in this area. Out of the families that use mains supply, 35% is using the mains supply as their only source of water. Remaining 65% uses other water sources while using the mains supply. A 40% of the sample does not use the mains supply. From them, 66% uses tube wells and 31% uses open wells with pumping. Only 3% of them uses tube wells and open wells. Our analysis points out that the current trend is not sustainable even at present. In the future, it will not be sustainable as the ground water demand by the residents cannot be fulfilled by the current conditions. There is no recharge to the ground water storage. Therefore, alternative water sources are needed. Also, there is a risk of saltwater intrusion. These issues can be further studied in the future researches. The information obtained from this study can be used by NWS&DB for planning the extension of service area.

***Keywords: water sources, tube wells, open wells, mains supply, ground water***

## I. INTRODUCTION

As one of the most consumed resource by the mankind, water is becoming scarcer. With the development and the increase of population this has become a great concern. Many factors have to be considered when using water for various purposes. Also, various sources of water are available. In this research, water sources used in the Pohaddaramulla area are discussed. Pohaddaramulla is a village in the coastal belt of Sri Lanka which belongs to the Kalutara district. Population is around 750 families (2700 people).

Different water sources are used in Pohaddaramulla. Mainly, mains supply for most of the houses. There is a preference of using tube wells over open wells even when the mains supply connection is there. These trends may be unsustainable as the ground water usage is more. As ground water takes time to replenish, there is danger of saltwater intrusion. Not many researches are found on selection of water sources other than Kaleel (2017). Ground water quantification is not available in previous studies often.

Demand for ground water has not been addressed much. Therefore, a study on these matters was necessary. Research area is limited to Pohaddaramulla village. Household water usage is only considered for this study.

Objectives

- To compare the trends in selection of water sources used in the area.
- To find why tube wells are preferred over the other sources.
- To find why the tube wells are used even when there is the mains supply from the NWS&DB.
- To find the sustainability of the current trends considering the population increase.

## II. LITERATURE REVIEW

Research studies have been carried out regarding water sources and their sustainability. Water sources like tube wells and open wells are described in these studies. They discuss about the ground water; about the quality of the water. Issues occurred when using wells as water sources.

The research carried out by Dharmaratna and Parasnis (2012) presents an analysis of the cost structure of the pipe borne water supply in Sri Lanka. The total cost is the addition of operating cost for the capital expenditure. Operating cost is the short run cost which is the sum of monthly expenditure on labour, chemical, electricity, maintenance and other costs. They are not restricted by any authority. Ground water can be drawn for any purpose and no charges are levied for that. This analysis assumes that the operational cost for different districts does not vary substantially. The other fact is that NWS & DB does not charge for extracting raw water, which should be added. By this analysis it could be seen that the all the marginal cost for the water supply are higher than the current average volumetric charges. Thus, water is under-priced in Sri Lanka. Although Sri Lanka receives average annual rainfall of 1850 mm, there is not enough water for drinking because the water supply is not managed properly. Only 14% of the rural area receive the mains supply from the NWS & DB (Dharmaratna and Parasnis, 2012).

In the article published by Kaleel (2017), it is mentioned that there is an increase in the pipe borne water consumption by the residents in the Panadura area for household work. Pipe borne water is preferred over the other water sources. This depends on factors such as population, lifestyle changes and modern machinery utilization. As it shows, water consumption for water for various purposes are as follows. Washing clothes – 22.26%; bathing – 23.27%; washing utensils – 16.67%; cooking – 8.17%; drinking – 9.84%; sanitary – 15.77%; watering home garden – 4.03%. Rise in the pipe-borne water consumption depends on income level increment (Kaleel, 2017).

Research by Boone, Glick and Sahn (2011) presents the choices of water sources and time allocation for water collection in a rural area. Choices of water sources depend on many household characteristics and distance to source as well. The time spent to collect water varies with gender, age, and distance to water. Household's choice of water source is sensitive to the distance. The water sources are used by the people, when the distance to the water source decreases. There is a relationship between the distance to the water source and the time spent for collection by individual household members. Factors like quality and quantity are not discussed(Boone, Glick and Sahn, 2011). Another study by Arouna and Dabbert (2009) analyses the factors determining the use of water sources in rural areas in Benin, Nigeria. The differences and similarities between the purchased water sources and free water sources are described. Purchased water demand is price in elastic due to the scarcity of water. Size and the composition of the household, access to water sources, income and time used for fetching water; are the determining factors for choosing water sources. But these factors can be challenged due to the reasons like seasons, policy changes and household types.(Arouna and Dabbert, 2009)

## III. METHODOLOGY AND EXPERIMENTAL DESIGN

*A.Data used for the study*

Population data were gathered from the Grama Niladhari. A brief introduction about the village and trends of using water sources were gathered. Observations were made by visiting the village.
The main source of data was the questionnaire survey. Information regarding identifying the trends and factors determining the selection of water sources were found using the data from the questionnaire survey. Rainfall data were obtained from the Department of Meteorology which were used to calculate the rainfall trend. The ground water calculations were done by using these data.

*B.Methodology adopted*

First, the data was gathered from the Grama Niladhari. Brief idea of the village and water sources and trends were taken from him. Also, population data were gathered to plot the population trend.

Questionnaire survey was carried out to obtain the data for the analysis of the trends. It consisted of 40 questions and two main section for the people who uses mains supply and who does not. Both open ended and closed ended questions were used. Sample size was 58 families. Questionnaire was translated to Sinhala for ease in understanding. Residents were interviewed personally, and their responses were noted.

Questionnaires were analysed, and classified qualitatively and quantitatively using MS Excel software. Population trend and rainfall trend were also obtained. Data from the questionnaire survey and the visits, were used in creating the map in Google Earth Pro software. Boundary, area and mains supply distribution area were clearly marked on the map. Locations of houses of the residents who participated for the survey were marked as shown in the figures in the results chapter.

The net annual replenishment of the ground water available is calculated in order to find the

sustainability of using ground water in the area. Water balance principle is used for this calculation (Zhang, Walker and Dawes,2002).

$$\Delta S = P - I - ET - RO - DD \ldots\ldots\ldots (1)$$

| | | |
|---|---|---|
| $\Delta S$ | = | Change in the ground water |
| P | = | Precipitation |
| I | = | Interception loss |
| ET | = | Evapotranspiration |
| RO | = | Surface runoff |
| DD | = | Deep Drainage |

Here it is assumed that the interception loss is negligible as the calculation is done for a long period of time (a year).

Deep drainage is a small percentage of the precipitation. Roughly about 5% (Zhang, Walker and Dawes, 2002). Therefore it is not been taken for the calculation.

$$\text{Ground water contribution} = P - RO - ET \ldots\ldots (2)$$

Precipitation is taken form rainfall data gathered. Evapotranspiration values are found using the nearest river basin. Evapotranspiration value of Kalu Ganga river basin is 1315mm for the year (Bastiaanssen and Chandrapala, 2003).
Runoff is calculated using the rational method.

$$Q = CIA/360 \ldots\ldots\ldots (3)$$

Runoff is given as a volume per unit time. This value is then converted to annual runoff volume, to be used in the water balance equation where the evapotranspiration and the rainfall are taken in volumes. This represents the water surplus or deficit clearly. Runoff coefficient is taken considering the soil type and topography. It is 0.4 for Pohaddaramulla area as the soil is sandy loamy and a residential area (Najim). Rainfall intensity is given in the rainfall data. The village area is taken as the catchment area, which is found using the Google Earth Pro software.
Net annual groundwater replenishment is considered here, as the remainder, from the ground water contributed to the selected area from rainfall, after the usage by the residents.

$$\textit{Net annual groundwater replenishment} = \textit{Ground water contribution} - \textit{Ground water usage} \ldots\ldots\ldots (4)$$

Ground water usage should be calculated to find the net annual groundwater replenishment. For this total water usage and mains supply water usage are found.

$$\text{Ground Water usage by the residents} = \text{Total water usage} - \text{Mains supply usage} \ldots\ldots\ldots (5)$$

$$\text{Total water used} = \textit{per person water consumption x population}\ldots (6)$$

Per person water consumption is taken as 135 l per day. (*The Sundaytimes*, 2013). This value ranges from 100 l to even 600 l depending on factors and region (Lo, Wong and Mui, 2018). This value is relevant to our region. Assumptions were made as to whether this value is not changing for gender or age, and stays the same for future years.
Mains supply water usage is found using the average mains supply water usage in a family.

$$\text{Amount of water used in a family} = \text{No. of units used in a house} \ldots\ldots (7)$$

$$\text{Amount of water used by the mains supply} = \text{water usage in a family x no. of families} \ldots\ldots\ldots (8)$$

Average monthly water bill for a house is calculated. From that the number of units of water used is found by referring to the water tariff (Prins, 2009).That amount is considered constant for every month and for the future years as well. Volume of water usage per house is calculated. The number of families are found using the population data. Number of members in a family are found from the questionnaire survey. Average number of members in a family is calculated as five (5) members and considered same for the future. Number of families change as per the change in population. From these values net annual groundwater replenishment (equation 4) could be found. Projections of the data were estimated assuming linear trends from 2017 to 2022 and 2027.

## IV. RESULTS AND DISCUSSION

Results of the analysis done with the questionnaire survey, the calculation for the ground water availability and the results from the Google Earth software are discussed here.

### *A. Results from the questionnaire analysis*

From the chart below, it is obvious that the other water sources are used by the majority (60%) of the population. Mains supply is used by only 40%. Other

water sources are used by the residents, where there is no connections to the mains supply.

Other water sources are used while having the mains supply by 65 % of the families. Mains supply alone is used by only 35% of the families. The trend in the present is using other sources while having the mains supply. Sustainability of this trend is identified through this research.

Those who do not use the mains supply, uses other water sources to fulfil their needs. Those water sources and their usage by the residents are presented in the chart below. These people use either tube wells or open wells. All these people use those wells with a pump. From that 66% use tube well with a pump. 31% use open well with a pump.

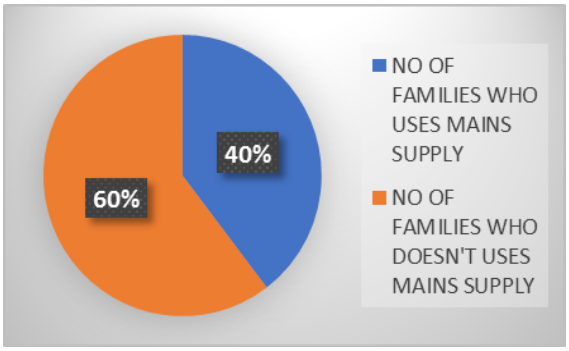


Figure 2. Usage of mains supply by the residents

Minority of 3% use both well and tube well for their water consumption.

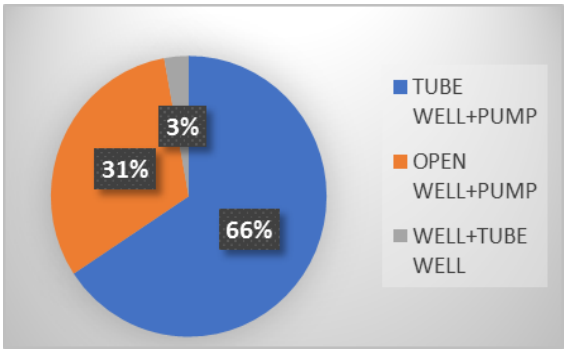


Figure 2. Use of other water sources while using the mains supply

As mentioned below, other sources are used while using mains supply. Type of water sources used with the mains supply are mentioned in the chart below. Tube with or without the pump are used by 60%. Pumps are used to lift water from the wells as it is easier than manually. These are some trends found in the area.

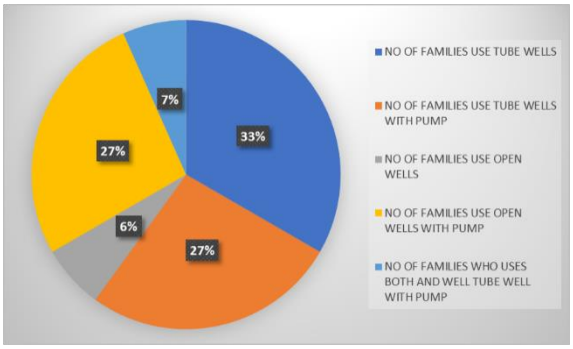


Figure 1. Use of other water sources while using the mains supply

B.*Results from the Google Earth Pro software*

The following are the results obtained by the data analyzed using Google Earth Pro software. Using its tools, boundary and the Area of Pohaddaramulla village found. Regions where the mains supply connections are laid were marked. GIS Locations of the residents who participated for the survey are marked. Rainfall trend is obtained as shown below. Annual rainfall data have been used to plot this graph. As seen in figure 7, there is a reducing trend with time. That means the rainfall is decreasing with time. As per the trend line, rainfall is likely to reduce further in the future.


Figure 4. Area of Pohaddaramulla village


Figure 5. Regions according to the availability of mains supply


Figure 6. Locations of the residents who took part in the survey

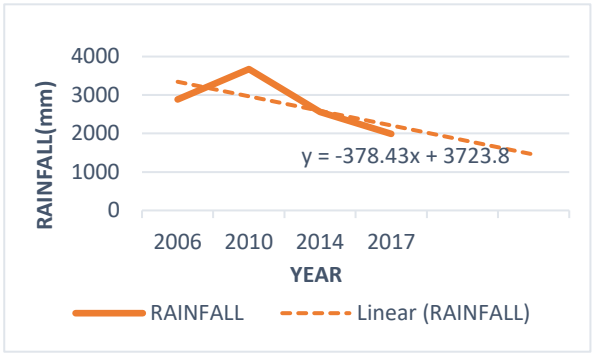


Figure 7. Rainfall trend in Pohaddaramulla Area

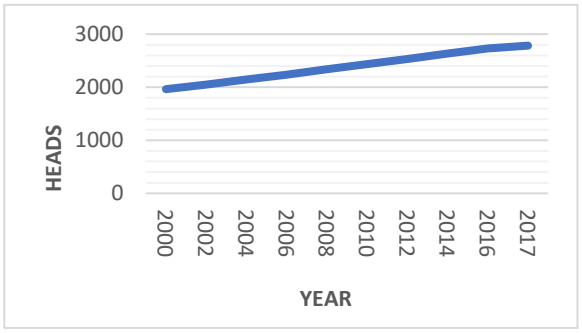


Figure 8. Population trend in Pohaddaramulla Area

Population chart of the Pohaddaramulla area is given in figure 8. This is plotted using the population data from the year 2000 up to 2017. There is an increasing trend of 48 heads per year on average. This will increase further in the future, as the trend increases with time. Population in 2017 is 2784.

*iv. Results of the calculation of ground water contribution*

Ground water usage in 2017, 5 years and 10-year time are mentioned in the Table 1. This gives the results of the calculation of ground water usage annually. It represents the future values for 5 and 10 years ahead. It is visible that the usage is increasing due to the population increase.

Table 1. Ground water usage of the people in Pohaddaramulla

| Years | Population | No. of houses | Total water usage($m^3$) | Mains supply usage($m^3$) | Ground water usage($m^3$) |
|---|---|---|---|---|---|
| 2017 | 2784 | 557 | 137181.6 | 58798.1 | 78383.5 |
| 2022 | 3831 | 766 | 188810.8 | 80927.1 | 107883.7 |
| 2027 | 4059 | 812 | 200034.6 | 85737.8 | 114296.8 |

Run off volume for 2017 is calculated using the Rational method. Runoff volume is taken to compare it with the precipitation and evapotranspiration volumes in the water balance equation.

Table 2. Runoff volume with respect to time

| Years | Rainfall (mm) | Rainfall Intensity | C | A(ha) | Runoff ($m^3/s$) | Runoff Volume $x10^3$ ($m^3$) |
|---|---|---|---|---|---|---|
| 2017 | 1990.1 | 0.227 | 0.4 | 103.58 | 0.0261 | 824.54 |
| 2022 | 652.4 | 0.074 | 0.4 | 103.58 | 0.0085 | 270.30 |
| 2027 | 206.5 | 0.024 | 0.4 | 103.58 | 0.0027 | 85.56 |

Table 3. Ground water available

| Year | Runoff Volume $x10^3(m^3)$ | Rainfall volume $x10^3(m^3)$ | Evapotranspiration volume $x10^3(m^3)$ | Ground water contribution$x10^3(m^3)$ |
|---|---|---|---|---|
| 2017 | 824.54 | 2061.38 | 1362.09 | -125.26 |
| 2022 | 270.30 | 675.77 | 1362.09 | -956.63 |
| 2027 | 85.56 | 213.90 | 1362.09 | -1233.76 |

Table 4. Ground water contribution

| Year | Ground water contribution $x10^3$ ($m^3$) | Ground water usage $x10^3$ ($m^3$) | Net annual groundwater replenishment $x10^3$ ($m^3$) |
|---|---|---|---|
| 2017 | -125.26 | 78.38 | -203.64 |
| 2022 | -956.63 | 107.88 | -1064.52 |
| 2027 | -1233.76 | 114.30 | -1348.06 |

As shown in Table 4, remaining volume of ground water after the usage is a deficit. This deficit is increasing with the time is shown in the Figure 9. In this case, what will be extracted by residents will be the paleo-groundwater in underground aquifer systems, which is unarguably unsustainable.

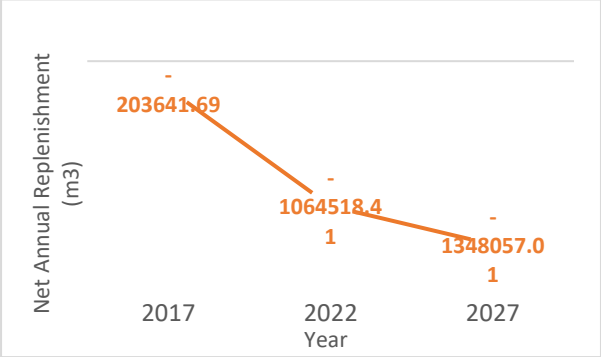


Figure 9 Variation of net annual ground water replenishment with time

## V. CONCLUSION

This study was done to find out the current trends in source selection in Pohaddaramulla area. Comparison among the current trends is done in parallel. Rainfall data, population data, data from the questionnaire survey are used in the study. Visits to the village and identifying the water sources was also useful in getting a clear idea on this study. MS Excel software is used in analysing the questionnaire survey and plotting the rainfall and population trends. Calculations were done to find the sustainability of the current trend of using ground water with the mains supply.

From the study, several conclusions regarding these matters were obtained. Mains supply is used by minority of 40% of the population. Ground water sources are used by 60%. Other sources are used while using the mains supply by 65% of the population. Cost effectiveness and easiness of usage at failure of the mains supply are main reasons behind this trend. Mains supply alone is used by 35%. Tube wells are preferred over the open wells because of the less space required and easiness in handling.

From the calculations, it is obvious that the current trend is unsustainable. At the end of the year, the change in the storage is a deficit. Higher runoff and evapotranspiration volumes are the reasons for this case. Ground water is drained from the storage rather than recharging. This will worsen in the future with the current conditions. Then there occurs a danger of saltwater intrusion since this area is in the coastal line. However, the paleo-groundwater in underground aquifers were not considered in fulfilling the demands, as this data is unavailable for the region and for most parts of the country. Even if these unrenewable resources were considered, still the ground water usage in the area can be considered to become unsustainable. It will only be a question of when it will become a deficit.

Rainwater harvesting could be a good solution for this issue. It will reduce the ground water usage. Studies developing solutions to afore-mentioned issue can be carried out in the future.

## ACKNOWLEDGEMENT

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