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Domestic Roof-water Harvesting in the Humid Tropics (August 1998 - July 2001)

Consolidated scientific report

Lanka Rain Water Harvesting Forum

Introduction

This work is being carried out as part of a programme titled 'Domestic Roofwater Harvesting in the Humid Tropics', which is an international 3 year, four partner, European Union funded, programme which started in August 1998.

Objective

The main objective of the research conducted by Lanka RWHF is to study the Household water security in relation to rainwater harvesting. Household water security was define as ‘accessibility, reliability and timely availability of adequate safe water to satisfy basic human needs”. Study was conducted to investigate how domestic rainwater harvesting can influence one or more of these aspects and how it has an impact on household water security.
Using the above definition to develop a water security model (HWS) to assess the household’s ability to obtain the required quantity of suitable water for drinking, personal hygiene, other household need and for minor economic activates with time and different water source options.

Activities under taken

Lanka RWHF was appointed the manager of the task D with participation from IITD and FAKT. Lanka RWHF’s contribution to the project was distributed for: Task D 60% to, Task A 10%, Task B 10%, Document Centre 15%, Task C: Water Quality 5%.

Task D: WATER SECURITY

Water User behaviour pattern

Water user pattern of rural households (rain water beneficiary and non-beneficiaries) were collected in four locations in the wet, intermediate and dry zone of Sri Lanka was studies over 6 month period. Daily water use data in thirty households (15 Rain water users, 15 non – users) in each location were collected including, disaggregate water for drinking, cooking, personal washing, toilet purposes, washing cloths and other activities. The householders themselves recorded water uses for each of these activities daily on a given format. Qualitative information such as

1. General socio-economic information from residence in the households.
2. Distance people travel to fetch water and time taken.
3. Responsibility in fetching water
4. Water quality perceptions
5. Managing household water
6. Reliability of other water sources
7. Direct and opportunity cost of time in fetching water
8. Preference and importance given to different water sources
9. Operation and maintenance sources
10. Use of filters and first flush systems in relation to quality of rain water

The qualitative information was reported in biweekly field reports, which included behaviour change of water users, and other important changes that could contribute to rural community water use pattern.

The quantitative data was analysed to compare water user pattern of different months for each water use activity (i.e. Drinking, Cooking etc). These data were normalised to cumulative membership in order to compare water use pattern for different months. The mean values for each activity in each month used in the Fuzzy set theory to establish the water security model.

Household strategies for operating total and partial DRWH to achieve water security under stressed condition were studied in four-location sin Sri Lanka. Studies was conducted in

The water security study was carried out in four tropical countries with varying degree of rainfall. Sri Lanka, and South India (Kerala and Tamil Nadu) from the Indian sub continent and Uganda and Ruwanda from East Africa.

The Water Security Model

A model based on Fuzzy set theory was designed taking into account high degree of flexibility in the field situation. This approach does not require quantifying water use for different activities. However, if such data is available, they can be expressed using linguistic variables.

The model used in this analysis consists of three-layered decision tree representing primary, secondary and tertiary factors. The nodes points where primary factors branch identifies the activities of water use. These are classified based on the source of supply namely, water obtained from ground and surface water sources (Source 1) and it supplemented with harvested rainwater (Source 2). These are identified as primary factors ‘ratings’ and are expressed using Fuzzy sets.

The secondary and tertiary factors represent ‘weights’ associated with water use and are described in table 1. The secondary factors weigh the relative importance of tertiary factors for a given activity and are considered common to all households.

Task A: TECHNOLOGY

Design low-cost below ground tank to collect rainwater for drinking and other household requirement.
Work was carried out in several stages comprising literature review, laboratory trials and field trial. Most optional tank design was design taking into account the optimum size, slope stability, low cost seepage and low cost cover.

The partial underground tank developed by Warwick University was pilot tested with some modification to suit the locations in 5 different geographical locations using local skills and materials.

SPECIAL DUTIES: DOCUMENTATION CENTRE
Set up and update web site for the research project, update Milestone reports, research papers, Quarterly Newsletter and other reports.
Set up a bibliography database on the web

TASK C: WATER QUALITY
Water quality in relation to household security was studied in 2 locations, Badulla and Matara. Survey was conducted to study water quality through, people's perception, absolute quality and comparison with other sources. Questions were asked on what a basis household decides on quality and how it relates to their usage. Absolute quality was tested on physical, chemical and bacteriological quality of collected rainwater and surrounding sources from 2 locations in Sri Lanka over a period of 6 months.

Results Achieved

Water Security
While rainwater harvesting has been in use in many countries of the humid tropics, precious little has been known about the water user patterns of the rainwater communities. Besides, there was hardly any discussion on "household water security" prior to the commencement of the study.

Studying the water use behaviour of rainwater communities in four countries in the humid tropics, viz: Sri Lanka, South India, Uganda, Ruwanda , have enlightened on the user patterns in a multiple water source situation. The research conducted during the study has clearly indicated the significant contribution rainwater harvesting has made in the household water use. While the contributions vary between countries, it can be as high as 96% during November- December in Nedego in Ruwanda and 33% 66% in Kyenjojo in Uganda. In countries like Sri Lanka, where annual rainfall can be very high, the rainwater contribution can vary from 66% to 74% in the southern wet zone. The study also reveals that having easy access to rainwater has increased the water consumption by about 15 litres per capita day (lpcd) during the wet season and 10 lpcd during the dry season among the rainwater communities in Sri Lanka. This clearly indicates that with improved access to water, there is an increased consumption in quantity of water per capita day and the time spent on fetching water too has reduced significantly. Timesaving have been reported in the magnitude of 90

to 150 minutes per day. The saved time has always being used to improve quality of life among the rural peasants. All countries have reported spending quality time with children as the most useful activity in improving quality of life.

Another important finding in the study understands the water use behaviour in a multiple water source situation including the use of harvested rainwater. Studies conducted in North Eastern Sri Lanka and South India has shown the greater reliance on rainwater when the ground water quality is saline. Interesting finding has been reported from Sri Lanka on the proportions of water use in a multiple water sources situation in combination with harvested rainwater.

The concept of "household water security " was on of the new ideas that emerged out of the study. The concept of water security, which was discussed previously by Webb and Iskandarani (1998) was further elaborated to include the household dimension. The working definition that emerged from the study states, household water security as " Accessibility, reliability and timely availability of adequate safe water to satisfy basic human need" This definition includes issues like "reliability" and "timely availability" which were not discussed in some of the earlier definition on water security. Further, this definition specifies to a household water needs hence; the focus is on the primary unit of water use. This definition has been used to assess the household water security of many rainwater communities in Sri Lanka and to a lesser extent in South India and East Africa.

The Model

This study attempts to capture both water usage and preferences of the user. User preference is determined by assigning weights to water usage. These variables expressed in linguistic terms are represented using Fuzzy Sets. Fuzzy Sets can be used to model HWS either by using field data in a quantitative approach, or using an expert's opinion in a qualitative approach.

Rural communities in Sri Lanka are subject to moderate water stresses towards the end of the dry season and they may have to obtain water from alternate sources, which reduce their HWS. A high HWS during dry season can be achieved through domestic rainwater harvesting. It is observed that a well-managed rainwater collection system increases HWS significantly compared to a poorly managed system.

The approach used in this study can be used to model HWS in communities of different environments provided that parameters defining water security are correctly identified.

Task A: Technology

Under ground tank of $3m^3$ capacity trapezoidal in shape with 2m x 2m square cross-section at the top and 1.4m x 1.4 m square cross-section at the bottom of the tank was build in 3 locations. Strips of bamboo is used both as a support to the tank walls and protection to the lining material, which is 500 gauge polythene sheet. Initially, the walls were lined with soil brought from Madurankuli (North western province). Later, when the walls cracked and dissolved, different cement-soil mixes were tested in the laboratory and ratio of 1:12 gave the best strength and durability. Therefore, the walls were plastered with cement soil ratio of 1:12. The total cost of the tanks was Rs. 5370 (US$ 60) including labour.

Four tanks were tested in 3 location, Sri Lanka Open University Complex, Madurankuli temple and household, Embilipitiya (Southern province) household. The tanks were cured well and filled with water for leaks. An evaporation pan was used to check on the water loss caused by evaporation. The tank was completed with asbestoses and cover and a hand pump to extract water from the tank.
Performance of the tank is to be monitored for further one-year period for structural behaviour of the walls, leakage in the plastic liner, durability of the bamboo reinforcement and damage by external forces such as roots etc.

Partial underground ranks constructed tanks of 10 m^3, and 20 m^3 were constructed with modification to original design by Warwick University. The modification was done to suit the local conditions, requirement, materials and skills.

Task C: Water quality

Taste plays a major role in drinking water. As rainwater do not contain any minerals and does not carry any taste it is not well accepted widely in rural Sri Lanka as means of drinking water. However, in some part of the country where the ground water is mineralised or saline rainwater is used for drinking
Consumption of rainwater is related to perception of quality. Most of the rainwater tanks are generally not tested for water quality, therefore householders has no knowledge of true water quality only perception of water quality. General quality of rainwater is measured at household level by

1. Presence of leaves and other material
2. Presence of mosquito larvae and other insects, rodents and frogs.
3. Colour
4. Taste

A survey conducted in five rainwater collection locations reveal that, in general quality of rainwater collected depends on the storage and management of the system.

Results shows that rain water collected meet the WHO standard for physical chemical quality except in few new tanks the pH is little high due to cement dissolving. Conductivity, Turbidity and Hardness in all locations meet the required WHO standards.
However bacteriological quality (Faecal Coliform) of rainwater does not meet the WHO standard except at Siyabaladuwa where all the tanks are fitted with filters. In other places better bacterial quality water was recorded from systems fitted with filters than without filters (Figure 2).

Survey also revelled that at the start of the rainy season (November) Figure 2, F.Coliform count in the tank is high due to roof washout. This contradicts the popular concept that rain water collected during the rainy season is better quality than the stored water. However, later during the rainy season as the roof are been washed clean the bacterial quality become better.

A comparison of Rainwater with other conventional water sources

Bacterial quality of rainwater collected in tanks has always been better than the conventional shallow wells in all districts sampled. In some dry zone district (Puttlam and Tangalle) hardness and conductivity in the shallow wells is higher than the recommended WHO standard. In these district people prefer to drink rainwater than the well water. In the wet zone (Bandarawella and Welimada) often in the conventional water sources water is acidic. This could be due to high agricultural activities and use of fertilizers and other chemicals in these areas.

Documentation centre

Web site was set up with the address www.rainwaterharvesting.com . The site contains Introduction to the project, project partners, publication page with 13 milestone reports and 12 other reports and publications; bibliography database links to other sites and newsletters.

Three Newsletters containing summary of milestones reports, Activities of partners, interesting finding from the field, publication by partners and announcement of conferences were published on the web.

Problems encountered

Water Security Model
Water security model could not be tested outside of Sri Lanka, due to inadequate time and resources. It should be tested in other countries to incorporate local conditions.

Technology :Under ground Tank
Under ground tank wall clasped in Madurankuliya temple site. This was due to bad selection of site, site has been filled with soil previously and due to heavy rain fall surrounding area was flooded and the tank was left empty.

Bamboo reinforcement and polypropylene sheet are thought to be liable to termite attack. However, no define proof of termite attack is Polypropylene is reported on available literature, further monitoring is necessary validate the claims.

Documentation Centre
Due to staff leaving most of the web update had to be done through outside consultant after the second year. This caused some delays, especially publication of newsletter.

Technology implementation plan

Research finding of this project was presented in Sri Lanka at 3 national symposiums**,** and 6 international symposiums. More than 12 papers were written and presented by the researchers at these symposiums.

Storage tanks developed by this project were pilot tested in different locations in collaboration with local organisation both non-government and government and local masons.

Publications and papers

1. T. Ariyananda, Rain Water Harvesting For Domestic Use In Water Policy, Paper presented at *National Water Conference "Status and Future Direction of Water Research in Sri Lanka*, 4-5 Nov. 1998,Colombo.

2. R.de.S. Ariyabandu, *Rainwater Harvesting: As a Means of Water Security, Paper presented at National Water Conference "Status and Future Direction of Water Research in Sri Lanka*, 4-5 Nov. 1998,Colombo.

3. T. Ariyananda , *Comparative Review of Drinking Water Quality from Different Rain Water Harvesting Systems in Sri Lanka*, Proceedings of the International Rainwater Catchment Systems Association Conference, Petrolina, Brazil, July 6^{th} – 9^{th}, 1999.

4. R.de S. Ariyabandu ……*Proceedings of the International Rainwater Catchment Systems Association Conference*, Petrolina, Brazil, July 6^{th} – 9^{th}, 1999.

5. R.de.S. Ariyabandu, *Development of Rainwater Harvesting for Domestic Water Use in Rural Sri Lanka*, Paper published in Asia Pacific Journal, July 1999.

6. T. Ariyananda, Rain water harvesting for domestic use in Sri Lanka, paper presented at *25^{th} WEDC Conference*, Addis Ababa, Ethiopia, 1999

7. R.de.S. Ariyabandu,Water Security through rainwater harvesting, paper presented at *25^{th} WEDC Conference*, Addis Ababa, Ethiopia, 1999

8. Ariyabandu R.de S., Ariyananda T, Hapugoda, D (January 2000) Water Resources & Development of RWH in Sri Lanka. *Waterlines*, Vol.18, No.3, p25-28, ITPUB, London

9. T.Ariyananda & M Ariyabandu. Water Security through rainwater harvesting in dry zone village in Sri Lanka. *10^{th} Stockholm water Symposium*, August 200, Stockholm

10. R.de S. Ariyabandu Achieving household water security in rural areas. *10^{th} Stockholm water Symposium*, August 200, Stockholm

11. T. Ariyananda Quality of Collected Rainwater from. Sri Lanka, *26th WEDC conference*, Dhaka, Bangladesh, November 2001.

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14. T.Ariyananda, Quality of Collected Rainwater in Relation to *Household Water Security*, *Proceeding* of Domestic Roofwater Harvesting Workshop, IIT Delhi,April 2001.

15. Prassana Ratnaweera, Water Security Model. *Proceeding of Domestic Roofwater Harvesting Workshop*, IIT Delhi,April 2001.

16. R.de S. Ariyabandu, Multiple Sourcing and water security. *Proceedings of the 10th International Conference on Rainwater Catchment Systems*, Mannheim, Germany, Septemebr 2001.

Conclusion

Although rain water has been used in households in many countries before, water user pattern was never studied before The research conducted during the study in four countries in the humid tropics, has clearly indicated the significant contribution rainwater harvesting has made in the household water use.

Studies has also revealed that with improved access to water through rain water collection, there is an increased consumption in quantity of water per capita day and the time spent on fetching water too has reduced significantly. The saved time has always being used to improve quality of life among the rural peasants. All countries have reported spending quality time with children as the most useful activity in improving quality of life.

Another important finding in the study is understanding the water use behaviour in a multiple water source situation including the use of harvested rainwater. The concept of "household water security " was on of the new ideas that emerged out of the study. Modelling of water security was also done for the first time and, the model should be tested out in different conditions and improved to suit the use.

The water security model can be used identify qualitatively the state of water security in a household. The formulation reflect both the quantity of water used weighted appropriately to reflect the expectations with respect to quality and the difficulties in obtaining water.

The model can be used in different regions, where parameters being identified with respect to the conditions of the respective regions.

The formulation and the concept can be effectively used to study the impact resulting from improvements or degrading taking place.

It also helps in identifying which areas that need improvement (i.e. with respect to different household activities).