*Report D1*

# Household Water Security in Sri Lanka Using Domestic Roof Water Harvesting

Lanka Rainwater Harvesting Form

Contents

# Household Water Security in Sri Lanka Using Domestic Roof Water Harvesting

## *Introduction*

The hydraulic civilization in Sri Lanka dates back to 5th century B.C. The large number of reservoirs built by the ancient kings bare testimony to this grate civilization. The dry zone of Sri Lanka, which covers 2/3 of the country depends on irrigation for cultivation. While irrigation development had taken great strides in the history of Sri Lanka, domestic water supply had its own mode of development. The rural peasantry in Sri Lanka mostly used ground water, through dug wells for domestic use. In the sparsely populated dry zone people used irrigation reservoir and canal water for domestic use, specially in the dry season when ground water sources deplete due to increase demand and high evaporation and evapotranspiration. Often the reservoir waters were not fit for human consumption due to contamination in extreme dry conditions. It is a common sight to observe cattle and human water needs are met by the same source. This situation prevails in most parts of the North Central, North Western and drier parts of the Southern Province where the mean annual rainfall is 1000-1750 mm and evaporation is temperatures are beyond 27 $^{0}$C in the dry season.

Rural peasantry in Sri Lanka may walk up to 10 Km. in the dry season to get good quality drinking water (Ariyabandu 1998). In some parts of the wet zone where water is not available at homestead due to low ground water table, people often had to trek steep terrain to fetch limited quantity of water. However, these practices have become a daily routine in the life and times of rural peasantry. In most cases it is the women who are involved in collecting water and have to sacrifice quality time with their families to fetch water.

Descending from the ancient hydraulic civilization, one could observe different types of Rainwater harvesting Systems adopted by rural people for domestic use in almost all parts of Sri Lanka. Ariyabandu (1998) describes three main categories of traditional rainwater harvesting systems in the report title “Wisdom of Traditional Rainwater Harvesting in Sri Lanka”. While two categories in this classification harvest rainwater from trees and direct open air, the third categories harvest rainwater from roof catchments. The progression from traditional rainwater harvesting systems to open rectangular surface tanks and in Irrigation Settlement Schemes, government buildings and official quarters were given assistance to construct ground pits with sufficient capacity of water to last two to three months Abeywickrama (1990). Collecting rainwater for domestic use was a popular practice in government quarters during 1950’s and 1960’s. However, this practice was gradually abandoned with the introduction of pipe borne water and tube wells.

The post 1977 economic liberalization, opened the rural sector for donor funded social infrastructure development programmes. This introduced protected dug wells, tube wells and pipe water supply systems to rural areas. These options provided safe drinking water to at least 60% of rural population as at 1997. (Minnatullah etal 1998). The total resource allocation for water supply and sanitation sector stands at 0.5% of the GDP. (Public Investment Programme 1996-2000). This incidentally compares well with that of the average of other developing countries. The government contributes approximately Rs. 3500 million annually for new constructions and reliabilitation of water supply facilities, of which 60% is from concessionaire foreign financing. Besides these major funding, small allocations have been made by Integrated Rural Development Programme (IRDP) funded by the government of Netherlands and from the state decentralized budget. Infect in the post liberalization period from 1977, IRDP has been a major contributor in rural water supply in number of districts in Sri Lanka. In 1993, Government of Sri Lanka with assistance from the World bank started the Community Water Supply and Sanitation Project (CWSSP). This project anticipated to provide water to 650,000 people in about 2700 settlements and 17 small towns in three districts (Minnatullah etal 1998). Hence, the present policy on water supply is **"Some water for all, rather than more water for some"** as endorsed at the New Delhi Global Consideration in 1990. According to the Public Investment Programme of 1996-2000 Sri Lanka needs an investment of Rs. 8000 million annually to supply safe drinking water to all by year 2010. However, this situation appears to be difficult due to high level of investment and operation and maintenance cost, growing conflicts among water users, drying of water resources and growth of demand for water due to population pressure. Due to this situation, there is a large percentage of rural population who would be deprived of good quality drinking water from conventional water supply options. It is this population who would be the potential beneficiaries of Roof Water harvesting Technology.

In 1995 World Bank sponsored CWSSP introduced Rainwater harvesting from roof runoff in three districts in Sri Lanka. Under the project two types of $5m^3$ storage tanks were introduced to each household. The surface Ferro-cement tank and underground brick-dome tank, both collects roof runoff through a system of gutters and down pipes. Towards the latter part of the CWSSP sand filters and hand pumps were introduced to draw water from underground tanks. This intervention in the latter stages of CWSSP facilitated to improve the quality of water. At present there are approximately 4000 $5m^3$ storage tanks in two districts in Sri Lanka. Incidentally both these districts receive an average annual rainfall of 1800 mm. Since the widespread acceptance of Rainwater harvesting under the CWSSP, there are number of other NGOs who have taken the "Rainwater Harvesting Technology to the dry zone of Sri Lanka. There are at least 100 more $5m^3$ tanks constructed in the dry zone by the communities with the assistance of national and international NGOs.

The organized rainwater harvesting programme initiated by the CWSSP and subsequent community - NGO rainwater projects used the roof surface as the catchment area. The storage design of $5m^3$ tank was based on a 20 liters per capita day for a 50 day dry period for a family of five. (Hepugoda 1995). This prescription was followed in the subsequent project without paying much attention to the requirement and long dry periods.

Introduction of Rainwater Harvesting in rural Sri Lanka has improved the water security of the beneficiary community, lessened the drudgery of women carrying water, gave reliable supply of water at homestead, and convenience of collecting water at homestead at any time by anybody irrespective of age and sex. Though Rainwater Harvesting has been accepted as an alternative rural water supply source in Sri Lanka, if did not fully satisfy the drinking water needs of rural communities. As at present less than 10% of Rainwater Users Consume rainwater. The main reason for this state is the perception of users on quality of water. Hence, the future progression of rainwater (roof water) harvesting technology in Sri Lanka would primarily depend on attitudinal change on user perception on roof water as a drinkable domestic source.

### *Present Water Status in Sri Lanka*

Sri Lanka is endowed with approximately 4,500 Km. of rivers, 2400 Km. of Irrigation canals and 3500 deep water tanks and reservoirs and artificial and natural wet lands. In the water supply sector, 48 million (26%) of the population is provided with pipe water, 1.4 million (8%) is provided with tube well water. In addition 27% of the rural population is provided with safe drinking water through dug wells. (Arriens 1996). Accordingly, 90% of the urban population and 57% of the rural population are provided with safe drinking water facilities.

The Comprehensive Assessment of the Freshwater Resources of the World (1997) predicts that 2/3 of the world's population will experience water stress condition by 2025. (ADB 1998) According to UN studies, countries whose water withdrawal against available resources exceed 40% would experience high water stress conditions, thus, needing urgent management of water supply and demand (ibid 1998). In south Asia withdraw against available resources is 48%, thus, Sri Lanka too could experience an acute shortage of water if stringent measures are not adopted to manage demand and supply of water.

Predications for Sri Lanka is that by year 2000, there will be a water deficit of 1400 MCM in the Northern dry zone and the capital city water demand would double from present 97 MCM/year (Arrienns etal 1996). Thus, the over all situation is that provision of good quality drinking water is becoming a challenging task, with drying up of water sources, pollution of water, growing conflict among users and growth in demand due to population pressure. (Ariyabandu 1998). Though Sri Lanka receives a mean annual rainfall of 1200 mm, high variability and non uniform distribution creates periodic shortages of water for both irrigation and domestic use. At present 60% of the rural population has access to safe drinking water (Minnatullh etal 1998). However, there is a significant population in rural Sri Lanka where non of the conventional water supply sources could provide water due to financial, technical or management reasons. Rainwater Harvesting has proved to be the only option available for these communities provided they are prepared to contribute as equal partners in the implementation process.

### *Definition of Water Security through Roof Water Harvesting (RWH)*

"Water Security" is a term that is emerging in usage to represent a similar mean as "Food Security" which has been in use for the past two decades. However, in the context of RWH water security refers to "domestic level" water security. Few literature on regional water security issues (Allan 1996) are available in the global literature search. However, Household Water Security is hardly available or practically absent in the global literature search. The present study on "Domestic Roof Water harvesting in Humid Tropics" attempts to initiate a definition that would be best suited to describe "Water Security". Since the beginning of research into RWH in South Asian countries few arbitrary definitions have been expressed. One of the initial attempts made by Ariyabandu and Dharmalingam in their study on "Harvesting Rainwater: A Means of Water Security to Rural Sri Lanka" (1997) defines domestic water security as:

**"To have adequate domestic water supplies, so that the productive livelihood of peasants can be sustained".**

This definition was further refined by Thomas (1998). He defines water security in two ways:

**a) Absolute Security**

Water Security as a concept means adequate water, reliably supplied to perform culturally normal life ($W_1$).

Hence, water security as a measure (WS) =

$$WS = \frac{\text{Water Available}}{W_1}$$

WS should be averaged over several years or fraction of time that water is available at level W1.

**b) Design Achievement**

Water security as a concept means reliably supplying the designed daily of water ($W_2$).

Hence, Water Security as a measure (WS) =

$$WS = \frac{\text{Water Supplied}}{W_2}$$

WS should be averaged over several years or fraction of time that water is available at level $W_2$.

Subsequently, Thomas. T. in his chapter for the book titled "Economic Health and Technological aspects of drinking water and sanitation" defines water security into three broad themes. i) Chronic water shortage ii) Acute water shortage and iii) Lack of entitlement for water.

While these are broad concept of water security, the Sri Lankan rural context would possibly fall into lack of entitlement and/or Acute water shortage concepts. More logically, rural peasants in Sri Lanka whether in the wet/dry zone, who do not have the benefit of good quality water at adequate levels are deprived of access to whatever water is available. It is this community who is the potential target group for domestic roof water harvesting.

Han Heijnen in personnel communication with Lanka Rainwater harvesting Forum (LRWHF), defines water security as the ability to ensure that the household has access to water of adequate quality and quantity for human consumption, hygiene and other households and (possibly) minor economic activities.

Hence, the need for water security expresses itself in;

- Access to (natural) water sources nearby the house
- Assured access to such sources at any time of need (time of the day/season of the year).
- Access against a reasonable effort in time of collection or energy (spent collecting).

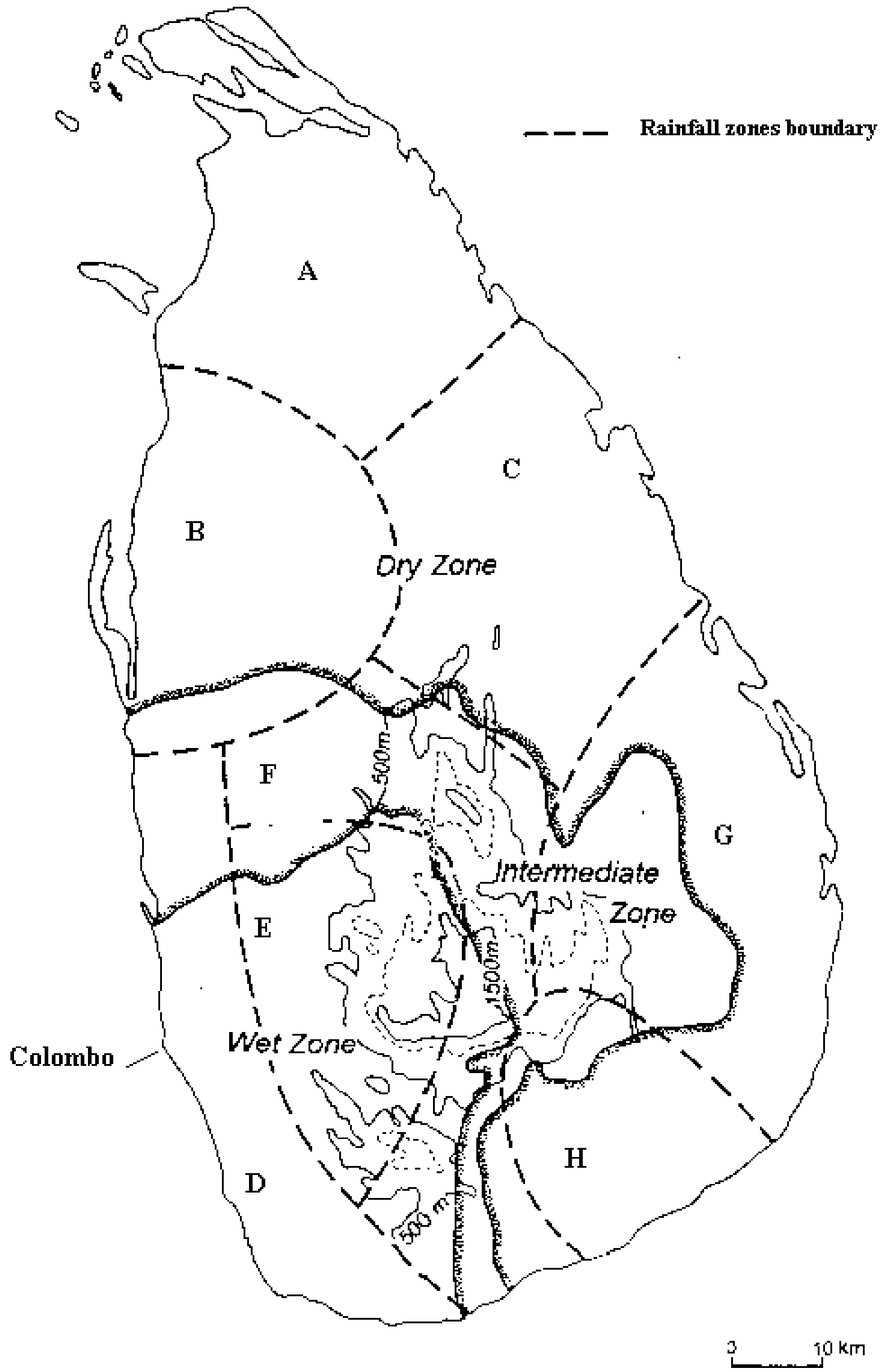
Thus, it may be necessary to construct facilities at the household to enhance the water security. This may include household level storage, closed tanks for drinking water, open tanks or ponds for other water uses. These storage tanks will be designed to ensure water security for a specified number of days based on local conditions and consumer parameters. (Heijnen 1998).

## *Rainfall Pattern in Sri Lanka*

Rainfall pattern in Sri Lanka exhibits a noteworthy regional and seasonal variation. There are two major monsoon periods in Sri Lanka. The North-East Monsoons brings rain to the dry zone of the country from November through April while the South-West Monsoon brings rain to the wet zone from May through October. With respect to regional variation, Chandrapala (1990) had identified eight rainfall coherent zones (figure 1) in the country using rainfall data for over 100 years in 41 stations. Seasonal rainfall variations in these zones are given in table 1 it can be safety assumed that roof water collection for domestic use is feasible in all zones (Abeyaratne 1998).

Concentration of rainfall during specific periods in different zones indicate that there can be considerable shortages of water during the months of low-rainfall. It is evident that during these months water levels of the wells generally deplete and in some locations it can completely dry-up causing acute drinking water problem to the rural communities, it is in this situation that, roof water harvesting can be potentially feasible for rural communities.

**Fig:1 Coherent Rainfall zones of Sri Lanka**




(Adapted from Chandrapala, 1996)

**Table 1: Seasonal Rainfall in Coherent Rainfall Zones in Sri Lanka**

| Season | | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| First Inter-Mon | M | 122.3 | 239.4 | 133.6 | 349.7 | 480.5 | 354.8 | 228.2 | 277.9 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (March-April) | SD | 58.8 | 91.7 | 79.3 | 113.9 | 129.1 | 105.8 | 91.7 | 103.2 |
| S.W. Monsoon | M | 199.8 | 244.1 | 330.5 | 920.7 | 1681. | 997.3 | 296.2 | 337.7 |
| (May-Sept.) | SD | 91.7 | 116.5 | 124.7 | 311.5 | 391.2 | 253.2 | 81.3 | 116.7 |
| Second Inter-Mon | M | 526.5 | 479.6 | 546.5 | 625.4 | 805.1 | 615.3 | 493.0 | 452.9 |
| (Oct.-Nov.) | SD | 186.1 | 151.3 | 183.7 | 185.0 | 189.7 | 161.9 | 141.7 | 144.3 |
| N.E. Monsoon | M | 392.9 | 314.9 | 633.8 | 297.8 | 430.2 | 467.1 | 733.1 | 387.9 |
| (Dec.-Feb.) | SD | 213.6 | 156.3 | 292.0 | 117.5 | 149.2 | 179.6 | 283.3 | 162.1 |
| Annual (Jan.-Dec.) | M | 1240 | 1278 | 1644 | 2189 | 3397 | 2432 | 1752 | 1455 |
| | SD | 305.1 | 257.3 | 370.3 | 448.8 | 491.7 | 334.1 | 328.0 | 295.5 |

Source: Chandrapala (1996).

Though Sri Lanka receives adequate annual precipitation, use of this for productive end use depends on roof catchment area and annual domestic demand. Table 2 indicates the potential feasibility of roof water harvesting with varying annual average rainfall and roof catchment area.

**Table 2: Feasibility of RWH Depending on Rainfall and Roof Area**

| Annual Average Rainfall mm | Roof Area $M^2$ | Run Off Coefficient | Annual Average Supply $M^3$ | Annual Minimum Demand $M^3$ | Feasibility |
|---|---|---|---|---|---|
| 1300 | 40 | 0.8 | 41.6 | 36.5 | Feasible |
| 1300 | 20 | 0.8 | 20.8 | 36.5 | Demand too high |
| 1750 | 20 | 0.8 | 28 | 36.5 | Demand too high |
| 1750 | 30 | 0.8 | 42 | 36.5 | Feasible |
| 3500 | 14 | 0.8 | 39.2 | 36.5 | Feasible |

Source: Hapugoda (1995)

RWH becomes feasible when the supply exceeds the demand. When the demand exceeds supply either the roof catchment has to be increased or stored water usage has to be restricted (Hapugoda 1995).

## *Traditional Rainwater Harvesting*

As mentioned earlier, people of Sri Lanka devised their own system of harvesting rain when the need arised. However, most of the traditional rainwater harvesting was limited to small quantities collected into household utensils. While different types of traditional rainwater harvesting was in use, roof water harvesting appears to be the most effective interms of quantity and adequacy. For quality and drinking purposes people mostly used tree-trunk rainwater harvesting or open air rainwater harvesting methods.

Roof water harvesting was practiced mostly by households who had permanent roofs either with tiles, asbestos or tin sheets. In very remote villages and in most trying conditions people have even used thatched roof too, to harvest roof runoff, though they were not using it for drinking.

One of the earliest, and most successful attempts to harvest rainwater in Sri Lanka is the 5th century B-C, Sigiriya rock fortress. On top of the Sigiriya rock fortress three is a series of ponds that collect rain water and an intricate system of underground canals which activates a multiple fountain system at the foot of the rock fortress. While documentation on the rainwater system of Sigiriya is rare, H.C.P Bell, the Archaeologist describes the Sigiriya rainwater harvesting system in the following way.

"Towards the South end of the Great Rock's West face a long ribbon like groove may be noticed cut perpendicular down the cliff. Exploration of the West slope of the Rocks summit showed this smooth "steak" to be a vertical discharge of a main drain of citadel on that side. It was led along from the northern end to this point so as to divert and carry off a rush of rain water which would otherwise have seriously unconvinced the occupants of terrace below and gallery. It is obvious that the volume of water could not have been allowed to run waste, must less to slump down, on to an approach of gallery and terrace. On the South some proper exist, reservoir, must have existed if only to prevent inevitable damage in rainy weather. The mana-covered terrace at a South-West of a Rock on a level with a gallery floor, offer the most likely solution and furnished it. Excavations disclosed in the middle of this a storage tank 42' sq. Inside brick walled 4' 8" in depth and paved with 18" brick. The walls 3' 6" and are strengthened by rabble backing 3 or 4 yds. In thickness. A single drain passes through a west wall, and it is hardly rash to summarize that a bath on "Cistern Rock" was supported by an overhead aqueduct led across and four intervening terraces". (Archaeological Survey of Ceylon North Central and Central provinces, Annual Report 1899).

Though the above account is not directly roof water harvesting, no rainwater documentation from Sri Lanka can escape a description of Sigiriya, which upto date is an architectural wonder!

Indigenous techniques of rainwater harvesting is still very much prevalent in most ports of Sri Lanka. Lack of adequate water is the motivation to sustain these indigenous system while quality of water also contributes to the same cause in some port of North Central Province where ground water is brackish.

Following account gives a description of indigenous roof water harvesting in various parts of Sri Lanka. In most of these cases the type of roof water differs with respect to the guttering system they have used and at times various storage systems.

### 1. Roof Water Harvesting Using Tin Sheets.

This is a technique where people use tin sheets formed into a shape of a gutter and attach it on to full length of the roof. The length of the roofs in some instances had been 10 to 20 feet and the width of the roof varies from 10 to 20 feet as well. The households who use this technique does not have provision in the roof to permanently fix these as gutters. Hence, they use jute/quior rope to tie the tin gutters. At the end of the gutter people use Royal Palm leaves or barks of trees formed into a funnel shape to avoid splashing of water at the point of exist.

Users of tin sheet gutters practice “first flush” system for atleast 30 minutes before they store water for consumption. Storing water is the main problem for most users. Most users collect water into all possible kitchen utensils. However, those who are more organized collect water into 200 liter barrels or small cement open tanks constructed under the gutters. These tanks usually hold 225-350 liters of water. These users close the storage vessels or tanks with cadjan leaves, polythene or tin sheets. However, as the system of storing is not very secure water can not be used for more than 5-7 days depending on the family size. The water thus collected is mainly used for drinking. People either fitter or boil the water before consumption. Water in excess after using for drinking is used for cooking and sometimes for bathing and washing. however, such multiple uses of collected rainwater can be possible only if it is stored in large containers like storage tanks.

Following are some of the advantages and disadvantages of harvesting rainwater using tin sheet gutters.

| Advantages | Disadvantages |
|---|---|
| 1. Saving time on water collection. | 1. Rusting of tin sheets when not maintained properly. |
| 2. Avoids drudgery of traveling long distances. | 2. Mosquito breeding in tin sheet wedges when not properly cleaned. |
| 3. Good quality water for consumption. | 3. Water contamination in open tanks. |
| 4. tin sheets last for long time. | 4. Breeding of other small insects in open tank water. Tin sheets are expensive. |

## 2. Roof Water Harvesting Using Banana Stem Files as Gutters.

This technique is used mostly by poorer segment of the people in the community. In some cases, this technique was used to collect water from thatched roofs. In this technique, the Banana Stem Files are tied firmly to a corner of the roof. In times of heavy rains, the Banana Stem Files are supported by props to prevent falling under heavy water pressure. The problem with this system is the Banana Stem Files have to be replaced frequently as it tends to break with 3-4 days of heavy rains. Users of this technique collects about 6-7 pots of water under average rainfall conditions. Though this techniques appears to be primitive, it has been very useful to the poorer section of the community, who does not have the capacity to buy polythene sheets or galvanized sheets.

## 3. Roof Water Harvesting Using Aricunut (Areca catehu) Sheaths.

This technique too is used to collect Roof runoff using Aricunut Sheaths as a temporary gutter. The quantity of water that can be collected using this system is limited. Those who use this system replace the Aricunut sheath atleast once in two weeks.

## 4. Rainwater harvesting Using Bamboo Gutters.

In most rural households in Monaragala district houses do not have gutters to collect rainwater,. Therefore, they either have to construct permanent gutters, in which case the cost will be high or use temporary gutters of like Banana Stem Files, Royal Palm leaves or install semi-permanent gutters like Bamboo. The bamboo gutters last along time than other temporary fixtures. Usually a Bamboo gutters collect water from the full area of the roof. Some households use folded Royal Palm leaves at the end of the Bamboo gutters to avoid water waste through splashing or spillage. Other households in Monaragala use split Aricunut trunks as gutters instead of Bamboo. Both techniques serve the same purpose, but Aricunut gutters last a longer time than Bamboo gutters.

## 5. Roof Runoff Collection into Rectangular Cement Motor Tanks.

This is a common system practiced in most houses in Kandy district where the water supply is inadequate to meet the demand of the household. In this system, roof fun off is collected through a gutter and a down pipe. In some households the down pipes are not used but the collection tank is constructed under the gutter. These tanks are of 8'X4'X3', and collects approximately 3000 liters of water. As there is no system of proper storage (no covers to the tanks) water collected can not be used for more than a week. People also use these systems during the rainy season to bath and wash cloths. Unfortunately people do not have the concept of storing water in these tanks for future use specially in the dry season. During the dry seasons people collect water from the same source (mostly dug wells) they are used to. Hence, rainwater in this instance is used only as a supplementary source during the wet season. Each of these tanks cost around Rs. 3000-4000 at present market prices.

## 6. Open Tank Roof Water Harvesting.

This is a unique technique of harvesting roof runoff into a tank constructed on the porch of a house. The study observed only one such house where a tank of 150 $ft^3$ (4300 liters) was constructed on top of the porch of the house. As it is constructed on the porch of the house, the height of the tank is only 2 ½ feet with 10 feet in length and 6 feet in width. This tank is not in use now, because the areas has received piped water supply. However, when the water supply was not available the owners of the house had a direct supply pipe line from the rainwater tank to the Kitchen and after requirement was met by the collection of this tank and another rectangular tank of similar capacity at the back of the house. The cost of the porch tank when it was constructed in 1994 was only Rs. 5000. The owner of the house is a businessman with a monthly turn over of Rs. 25000. Hence, these types of new innovations indicate that people of all walks of life have used rainwater harvesting techniques prior to getting pipe water supply. Unfortunately these traditional rainwater systems are now out of use.

## 7. Collection of Roof Water Through Polythene Gutters.

Most of the people in the Anuradhapura district depend on dug well water for domestic use and irrigation canals and natural streams for bathing and washing. Both these sources have adequate water throughout the year. Specially when dug wells are privately owned the problem of having access to the source of water is also less. Though drinking water is not an acute problem for these households, they too practice rainwater harvesting during the rainy season.

The techniques of collecting roof runoff through polythene gutters is not new to this area, however, households practicing this technique has a long (8-10 feet) polythene gutter attached to two roofs tapering towards the same side. Hence the roof catchment is large rough to collect sufficient quantity of water for domestic use. Though the potential exist to collect large quantity of water, they are constrained with storage facilities. Most of these households collect rainwater only into small containers usually used in the kitchen. Therefore a large amount of rainwater goes waste without being made use of. According to these practitioners, they collect 5-10 gallons (25-45 liters) of water from an average day of rain.

These people collect rainwater purely as a drinking water source as they prefer the “soft” rainwater to “hard” ground water. Another benefit attributed to harvesting rainwater is it availability in close proximity to the house specially during rainy season. People say that it becomes difficult to collect water from dug wells located away from the house during rain. Hence, harvested rainwater becomes an easily accessible source of water. An important benefit of collecting rainwater is, during the rainy season usually people are busy with paddy and chena cultivations. Thus rainwater harvesting gives them additional time to work in the fields instead of collecting water from wells or sometimes from distant sources such as Tube-wells.

An improved version of indigenous roof water collection was constructing rectangular cement tanks. This was a practice mostly in government quarters during late 1950’s to late 1960’s. In the dry zone irrigation settlement schemes, domestic (drinking) water was an acute problem specially during the dry period. The usual mode of water supply was by bowsers, where a limited quantity of water was delivered to door step (Abeyawickrama 1989). This mode of water supply was expensive and could not be provided for ever due to high cost involved. Hence, government assistance was provided to design government quarters and permanent buildings to collect roof runoff into ground pits through a system of gutters and down pipes. These ground pits had sufficient capacity to store water for two to three months for normal domestic use (ibid 1989).

This techniques was late extended to farmer families who had permanent roofs. However, the tank was subsequently modified to a smaller surface tank. Usually the tank was constructed at a point where the two roofs (main house and kitchen) meet. Thus the gutter installed carriers water from both roofs sufficient to fill a tank of about 1500 liter capacity. The collected water is sufficient for an average family for a few days. These tanks were generally kept open, hence, the quality of water deteriorated rapidly.

These tanks are being widely used at present by farmer families in the dry zone irrigation settlement schemes. However, most of these tanks are illmanaged with respect to roof water collection due to poor awareness on the part of settler families.

## Introduction of Organized Rain (Roof) Water Harvesting

### *Need*

The government of Sri Lanka proposes to provide safe drinking water to all by 2010. However, this proposal is becoming a challenging task due to drying up of water sources, pollution of water resources combined with growing demand and conflict among users. On the other hand pipe borne water to all households is becoming expensive given the level of investment required (Rs. 8000 million Annually) and increased operation and maintenance cost. Due to this situation large percentage of the rural population were expected to be without any form of safe drinking water. Therefore it become nationally important to look for low cost alternative options which could be managed and afforded by the communities themselves.

Due to limitations in present conventional sources, i.e. ground water and surface water for drinking purposes. Depletion of the fresh water lens in coastal aquifers, deep aquifers in hilly and rocky areas and in areas identified as high Fluoride in ground water are seen as potential areas for rainwater harvesting. It is accepted that the most effective may of collecting rainwater is harvesting through the roof catchment.

The practical significance of Roof Water Harvesting was realized when the CWSSP was expected to provide safe drinking water to rural communities in three district under the World Bank sponsored programme. The CWSSP initiated in 1993 offered a sufficient choice of technology for rural water supply. However, at the end of 1994, it was clear that the rural communities living in hilly settlements in Badulla district faced acute water shortages due to their to their own geographical location. Extensive, multistage pumping schemes were proposed, but CWSSP could not approve the same as the long term sustainability was in doubt. Also most springs and wells lower down the hill did not have sufficient yield during the dry months and they were quick to dry out (Heijnen and Mansur 1998).

In 1995 a study was commissioned to assess the possibility of Rainwater Harvesting through roof catchment as a source of domestic water supply. On the basis of the recommendations, rainwater harvesting was possible through existing roofs in the hilly areas of Badulla and the study identified number of other experiences in Kandy and Badulla districts where, Roof water harvesting have been successfully practiced. This led to the design and construction of low cost rainwater harvesting storage tanks using roof catchments. Thus, after a pilot test recommendation, CWSSP accepted rainwater harvesting using roof catchments as a feasible option in the rural water supply sector.

**Roof Water Harvesting in Dematawelihinna - A Village in Badulla District**

Many options of providing water to the village were consider at the initial stages. A natural spring was identified which could provide water to 45 households but the option was discarded as there were 204 settler families. Second option was dug wells. This too was discarded due to elevation problems and high cost of construction. The third option, Tube-wells were investigated and 15 locations were identified. The cost of the tube well programme was estimated at Rs. 871611 from state support and Rs. 51547 from community contribution. However, this option too was rejected on technical grounds. The forth option was pumping water from the town water supply tank. The cost estimated for this option was Rs. 3 million. However, the total funds allocated to supply water to Dematawelhinna Village was only 1.1 million. Hence, the difference had to be borne by the village community. Under this option each household had to contribute Rs. 2000 as the cost of the option and a monthly Rs. 145 for operation and maintenance of the pump houses.

This option though technically feasible had to be rejected due to cost considerations. The economy of Dematawelhinna villagers are poor thus they could not effort the expected contribution. With all possible regular options failing due, to various reasons, Rainwater harvesting from Roof catchments was decided as the only option available. Total estimated cost of the entire project was Rs. 1314 706 with a total community contribution of Rs. 262025 (20% of project cost) which include labour and material.

Initially the rainwater option was rejected by the majority due to health reasons. Villagers questioned the possibility of mosquito breeding in stagnant waters. Of the first 100 applications for Rainwater tanks only 46 households consented. However at the first meeting a further 100 households consented. Hence, at present there are 146 Rainwater tanks constructed in the village.

### *Technology*

Discussion of the rainwater harvesting technology under this section will limit to CWSSP interventions. The other type of limited technology interventions will be discussed separately under its respective topics.

It is also noteworthy to mention that CWSSP initiated technology is the most accepted and widespread at present in use for Roof water harvesting in Sri Lanka.

The reliability of a roof water harvesting system is a combination of catchment area, frequency and intensity of rainfall, storage capacity and domestic consumption. Assuming that the catchment area in most rural areas is the roof (fixed and between 30-100 $m^2$ average 60 $m^2$), domestic consumption can be managed to suit the quantity of water available, if rainfall is adequate, then it is the cost of the storage tank that determines the economic feasibility and user satisfaction.

On the basis of rainfall data and service levels that could be provided, it was decided that a family of should have a minimum of 20 liters per day for a minimum period of 50 days (dry period). Thus the volume would be 5X20X50 = 5000 liters or $5m^3$. During the rainy season it would take only a few days to fill such a tank. (Heijnen and Mansur 1998). Following some trails two types of tank design were decided for adoption. An underground brick-dome type tank to the model of the Chinese biogas degester and a free standing Ferro-cement tank. While the size of the tank was decided on the criteria mentioned earlier, the subsidy available per tank also influenced the size to a grate extent. The brick-dome tank could be constructed with the subsidy given under the project while the Ferro-cement tank required an additional 20%, besides the contribution obligatory contribution.

While the size of the storage tank can differ depending on the household requirement, rainfall and income, Rajkuma (1998) express the following mathematical formula to determine the most important components of a roof water collecting system.

Amount of rainwater collected from a roof (liters/year) = A x h x f

where "A" is the catchment area of the roof ($m^2$) "h" is the annual rainfall (mm) and "f" is the run-off coefficient (taken as 80% in most cases).

Required roof catchment

Annual Consumption Qa ($m^3$) = n x q x 365

Required Roof Catchment A($m^2$) = Q x a (f x p)

Where, n = No. of persons in a family

q = Daily consumption per person (20 liters)

p = Annual rainfall (lowest value in 5 years is considered)

f = Run-off coefficient

Hence the Required Tank Volume is;

$$V = t \times n \times q$$

Where, n = No. of persons per family

q = Daily consumption per person (20 liters)

t = Required period of time (days)

A more precise estimation of tank volume can be made if reliable monthly rainfall data exist. Preferably data should be available for atleast for a 10 year period, from which the lowest rainfall figures should be selected. In the absence of reliable data, it is recommended to increase the tank volume by 20%. Rajkuma, concludes his sizing of the tanks by relying on community skills, availability of local material and labour feasibility of roof water collecting systems. He also stresses that for larger systems, availability of equipment too becomes a fractor for feasibility of such systems.

## Guttering System and First Flush

Effective guttering is an important part of the roof catchment system. GI of PVC can be used for gutters and Down Pipes. Length of gutters required will depend on the roof area (Hapugoda 1995) various types of gutters have been used to collect roof run-off. While the CWSSP advocated on PVC/GI guttering (Part of community contributing) several rainwater users have used indigenous guttering like Bamboo/Kitual (Caryota urens)/Aricunut (Areca catechu). Though these type of guttering is cheaper than PVC/GI it fails to collect full potential rain run-off due to the shallow depth of these shutters. Management of indigenous gutters are difficult as there is a tendency to obstruct the natural flow of water.

Down pipes are usually made of PVC in most cases, but, polythene tubes and small diameter rubber tubes have also been used for the same purpose. In the latter case, it is temporarily or to reduce cost of a Roof water harvesting units.

## Filter

Initially the CWSSP did not introduce a filter in Rainwater Harvesting units. However, it was later realized that due to poor management of Rainwater harvesting units, quality of water deteriorated faster due to contamination of stored water with leaf litter. One of the principal methods of leaf litter accumulation is through poor management of the roof surface and gutters. In order to mechanically minimize the contamination, slow sand filters were introduced into all the RWH units introduced towards the later stage of the project. This improved the quality of water significantly. It is believed that water harvested from a regularly maintained roof surface, coming through a slow sand filter can be fit for consumption after boiling the same. In brick-dome type tanks these filters were constructed on ground adjacent to the tank with a PVC pipe being used as a conduit. In Ferro-cement tanks, the filter is constructed on the top side of the tank wall.

### Water Extraction Device (Hand Pump)

When storage tanks, specially brick dome tanks are built on embankments (as in the hilly areas), water can be taken by gravity through a faucet fixed to the bottom of the tank. But when underground tanks are built-in flat surfaces like in most parts of the flat terrain in the hill country or in the flat dry zone, a hand pump is an important component in the system. The project introduced a low cost plunger type hand pump but most people have devised their own pumps which resembles the Indian Mark II type hand pumps. This incidentally is an influence from the tube will programme which uses such type of pumps which are widespread in rural Sri Lanka.

### Tank Cover (lid)

Ideally the tank cover is a part of the tank itself. Unfortunately, this component was not included in the subsidy under the project. As a result most people used temporary covers such as polythene sheets, fertilizer bags, asbestos or tin sheets. These improvisations did not properly secure the tanks, hence, stored water was subject to contamination. In subsequent tank constructions, the lid was made compulsory but the weight of the lid has now become a practical problem of use, specially to women, in the absence of hand pumps.

## *Cost and Subsidy*

Success of any technology intervention depends on the cost and affordability by the users. This principle was one of the foremost criteria considered when designing the Rainwater Storage tanks under the CWSSP. However, the cost of rainwater tank unit depends on number of factors. Community contribution, cost of locally found building material, transport, cost of skilled and unskilled labour.

The costs of a 5m$^3$ tank as estimated under the CWSSP in 1997 are given below.

**Table 3: Cost Estimates for 5m$^3$ Brick and Ferro-cement Tanks**

| Description | Unit | Rate | Brick Tank | Ferro-cement Tank |
|---|---|---|---|---|

| | | | Quantity | Total in Rs. | Quantity | Total in Rs. |
|---|---|---|---|---|---|---|
| Cement | Bags | 310 | 8.5 | 2635 | 8.0 | 2480 |
| Sand | Cubes | 1700 | 0.4 | 680 | 0.6 | 1020 |
| ¾" Metal | Cubes | 4000 | 0.1 | 400 | 0.06 | 240 |
| Brick | Nos. | 2/10 | 800 | 1680 | | |
| Padlo Cement | Kg. | 100 | 0.5 | 50 | 0.5 | 50 |
| Chicken Wire | Sq.m. | 40 | | | 40 | 2200 |
| Binding | Kg. | 85 | | | 1 | 85 |
| | | | | | | |
| Skilled Labour | Days | 250 | 4 | 1000 | 8 | 2000 |
| | | | **Total Rs.** | **6445** | **Total Rs.** | **8075** |
| Unskilled Labour | Days | 150 | 12 | 1800 | 14 | 2100 |
| | | | **Total Rs.** | **8245** | **Total Rs.** | **10175** |

Costing are inclusive of transport Heijnen and Mansur (1998)

According to the above table, community contribution interms of unskilled labour is 22% for Brick tanks and 21% for Ferro-cement tanks. Hence, as at present, the CWSSP Subsidy per tank (Rs. 6500) can cover the cost (excluding unskilled labour) of a brick tank but needs and additional Rs. 1500 for a Ferro-cement tank. Unfortunately, under the project the additional cost was also borne by the subsidy.

Cost of Roof water harvesting unit changed in subsequent projects undertaken by NGOs in Hambantota. In a project undertaken by Sri Lanka Canada Development Fund in an extremely dry area of Hambantota (Suriyawewa), The total cost including house guttering and down pipes were Rs. 11,897 for a brick tank. Of the total cost Rs. 4955 (41%) was the community contribution and Rs. 6942 (59%) was project subsidy.

**Table 4: Cost of a Roof Water Harvesting Unit (Brick-dome Tank) in Suriyawewa (Hambantota District)**

| Sr. No. | Item | Community Contribution (Rs.) | Project Contribution (Rs.) |
|---|---|---|---|
| 1 | 800 Bricks @ Rs. 1.50/brick | 1200 | - |
| 2 | 24, ¾" concrete metal (stone) Motor pans @ Rs. 20/pan | 480 | - |
| 3 | 50, motor pans of sand | 400 | - |
| 4 | 9 bags (50 Kg.) of cement @ Rs. 310/bag of cement | - | 2790 |
| 5 | Skilled labour 4 days @ Rs. 500/day | - | 2000 |
| 6 | Unskilled labour | 2000 | - |
| 7 | House gutters | 900 | - |

| | | | |
|---|---|---|---|
| 8 | Down Pipes | 475 | - |
| 9 | Hand Pump | - | 1250 |
| 10 | Transport cost (Cement and bricks) | - | 300 |
| 11 | Pedlo cement (500 gr) | - | 32.50 |
| 12 | coordination | - | 500 |
| 13 | Other costs (Photographs) | - | 70 |
| | **Total Cost** | **4955<br>41%** | **6942.50<br>59%** |

Source: Project implementation cost by Womens Development Federation Hambantota 1997.

In another project implemented in Ranmuduwawe in Hambantota district with financial assistance from the Lanka Rainwater Harvesting Forum (LRWHF) the total cost of a unit was Rs. 15903 including house guttering, down pipes, filter and hand pumps. The community contribution in this instance was Rs. 7550 (49.6%) while the project subsidy was Rs. 8015 (50.3%). These latter interventions indicate the "need" for good quality water and community capacity to contribute.

**Table 5: Cost of a Roof Water harvesting Unit (Brick-dome Tank) in Ranmuduwewa (Hambantota District)**

| Sr. No. | Item | Community Contribution (Rs.) | Project Contribution (Rs.) |
|---|---|---|---|
| 1 | 800 Bricks | 1200 | - |
| 2 | 35, ¾ concrete metal pans | 525 | - |
| 3 | 2 ½ tractor loads | 450 | - |
| 4 | House guttering | 1413 | - |
| 5 | Down pipes | 700 | - |
| 6 | Unskilled labour for digging the pit (8 man days) | 1200 | - |
| 7 | Construction of the tank (14 man days) unskilled labour | 2100 | - |
| 8 | Unskilled labour (fixing gutters and hand pump) | 300 | - |
| 9 | 9 bags (50 Kg. Each) cement | - | 2587 |
| 10 | Skilled labour | - | 2000 |
| 11 | Transport of construction material | - | 900 |
| 12 | Hand pump | - | 1500 |
| 13 | Coordination | - | 500 |
| 14 | Others | - | 500 |
| | **Total** | **7888<br>49.6%** | **8015<br>50.3%** |

Source: Project implementation cost documentation by Womens Development Federation, Hambantota 1998

Incidentally, in CWSSP due to the loosely formulated subsidy structure, users did not make an effort to construct a tank cover (lid) which finally effected the quality of water. In this project, the subsidy did not include the tank cover but included the rest of the tank construction material and skilled labour. However, by end of 1998, there was a suggestion to charge the subsidy structure to include tank cover, gutters and down pipes in the subsidy and exclude building material like brick, sand and metal (3/4" metal stones) to be supplied by the users as their contribution.

### *Institutional Arrangement and Dissemination*

The institutional arrangement adopted by CWSSP was, water supply sector development through increased user participation and enable the public sector to shift its role from being a provider to a promoter of services. To implement this strategy, five key principles were endorsed by the cabinet of Ministers in March 1993. (Minnatullah etal 1998).

1. The community's role is central beneficiaries are both the decision makers and the doers.
2. The government has a catalytic role in mobilizing all available resources toward achieving the objectives set by the community.
3. Partner organizations play a key role in assisting communities to develop the necessary competence, skills, and institutional capabilities.
4. People in communities provide an in-kind contribution of 20 percent of the capital cost and women participate actively in decision making.
5. An appropriate community-based organization representing beneficiaries is established to be actively involved in planning and construction and to manage the day-to-day operations and maintenance of the schemes, with full cost of operations and maintenance financed by the beneficiary community.

The Institutional arrangement adopted in the Badulla roof water collecting project to achieve water security is as follows.

The village Rainwater harvesting project is implemented through village community Base Organizations (CBOs). The village population is grouped into small groups of 10 people. The leaders of these small groups are formed into a CBO. The CBO which is implementing the Rainwater Harvesting project has a executive committee of 11 members with the secretary and two committee members being women.

The Rainwater Harvesting project is implemented through the following organizational structure.

CWSSP ——— District Partner Organization ——— Community Base Organizations

In this case the partner organization is the Badulla Thrift and Credit Society (locally known as SANASA) which also acts as a rural bank in Sri Lanka.

The village CBOs are expected to show their strength in participation and community work prior to under-taking any major project. The state provides Rs. 5000 (US $ 40) to CBOs which has less than 100 households and Rs. 7500/- (US $ 60) to CBOs which has 100-200 households. The CBOs are expected to use these funds in any village development actively. In this case the CBO used the allocated Rs. 7500/- to improve the village community hall.

In the Rainwater Harvesting project the CBO participated in the initial survey to identify village needs, once the need was identified, the Technical Officer attached to the partner organization decides on the appropriate technology to be used. (Ariyabandu and Dharmalingam 1997).

In NGO implemented projects, once a request is received by beneficiaries, the partner NGO (like the partner organization in the earlier case) contacts their field base NGO (FBN) in the irrespective area to make an assessment of the "Need". On the assessment report submitted by the FBN, funds are sanctioned to the FBN to implement the project. In this case all locally available building material, unskilled labour and house gutters and down pipes are expected to be from the beneficiaries.

### *Distribution of Roof Water Harvesting in Sri Lanka*

As explained in this report earlier, people of rural Sri Lanka devised their own systems of roof water harvesting to fulfill their water security needs. As such there are number of different types adopted by large number of people specially in the dry zone. These numbers are so large that a physical count is not possible. However, since the commencement of the organized rain(roof) water harvesting into 5m$^3$ storage tanks an approximate count had been maintained. Following 95 the present distribution of roof water harvesting systems since 1995.

| **Location** | **No. of Tanks** | **Status** |
|---|---|---|
| Badulla District | 3000 | Completed |
| Matara District | 1000 | Completed |
| Suriyawewa Village | 3 | Completed |
| Muruthalawa Village | 5 | Completed |
| Siyabalanduwa Village | 16 | Completed |
| Ranmuduwewa Village | 3 | Completed |
| Mundal Town | 1 (School) | Completed |
| Weerawila Village | 50 | In progress |

### *Involvement of NGOs*

Non-governmental Organizations have been actively involved in Rural Development in Sri Lanka for the past 3-4 decades. However, Rainwater harvesting as a means of water security was not an option considered by NGOs till 1995. In 1997, The Sri Lanka Canada Development Fund (SLCDF) initiated the first organized Rainwater harvesting project to improve the water security situation of the rural communities in Suriyawewa in Hambantota district. Since this initiative, several NGOs have taken stepped to introduce roof water harvesting to improve water security among water scarce communities, specially in the dry zone of Sri Lanka. While most NGO sponsored projects were utilizing foreign funds to develop Roof water harvesting units, atleast one state owned Environmental project (EAIP) has funded an NGO (SARANA) to construct 50 Roof Water harvesting units. The success of the Roof Water harvesting initiated by CWSSP and subsequently propagated by NGOs has influenced the President of Sri Lanka to instruct authorities in the Ministry of Housing Construction and Public utilities to allocate Rs. 2 million to provide water to a village in Kandy district. This work however, is expected to be implemented by the National Water Supply and Drainage Board which is the state authority for water supply in Sri Lanka.

### *Water Use Pattern*

Water use pattern of Rainwater users has been studied by the author in one wet zone location (Dematawelihinna in Badulla District). Following is an account of water use pattern and achievement of water security by the Dematawelihinna Village Community.

Prior to the RWH project, the people of Dematawelihinna were used to collect their total domestic water requirement from natural springs. These people collect water for all household activities. A survey conducted among non-RWH system beneficiaries indicate that collected water is used for Drinking, Cooking personal washing, washing cloths, for toilet purposes and other activities such as for animals and home gardening. A survey conducted among non-beneficiary households reveal that the per capita water consumption varies between 27 to 73 liters depending on their usage pattern. Highest water usage among these people are for toilet purposes and cooking followed closely by the water use for personnel washing (Table 6).

**Table 6 : Water use Pattern of Non-Beneficiary Households (15 day period) Spring / Well in Liters**

**Table 6**

**Water Use Pattern of Non - Beneficiary Households (15 day period)**

**Spring/Well Water in Liters**

| Household | A | | B | | C | | D | | E | | F | | G | | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activity | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | | |
| Drinking | 255 | 28 | 510 | 43 | 360 | 36 | 195 | 15 | 165 | 11 | 225 | 20 | 203 | 16 | 1913 | 15.58 |
| Cooking | 345 | 38 | 585 | 49 | 672 | 67 | 492 | 38 | 204 | 19 | 285 | 26 | 405 | 31 | 2988 | 24.96 |
| Washing Cloths | 360 | 40 | | | 588 | 59 | 522 | 42 | 240 | 22 | 427 | 39 | 60 | 5 | 2197 | 18.36 |
| Washing Face | 330 | 37 | 450 | 38 | 492 | 49 | 192 | 15 | 408 | 37 | 158 | 14 | 293 | 23 | 2323 | 19.41 |
| Toilet purposes | 300 | 33 | 600 | 50 | 420 | 42 | 198 | 45 | 31 | 3 | 525 | 48 | 435 | 33 | 2509 | 20.96 |
| Others | | | | | | | 39 | 3 | | | | | | | 39 | 33 |
| Total | 1545 | 172 | 2130 | 176 | 2412 | 241 | 1680 | 129 | 1725 | 157 | 1620 | 147 | 1395 | 107 | 11969 | |
| lpcd | | 57 | | 35 | | 34 | | 43 | | 31 | | 73 | | 27 | | |
| | 1590 | 122 | 2145 | 165 | 2532 | 195 | 1638 | 126 | 1048 | 81 | 1620 | 125 | 1396 | 107 | | |
| | | 41 | | 33 | | 28 | | 42 | | 16 | | 62 | | 27 | | |

TQU : Total Quantity of Water Use for 15 Day Period

TDU : Total Water Use Per Day

### *Rainwater Use*

These people of Dematawelihinna who were used to collect domestic water from natural springs/dug wells were given rainwater harvesting tanks as a measure to improve their water security. This intervention gave them additional quality time to spend with their families, time to be involved in small-scale economic activities and lessened the drudgery of carrying water on steep treks.

Though the 5m$^3$ Rainwater tanks were designed to supply 20 liters per capita for a family of five for a 50 day dry period, storage in these tanks are being used throughout the year due to intermittent rain received in the wet season. However, during the dry season, which usually lasts for about 4-5 months, these beneficiaries, change their water use pattern. During the dry season they bring more spring water and try to maintain the Rainwater storage as a security. This pattern changes with the on-set of the wet season. It has been reported that during wet season Rainwater tank beneficiaries use the stored water even for bathing and washing cloths. This pattern of rainwater use classifies the beneficiaries as partial rainwater users. Rainwater tank beneficiaries collect spring water mainly for Drinking and Cooking. It is a general belief that Roof runoff rainwater is not fit for human consumption.

However, some of the beneficiaries who are located at the far end of the Dematawilihinna peak use only rainwater for all domestic needs. The reason for total dependence on rainwater is due to the physical location of houses with respect to natural springs/dug wells.

Spring water use of rainwater tank beneficiaries vary from 2 liters per capita day to 41 liters per capita day. Water collection per day varies from 15 liters to 284 liters among the 10 beneficiary households. In this instance too, the quantity of water brought from springs do not depend only on the family size. The household which collects 284 liters per day has 7 members while the household with 15 liters per day has 5 members (Table 7).

**Table7: Natural Spring Water Usage Pattern of Rainwater Tank Beneficiaries**

**Table 7**

Water Use Pattern of Beneficiary Household-Spring/Well Water (15 day Period) - DEMATAWELIHINNA in Liters

| Households | A | | B | | C | | D | | E | | F | | G | | H | | I | | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activity | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | | |
| Drinking | 216 | 18 | 383 | 35 | 390 | 30 | 165 | 13 | 192 | 21 | 288 | 24 | 252 | 19 | 620 | 48 | 127 | 11 | 2633 | 18.28 |
| Cooking | 288 | 24 | 653 | 59 | 390 | 30 | 368 | 28 | | | 432 | 36 | 240 | 18 | 1300 | 100 | 169 | 14 | 3840 | 26.66 |
| Washing Cloths | 696 | 58 | 458 | 42 | 2115 | 163 | 35 | 10 | | | | | | | | | | | 3304 | 22.93 |
| Washing Face | 432 | 36 | 173 | 16 | 405 | 31 | 30 | 2 | | | 12 | 1 | | | | | 133 | 11 | 1185 | 8.23 |
| Toilet Purposes | 372 | 31 | 38 | 3 | 390 | 30 | 15 | 1 | | | 336 | 28 | | | 1300 | 100 | | | 2451 | 17.01 |
| Others | 372 | 31 | 375 | 40 | | | 30 | 2 | | | 216 | 18 | | | | | | | 993 | 6.89 |
| Total | 2004 | 154 | 2080 | 160 | 3690 | 284 | 643 | 49 | 192 | 15 | 1284 | 99 | 492 | 38 | 3220 | 248 | 429 | 33 | 14406 | |
| lpcd | | 38 | | 16 | | 41 | | 12 | | 2 | | 25 | | 8 | | 41 | | 8 | | |

TQP : Total Quantity of Water use for 15 Days period

TDU : Total Daily Water use

The rainwater use of the same beneficiary households vary from 12 lpcd (liters per capita day) to 67 lpcd. In this instant, rainwater has been mainly used for washing face, for toilet purposes, washing cloths and for other purposes like feeding animals and watering small home gardens (Table 8).

**Table 8: Water Use Pattern of beneficiary Households Rainwater (15 day period) - Dematawelihinna - In Liters**

**Table 8**

Water Use Pattern of Beneficiary Households -Rainwater (15 day period) - Dematawelihinna - in Liters

| Households | A | | B | | C | | D | | E | | F | | G | | H | | I | | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activity | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | TQU | TDU | | |
| Drinking | | | 15 | 1 | 390 | 30 | | | | | | | | | 520 | 40 | | | 925 | 4.76 |
| Cooking | 135 | 11 | 68 | 6 | 585 | 45 | 45 | 3 | 432 | 48 | | | 192 | 15 | 1040 | 80 | 101 | 8 | 2598 | 13.38 |
| Washing Cloths | 468 | 39 | 83 | 8 | 1770 | 136 | 375 | 29 | | | | | 588 | 45 | | | 1650 | 140 | 4934 | 25.41 |
| Washing Face | 336 | 28 | 315 | 29 | 390 | 30 | 255 | 20 | 348 | 39 | | | 408 | 31 | 1120 | 86 | 455 | 38 | 3627 | 18.68 |
| Toilet Purposes | 468 | 34 | 540 | 49 | 390 | 30 | 345 | 26 | 288 | 32 | | | 576 | 40 | 1020 | 78 | 485 | 40 | 3992 | 20.56 |
| Others | 300 | 25 | 323 | 29 | | | 1050 | 81 | | | | | 120 | 9 | 780 | 60 | 770 | 64 | 3343 | 17.22 |
| Total | 1647 | 127 | 1344 | 103 | 3525 | 271 | 2070 | 159 | 1068 | 82 | | | 1824 | 140 | 4480 | 345 | 3461 | 266 | 15419 | 100 |
| lpcd | | 32 | | 10 | | 39 | | 40 | | 12 | | | | 28 | | 57 | | 67 | | |

TQU : Total Quantity of Water use for 15 Day Period

TDU : Total Water use Per Day

### *Water Security*

While understanding the water use pattern of Rainwater beneficiaries. The author attempts to express the achievement of water security by rainwater users. Water security is explained by comparing the water use pattern of rainwater users who are beneficiaries of roof water harvesting tanks and those who are users of spring/dug wells for their domestic use. In this analysis, the water use pattern of non-beneficiaries are considered as the pre-project situation. These latter families a live in the same village and in most instances the selected families had a similar family size.

Per capita water use of the two types of beneficiaries are given in table 9 and 10.

**Table 9: Pre Project Per Capita Water Consumption of beneficiary Households**

| Household No. | A | B | C | D | E | F | G | AVE. |
|---|---|---|---|---|---|---|---|---|
| Per Capita Consumption (lpcd.) | 41 | 33 | 28 | 42 | 16 | 62 | 27 | 36 |
| Ave. design lpcd. | 140 | | | | | | | |
| % achievement of design lpcd. | 29 | 24 | 20 | 30 | 11 | 44 | 19 | 25 |

Source: Monitoring Data 1998.

**Table 10: Post-Project Per Capita Water Consumption of Beneficiaries**

| - Beneficiary Households | A | B | C | D | E | F | G | H | I | AVE. |
|---|---|---|---|---|---|---|---|---|---|---|
| - Spring/well water consumption lpcd. | 38 | 16 | 41 | 12 | 02 | 25 | 08 | 41 | 08 | 21 |
| - Rainwater tank consumption lpcd. | 32 | 10 | 39 | 40 | 12 | - | 28 | 57 | 67 | 32 |
| - Total | 84 | 29 | 79 | 52 | 20 | 27 | 36 | 98 | 39 | 52 |
| - AVE. design lpcd. | 70 | 26 | 80 | 52 | 14 | 25 | 36 | 98 | 75 | 53 |
| - % achievement of design lpcd. | 50 | 19 | 57 | 37 | 10 | 18 | 26 | 70 | 53 | 37 |

Source: Monitoring Data 1998

lpcd. : Liters per capita day

Table 9 indicate that prior to the project, beneficiaries could achieve only 36 lpcd which is 104 lpcd less than the standard rural per capita consumption, which is 140 liters. Thus, only 25% of water security could be achieved with respect to design achievement. This could be due to the distance they had to travel to get water and high demand from the rural community on limited sources of water. Dematawelihinna, though situated close to the Badulla town, experiences a dry spell from May to August. During this time most of the spring water sources either dry-up or get reduce to a trickle leaving the people to stand in water lines for long time.

Per capita daily consumption of water in the post project situation appears to be an improvement to the pre-project situation. What is important in this situation is that Rainwater tank beneficiaries use rainwater only as a partial source to satisfy their water needs. The other part of the water is collected from natural springs and dug wells. Table 10 indicates the water usage pattern of Rainwater tank beneficiaries over a 14 days period.

Table 10 indicates that, since getting Rainwater harvesting Tanks, the average per capita consumption has increased to 53 lpcd. This is an increase of 17 lpcd from the pre-project situation. The increase per capita consumption has elevated the percentage design security from 25 in the pre project situation to 37 in post project situation. Thus the Rainwater tank beneficiaries are 12% more secure with respect to water availability.

The average water consumption pattern of Rainwater tank beneficiaries are presented below.

| | | | |
|---|---|---|---|
| - | Average per capita water consumption of the beneficiaries | 53 lpcd | A |
| - | Average per capita water consumption prior to project | 36 lpcd | B |
| - | Average spring water collection by beneficiaries (Post-project) | 21 lpcd | C |
| - | Increase consumption of beneficiaries (A - B) | 17 lpcd | D |
| - | Quantity of spring water not brought due to Rainwater use (B - C) | 15 lpcd | E |
| - | Total rainwater usage (D + E) | 32 lpcd | |

The above calculation indicates that 82% of the beneficiary water needs prior to project has now been satisfied by Rainwater.

$$\frac{\text{Total Per Capita Rainwater Usage}}{\text{Per Capita Water Consumption Prior to Project}} \text{ X } 100 = \frac{32}{36} \text{ X } 100 = 82\%$$

this leaves beneficiaries with only 04 additional liters (36-32) to be brought to satisfy their pre project water demand. However, the current spring water collection of beneficiaries is 21 lpcd. Indicating that they bring 15 liters per person in addition to their requirement.

This can be attributed for two reasons.

a. The beneficiaries were using less water than required in the pre-project situation or

b. the beneficiaries are using more water since getting Rainwater harvesting Tanks. In other words increased water security has increased the demand for water.

According to the water use behavior pattern of the beneficiaries the second attributory reason can be more valid than the first reason.

Water use behavior of the beneficiaries after project can be further strengthened by analyzing the pattern of water collection from natural springs.

**Table 11: Water Use Pattern of Beneficiaries from, Natural Springs After Project Establishment**

| Household No. | Water Fetched Before Tank Establishment (liters/day) | Water Fetched after Tank Establishment (liters/day) |
|---|---|---|
| A | 600 | 202 |
| B | 300 | 187 |
| C | 325 | 25 |
| D | 70 | 40 |
| E | 240 | 21 |
| F | 75 | 107 |
| G | 180 | 42 |
| H | 400 | 215 |
| I | 140 | 36 |

Source: Monitoring Data 1998

**Table 12: Time Spent on Fetching Water**

| Household No. | Before RW Tank Establishment (min) | After RW Tank Establishment (min) | Time Saved |
|---|---|---|---|
| B | 180 | 115 | 65 |
| C | 120 | 80 | 40 |
| D | 210 | 120 | 90 |
| F | 90 | 130 | -40 |
| H | 180 | 90 | 90 |
| I | 180 | 45 | 135 |

Source : Monitoring Data 1998

Time spent on collecting water before and after Rainwater harvesting tanks show a significant saving on time.

Table 11 indicates that, besides “household F” all others collect less water from natural Springs than prior to project initiation. The “household F” collects more water than what they use to collect prior to the project. The reason for this situation is at the time of the study, the underground Rainwater tanks of “household F” was leaking and had no water. However, as they were use to a larger absence of rainwater from the tank, they try to supplement by bring additional spring water. This situation is reflected in table

12 where "household F" spends an additional 40 minutes in collecting water from springs, while the rest of the households save time between 40-135 minutes per day.

This study was conducted during the dry month of August. During the period of study there were only two days of average rainfall. Three months prior to August was also dry, hence the results obtained is specific to a dry season water consumption pattern.

Therefore, the water security mentioned under these conditions can change during the wet season. It can be safely assumed that water security can improve during the wet season, with increased availability of rainwater. Water security under the same existing conditions can be improved if another tank can be constructed or the roof area can be increased with polythene extensions.

### *Impact of Water Security on Rural Communities*

The most significant impact of the Roof Water Harvesting in Sri Lanka is the assured supply of domestic water at homestead. As explained earlier water security has increased due to the use of rainwater. This has obviously led to increase use of water per capita, which incidentally has been used to improve personnel hygiene of rural communities. This situation is clearly expressed in the pattern of water usage given in table 6-8.

Impact on Social Life According to the studies conducted by the author in Dematawelihinna, people in water scarce areas had to restrict their social visits, personnel development and entertaining friends and relations due to pre occupation in fetching daily quota of water. When women are involved in fetching water the usual household chores had to be handed over to the men and in-laws. When young girls had to attend festivals and social functions out side the village, they had to fetch more water per day to compensate for their absence. (Ariyabandu and Dharmalingam 1997). Since getting the Rainwater tank most of these problems have been rectified. The mere presence of assured water (water security) have changed their life style dramatically. With the availability of a $5m^3$ tank the users could entertain friend and relations, indulge in social visits and attend to career development programmes without having to think about the problem of domestic water requirement.

### *Impact on Children*

In water short villages, children are a not spared in fetching water. This sometimes takes place during the night due to the heavy demand on limited water sources. In such instances, children lose precious time, otherwise can be used for studying. In Dematawelihinna, school teachers have complained of poor school attendance of children and frequent failure to complete home work. Though the parents were reluctant to divulge the truth to teachers, it was due to fetching water in the night. This problem has been totally eliminated since getting rain water tanks. The limited quantity of spring/dug well water collected since getting the tank has been the responsibility of adult women and men.

### *Impact of Physical Health*

Though water borne diseases is a common occurrence among users of polluted water, this was not reported as a serious problem from Dematawelihinna. This could be mainly attributed to good quality of spring water usually available to these villagers at the foot hills. However, due to the steepness in the climb to their houses, most women complained of back pains and limb pains carrying heavy water containers.

Though not reported specifically, this type of work for a long time can develop into potential cases of ship-disk. Hence, roof water harvesting has given these women a consolation to improve their health and avoid potential risks of being slip-disk patients.

Besides personnel benefits from roof water collections, the concept of RWH had encouraged NGOs to consider this as a feasible option to water scarces situations. The impact of RWH as a rural water supply option has encouraged IDA and ADB to consider RWH technology as an alternative source to supply good quality water to rural communities, where other options are not feasible.

### *Water Quality*

Perception of most rural people is Rainwater is unfit to drink, more so, when it is collected from roof catchments, it is totally unfit for consumption. Incidentally, this perceptional attitude is the driving force for RWH in future.

However, test conducted on quality of rainwater indicate that it is fit to drink after boiling. Water quality test conducted in September/October 1997 from sample collected from Dematawelihinna indicate that the colour and turbidly is little higher than expected, due to non application of first flush devices. Total coliform counts of over 100 colonies per 100 ml was found in 21% of the samples but E-coli count was consistently zero (Heijnen and Mansur 1998).

Test conducted in Kandy district indicate that conductivity of roof water was as high as 260 μS/cm, colour is high due to the presence of decaying leaves in the storage tank. Turbidity is high due to accumulation of dust in the atmosphere but PH is within required range of drinking water (Padmasiri 1998). Total coliform in most samples were higher than the drinking water standards and fecal coliform was found to be present in few samples (ibid 1998). Hence, the quality water was not fit for drinking unless boiled. Generally, rainwater tastes flat due to low mineralization, this plays a vital port in peoples acceptance of rainwater as a drinkable source. However, research conducted so far on user perceptions of rainwater indicate that people reject it mainly due to it poor (assumed) quality. In fact research findings in Kandy indicate that roof run off had lower microbiological population compared to water samples analyzed from dug wells in the same area.

While acid rains can be a major threat to rain water utilization, in Sri Lanka it is not a major problem compared to other countries in the region. However, there had been number of locations in the Central and North Central Province where high (PH<5.6) rainwater acidity has been recorded. This can be of concern to any programme initiating to harvest rainwater for domestic use. (Ileperuma 1998). Analysis of Sulphates and Nitrates indicates that this atmospheric pollution is due to high nitrate containing air being transported from Western province, fumes originating from Tamil Nadu, India, being transported and increased burning of diesel fuel from Rice mills (ibid 1998).

As such quality of harvested rainwater is crucial factor for the sustainability of Rainwater (Roof) harvesting technology in Sri Lanka.

### *Problems and Prospects*

After nearly five years in operation, researchers have identified problems and constraints that threatens the sustainability of rainwater harvesting (RWH) technology in Sri Lanka. However, it is heartening to note that most of these problems can be resolved with basic interventions in the technology adoption process.

#### 1. Project Orientation

The technology intervention should move from "donor driven" approach to a more need base "demand driven" approach. Though the present project approach is expected to be demand driven it is only limited to a request application. In future the demand driven approach should include enhanced community participation, where the donor and the community should contribute as equal partners. This could facilitate more wider distribution of RWH units in a locality.

#### 2. Awareness on Technology Intervention

At present there is a lacuna in technological awareness among the Rainwater users. This inadequacy has led to substandard construction by masons, poor guttering and installing down pipes, wrong operation of first flush systems etc. This situation could be rectified by post construction operation and maintenance, training and subsequent periodic awareness programmes.

## 3. Cost and Subsidy

The present subsidy disbursed structure should be changed to enhance more community contribution. This could be on a equal partner basis. The project subsidy should be limited to cement, skilled labour and hand pumps (where applicable). However, it is mandatory to ensure that the tank lid (cover) is included in the subsidy component. In the past, exclusion of the tank cover from the subsidy resulted in users covering the tank with material like, polythene, old fertilizer bags, galvanize sheets etc. These improvisations have caused water contamination leading to limited use of stored rainwater.

## 4. Construction of Tanks

Past experiences indicate that there is a possible problem with respect to structural durability of tanks due to substandard constructions. There had been cases reported where cement meant for tank construction had been used in other household constructions, thus, threatening the durability of tanks. This can be negated by either appointing a construction supervision committee among the users in large scale projects or strengthening the technical knowledge of beneficiary users.

## 5. Quality of Rainwater

Quality of stored rainwater is one single factor that threatens the sustainability of RWH technology. Many users do not use rainwater for consumption purposes due to the notion that it is unfit to drink. Though microbiological assessments have indicated that it is safe to drink after boiling, user perceptions deter use of rainwater as a drinkable source. Some of the main reasons for this situation are

1. Non use of fitters or under utilization of fitters
2. Poor maintenance of roofs and gutters
3. Wrong management of RWH units which promotes access to biological fauna into water tank
4. Mosquito and other insect breeding in gutters/tanks
5. Ineffective use of first flush systems

All these negative factors can be rectified if the RWH units are properly operated and maintained. One of the main reasons for roof litter is overhanging branches. While this problem can be easily rectified by cutting overhanging branches, at times, users hesitate to cut branches of trees like lime and oranges which are economic crops for subsistence survival. Mosquito and insect breeding can be minimized by regular cleaning of gutters and closing the water tanks securely. One of the contributory factors in this regard is the heavy weight of the tank cover. As such, women, who are the main users of rainwater, found it difficult to manipulate the tank cover every time they need water. Thus, they kept it open once they open in the morning. This practice promoted mosquito breeding, algal growth and contamination with organic matter. Sometimes this also encouraged small biological fauna contaminating stored water. A simple solution to this problem would be to include a hand pump in the RWH unit. Incidentally, in subsequent constructions, hand pumps were included though functioning of the same had problems due to technological defects.

## *Conclusion*

RWH technology is well accepted as a rural water supply option. However, only less that 10% of the users consume rainwater due to wrong notions and personal beliefs that deter the use of rainwater. As a result water security stands at well below 50%. Future efforts on awareness creation to shed the misnomer on rainwater, will witness an improvement in consumption levels and water security, which is expected to increase beyond the present fifty percent.

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