Optimum Tank Capacity for Rain Water Harvesting Systems in Home gardens

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Sri Lanka is a tropical agricultural country, which is situated between 5^0 and 10^0 north latitude and between 79^0 and 82^0 east longitude with a total land area of 65,610 km^2**.** The hazards associated with the tropical environment similarly influence for crop production in Sri Lanka. The average rainfall and average temperature of the country vary from 900 – 5100 mm and from 20 – 34^0C respectively. The distribution of the rainfall pattern of the country indicates the bimodal pattern with the uneven distribution of rainfall timely and spatially. It makes both rainless periods and excess of rainfall periods, which adversely affects the growth of the crop, and the ultimate result is the reduction in yield. Therefore the major irrigation schemes have been developed on priority basis since 500 B.C to optimize the crop production, which were mainly aimed for the paddy cultivation and the large-scale up-land crop cultivations.

On the other hand, Sri Lankan Agriculture is dominated by smallholders. Nearly 73% percent of agricultural lands belong to smallholdings. The land holdings of them are usually small, about 0.1-0.4 ha per family (Waragoda, 2002). Usually they have a multi-storeyed, mixed cropping system in the vicinity of the house. It is called as home gardening and there can be both perennial and annual crops around the house. The rural women's endeavor is to maintain and improve their home gardens in order to cope with the problems posed by the malnutrition. Hence, output generated by the home gardens can improve the diet of the family and their health situation as well as it derives additional income for the wellbeing of the family. A well-developed home garden is a stable and partly self-generating ecosystem. Since home gardens in up lands are dearth with inadequate water resource, rural women compel to shed extra energy for irrigating their home gardens or if it is not so, leaving it barren. Therefore, rainwater harvesting through roofs during wet periods enabling to irrigate crops during dry periods within the same area, is one of productive options in order to deal with their grievance on water scarcity. If this could be practiced, it would save the water and eliminate the risk of water shortage that affects the cropping seasons. The roof water harvesting for domestic and agricultural uses have been a common practice in developing countries.

Rainwater harvesting

Rainwater harvesting has attracted considerable attention in recent years in work covering a wide range of techniques, from the collection of rainwater from roofs to the retention of surface and subsurface flow in rivers. The study aims to find methods of collecting and conserving rainwater at early stage of the hydrological cycle to ensure the best use of rainfall. The systems described in this study will benefit for thousands of scattered, small communities that cannot be served by more centralized water supply schemes in the foreseeable future.

The technique of rainwater collection for home gardening is essentially small in scale. It utilizes the roofs of individual houses to maximize the efficiency of runoff collection. Thus a scatter of small rainwater catchments, each serving an individual home garden, is the characteristic pattern.

Hapugoda (1998) explored feasibility of rainwater harvesting in regions of Divulapitiya and Mirigama. Heijnen and Mansur (1998) showed successful rainwater harvesting in Badulla and Matara districts under the Community Water Supply and Sanitation Project in Sri Lanka. They found that rainwater harvesting for domestic consumption was extensively practiced in Sri Lanka especially in upland areas such as Kundasale and Bandarawela.

Ilaankovan (1998) pointed out that it is difficult to get drinking water using wells in certain areas closer to Baticoloa town. Rainwater harvesting in these areas will be suitable for domestic use and irrigation.

Methods of designing micro level rainwater harvesting tanks for home garden irrigation

The objective of this research is to collect rainwater from roofs to irrigate home gardens. Collecting the roof runoff will save household's time, cost for irrigation and labour requirement, reduces soil erosion, keep fertility in the garden and minimize road floods. The water balance in different agro-ecological regions of Matara district was assessed to determine the optimum tank capacity to store roof runoff water for irrigation in home gardens.

Based on literature, there are no precise tank capacities for roof runoff water harvesting defined for Sri Lankan conditions. There are rainwater tanks available in Sri Lanka. However their capacities are usually determined by what people could afford. The choice of the tank may also depend on what contribution it makes to people's livelihoods. Water balance methods are not practiced to decide tank capacities.

When water is to be collected from house roofs, it is a must to have specific capacity of storage tank. It can be achieved by three ways.

(i). Matching the capacity of tank to the volume of water collected from the roof.

(ii). Matching the capacity of tank to the quantities of water required by its users.

(iii). Choosing the size that is appropriate in terms of costs, resources and construction methods.

A considerable attention was paid to calculate tank size to meet first two requirements mentioned above. This may be appropriate in some developed countries where the usual approach is to start with the requirement of water, by specifying a desirable level of consumption and then designing catchment (roof) areas and storage tanks. In developing countries much greater weight has to be placed on cost. It is also important to take account of the resources available; roofs as catchment areas, local materials to construct the tank and labour. Keller (1982) used all these resources to estimate the storage capacity of the tank to match as close as possible to a target for water consumption. In practice, costs and construction methods tend to limit tanks to smaller capacities.

Rationing method (Pacey and Cullis 1986) was used to find precise tank capacity. Cumulative weekly runoff values in volume basis is represented in a column graph which is beginning after accumulation of 100 mm of rainfall at 75% probability over the area for *Yala* and *Maha* seasons. Cumulative crop irrigation need for the season is also plotted in the same graph. The highest deviation between two graphs is considered as optimum tank capacity.

Matara district is selected for the study. It lies in Wet zone of southern of Sri Lanka. The average annual rainfall and average daily temperature of the area are 2425 mm and 28^0C respectively. Weekly rainfall data at Mapalana rain gauge station from 1950 to 2000 are used to find weekly runoff values. The average roof area of a farmer is $40m^2$.

This was obtained after surveying 25 farmers around the area. As most of houses available in the study area, are made of tiles, 0.75 is used as runoff coefficient.

Rainfall in Sri Lanka is governed both by monsoonal systems as well as by local convectional phenomenon. As a result there are two cropping seasons per year. They are from April to September (*Yala* season) and October to March (*Maha* season). These two cropping seasons are based on the rainfall patterns unique to the country. The rainfall pattern shows the bimodal rainfall distribution throughout the year. Most parts of Sri Lanka received rainfall through the southwest monsoon which is effective from mid May to September (*Yala* season) and northeast which is effective from mid November to February (*Maha* season).

Crop commencement dates were considered based on the 75% of the forward accumulation probability of weekly rains commencing from 1st of March which is the beginning of *Yala* season after the January and February dry period and 1st of August which the beginning of *Maha* season (Navaratne 2003). 100 mm rainfall at 75% probability was accumulated in the location at the beginning of onset time (Navaratne 2003).

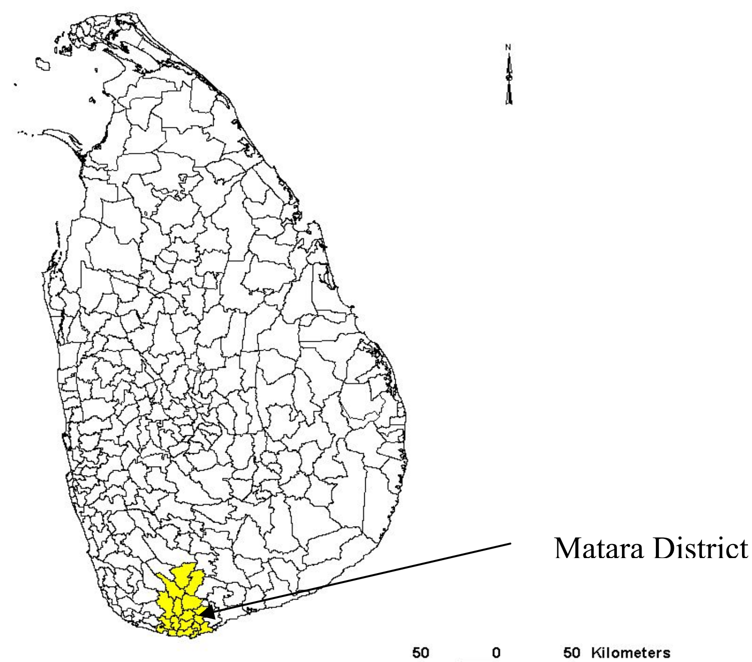

Fig.1: Location of Matara District

Application of Rationing Method

The total runoff from the tile roof during *Yala* and *Maha* seasons were recorded as 813 mm (32.52 m^3) and 870 mm (34.80 m^3) respectively. The total irrigation need by plants under drip irrigation system for *Yala* season was 62.2 mm and, for *Maha* season 89.5 mm. Based on the above values when the tank is designed to collect the total amount of water during respective seasons, the tank capacity should be 32.5 m^3 for *Yala* season and 34.8 m^3 for *Maha* season. Installation of such large capacities of tanks in small home gardens is not practicable since it needs high construction cost and covers the land area. It was clear that plants consume irrigation water continuously and in almost every week, there was an irrigation need. Therefore, the present work considered the water balance between roof runoff and irrigation water consumption to determine optimum tank capacity.

Cumulative weekly volume of water colleted from tile roofs and cumulative weekly volume of irrigation water consumption (weekly irrigation need x cultivable land area) by plants under drip irrigation system for *Yala* and *Maha* seasons are given in Fig: 2 and 3. When the two curves are farthest apart, it indicates the maximum excess of water. The tank stores the maximum amount of water at that point of the selected season and it was considered as the optimum tank capacity for a home garden which has a house with an Asbestos roof of 40 m^2 area.

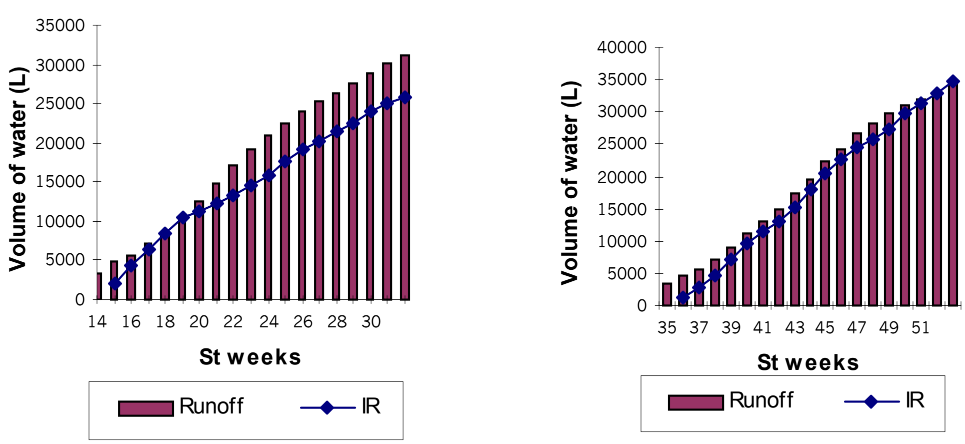

Fig. 2 & 3 Volume of water collected from tile roofs and consumption of water by plants under drip irrigation system for *Yala* and *Maha* seasons

The maximum excess of water recorded in *Yala* and *Maha* seasons were 5.9 m^3 and 3.0 m^3 respectively. The highest value; 5.9 m^3 was selected as the optimum tank capacity for home gardens having houses of 40 m^2 roof area for irrigation.

The Cultivable land area with respect to the optimum tank capacity

The ratio between weekly cultivable land area: roof area, based on the available roof runoff and irrigation water consumption were calculated using the following equation for entire cropping seasons.

$$CultivableLandArea : RoofArea = X/Y$$

Where,

X - Weekly cumulative roof runoff depth

Y - Weekly cumulative irrigation requirement depth

These values are graphically represented in Figures 4 and 5.

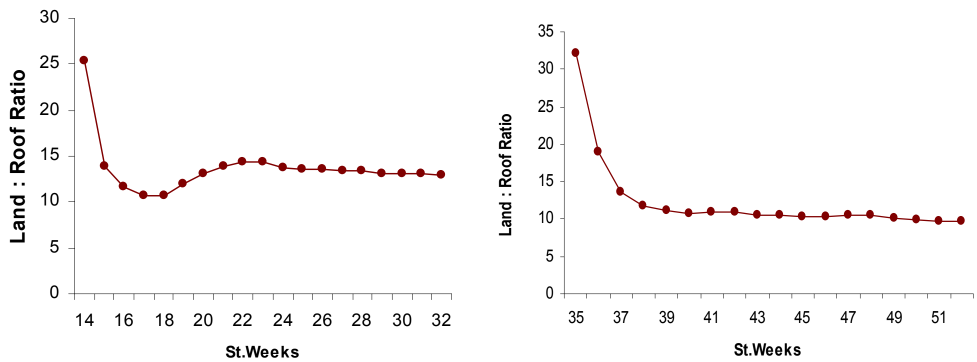

Fig. 4 & 5: Weekly cultivable land :roof area for *Yala* and *Maha* seasons under drip irrigation system

The least value of the weekly land: roof ratio was multiplied by roof area and that was selected as precise cultivable land area to match the amount of rainwater available in the garden for irrigation. Based on the analysis, the farmer could be able to cultivate 11 times greater land area in respect to roof area without any irrigation water source other than roof runoff water.

Conclusion

The analysis clearly indicates the optimum tank size and the irrigable land area with respect to the tank size, considering the water balance between the roof runoff and the irrigation need. The optimum tank capacity as well as the cultivable land area depends on area of the roof.

The optimum tank capacity needed to store rain water from a $40m^2$ of tiled roof, was found as 5.9 m^3 when the drip irrigation method is practiced for irrigation in the home gardens of southern part of Sri Lanka. The study illustrates that the land area of around 440 m^2 could be irrigated using the above tank capacity. Thus, the land area of 11 times of roof area could be cultivated using water through household's own roof.

References

Hapugoda, K.D., 1998. **Feasibility of rain water harvesting in the Divulapitiya and Mirigama area**. Proceedings of the Symposium on Rain Water Harvesting for Water Security. Vol. I & II, Lanka Rain Water Harvesting Forum, Sri Lanka.

Heijnen, H. and Mansur, U. 1998. **Rain Water Harvesting in the Community Water Supply and Sanitation Project**. Proceedings of the Symposium on Rain Water Harvesting for Water Security. Vol. I & II, Lanka Rain Water Harvesting Forum, Sri Lanka.

Ilaankovan, K., 1998. **Proceedings of the Symposium on Rain Water Harvesting for Water Security**. Vol. I & II, Lanka Rain Water Harvesting Forum, Sri Lanka.

Keller, K. 1982. **Rainwater harvesting for domestic supply in developing countries:** a draft literature review, Washington DC:U.S Agency for International Development, Office of Health, WASH Working Paper No.20

Navaratne, C.M. 2003. **Low Cost Auto Irrigation System for Home Gardens Intensification to Minimize the Agro-Climatic Risk: A case study in Matara District.** PhD. Thesis, Faculty of Agriculture, University of Ruhuna, Matara, Sri Lanka.

Pacey, A., Cullis, A. 1986. Rainwater Harvesting – The collection of rainfall and runoff in rural areas. Intermediate Technology Publications. 103-105 Southampton Row, London, WC1B 4HH, UK**.**

Waragda,W.2003, **Impact of Land Utilization Systems on Agricultural Productivity**, Country paper for Sri Lanka. Asian Productivity Organization, Tokyo.