

**IMPROVED WATER CONSERVATION PRACTICES USING
RAIN WATER HARVESTING IN THE WET AND
INTERMEDIATE ZONES OF SRI LANKA**

R.K.W. K. Ranasinghe

This dissertation was submitted in requirements for the Master of Engineering degree in Water Resources Engineering and Management.

Department of Civil Engineering,

University of Moratuwa.

Sri Lanka.

September 2004

93013

ABSTRACT

Fresh water is a limited and precious resource that is often taken for granted. However many areas of the developing world suffer a lack of safe water. Therefore, water borne diseases account for an estimated 80% of all illnesses in developing countries. In addition, millions of women and children walk several kilometers every day just to fetch a minimum quantity of water for their families. Furthermore, the Sri Lankan government also faces many problems in finding safe water sources to meet the growing water needs of the entire population. Roof rainwater harvesting is the only feasible option in some parts of the country, to deal with this issue to a certain extent where no other water sources are available.

The research is targeted to study the water conservation practices using Rainwater Harvesting in the wet and intermediate zones of Sri Lanka. To analyze performance of a selected roof rainwater harvesting system, thirty years (1968-1998) of daily rainfall data from Galle, Rathnapura, and Kurunegala districts have been used. The roof sizes considered were 50 m², 75 m², 100 m² & 200 m² and tank capacities considered were 1 m³, 2 m³, 5 m³ & 7.5 m³ for family size of five members. The daily water demand is taken as 120 liters per capita per day.

The results show that there is a 79% probability of success in the Galle district for supplying 300 liters of water per day per family (i.e. 50% demand fulfillment) by using a 5 m³ tank with a roof catchment area of 75 m². The equivalent result for Rathnapura is 93% while for Kurunegala it is approximately 71%. Hence, the results clearly show that rainwater harvesting is an excellent alternative option for the partial fulfillment (50%) of daily domestic water demand within the wet and intermediate zones of Sri Lanka.

Finally, it can be concluded that roof rainwater harvesting is a very promising alternative solution for increasing water demand of the country. However, the research also shows that during a few months in the year, domestic users will be unable to survive comfortably only with rainwater harvesting.

CE 2/10

LB/DON/64/09

**IMPROVED WATER CONSERVATION PRACTICES USING RAIN WATER
HARVESTING IN THE WET AND INTERMEDIATE ZONES OF SRI LANKA**

**BY
R.K.W. K. RANASINGHE**

**SUPERVISED BY
Prof. S.S. WICKRAMASURIYA**

**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE MASTER OF ENGINEERING DEGREE IN ENVIRONMENTAL WATER
RESOURCES ENGINEERING AND MANAGEMENT, 2004**

**LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
MORATUWA**

University of Moratuwa



93013

**DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MORATUWA
SRI LANKA
SEPTEMBER 2008**

93013

624 "08"

627(043)

TH

93013

DECLARATION BY THE CANDIDATE

I declare that the work included in the dissertation, in part or whole has not been previously presented for any other academic qualification at any institution for a higher degree.



Eng. R.K.W. Kalum Ranasinghe

September 2008



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the Director, Post Graduate Studies for giving me the opportunity to carry out this research study at the University of Moratuwa

I wish to express my heartiest admiration and appreciation to my supervisor Prof. S.S. Wickramasuriya, for his precious advice, guidance and encouragement throughout this study.

I also would like to express my sincere and deep gratitude to Mr. R.S. Liyanage (Assistant General Manger – Uva region) from National Water Supply & Drainage Board) and Mr. Abu Ubeidha, Chief Engineer from consultancy firm in Sri Lanka for them consent in undertaking the supervision of my research for giving invaluable advice and encouragement throughout the study. Moreover, I want to thank to the present General Manager (Mr. K.L.L. Premanath), Assistant General Manager (Rural Water Supply), (Mr. W.B.G. Fernando), Chief Sociologist (Mr. A.H. Gunapala), and Mr. K.S.K. Ranasinghe (Assistant General Manager, Co-ordination) from National Water Supply & Drainage Board for their advice, financial assistance, encouragement and guidance.

Finally but not least, I give my special thanks to my dear wife Eng. D.M.C.S. Kumari and my loving parents for all encouragement and supports.

ABSTRACT

Fresh water is a limited and precious resource that is often taken for granted. However many areas of the developing world suffer a lack of safe water. Therefore, water borne diseases account for an estimated 80% of all illnesses in developing countries. In addition, millions of women and children walk several kilometers every day just to fetch a minimum quantity of water for their families. Furthermore, the Sri Lankan government also faces many problems in finding safe water sources to meet the growing water needs of the entire population. Roof rainwater harvesting is the only feasible option in some parts of the country, to deal with this issue to a certain extent where no other water sources are available.

The research is targeted to study the water conservation practices using Rainwater Harvesting in the wet and intermediate zones of Sri Lanka. To analyze performance of a selected roof rainwater harvesting system, thirty years (1968-1998) of daily rainfall data from Galle, Rathnapura, and Kurunegala districts have been used. The roof sizes considered were 50 m², 75 m², 100 m² & 200 m² and tank capacities considered were 1 m³, 2 m³, 5 m³ & 7.5 m³ for family size of five members. The daily water demand is taken as 120 liters per capita per day.

The results show that there is a 79% probability of success in the Galle district for supplying 300 liters of water per day per family (*i.e.* 50% demand fulfillment) by using a 5 m³ tank with a roof catchment area of 75 m². The equivalent result for Rathnapura is 93% while for Kurunegala it is approximately 71%. Hence, the results clearly show that rainwater harvesting is an excellent alternative option for the partial fulfillment (50%) of daily domestic water demand within the wet and intermediate zones of Sri Lanka.

Finally, it can be concluded that roof rainwater harvesting is a very promising alternative solution for increasing water demand of the country. However, the research also shows that during a few months in the year, domestic users will be unable to survive comfortably only with rainwater harvesting.

CONTENTS

TITLE PAGE.....	i
ACKNOWLEDGEMENT	iii
ABSTRACT.....	iv
CONTENTS.....	v
LIST OF TABLES.....	vii
LIST OF FIGURES	x
ABBREVIATIONS	xii

CHAPTER I

INTRODUCTION

1. General Introduction.....	1
1.2 Rainwater harvesting in a worldwide and Sri Lankan context.	2
1.3 Principles of Rainwater Harvesting & Utilization.....	6
1.4 Ways of using Roof Rainwater Harvesting	6
1.5 Key Benefits & Limitation	7
1.5.1 Benefits.....	7
1.5.2 Limitation.....	8
1.6 Objectives of the study.....	8

CHAPTER 02

URBANIZATION AND WATER

2.1 Population growth & Urbanization.....	9
2.1.1 Land Use Pattern & Population.....	9
2.2 Rainwater Harvesting in Urban Areas.	12
2.3 Urban Flooding.....	13
2.4 Gross Domestic Water Usage.....	14

CHAPTER 03

ANALYSIS OF THE RAINWATER HARVESTING SYSTEM

3.1 Introduction.....	15
3.2 Climatic Conditions	15
3.2.1 Rainfall	15
3.2.2 Relative Humidity	17
3.3 Data Analysis.....	18

CHAPTER 04

ECONOMIC ASPECTS OF RAINWATER HARVESTING

4.1	Introduction.....	22
4.2	Economic aspects of roof rain water harvesting	22
4.2.1	Environmental advantages	23
4.2.2	Qualitative advantages.....	23
4.3	Pipe borne water and economic impacts.....	25
4.3.2	Comparison of water & water bill saving	27

CHAPTER 05

RESULTS AND DISCUSSION

5.1	Average numbers of successful days per month.....	30
5.3	Results of the economic analysis	32
5.4	Economic aspects of the use of rainwater harvesting at large scale housing projects	33

CHAPTER 06

CONCLUSION



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

6.1	General.....	34
6.2	Recommendations for further research	35

REFERENCES	36
------------------	----

ANNEX – A.....	38
ANNEX – B.....	51
ANNEX – C.....	58
ANNEX – D.....	62
ANNEX – E.....	69

LIST OF TABLES

Table 01: Land use pattern.....	10
Table 02: Number and percentage of population by district and sector	11
Table 03: Number of occupied housing units by district & sector	11
Table 04: Number and percentage of occupied housing units by district and type of housing unit	11
Table 05: Estimated gross domestic water requirements.....	14
Table 06: Average rainfall in mm (1968 – 1998)	17
Table 07: Specimen calculation for derivation of successful days – Galle district (50% demand fulfillment)...	19
Table 08: Recommended runoff coefficients of various catchments types.	21
Table 09: Water tariff of NWS&DB for Domestic Consumers (<i>Revised rates effect from 31.03.2005</i>).....	25
Table 10: Water tariff of NWS&DB for Non-Domestic Consumers.....	26
Table 11: Percentage of monthly saving of domestic water by use of different tank capacities with deferent catchment (the roof) area.....	28
Table 12: Percentage of monthly saving of domestic water bill by use of different tank capacities with deferent catchment (the roof) area.....	29
Table 13: Probability of Success (annual level) relevant to water demand and area of the catchment	32
(Roof Area) at each district	32
Table 14: Average number of successful days per month with relevant to the catchment area (50m ²),	39
tank capacity & daily demand at Galle district.	39
Table 15: Probability of a successful day at each month with relevant to the catchment area (50m ²),	39
tank capacity & daily demand at Galle district.	39
Table 16: Average number of successful days per month with relevant to the catchment area (75m ²), tank capacity & daily demand at Galle district.	40
Table 17: Probability of a successful day at each month with relevant to the catchment area (75m ²),	40
tank capacity & daily demand at Galle district.	40
Table 18: Average number of successful days per month with relevant to the catchment area (100m ²),	41
tank capacity & daily demand at Galle district.	41

Table 19: Probability of a successful day at each month with relevant to the catchment area (100m ²),	41
tank capacity & daily demand at Galle district.	41
Table 20: Average number of successful days per month with relevant to the catchment area(200m ²),	42
tank capacity & daily demand at Galle district.	42
Table 21: Probability of a successful day at each month with relevant to the catchment area (200m ²),	42
tank capacity & daily demand at Galle district.	42
Table 22: Average number of successful days per month with relevant to the catchment area (50m ²),	43
tank capacity & daily demand at Rathnapura district.....	43
Table 23: Probability of a successful day at each month with relevant to the catchment area (50m ²),	43
tank capacity & daily demand at Rathnapura district.....	43
Table 24: Average number of successful days per month with relevant to the catchment area (75m ²),	44
tank capacity & daily demand at Rathnapura district.....	44
Table 25: Probability of a successful day at each month with relevant to the catchment area (75m ²),	44
tank capacity & daily demand at Rathnapura district.....	44
Table 26: Average number of successful days per month with relevant to the catchment area (100m ²),	45
tank capacity & daily demand at Rathnapura district.....	45
Table 27: Probability of a successful day at each month with relevant to the catchment area (100m ²),	45
tank capacity & daily demand at Rathnapura district.....	45
Table 28: Average number of successful days per month with relevant to the catchment area (200m ²),	46
tank Capacity & daily demand at Rathnapura district.....	46
Table 29: Probability of a successful day at each month with relevant to the catchment area (200m ²),	46
tank capacity & daily demand at Rathnapura district.....	46
Table 30: Average number of successful days per month with relevant to the catchment area (50m ²),	47
tank capacity & daily demand at Kurunegala district.....	47
Table 31: Probability of a successful day at each month with relevant to the catchment area (50m ²),	47
tank capacity & daily demand at Kurunegala district.....	47
Table 32: Average number of successful days per month with relevant to the catchment area (75m ²),	48
tank capacity & daily demand at Kurunegala district.....	48

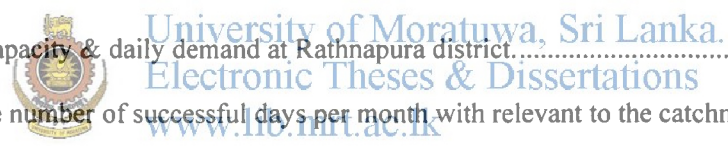
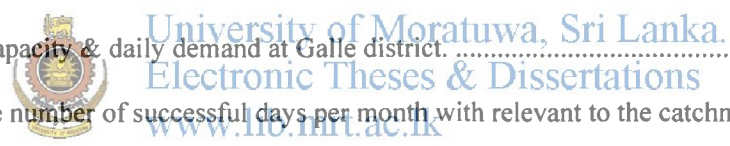


Table 33: Probability of a successful day at each month with relevant to the catchment area (75m ²),	48
tank capacity & daily demand at Kurunegala district.....	48
Table 34: Average number of successful days per month with relevant to the catchment area (100m ²),	49
tank capacity & daily demand at Kurunegala district.....	49
Table 35: Probability of a successful day at each month with relevant to the catchment area (100m ²),	49
tank capacity & daily demand at Kurunegala district.....	49
Table 36: Average number of successful days per month with relevant to the catchment area (200m ²),	50
tank capacity & daily demand at Kurunegala district.....	50
Table 37: Probability of a successful day at each month with relevant to the catchment area (200m ²),	50
tank capacity & daily demand at Kurunegala district.....	50
Table 38: Average number of successful days per month with relevant to the catchment area (3750m ²),	66
tank capacity & daily demand at Galle district.	66
Table 39: Probability of a successful day at each month with relevant to the catchment area (3750m ²),	66
tank capacity & daily demand at Galle district.	66
Table 40: Average number of successful days per month with relevant to the catchment area (3750m ²),	67
tank capacity & daily demand at Rathnapura district.....	67
Table 41: Probability of a successful day at each month with relevant to the catchment area (3750m ²),	67
tank capacity & daily demand at Rathnapura district.....	67
Table 42: Average number of successful days per month with relevant to the catchment area (3750m ²),	68
tank capacity & daily demand at Kurunegala district.....	68
Table 43: Probability of a successful day at each month with relevant to the catchment area (3750m ²),	68
tank capacity & daily demand at Kurunegala district.....	68



LIST OF FIGURES

Figure 01: "Rojison", a simple and unique rainwater utilization facility at the community level in Tokyo, Japan.....	2
Figure 02: The Sigiriya; A critical example for the utilization of rainwater harvesting for landscaping and domestic purposes during the ancient time in the Sri Lanka.....	5
Figure 03: A Rainwater Harvesting System, which constructed under ADB assisted third water supply and sanitation project.....	5
Figure 04: Climatic Zones in Sri Lanka.....	9
Figure 05: Location map of the considered district for the analysis.....	14
Figure 06: Variation of average monthly rainfall (1968-1998).....	15
Figure 07: Average annual rainfall over the Island(1961-1990).....	16
Figure 08: Variation of the average numbers of successful days with deferent rainwater harvesting systems in Galle district (50% demand fulfillment).....	52
Figure 09: Variation of the average numbers of successful days with deferent rainwater harvesting systems in Galle district (100% demand fulfillment).....	53
Figure 10: Variation of the average numbers of successful days with deferent rainwater harvesting systems in Rathnapura district (50% demand fulfillment).....	54
Figure 11: Variation of the average numbers of successful days with deferent rainwater harvesting systems in Rathnapura district (100% demand fulfillment).....	55
Figure 12: Variation of the average numbers of successful days with deferent rainwater harvesting systems in Kurunegala district (50% demand fulfillment).....	56
Figure 13: Variation of the average numbers of successful days with deferent rainwater harvesting systems in Kurunegala district (100% demand fulfillment).....	57
Figure 14: Variation of the probability of success with relevant to the rainwater demand and different catchment areas in Galle district.....	59
Figure 15: Variation of the probability of success with relevant to the rainwater demand and different catchment areas in Rathnapura district.....	60

Figure 16: Variation of the probability of success with relevant to the rainwater demand and different catchment areas in Kurunegala district..... 61

Figure 17: Large-scale roof rainwater harvesting system analysis in Galle district 63

Figure 18: Large-scale roof rainwater harvesting system analysis in Rathnapura district..... 64

Figure 19: Large-scale roof rainwater harvesting system analysis in Kurunegala district 65

Figure 20: Variation of Probability of exceedance of monthly rainfall(1968 – 1998) 70

Figure 20(a): Variation of Probability of exceedance of monthly rainfall(1968 – 1998)..... 71

Figure 20(b): Variation of Probability of exceedance of monthly rainfall(1968 – 1998)..... 72

Figure 20(c): Variation of Probability of exceedance of monthly rainfall(1968 – 1998)..... 73



University of Moratuwa, Sri Lanka.
 Electronic Theses & Dissertations
www.lib.mrt.ac.lk

ABBREVIATIONS

NWS&DB - *National Water Supply and Drainage Board*

RW - *Rainwater*

RWH - *Rainwater Harvesting*

RRWH - *Roof Rainwater Harvesting*

RRWHS - *Roof Rainwater Harvesting System*

RWHS - *Rainwater Harvesting System*

RWT - *Rainwater Tank*

Lpd - *Liters per day*

Lpcd - *Liters per capita per day*

TC - *Tank Capacity*

CWSSP



University of Moratuwa, Sri Lanka.
Community Water Supply and Sanitation Project
Electronic Theses & Dissertations
www.lib.mrt.ac.lk