INVESTIGATING THE POTENTIAL FOR RAINWATER HARVESTING AND ITS USE AS SAFE POTABLE WATER IN THE NORTH CENTRAL PROVINCE OF SRI LANKA

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ABSTRACT

This study investigates the potential of promoting rainwater as a source of safe potable water in the North Central Province (NCP) of Sri Lanka. Study location is the North Central Province (NCP) of Sri Lanka, namely Anuradhapura and Polonnaruwa Districts. Madawachchiya and Kabithigollawa were selected from Anuradhapura District while Madirigiriya and Dimbulagala from the Polonnaruwa District as the sampling Divisional Secretariat (DS) areas. Sample covered all the selected GN divisions in relevant DSs. Both primary and secondary sources were used for data collection. Primary data was collected mainly through a structured questionnaire taken from a sample of 300 households. The questionnaire survey focused on the general socio-economic status of households, water sources used for domestic purposes, water related issues and the impact of the drought on livelihood activities. The quality of drinking water was tested using 100 water samples. Quality parameters, such as important chemical, physical and biological parameters of drinking water from all sources in the entire sampling area, including rainwater tanks and water from RO plants and wewas were tested.

According to the survey data, 87% of people had a positive impression of drinking rainwater. Most of the people drink rainwater without any purification practices. According to the results, harvested rainwater water quality was found to be better than the samples tested from well water. Rainwater was found to have been not biologically contaminated to the extent of more than 90% and 10% biological contaminated, due to bad maintenance of tanks, and mixed rainwater in the tank with surface water, when the tank gets empty. People try to use it as a storage tank. Chemical and physical parameters in rainwater tanks were within the safe range for drinking purposes, under the maximum tolerant level according to the standards (SLS 614:2013) (UDC 663.6). Water obtained from rainwater was

in good quality and low cost and considered a suitable and reliable water source for consumption for CKDu patients. Therefore, to collect rainwater during the rainy season is very important, and recommended as a reliable water source for NCP with special reference to climate change impacts and social benefits.

***Key words**: Rainwater, water quality, reliable water source, CKDu, water consumption*

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INTRODUCTION

The Annual Health Bulletin (2015) of the Ministry of Health, reported that the water quality for drinking purposes in the North Central Province (NCP) was not within the accepted standard level. There are lots of factors that affect the quality of water. Heavy use of agrochemicals and the geological formation of the area are the main factors affecting the water quality of the study area (Jayasinghe, 2011).

Rainfall analysis by the Meteorological Department for Polonnaruwa from 1951 to 2010 presented that the rainfall during the Maha season (second inter-monsoon and North-East monsoon) had reduced by 230 mm over a period of 55 years at the rate of 4 mm/year. The population and the demand for water have increased over that period. Likewise, the rainfall during Yala season (first inter-monsoon and South-West monsoon) has also decreased according to the Meteorological Department data. The low rainfall resulted in a drastic drop in water levels in hydro catchments and reservoirs, with severe disruption to hydropower generation, domestic water supply and agriculture. Anuradhapura and Polonnaruwa districts were the worst affected by the drought. (De Silva, 2015).

Chronic Kidney Disease of unknown etiology (CKDu) which is the most threatening non communicable disease in the agricultural districts, mainly including North Central Province (Wanigasooriya, 2012). The duration that a person survived after being diagnosed of CKDu depends on how early the disease is identified and on how well the treatment is received and quality of life is maintained as drinking good quality water (Jayasinghe, 2011). It is impossible to supply quality pipe born drinking water in the short run without a high financial cost in terms of capital and maintenance expenses to the government.

As a result, rain water harvesting for drinking purposes which is a long introduced strategy for the easy access of safe quality water seems to be the best option. However, there are misconceptions still prevailing over rain water consumption. This has resulted from a lack of awareness among communities although the rain water harvesting has become an important theme in the international Millennium Development Goals as well. Sri Lanka has used rainwater for both

domestic and agricultural use for many centuries (Kandasamy et al., 2014). Rain water harvesting should be re-encouraged and should be facilitated as a short term measure for CKDu affected areas in Sri Lanka (De Silva, 2014). Research studies have shown that the rainwater harvesting as an adaptation measure for the impact of climate change on water resources in Dry Zone and Central Hills of Sri Lanka (De Silva, 2014).

METHODOLOGY

The two study locations were Anuradhapura and Polonnaruwa Districts in the North Central Province of Sri Lanka. In the first stage, Madawachchiya and Kabithigollawa were selected from Anuradapura District and Madirigiriya and Dibulagala were selected from the Polonnaruwa District. Study locations were selected based on the experiences of preliminary surveys, considering the water shortage and the water sources used by the communities.

Respondents were selected from households, in proportion to the number of households in the villages who are mostly affected by the lack or absence of safe drinking water. Multistage sampling technique was used to derive the study sample.

In the first place of the sample selection, two of the most affected DS divisions in terms of scarcity of safe drinking water, were selected from each of the two study districts. Next, two of the most affected villages of each of those four DS divisions, were selected to draw the sample of 300 households which would represent each village, in proportion to the number of households it consists of.

Data and information were collected both through primary and secondary sources. A structured questionnaire was employed to extract the required primary data from a sample of 300 households in the study area, which was the North Central Province.

Focus group discussions were also used to collect primary data from officers of the rainwater harvesting forum, officers of the presidential task force on CKDu prevention, divisional medical officers, officers of the environmental authority, district office and village level officers- such as Grama Niladari and PHI officer of the relevant area, and the members of the farmer organizations in the relevant area. Secondary data was collected from relevant sources and authorities.

Water quality parameters

(important chemical, physical and biological parameters) of rain water tanks, Reverse Osmosis (RO) plants, filter water, well water, and water sellers of relevant areas were identified using water quality testing. Sampling was done covering all the GN divisions (Yakawewa, Thiththagonnewa, Thammennaelawaka, Madawachchiya, Meegaswewa, Kumudupura, Dalukane and Kajuwatta) in the relevant districts. Sampling was done using the standard water sampling methods.

Quality parameters of the water sample were determined at the National Water Supply and Drainage Board labs in Anuradhapura (Regional Laboratory Anuradhapura) and Polonnaruwa (Regional Laboratory Gallella) districts and Agricultural Plantation Engineering Laboratory of the Open University of Sri Lanka, according to the SLS 614: 2013.

This standard was approved by the Sectoral Committee on Agricultural and food products and was authorized for adoption and publication as a Sri Lanka Standards Institution on 2013-08-28.

RESULTS AND DISCUSSION

- **Water sources used in the study area**

The majority of the people in Madawachchiya and Madirigiriya DS divisions used well water as their drinking water source (Table 1 and 2). Similarly, people in both Kabithigollewa and Dimbulagala DS divisions, used well water as their main drinking water source. The Madirigiriya DS division RO plant was the main drinking water source, and then the well water. According to Table 1, in Madawachchiya DS, 69% were suffering from CKDu and it may be due to the use of unreliable water sources for drinking (surface water and tube well water). Only 50% were using reliable water sources such as RO water, filtered water or spring water.

Table 1: Water sources used in the Anuradhapura study area, for drinking purposes

Drinking Water Source	Anuradhapura			
	Madawachchiya		Kabithigollewa	
	Frequency	Percentage	Frequency	Percentage
Well	29	38.7%	53	57.6%
Tube well	6	8.1%	9	9.8%
Spring	5	6.7%	25	27.2%
Tap water	1	1.3%	0	0.00%
Filters	26	34.7%	1	1.1%
RO plant	7	9.3%	3	3.3%
Both wells and streams	0	0.0%	1	1.1%
Both filter and RO plant	1	1.33%	0	0.00%
Total	**75**	**100.00%**	**92**	**100.00%**

(Source: HARTI survey data, 2018)

Table 2: Water sources used in the Polonnaruwa study area, for drinking purposes

Drinking Water Source	Polonnaruwa			
	Madirigiriya		Dibulagala	
	Frequency	Percentage	Frequency	Percentage
Well	24	31.6%	50	64.1%
Tube well	1	1.3%	3	3.9%
Spring	12	15.8%	2	2.6%
Tap water	0	0.00%	9	11.5%
Filters	12	15.8%	11	14.1%
RO plant	27	35.5%	1	1.3%
Both wells and streams	0	0.0%	1	1.3%
Both filter and RO plant	0	0.00%	1	1.28%
Total	**76**	**100.00%**	**78**	**100.00%**

Source: HARTI survey data, 2018

- **Rainwater harvesting and its usage**

Figure 1 and 2 indicated the water usage in Anuradhapura and Polonnaruwa districts. Rainwater harvesting (RWH) systems were constructed primarily to meet water security at household level by providing safe water. The harvested rainwater is used for drinking needs with or without treatment. However, people in the study area, use the RWH systems for various purposes including drinking, sanitation, cooking, washing, bathing, gardening and other household needs. The findings indicate that 62% of the rainwater harvesting tanks are being used either throughout the year or during the rainy period.

However, about 33% from the total sample had been fully abandoned at the time of the survey. And another 5% of the tanks from the total sample are not used to harvest rainwater but used as a storage tank to store water from other sources. Among the people who have RWH tanks, percentage of rainwater users for drinking purpose were higher in Polonnaruwa district than in Anuradhapura district (Table 3).

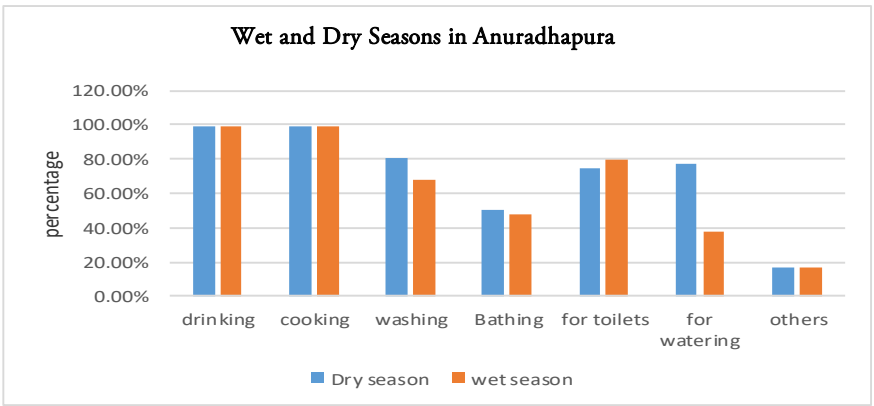

Figure 1: Harvested Rainwater Usage in Anuradhapura in 2018

(Source: HARTI survey data, 2018)

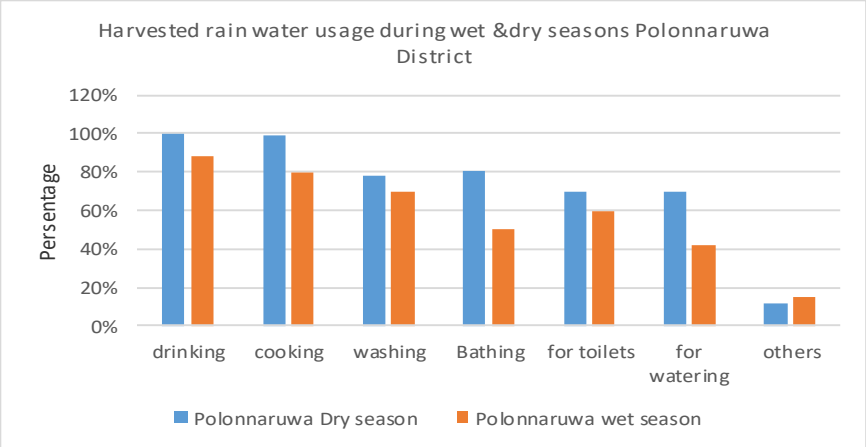

Figure 2: Harvested Rainwater Usage in Polonnaruwa in 2018

(Source: HARTI survey data, 2018)

Table 3: Rain Water Tank Usage in Anuradhapura and Polonnaruwa Districts

Use rainwater for drinking purpose	District			
	Anuradhapura		Polonnaruwa	
	Frequency	Percentage	Frequency	Percentage
Yes	96	72.2%	65	83.3%
No	37	27.8%	13	16.7%
Total	133	100.0%	78	100.0%

(Source: HARTI survey data, 2018)

- **Duration of Using the Rainwater Tanks**

According to the survey data (Figure 3), nearly 28% of the consumers in Anuradhapura and 64% in Polonnaruwa can use their 5000 liters rainwater tank for about 4-6 months. If they fill the tank once, 52% use it for 10-12 months in Anuradhapura and 12% in Polonnaruwa. This may be due to the awareness among the community.

According to the survey data in Anuradhapura, there were more rainwater tanks and also more training programs about rainwater harvesting and its usage.

According to the observation, 80% of the rainwater tank owners said they could fill the 5000L tank twice a year, 14% can fill only once a year and 5% can fill it, thrice a year (HARTI survey data, 2018).

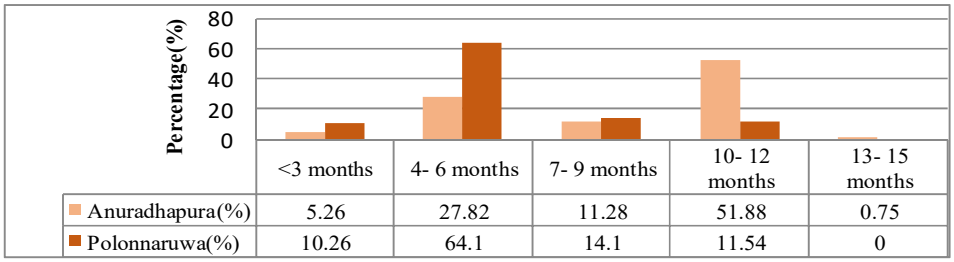

Figure 3: Duration of Using the Rainwater Tanks

(Source: HARTI survey data, 2018)

- **Reason for Adapting to a Rainwater Tank**

Some people have to travel a long distance to bring water, they have to devote a lot of time and money on this. If they had a rainwater tank at their premises, it would be an advantage for them. They can reduce transportation costs and save time. They could then use that time for leisure and other activities.

The major factors for selecting the rainwater tanks were availability of rainwater for drinking and the rainwater tank at home, non reliability of existing water sources to have enough water throughout the year as groundwater is contaminated in the area, and kidney disease.

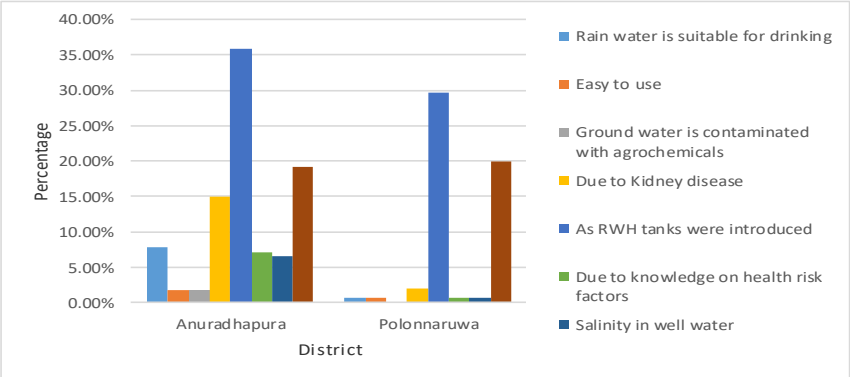

Figure 4: Reason for Adapting to a Rainwater Tank

(Source: HARTI survey data, 2018).

- **Monthly Expenditure to buy water in the study Area**

According to the districts and monthly expense cross-tabulation, it was found that 75% of the families in Polonnaruwa district spend from Rs 500 to Rs 2000 per month to buy water.

Figure 5 illustrates that 90% of the total population in Anuradhapura have have an income level of over Rs 15,000. When we consider the Rs 15,000 as the minimum level of income, they have to spend 13.3% of their earnings to buy water, which is a considerable expense.

From the population, 75% from Polonnaruwa have to spend Rs 500 to Rs 2000 to buy water due to the lack of rain water harvesting tanks in Polonnaruwa compared with Anuradhapura District. In Anuradhapura, 64.3% have to spend up to Rs 2000 to buy water.

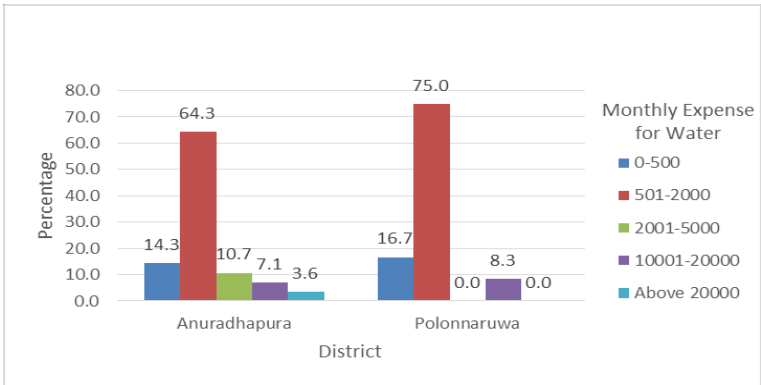

Figure 5: Monthly Expenditure to Buy Water in the Sample Area

Source: HARTI survey data, 2018

- **Villager's Perception about the Drinking of Rainwater**

According to survey data, 87% of people had a positive impression of drinking rainwater. Most of the people drink rainwater without any purification practices. According to survey data, 85% of the people who do not have a rainwater tank, admitted rainwater is suitable for drinking and the desire to use a RWT (HARTI survey data, 2018).

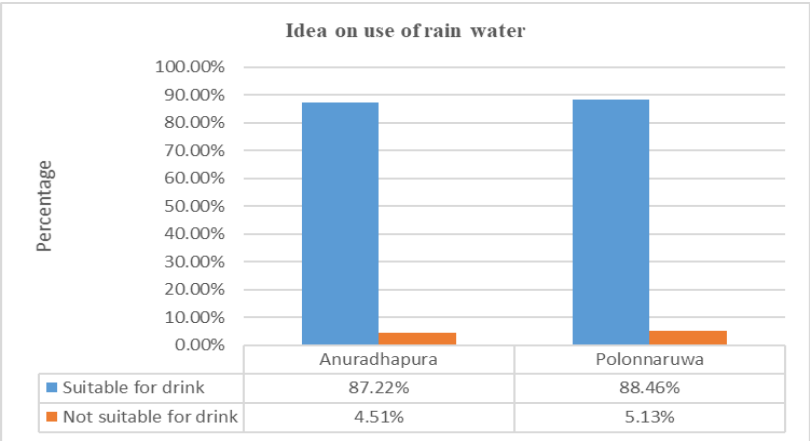

Figure 6: Perception about the Drinking of Rainwater

(Source: HARTI survey data, 2018)

Table 4: (*SLS 614:2013*) (*UDC 663.6*) *recommended maximum permissible limits.*

Parameters(Physical/Chemical & Biological)	Maximum Requirement (SLS 614:2013) (UDC 663.6)
Turbidity [NTU]	2
pH[At 25 ^{0}C +/- 0.05 ^{0}C]	6.5-8.5
Total Dissolves Solids [mg/l]	500
Total Hardness (as $CaCO_3$[mg/l]	250
Fluorides (as F) [mg/l]	0.1
Coliform Bacteria in 100ml	220
E.coli in100ml of Sample	70

(Source: HARTI survey data, 2018)

- **Total Dissolved Solid (TDS)**

Figure 8 indicates the TDS level in rainwater and other water sources in the study area. According to the distribution, some tube wells exceeded the reference level- Total Dissolves Solids Maximum Requirement (SLS 614:2013) (UDC 663.6) is 500 mg/l (Table 4).

From the 22 well water samples, 17 samples were within the reference range. RO water is within the permissible TDS range. Out of the 46 rainwater tanks, only one sample exceeded the permissible level, it was due to bad maintenance of the tank.

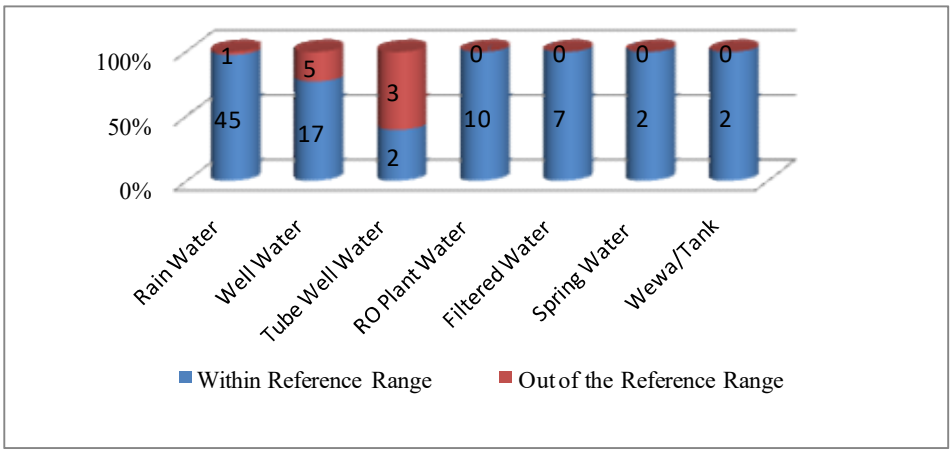

Figure 8: *Level of Total Dissolved Solid in Each Water Source*

(Source: *HARTI survey data, 2018).*

- **pH**

The mean pH value of rain water tanks (43 samples out of 46) in all the DS divisions, not exceeding the maximum requirement for drinking purpose, according to the SLS 614:2013 (UDC 663.6) standards as 6.5-8.5 pH [At 250 C +/- 0.050 0C] (Table 4).

The pH values are found to be within the recommended standards. A well designed and maintained RWH system can cause low health risks and high improvement in the health of humans (Ariyananda, 2003).

This physical property is permissible for drinking, as shown in the average pH of rainwater obtained was found to be slightly acidic in values in Kabithigollewa, during the sampling period. But it was within the safe range. Out of 10, eight from tested RO plant water exceeded the standard levels pH [At 25 0C +/- 0.05 0C]. Maximum requirement (SLS 614:2013) (UDC 663.6) 6.5- 8.5.

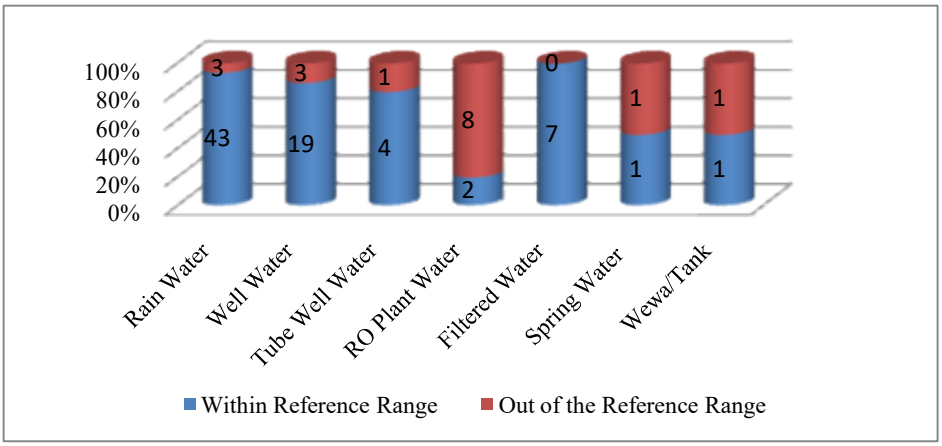

Figure 9: Level of pH in each water source

(Source: HARTI survey data, 2018).

- **Total Hardness**

Recommended standards on the total hardness of drinking water had been maintained for all rainwater tanks except one (Figure 10).

Shallow well water (12 out of 22) and tube well water (2 out of 3) total hardness had exceeded the standards. Total Hardness (as CaCO3) in mg/l Maximum Requirement (SLS 614:2013) (UDC 663.6) 250 (Table 4)

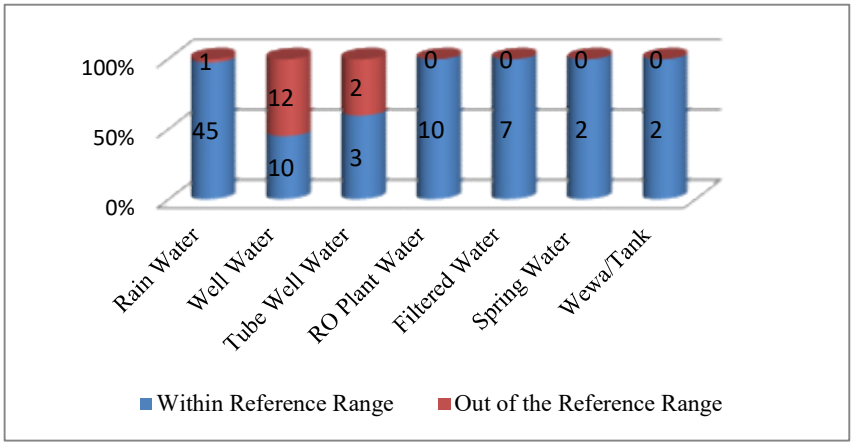

Figure 10: Level of Hardness in each water source

(Source: HARTI survey data, 2018)

- **Coliform Bacteria Count in water sources**

Overall, 80% of the tested rainwater tanks recorded without the coliform bacteria (Figure 11). The recommended total number of all types of coliform bacteria present in 100 ml sample at 370C is <10 for drinking water (well water).

Maximum Requirement (SLS 614:2013) (UDC 663.6) Coliform Bacteria in 100ml is 220 (Table 4)

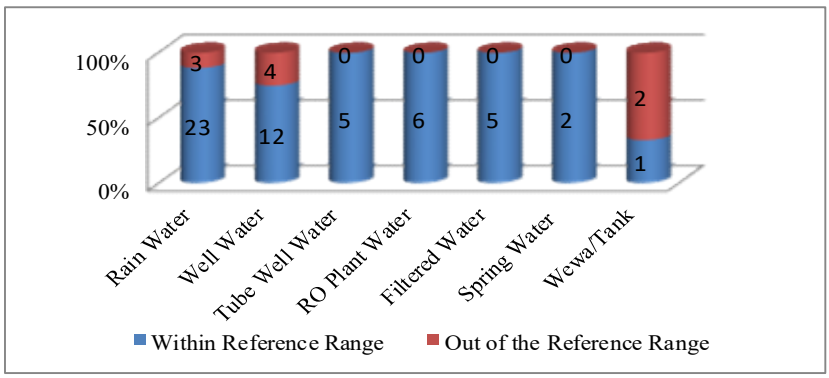

Figure 11: Level of Coliform Bacteria Count in Each Water Source

(Source: HARTI survey data, 2018)

- **E-Coli count in harvested rainwater in tanks**

Having a simple charcoal and gravel filter and first-flush systems reduce the contamination levels in the tanks markedly (Ariyabandu, 1999). E. Coli levels in the tanks receiving rainwater from G.I roof are lesser than from other (HARTI survey data, 2018), roofs due to the heating of the G. I roof which result in perishing of E. Coli in the roof (Vasudeva et al., 2001). E. Coli in 100ml of Sample Maximum Requirement is 70 (SLS 614:2013) (UDC 663.6) (Table 4).

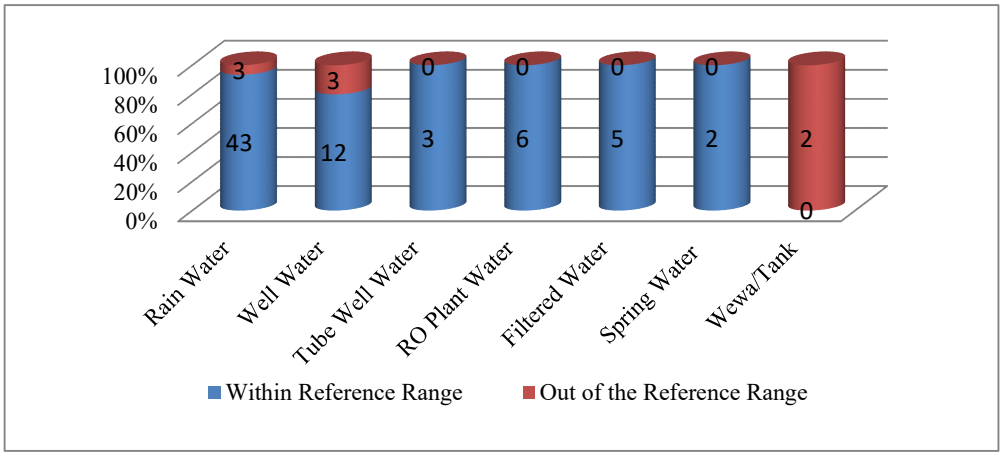

Figure 12: Level of E-Coli Count in Harvested Rainwater

(Source: HARTI survey data, 2018)

CONCLUSIONS

According to the survey data, a total of 167 HH from Anuradhapura and 155 HH from Polonnaruwa, people have to face many problems when collecting water, for their drinking purposes. People in these areas have many water quality problems because the existing water source does not have enough water throughout the year, groundwater contamination problems in the area and the kidney disease of unknown etiology are the problems they have to face.

The rainwater tank owners used the tank for various purposes during rainy seasons as well as in

the dry seasons. There are no health issues recorded resultant on the drinking of rainwater when comparing the health issues between the users and non-rainwater users. A rainwater system, offers the people a lot of advantages. Rainwater harvesting is a feasible strategy to mitigate the increasing water crisis.

Nearly 10% of the water samples collected from water sellers were not in the safe range. But the people of the area have to spend money to buy this water.

According to the results, harvested rainwater water quality was found to be better than that of the water in the samples tested from shallow wells. Rainwater was found not to have been biologically contaminated to the extent of more than 90 percent. And 10% biological contamination was due to the improper maintenance of their tank and mixing rainwater with surface water, when the tank gets empty or gets used as a storage tank.

Chemical and physical parameters in rainwater tanks were within the safe range for drinking purposes, under the maximum tolerant level according to the standards (SLS 614:2013) (UDC 663.6).

When taking these facts into account rainwater harvesting is undoubtedly the most rational, cost-effective, socially acceptable and ecologically sustainable method of providing clean drinking water to widely scattered rural households in the CKDu affected in North Central province in the dry zone of Sri Lanka.

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