Domestic Rainwater Harvesting
Research Programme

VERY-LOW-COST ROOFWATER HARVESTING IN EAST AFRICA
(Based on a Feasibility Study performed in the Great Lakes Region during May – July 2000)

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CONTENTS

DEFINITIONS, ABBREVIATIONS & COSTING UNITS

A = area of roof (in m^2)

C = cost per litre

D = daily demand (not necessarily constant through the year)

DRWH = domestic roofwater harvesting

Dry season = all days when total runoff in the preceding 14 days < 7 R

E = W / (P x A x F) = efficiency of rainfall capture

F = 'Run-off fraction' = Water volume reaching the downpipe ÷ volume falling on roof (e.g. .85)

K = ratio of dry season water value per litre to wet season value

lpcd = litres per capita per day

P = annual precipitation (in mm)

Q = rainwater harvested (in litres per day per household)

R = P x A x F / 365 = mean daily runoff

RWH = Rainwater Harvesting or Roofwater Harvesting

S = 'security' of supply = fraction of days demand is satisfied

Sf = W ÷ ΣD = fraction of demand volume that is satisfied

T = V ÷ R = tank volume expressed in 'days mean supply'

Target Area = S Uganda, NW Tanzania & Rwanda

U = W ÷ V = utilisation factor for storage (in number per year)

V = volume of tank (in litres)

VLC = very-low-cost (say <$50 per system)

W = annual water supply volume obtained from RWH system (in litres per year)

Wet season = all days when total runoff in the preceding 14 days exceeded 7 R

Costing has been expressed in £ sterling (or in pence sterling 1p = £0.01). At the time of the study the approximate conversion rates into the three local currencies were:

£1.00 ≡ USh.2250/- ≡ TSh.1190/- ≡ RWF540 ≡ $US1.50

1. INTRODUCTION

Although numerous new water supplies have been constructed in rural Africa in the last decade, population growth has resulted in only a small projected increase in the fraction (32% to ca 36%) (WHO/UNICEF,1996/2000) of households having 'access to adequate quantities of safe water'. Moreover official statistics are based on understandings of the words 'access', 'adequate' and 'safe' that seem inappropriate to rural Africa. 'Adequate' is taken to mean over 20 litres per person per day (lcd) and 'access' is taken to mean a water source within 1 kilometre of the home. Actually 20 lcd is well above current usage and immediate aspirations; it is quite incompatible with a carrying distance as long as 1 km. Collecting even only 10 lcd for a household with 6 members requires 3 round trips per day. If the source were 1 km away, this would take at least 2 woman-hours per day (collection is predominantly by women and children). "Water equals walking" has long been an accurate adage in rural Africa. It will be decades before point sources like wells or standpipes are sufficiently numerous, and hence close-spaced, that walking for water is no longer a major household burden. Yet most water programmes are still solely concerned with providing new point sources, often using techniques that have proven operationally unsustainable.

In recent years rainwater harvesting, for long an informal water technology (Agarwal, 1999) has been acquiring a higher official status world-wide. Its main domestic form, *roof*water harvesting (DRWH), has been aided by the rapid growth in the use of hard roofing (usually corrugated iron sheeting) in areas formerly dependent on grass roofing. DRWH has thereby become feasible in most of Sub-Saharan Africa. It is a technique with the great attraction of delivering water to the very door of the user's house. Its main perceived disadvantages are its high cost and its individual nature. The former however only applies to some forms of DRWH, not all, and the latter's unattractiveness to promotional agencies like NGOs is diminishing as they lessen their former overwhelming emphasis on *group* enterprise.

The Target Area (see map in Appendix III) of this Feasibility Study is technically favourable for very low cost DRWH, by reason of its good rainfall and convenient rainfall distribution. Even so, DRWH is likely to be affordable only when it is combined with some other 'back-up' source. Fortunately multiple sourcing can be shown to be already a common rural water practice across much of the tropics. The Target Area has characteristics that make existing water sources rather unsatisfactory. Its poverty means that clean sources are few in number. Its topology results in a paucity of perennial streams and springs and arduous carrying conditions in most places. The water table is commonly deep except near swamps (where dwellings are understandably sparse) and in some areas the ground water is so mineralised that it is dangerous to ingest or objectionable in taste.

In association with local organisations in Africa and tropical Asia, the Development Technology Unit at the University of Warwick has been researching DRWH systems for some years, looking for better understanding, lower costs and higher performance. It has found that DRWH development has reached a point where 'partial' DRWH systems could be affordable by the bulk of rural households in the Target Area. Such systems would typically increase a household's annual water consumption by 50% while reducing its water-fetching time by 70% - at a cost as low as $\$40_{US}$ which equals about half the cost of roofing a small house. We may call this form of RWH 'very-low-cost' roofwater harvesting (VLC DRWH).

A Study – financed jointly by the Laing Trust and by the University of Warwick – was therefore initiated in May 2000 to evaluate its apparent promise, in an area where rainwater currently providing under 2% of household water because it is largely restricted to expensive forms. The purpose of the study was to confirm or rebut the apparent promise of VLC DRWH, examining both its performance and its unsubsidised affordability by the bulk of rural households.

The form of the three-month study, whose headquarters were an organic farming training centre, Kyera Farm, near Mbarara in southern Uganda, was;

(a) to field-test and refine candidate VLC DRWH technologies, and

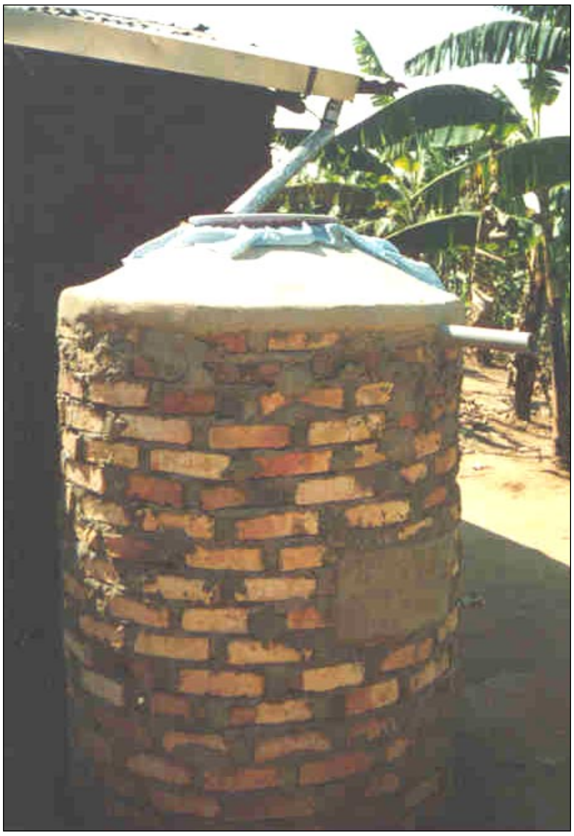
(b) to interact with 9 agencies already involved or interested in RWH in the target area.

At a concluding seminar in July 2000, the findings were presented to all these parties for their information and comment. The Study was intended not only to assess the desirability of switching to much smaller DRWH designs than used hitherto, but also to prepare for a major programme with such agencies to kick-start the adoption of VLC DRWH in the region.

In the ensuing sections technical, economic and social analyses are presented, backed by appendices containing more detailed data such as design drawings of novel system components.

The DTU team of three are very appreciative of the financial support of the two Study funders (Laing Trust and The University of Warwick), the energetic input from local staff in Uganda and the unstinting collaboration of the partner agencies in Southern Uganda, Rwanda and NW Tanzania.

2. THE CANDIDATE TECHNOLOGY (VLC-DRWH)



A roofwater harvesting system comprises a roof, a storage tank and a means such as guttering of connecting the one to the other. Other possible components are filters or 'first-flush' diverters to reduce the quantity of dust or debris entering the tank, access points for cleaning, a means of extracting water from the tank and in-tank devices to aid water management or to maximise water quality.

The most costly system element is usually the store (tank), which in a 'stand-alone' system may be designed to hold all the water required throughout the longest expected dry season. Middle class households in the *humid* tropics might have upwards of 10000 litres of storage, while in a Monsoon (summer rains) climate storage may be two times larger. Such large structures are expensive unless use can be made of some natural rock foundation. Underground stores are less space-consuming and are generally cheaper, volume for volume, than surface mounted stores; however the former need a pump and are prone to failure modes that are difficult either to calculate or monitor.

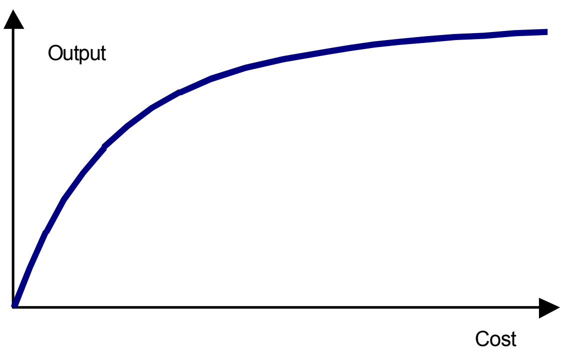
The quality of the collected water is usually quite high although it drops following the arrival of the first rains after a dry season due to dust on roofs. Bird droppings and other contamination may cause a sharp temporary rise in such pollution measures as counts of faecal coliforms. In rural areas it is thought that contamination by human pathogens is uncommon - 30% of farmers have long drunk roofwater in Australia, a country with high environmental health standards - but untreated roofwater does not reach the strict standards used for urban supplies in industrialised countries. Besides bacterial quality, there are other health and taste factors affecting DRWH and these are discussed in Section 6.

A striking feature of DRWH systems is the strong law of diminishing returns that operates for tank sizing. As the graph below shows, a system containing a very small tank (holding only 7 day's household consumption) might yield 75% of the water per year of a system with a very large tank (capable of holding 100 days' consumption). This suggests a route to cost minimisation, provided that an alternative, albeit more costly per litre, alternative back-up water source is available. In rural areas such a back-up supply is likely to be the distant spring, well or pond formerly used.

Besides keeping tanks very small, economy measures in LDCs include constructing tanks more efficiently, using cheaper materials, devising slimmer gutters and downpipes, substituting low-cost local labour for more capital-intensive production and devising management strategies that minimise the cost:benefit ratio. These matters are discussed in Section 4.

Currently DRWH systems in developing countries commonly use, for their storage element, mortar jars, ferrocement jars, cylinders and cuboid shapes of plastered brick, oil drums and corrugated iron cylinders, reinforced concrete tanks or (for richer households) plastic drums. Usually these are not tightly designed and have failure safety factors that are uneconomically high. (Very large tanks however need and get engineering design, as their failure can be dramatic and dangerous.) There is therefore considerable scope for material savings. Little-used materials of promise are stabilised earth, plastic sheets and the ground itself, especially if designs separate the functions of strength and water-tightness. Prior to this Study the DTU had identified three promising designs for small stores (500-800 litres) as well as a large (8000 litre), but relatively low-cost, 'partly-underground' tank, with associated village-manufacturable pumps. It was estimated prior to the Study that complete systems containing 750 litres (ca '7 days') of storage might be producible in the Target Area for 40_{US} and 2000 litre systems could cost under 80_{US}. These estimates took into account the high prices of items like cement in the Area. Field-testing and construction were needed to confirm these estimates and affordability studies focussed on identifying what figure to design to.

Figure 2.1: 'Diminishing returns' Output v Cost curve



Fortunately DRWH is amenable to 'staged' construction, with guttering and storage being increased in steps over several years. In Thailand and Cambodia it is common to see a house surrounded by several large, mortar, rainwater jars - presumably not all installed at the same time.

Development agencies are understandably nervous of involvement with technologies having a bias to the rich, and DRWH has been accused of that tendency. Concentrating on small systems is one way of counteracting that danger. Developing the ability to service the grass roofs of the poorest would be another. Water can be collected from crude thatch, but it is coloured and turbid and its capture requires wide gutters. There are some directions for possible progress, including clarifying the stored water and employing sheet-plastic gutters. For the Study reported here, ability to work with grass roofs was decided to be desirable but not essential if the fraction of homesteads with hard roofs were found to exceed 70% and to be still rising. In fact the fraction of homesteads in the Target Area with at least one hard roof does generally satisfy this test: the prevalence of iron roofs in particular has risen dramatically in the last decade.

3. WATER NEEDS IN THE REGION AND THE POSSIBLE CONTRIBUTION OF VLC DRWH

3.1. Existing water sources and collection times

Data on water sources in the Target Area is not very readily available. In Rwanda there is a national register of springs. In Uganda the 1991 census recorded some relevant data from which the following tables for (old) Mbarara District, whose population was then 0.9 million people, were constructed.

Table 3.1: Use of different water sources in Mbarara District

Source type	Percentage of households using
Piped water	3.3
Boreholes	5.5
Protected well/spring	8.6
Open well/spring	45.2
Stream/river	19.6
Lake/pond/dam	17.4
Total 'clean'	**17.5**

Source: Uganda Nat Census (1991)

Table 3.2: Distribution of roofing types in Mbarara District

Roofing type	Percentage of households using
Iron	37.2
Tile/asbestos/concrete	0.7
Total 'hard' roofs	**37.9**
Grass/papyrus	39.2
Banana	22.9
Total 'soft' roofs	**62.1**

Source: Uganda Nat Census (1991)

Since 1991 however, Uganda has undergone significant economic and demographic growth and there has been some improvement in the fraction of households using such 'clean' sources as protected springs, protected shallow wells and boreholes. Piped water supplies in the few serviced urban areas have also improved. Nationally the fraction of the population having 'access' to clean water in 1994 was deemed to be 47% for urban areas and 32% for rural areas. Figures for Tanzania and Rwanda have not been obtained, neither country is listed in the source below. However the source suggests that for Africa as a whole clean water coverage has changed little from 54% over the last decade.

(Source: WHO/WSSCC/UNICEF http://www.thewaterpage.com/coverage_figures.htm)

Locally in the Study Area there are areas like Rakai District where highly mineralised groundwater forces reliance on surface sources such as swamps.

The Ugandan building data above is seriously 'out of date'. It indicates that only 38% of roofs as being suitable for RWH whereas the proportion of dwellings for which at least one building has a hard roof is now probably over 65%. None of the 12 NGOs contacted, all working in DRWH, felt that absence of hard roofs was a serious restriction in the uptake of the technology. Corrugated iron roofs, that cost about £1 per m^2 of building plan area, have become the norm for both housing and institutional buildings.

Rwanda is characterised by very steep but not mountainous terrain. In much of the country hillside springs have been the traditional water sources, augmented in the 1970s and 1980s by gravity-fed distribution piping. However since 1990 a growing fraction of the population may be found living considerably *above* the spring line and are carrying their water up through considerable heights. In the drier and flatter parts of the country to the East where springs are few, former National Park land has been recently settled by returned refugees. Rwanda was well-known for its attractive fired-tile roofing, today however cheaper corrugated iron has gained in popularity there.

In Tanzania the Target Area comprises Kagera Region, which is much wetter than the national average and thus more prone to have hard roofing. The terrain is less steep than in neighbouring Rwanda and good springs are far less common. Piped water is rarely encountered and shallow wells (some protected, some not) are widely used. The area is very 'peripheral', being 3 days journey from the capital, so material prices are relatively high.

Figure 3.1: A typical traditional water source in NW Tanzania

In all three countries, water collection distances are significant and the terrain is rarely flat. A survey of (only) 120 households in parts of the area is summarised in Table 3.3. From the table it can be seen that it took about 3 hours per household per day to collect water. These figures were based on a mean round trip speed *on the flat* of 65 meters/minute and lower speeds on slopes. This norm may be rather high although it is compatible with the few direct speed measurements made. Queuing time is not included and if it were collection times might be about 25% higher.

In some well-populated plateau locations, water collection in the dry months is especially onerous because convenient sources dry up. Water then has to be hauled up from valley sources as much as 5 km from (and 200 m lower than) the homestead.

3.2. A survey of small-scale RWH systems in Kabarole District, Western Uganda

A survey being carried out in Kabarole district, Western Uganda, gives some idea of the benefits that can be obtained using a small tank. The survey covers 6 households distributed around the district. To date the data for the months of May, June and July 2000 has been collected and analysed. The survey will continue for a further 3 months into the wet season. The survey analysis to date can be considered as a dry season analysis. The jars had been built as part of a study into water quality from cement jars and were 400 – 500 litres in size (the variation due to manufacturing variability).

Table 3.4 shows the initial analysis of the survey data. It is also worth pointing out that the survey form was designed to measure water carried from the traditional water source. The survey therefore measures the minimum benefit, as water consumption is likely to be higher when water is taken from the jar during the wet season.

Table 3.3: Analysis of water-collection distances/times

	Mbarara, Uganda	Biharum'lo Tanzania	Mbarara, Uganda	Karagwe*	Mbarara*	ALL
Agency	IVA	BRATIS	DTU	KARAD'A	MUST	
People (no)	210	385	175	381	359	1,510
Water (litres)	3,400	5,260	1,560	3,440	2,360	16,020
Households	40	60	20	60	60	240
Sources	2	3	3	3	3	12
Time (mins)	4,030	12,639	7,209	12,929	11,250	53,464
Distance (m)	207,300	725,894	640,364	789,739	415,580	2,586,768
Notes				**December*	**November*	

Averages for all households/people

people per H/H	number	6.3
water per H/H	litres/day	66.8
time per H/H	hour/day	3.7
distance per H/H	km/day	10.8
water per person	lcd	10.6
time per person	hour/day	0.6
distance per person	km/day	1.7

It can be seen that the percentage coverage for the period looks quite low, only 35% to 57.5%. It should be noted, however, that the percentage of rainy days during the period (19% - dry season) is low compared with the annual average (35%) and so the annual coverage figures will be higher. Also it can be noted that where the number of persons in the household is low, the savings are greater (with the exception of Kaahwa).

An indication of the walking time and walking distance shows that particularly high savings can be made when the distance to the traditional source is high (Katenta and Kayula), or where lpcd consumption is high (Mugisa) which is obvious. The actual daily time and walking saving are very significant – 55 minutes and 125 minutes being the outstanding examples.

It is interesting to note that there is no strong correlation between distance walked and lpcd consumed, which is generally believed to be the case. The lpcd figures do correlate well with estimated consumption figures for the region and with observations made by the authors

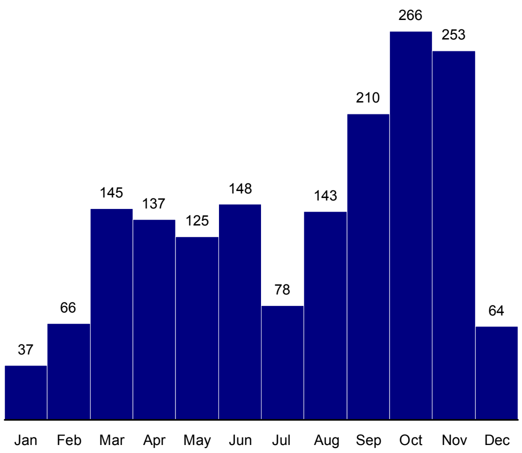


Figure 3.2: Average monthly rainfall for Kyenjojo, Kabarole, Uganda

Table 3.4: Analysis of survey data

		Kandole	Katenta	Mugisa	Kaahwa	Karamagi	Kayula
General data	Distance to source (m)	200	500	400	400	300	1500
	Number of occupants	6	5	4.5	4	9	8
	Roof area (m sq)	20	27	24	22	24	30
	Total days considered	106	106	92	85	92	106
	Rainy days during period	15	28	20	11	21	18
Calculated data	Jerry cans carried from source (daily average)	3.4	1.3	2.5	2.2	3.2	3.3
	Jerry cans consumed (daily average)	5.4	3.0	5.3	3.0	4.9	5.0
	Average lpcd consumed	18.0	12.0	23.5	14.8	11.0	12.4
Estimated savings	Litres (daily average)	40.7	34.5	57.5	18.1	35.5	34.8
	kilometres walking (daily average)	0.81	1.73	2.30	0.73	1.07	5.21
	Minutes walking (daily average)*	19.5	41.4	55.2	17.4	25.6	125.1
	%age total water consumed	37.7	57.5	54.3	30.6	35.9	34.9

*assuming a walking speed of 2.5kms per hour – in the majority of cases the terrain is steep

4. ECONOMICS OF DRWH

4.1. Economic overview

All households already have some access to water from point sources. For some days per year, many also employ 'informal' rainwater harvesting, placing bowls and jugs under eaves or even trees during rainfall.

The introduction of more formal (and productive) RWH will normally be accompanied by three benefits. The most obvious is a reduction in the time spent carrying water from point sources – a reduction more or less proportional to the volume of water no longer carried. The second is an increase in household water consumption wherever it was previously constrained by the effort of collection. The third is a common, although not invariable, increase in water quality. All these benefits rise with DRWH storage capacity, albeit in a way showing diminishing returns.

Figure 4.1: Typical informal RWH using an old 200 litre oil drum at a household in SW Uganda

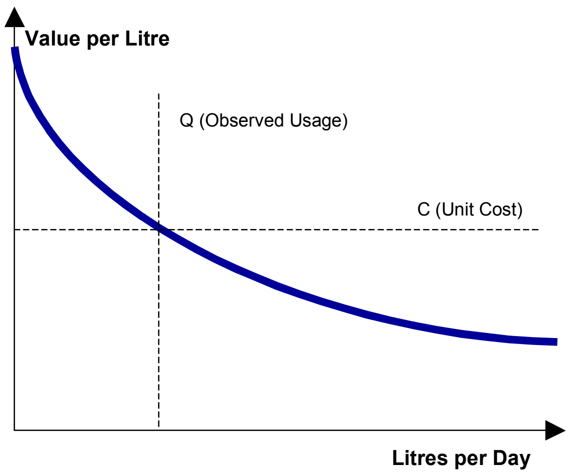
The increase in water consumption with VLC RWH has not been widely measured. Generally any increase is restricted to the wet seasons. DRWH (and VLC DRWH in particular) is not generally capable in the dry seasons of supplying quantities larger than already obtained from point sources: this means that it will be used to supplement, but not to substitute point-source water.

The costs of DRWH are overwhelmingly capital costs, as neither operation nor maintenance usually involves significant expenditure. Storage-tank cost is usually the dominant item, by contrast guttering accounts for only about 25% of the total system cost. These capital costs are subject to economies of scale. The sensitivity (elasticity) of tank cost to storage capacity is about 0.8. The sensitivity of gutter cost to gutter capacity is even lower, so that it is usual to install gutters that are so large (e.g. designed for rainfall intensities up to 2mm per minute) that they can catch all but 1 or 2% of the annual run-off reaching them.

4.2. Value of water

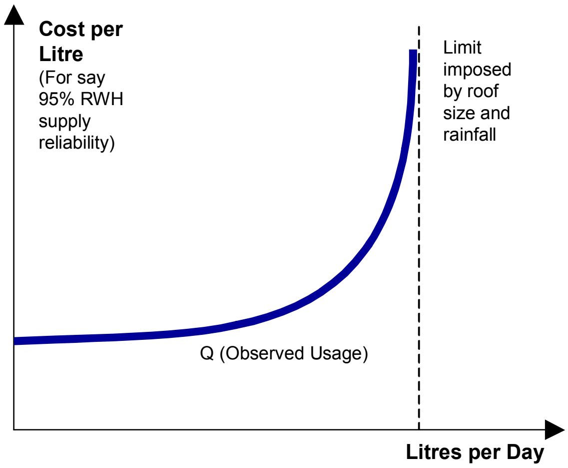
As with many other goods, water has a declining value with quantity. The first litre per day is worth more than the tenth. By examining the limited data available that relates household consumption per day to the effective unit cost of water (i.e. cost per litre), we might construct a curve such as shown in Figure 4.2. Each socio-economic group would have its own curve.

Figure 4.2: value v quantity



The cost line on Figure 4.2 is horizontal, which reasonably represents the situation where water is fetched, each successive litre requiring the same input of labour. Such a line does not fairly represent harvested roofwater, where the effective cost general rises with daily consumption despite the economies of scale in tank construction. A typical cost v volume characteristic for RWH supply is shown in Figure 4.3.

Figure 4.3: cost v volume



Sometimes we can find examples of water purchase and use them to infer the value of water. Richer households, or those experiencing illness, may pay for water to be brought to the house. More usually we have to infer costs indirectly through conversion of fetching distance/height into time and then time into money. Such costs, like the value of water discussed above, will be lower for poorer households than for richer ones.

4.3. Time cost of water carriage

This is a function of a household's distance to, and height above, a water source, of the means of transport used, and of the persons involved in carriage and their respective unit time costs (actual or opportunity). So we will examine each of these factors in turn.

(a) Haulage distance

Table 3.3 shows the results of a small survey of walking distances (users of 6 sources). Although there are some homesteads in the Study Area that haul water from distances greater than 5 km away in very dry months, the dry season average for 120 users of 6 point sources in the Target Area was 1.5 km to the source.

A much larger survey is required to give reliable averages for the whole Area and to measure the seasonal variation of haulage distance, walk time and water consumption.

(b) Height

Point water sources are generally *lower* than homes, so that the laden return journey is usually uphill. A round trip that comprises walking downhill with an empty water container and returning laden uphill is always slower than one of the same distance on the flat. For calculation purposes it would be convenient either to replace any climb height by an extra horizontal distance of equivalent carriage time, e.g. "add 1 km for every 100 m climb". Alternatively we might assign a different round-trip mean speed for each gradient. It is likely that a very steep (return) uphill slope of say 1-in-5 will halve the round-trip mean speed, especially for climbs exceeding 100m. A gentle gradient of say 1-in-30 will have little effect on round trip time. Experiments were undertaken to measure the effect of gradient on walking speed, but they gave rather inconclusive data because the samples were small and it proved impractical to control other variables such as youths' desire to impress, sense of urgency or tiredness etc.

(c) Walking speed

The speed of movement of a person collecting water depends upon many factors and varies between about 1.5 and 5 km/hour.

For short haulage distances some people use a strategy of hurrying to minimise time or arm strain; this strategy cannot be maintained for more than about 200m. Running down a gentle slope with an empty jerrycan, some young people exceed even 5km/hour. Conversely, long uphill hauls require a slow steady pace with regular rests. Young children tire more quickly with distance than adults, even though they usually carry only 3 or 5 litre loads.

For distances over 1.5 km but only where slopes are gentle, pushed or pedalled bicycles are sometimes used to carry 1 or 2 x 20 litre jerrycans (especially by 'commercial' water fetchers) at speeds of about 3.5 km/hour. There is virtually no evidence of water carriage by pack animal in the target area – neither mules nor donkeys are commonly available. Such animals have to be driven slowly (3 km hour) but carry up to 80 litres at a time (recent Mexican experience).

Table 4.1: Survey of variation of walking speed with path steepness

Route No		1	1	2	2	3	3	3	4	5	6
Slope when carrying water		flat	flat	easy down	easy up	med up	med up	med up	steep up	med up	med up
Date	d/m/2000	16-7	16-7	16-7	16-7	16-7	16-7	16-7	8-8	8-8	8-8
Slope angle (up) source-to-house	Degrees	0	0	-5	5	11.5	11.5	11.5	14.2	7.6	9.5
Person carrying	Sex	f	m	f	f	m	f	f	2f	2f	2m
	Age	15	17	16	NK	20+	15	15	14/20	14/20	14/20
Height of 'source'	m	1424	1424	1450	1424	1434	1434	1434	1662	1662	1655
Height of 'house'	m	1424	1424	1424	1450	1478	1478	1478	1844	1702	1688
Rise *H* from source to house	m	0	0	-26	26	44	44	44	182	40	33
Distance *D*	m	300	300	300	300	300	300	300	740	300	200
Time (empty)	T_o secs	240	223	251	232	206	238	245	1114	360	188
Time (full)	T_b secs	270	230	315	270	265	347	297	1875	485	270
Total walk time (round trip)	$T_r = T_o + T_b$ secs	510	453	566	502	471	538	543	2989	845	458
Gradient (full)	H/D %	+0	+0	-8.5	8.5	14.5	14.5	14.5	24.5	13.3	16.5
Speed out (empty)	m/min	75	81	72	76	87	76	73	39.8	50	44.4
Speed back (full)	m/min	67	78	57	67	68	52	61	23.7	37	44.5
Mean speed (round trip)	m/min	70.5	79.5	63.5	72	76.5	67	66.5	29.7	42.5	64
Speed ratio	(full/empty)	0.89	0.97	0.80	0.86	0.78	0.69	0.82	0.59	0.74	0.70
Experiment	Number	A1	A2	A3	A4	A5	A6	A7	B8	B9	B10

Notes:

a. 'easy' slope = 3% to 10%, 'medium' slope = 10% to 20%, 'steep' slope = >20%

b. NK = not known

c. Men walked faster than the females during some of the early trials but were slower on the later trials. The "macho" image may be the reason for the early trials being at faster rate. The slower rates on the later trials may be due to the fact that the men did not pace themselves, having less experience than the females in carrying water.

d. The considerably slower rates on route No4 of 29.7 may be partly explained by the fact that the actual route was longer than 740m as the path meandered its way through the plantations. Also negotiating the rough ground on the way down tended to impede ones progress.

e. There are many factors which could give rise to data varying, some of which may be:
   - Whether the person is aware of being timed or not a (10% increase in the walking speed maybe a reasonable value when the person is aware of being observed)
   - The number of people queuing at the water source
   - The number and length of rests a person takes
   - The flow rate of water at the source (this decreases during drought periods)
   - Who is performing the task, i.e. children are prone to the least distraction whereas a women may walk quickly to get back to other household chores
   - Tiredness of the person

(d) The carrier's age, gender and urgency

Water is most commonly carried by women and therefore by (in Africa) busy people. Babies may be left behind (a reason to increase speed) or may be carried (which reduces speed). Women often carry together, waiting at the source until a friend has filled her container. School children regularly carry water (more often girls than boys) especially at weekends. They are usually in less hurry than adults and more prone to combine water collecting with 'social' activities. There has been some recent discussion of the (moral/AIDS) danger to teenage girls of going alone to fetch water at dawn or dusk, which might lead to parental pressure on them not to loiter en route. In dry periods when distances are greater, men play a larger role in water fetching and probably travel a little faster than women. However, even strong men do not carry two jerrycans over any significant distance – the adult unit of water carriage is largely standardised at 20 litres (= 20kg).

(e) Total time and time cost

The table above indicates a mean time for water collection of 3 hours per household per day. Insofar as the survey was small and the month was dry, this can only be taken as a crude estimate. It is perhaps an over-estimate in that none of the households surveyed were in trading posts or other population concentrations. However the figure is only an inferred walking time and does not include waiting time. In the drier months it is not uncommon to see a queue of 20 jerrycans at a source yielding under 5 litres per minute, implying a waiting time there of 80 minutes. The queue rarely includes adults; women try to avoid such queues by fetching water before dawn, an expedient not without physical dangers (falls in the dark, snakebites etc.).

The opportunity cost of 3 hours per household is, in rural East Africa today, between $\$_{US}0.2$ and $\$_{US}0.6$. The payment to a youth in a trading post to carry four jerrycans (a typical quantity - see Table 3.3) from a source 1.5kms away is currently about $0.5.

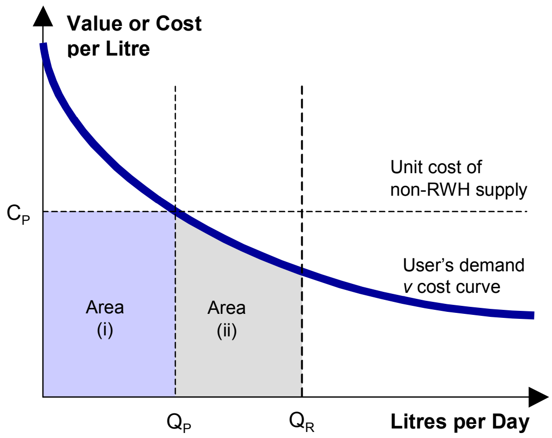
4.4. Combining RWH with other water sources

The following two Sections (4.4 & 4.5) are an in depth study of the economics of combining water sources (multi-sourcing) and the effect of using differing water management strategies on seasonal water security. Those who are looking for a brief overview can skip these sections.

For a given size and location of RWH system and for a given operating strategy, there will be a limit on the water it can supply per day, per week or per year. The maximum per year, corresponding to zero tank overflow, in litres will be the product of roof area (m^2), the annual rainfall (mm) and a run-off capture factor (typically 0.85).

Consider first the situation where we can disregard seasonal factors, and assume that before RWH arrived, daily consumption from a point source was Q_P (litres/day). Q_P is determined by the interaction of the user's demand (cost v volume) curve and the unit cost C_P of supply from the point source. The daily cost to the user was therefore Q_P x C_P.

Figure 4.4: Value of rainwater



If the water Q_R available per day from RWH is *less* than Q_P, then the users will draw Q_R from the RW system and the remainder Q_P-Q_R from the point source. The total consumption will not increase and the effective value of the harvested rainwater will be the saving Q_R x C_P .

If the water Q_R available per day from RWH is *more* than Q_P, then the users will increase their consumption from Q_P to Q_R and the rainwater will be worth more than the former total cost Q_P x C_P. Exactly how much more will depend on the user's demand curve. The situation is represented in the diagram below, where Area (i) is the saving (Q_P x C_P) while Area (ii) is the value of the extra water.

Note that Q_R is the daily amount *available* from RWH, whereas Q_P is determined by the price of supply (from non-RWH sources). The total value Area(i) + Area(ii)) is less than (Q_R x C_P) because the extra water is per litre less valuable to the user than the water 'replaced'.

4.5. Seasonal effects and water management strategies

In the last section we ignored seasonal effects, although one can identify the condition Q_R<Q_P as representing a dry season and Q_R>Q_P as representing a wet one. However seasonality is central to the operation and performance of a RWH system. A user can choose to emphasise dry season security or alternatively to emphasise roofwater capture. To some extent the dry and wet season water needs are in competition with each other. Consider the following four water management strategies for an already built RWH system.

To make the strategies easier to visualise, assume a scenario typical of a homestead in the Great Lakes region where mean daily roofwater runoff is R = 100 litres). Assume that 'dry' weeks (runoff less than 350 litres per week) comprise 1/3 of each year and that the RW storage capacity is 700 litres (7 x R or '1 week'). This storage is only modest, but corresponds to perhaps 50 days drinking water or 14 days total water under very careful management.

Strategy 1 – *High Water Capture* – Water is withdrawn at a high rate, Q = 1.5 R, (e.g. 150 litres/day under our scenario) whenever it is available. This will result in fairly low occurrence of tank overflow, but leave little reserve for dry weeks.

Strategy 2 – *High Security* – Water is withdrawn at a low rate, Q = 0.5 R, (e.g. 50 litre/day) whenever it is available. Much water will overflow the tank, so annual capture will be low.

Strategy 3 – *Adaptive* – Water is withdrawn at a rate Q determined by how much is in the tank, thus:

Q = 1.5 R (e.g. at 150 lpd) if tank > 2/3 full;

Q = R if tank < 2/3 but >1/3 full;

Q = 0.5 R, if tank < 1/3 full.

Strategy 4 – *Maximum Security* – Water is saved for the dry seasons and drawn frugally (e.g. 50 litres/day) *only* after nearby point sources have run dry or after 2 weeks without rain.

The trade-offs involved between these alternatives are summarised in the following table, in which the word 'security' is taken to mean the fraction of days the demand is met by RW (the tank does not run dry). The factor K is the dry-season value of water (valued at its cost from the nearest point source) divided by its wet season value. Thus K=1 represents places where point-source water is unvarying through the year, whereas the extreme value K=10 represents places where in the dry months all local sources dry up, so water must be queued for, then carried from, very far away. A typical value of K in the Target Area might be 2.

Table 4.2 suggests how we might account for seasonal differences in our economic evaluation, namely by assigning different wet and dry season values for water and operating the system to maximise their sum.

Table 4.3 represent the simulation of the four strategies applied to respectively a small DRWH system (storage volume V = 7 x mean daily run-off, R), a medium size system (V/R = 21) and a large system (V/R = 63). Data from Mbarara (daily rainfall for 10 years) has been used and a roof area of 45 m^2 has been selected to give the assumed mean run-off R = 100 litres/day. For Mbarara the dry season (defined by rain in the last fortnight being under 50% of mean fortnightly rainfall) is 36% of the year.

As well as water supplied (column 5), a 'weighted' water supplied column is shown alongside in which effectively K = 5. This yields the weighting (a 'wet season litre' is a cost-equivalent volume): 1.0 dry season litre is deemed to be worth 5.0 'wet season litres'

The **bold** columns in the table contain the performance measures of most interest.

Column 3 shows 'Capture efficiency', (*E*) – a high value indicates that most of the roof run-off is being consumed.

Column 8 shows 'Dry season water security', (S_d) – the fraction of dry season that tank does not run dry and so demand has been satisfied; note however that under Strategy 1 the dry season demand is maintained very high at 1.5 *R*, whereas the other strategies are using demand of only 0.5 *R* for the dry season.

Column 6 shows weighted annual water consumption, Q_5, which is a measure that attempts

Table 4.2 System Performance under Different Operating Strategies

Strategy No	Annual consumption	Relative value of annual water harvested		Wet season security	Dry season security
		if K=1	if K=10		
1	high	high	med	high	v. low
2	low	med	med	high	low
3	medium	low	v. low	high	low
4	very low	med	med	nil	med

to combine quantity, and security measures, by valuing wet season water much more highly than dry season water.

Examination of the top part of the table – which is for a VLC system with V/R only equal to 7 days – indicates that Strategy 1 (in which water is drawn generously whenever available) gives the highest annual water yield E, the lowest level of dry season security S_d, yet a high value for the seasonally-weighted yield W_e.

By contrast Strategy 4 (water is drawn sparingly and only in the dry season) gives the highest dry season security at the cost of the lowest annual yield. The seasonally-weighted yield is however also low. In fact we can dismiss Strategy 4 because even here, where per litre we have valued dry season water at *five times* wet season water, it still gives the lowest output valuation.

Table 4.3: Relating RWH system performance to operating strategy and storage volume

Strategy number / type	$\frac{V}{R}$	Capture Efficiency	Tank Utilisation	Mean daily consumption Q in litres		'Security' (*S*) = fraction of days demand is satisfied by roofwater		
	tank size days	*E*	*U*	Q_1 *K=1*	Q_5 *K=5*	S_w Wet	S_d Dry	All year
Small tank, VLC system								
1 High demand High capture	7	**0.70**[1]	36.5	70	**95**	0.75	**0.22**	0.56
2 Low demand High security	7	**0.41**[3]	21.4	41	**80**	na	**na**	na
3 Adaptive	7	**0.66**[2]	34.4	66	**93**	0.94	**0.38**	0.74
4 Max security in dry seas	7	**0.17**[4]	8.9	17	**84**	na	**0.52**	na
Medium size tank								
1	21	**0.91**	15.8	91	**125**	0.90	**0.25**	0.67
2	21	**0.47**	8.2	47	**107**	na	**na**	na
3	21	**0.86**	14.9	86	**138**	1.00	**0.66**	0.88
4	21	**0.26**	4.5	26	**128**	na	**0.73**	na
Large tank								
1	63	**1.00**[1=]	5.8	100	**165**	0.92	**0.38**	0.72
2	63	**0.51**[3]	3.0	51	**123**	na	**na**	na
3	63	**0.99**[1=]	5.7	99	**203**	1.00	**0.98**	0.99
4	63	**0.37**[4]	2.1	37	**182**	na	**1.00**	na

Notes:
1. Data is for Mbarara, Uganda
2. Annual run-off = annual demand
3. na indicates strategy does not allow demand to be met.
4. Highlighted cells indicate best strategy or within 3% of best
5. Strategy 1 gives best $\mathbf{Q_1}$ (highest water capture)
6. Strategy 3 gives best $\mathbf{Q_5}$ (highest benefit if K = 5)
7. Strategy 4 gives best $\mathbf{S_d}$ (highest dry season security)
8. Strategy 3 is always best or second best by all measures.

'Value' is calculated assuming first litre per day is worth 1.5 falling via 0.5 at the 100th litre to zero at the 150th litre

Strategy 1 is to withdraw 1.5 times base demand when available (and otherwise what is available)

Strategy 2 is to withdraw 0.5 times base demand when available (and otherwise what is available)

Strategy 3 is to withdraw 1.5, 1 or 0.5 times base demand, according to amount in tank

Strategy 4 is to withdraw nothing in wet season and in dry season base demand when available (and otherwise what is available).

Strategies 2 and 3 are intermediate in performance, with Strategy 3 (adaptable) generally outperforming Strategy 2 (fixed low-demand).

From this table we can conclude that unless dry season water has exceptional value – e.g. it is per litre worth more than the 5 times wet season water assumed in the table – Strategies 1 (high usage) and 3 (adaptive) are superior to the other strategies.

The bottom band of the table is for a much more expensive system with 9 times larger storage. With such a large tank, the relative superiority of Strategy 3 is increased. We also see the benefit of the larger store. Comparing say Strategy 3 for the very large tank with that for the small one, we find a 50% increase in water harvested (E), a nearly 4-fold increase in dry season security (S_d) and under the assumed value ratio (K=5) a 120% increase in water value. The graph below shows the variation in value of water harvested for varying values of K and for various sizes of tank. It confirms that VLC systems (V/R < 10 days) give a generally acceptable performance unless dry season water is deemed very much more valuable (e.g. K=5) than dry season water. Note the clear 'diminishing returns' with increase in tank size. If water value had been plotted against tank *cost* rather than tank *size*, the same pattern of diminishing returns would appear but with a slightly reduced strength.

A VLC system in the Target Area, attached to a $50m^2$ roof, might be expected to harvest around 25,000 litres of water per year (say 75% of run-off), averaging about 90 litres per day in the wettest 8 months and 30 litres per day in the driest 4 months.

Table 4.4**:** Performance under Strategy 3 – Table showing variation of value ratio, capture efficiency and security with tank size

	dry:wet value per litre	**Normalised tank size – V/R in days**								
		1	**3**	**5**	**7**	**14**	**21**	**30**	**60**	**90**
Benefit ratio = value of water harvested ÷ value water demanded	if K=1	0.29	0.49	0.60	**0.66**	0.79	0.86	0.91	0.98	1.00
	if K=2	0.24	0.40	0.49	**0.53**	0.65	0.72	0.79	0.90	0.94
	if K=5	0.18	0.30	0.35	**0.38**	0.48	0.56	0.65	0.82	0.88
Capture efficiency		0.39	0.66	0.76	**0.82**	0.90	0.93	0.95	0.99	1.00
Security		0.15	0.41	0.57	**0.67**	0.81	0.86	0.90	0.98	1.00

Notes:

1. Under this strategy the demand is varied from 0.5 to 1.5 times the mean daily runoff according to how much water remains in the tank
2. V/R is tank size (normalised to mean daily run-off); K is dry-to-wet season water value ratio; the bold column shows the performance of a typical very-low-cost RWH system

5. THE MANAGEMENT AND SOCIAL IMPACT OF DRWH – QUOTATIONS AND EXAMPLES

During the recent study in Uganda, information was gathered from communities regarding the social aspects of water collection and the impact of the RWH systems. The information is given in anecdotal form in the following examples. The experience with small scale RWH in Thailand is shared in Section 5.6

1.1. Children and water collection

Children collect water in containers of varying sizes. The containers used by the children vary from 3litres to 10litres for children below 8 years of age. Children above 8 - 10 years of age use larger containers and take on a more responsible role.

Where water is close to the house, say within one kilometre, children may be the sole collectors of water. When water sources are more distant, women will help the children. During the dry spells, the men may also help as the nearest water source may be 4kms or 5kms distant. Men tend to use bicycles, carts or donkeys for water collection.

Some children do not find water collection such a burden, as we see in the example below:

Moreen. Birere, a young girl from Rukungiri was asked how she spends her time.

> *"Our parents are very strict, the only time to let us out from home is, when going to school, church or collecting water. It's harder in the holidays. The only chance to meet friends is at the spring (water collection)"*

1.2. Sickness and water collection

The elderly and the sick tend to suffer disproportionately. This is due to the fact that the sick find it difficult to collect water and usually carry smaller quantities of water.

Timanya: An elderly women of (65yrs) in Kabale, Uganda.

> *"Water collection has become more of a problem than before in my life, I suffer from backache, all my grand children stay with their parents in turn, every day I collect 5 litres. At times children from the neighbours help me".*

1.3. Ranking of water sources

A ranking system is used by beneficiaries of RWH to determine the value of the captured rainwater. There are three main categories used for ranking water:

Ranking of sources by quality

Communities consider rainwater to be of high quality, hence other water sources are used where high quality is not an issue e.g. making mud for houses, mixing building mortar.

Ranking source by effort cost

For certain activities requiring large quantities of water, e.g. washing clothes or watering the animals, rainwater is not used. Usually people will take their clothes or animals to a water point for cleaning and watering as the effort involved in carrying the water is reduced greatly this way.

Ranking of sources by seasonal reliability

Communities vary their source of water depending on season. The closest available source is preferred, but sources that are used for cattle watering in the wet season may get priority for human consumption during the dry season.

1.4. Rainwater and water security

Householders consider RWH to be a water source that is supplemented by other sources. This has been an advantage in the dissemination of small rainwater tanks, as the beneficiaries see the tanks as a partial supply and their expectations are not too high.

Member of Rakai women's group:

> *"We know our jars are small, they cannot meet all our water demands, but we use the water sparingly, to prepare tea, drinking only after boiling".*

1.5. Rainwater management

Rainwater is managed in a number of ways. The main management strategies are listed here:

Maximum security

The water from the tank is not utilised not until all the possible water sources are completely depleted. In this case, in the rainy season, after the tank has been filled it is locked up. This has a disadvantage of not maximally using the water from the roofs; the tank is left to over flow.

Maximum capture

The tank is used as a water source throughout the rainy season. It keeps filling as the stored water is being utilised. However, there is a tendency of reducing the daily consumption as the dry season sets in.

1.6. Comparative experiences with small-scale RWH in Thailand

Rainwater harvesting is more widespread in Thailand than any other country in the world. More than 10 million 1000 to 2000 litre rainwater jars and hundreds of thousands of 6 – 12m^3 rainwater tanks were constructed between 1985 and 1992. Most of the households in north-eastern Thailand have at least one, and some have many, rainwater jars. The Thai RWH programme is considered to be one of the most successful examples of how potable water supplies can be increased on a national scale.

The rapid growth and success of the Thai programme was made possible by a combination of factors that may be relevant to other countries interested in developing broad, as well as limited scale, RWH programmes. Government commitment was very strong ad national objectives and targets were clearly defined, and there was popular support at all levels including NGO's, community based initiatives and the private sector. RWH is a long-standing tradition in Thailand and the annual rainfall is high relative to many other regions of the world, with a rainfall pattern favourable to RWH. The demand for improved water supplies in rural areas was tremendous, and this demand led to the emergence and growth of many independent jar making micro-enterprises. Thailand also experienced a period of national economic growth and an increase in private affluence during the life of the programme which made it easier for families to invest in RWH technologies. Funding came from a number of sources, including the well-established Rural Job Creation Project, the Provincial Development Fund, the Provincial Administrative Organisation, as well as the private sector and non-profit organisations.

Originally, the jar construction programme was to be financed by a revolving fund, using start-up money from the government. However, the programme expanded so rapidly that the administration of the funds could not keep up with demand and these funds were generally not used. Many districts provided construction materials, tools and training and people contributed labour to construct their own jars under the guidance of experienced technicians.

It was initially envisaged that villagers would construct their own jars, but as the programme evolved the private sector became very much involved in rain jar construction. Small jar making factories sprang up and developed into successful micro-enterprises in many provinces. The price of a 2m^3 jar in 1992 was US$40 and many of the village based companies were manufacturing up to 30 jars per day. Subsidised and affordable cement added to the favourable conditions.

Some of the early tank designs suffered form major problems. More than 50,000 bamboo reinforced tanks were constructed and these suffered from attacks by fungus, termites and bacteria. An interlocking block tank design was abandoned because the skill levels required were not suited to local conditions. The eventual design that was adopted by the Ministry of Health is a cement mortar jar that has a lid on the top to prevent contamination; a tap for easy access to water; and a drainage plug for easy cleaning. Commercially made jars often did not have these essential features. Numerous moulds have been used, including jute bags filled with rice husks, a 54 piece cement mould, and the star fruit (segmental) steel or cement mould. Larger jars of up to 3 – 5m^3 were also constructed for individual households with iron reinforcement. Thousands of larger tanks have also been constructed at schools, clinics, temples and private homes.

A major rainwater quality study, published in 1989, showed that only 40% of samples met the WHO guidelines for total bacterial count for drinking water. It was convincingly shown that much of the contamination came from secondary causes, such as poor water handling. Despite the problems found with the water quality, the study concluded that rainwater is still the safest and most economical source of drinking water available in most rural areas.

(Source: Raindrop, Rainwater Harvesting Bulletin, July 1992)

6. HEALTH ASPECTS

6.1. Health

Water relates to health in complex ways. It is conventional (Cairncross & Feacham 1993) to identify five types of water-related illness

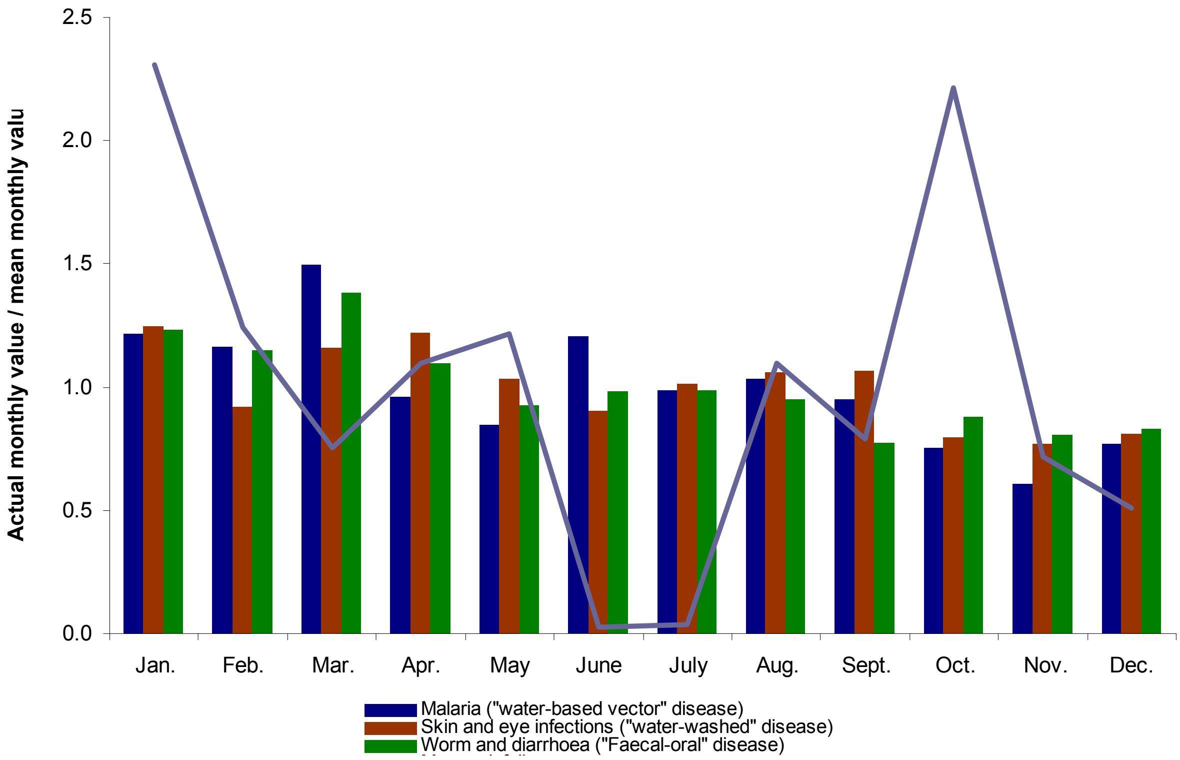
1. Water-born or faecal oral diseases caused by biologically contaminated water
2. Water-scarce or water-washed diseases, mainly skin and eye infections – however as water scarcity lowers hygiene standards, some diseases are both water-borne and water-washed.
3. Water-based diseases involving agents like bilharzia parasites that have an aquatic stage in their life cycle
4. Water-related (insect) vector diseases like all those carried by mosquitoes
5. Poisoning by substances dissolved in water.

Practically the introduction of DRWH might be expected to definitely reduce categories 3 and 5 diseases. Only where it increases water consumption might it reduce category 2 disease.

The impact of DRWH on category 1 disease depends on whether it is a bacterially cleaner or dirtier source than was used hitherto. The debate on RW quality is a complex one (Gould & Nissen Petersen Chap 6). Generally, RW stored in well-covered tanks is as clean as water carried to a house from even a very clean source and is certainly cleaner than water from swamps or streams. Conversely water from a RW tank containing drowned rats is unhealthy.

The impact of DRWH uptake on mosquito breeding has also been much, but not very conclusively, discussed. It is not easy to maintain effective anti-mosquito screening throughout the life of a water tank. So RWH might be expected to increase malaria, particularly during the dry seasons when other mosquito breeding sites are scarce. Conversely

Figure 6.1: Fluctuations of normalised malaria cases, skin+eye cases, worm+diarrhoea cases and rainfall for 1998



present water sources are often valley-bottom wells close to swamps. Queuing at these at dawn or dusk carries a high risk of being bitten by mosquitoes, a risk that DRWH should reduce.

In the absence of DRWH one might expect a fall in malarial cases and a rise in water-washed diseases during the drier months. Medical data was collected from Mbarara hospital and grouped to emphasise any such seasonal variations. Many thousands of cases were summarised. Skin+eye infections were taken to represent water-washed disease, worm+diarrhoea cases to represent water-borne disease and malaria to represent water-related insect vector disease. Figure AA below plots the normalised incidence of each disease group alongside rainfall for each month of 1998. Inspection of the bar chart does not confirm the seasonal relations forecast above. Indeed formal statistical analysis shows insignificant correlation between monthly variations in rainfall and any disease group ($R^2<0.5$). Against this background it is very hard to predict the health implications of any large increase in DRWH use.

Insofar as DRWH replaces water haulage by women and children, there are safety benefits associated with mothers not having to leave young children attended only by older ones (babies burnt in fires) and children not having to venture in lonely places before dawn or after dusk (an oft-expressed concern). A reduction of jar-carrying probably also reduces the incidence of arthritis and back injury. Falls are a danger during water carriage on steep slippery slopes during or soon after rains, so that being able to avoid trips at this time is particularly valued. East Africa does not generally have the sort of society where water-collecting gives women their only legitimate reason for leaving the home; even so a reduction in walking might slightly reduce social interactions.

Table 3.3 indicates a mean daily water consumption of about 10 litres per capita. This figure was confirmed by a small survey in Kabarole District and thought to be representative by officers of local water NGOs. The WHO recommended minimum is 20 lcd but this figure is rarely reached where water has to be hauled for significant distances. A generation ago Bradley and White (1972) explored in *Drawers of Water* the influence of haulage distance and family size on per-capita consumption of water drawn from point sources in East Africa. Their study is reportedly being currently updated under a project named *Drawers of Water II,* but no data could be obtained from that source for this study.

Lastly come the issues of reduced exhaustion, better nutrition and the use of released time, all of which have a difficult-to-quantify health impact.

Qualitative evidence from Rwanda indicates no change in malaria morbidity with DRWH introduction.

Other 1991 census evidence from Uganda, shown here, suggests that Districts within the Target Area having better access to safe water do broadly have a lower infant mortality rate. However the definition of access is a very broad one. Kabale and Rukungiri Districts are very hilly so water carriage there is especially onerous.

6.2. Findings from a recent study into water quality in DRWH systems

A study was carried out recently at the Indian Institute of Technology in Delhi, India, to determine the quality of rainwater from domestic rainwater harvesting systems. The major conclusions reached

Table 6.1: Health data from the Target Area

District	Infant mortality	Access to clean water	Population in 1991	Population density
Units	**per live birth**	**%**	**1000**	**Persons/km^2**
Rakai	0.199	6	383	99
Kabarole	0.136	6	746	92
Mbarara	0.145	19	931	98
Rukungiri	0.125	27	391	151
Kabale	0.114	58	417	246

Source: 1991 Uganda Census

are as follows:

1. Generally, the physico-chemical quality of water in terms of colour, odour and taste, pH, total dissolved solids (TDS) and total hardness (TH), meet the prescribed standards. Occasionally pH has been reported to be low (acidic) or high (alkaline).
2. Toxic metal ions and toxic chemicals are reported only in rare cases and may arise from material used for the roof or atmospheric pollutants adsorbed on dust.
3. Most of the material used for storage tanks e.g. cement, iron, wood and plastics do not negatively affect the physico-chemical quality, with a few exceptions.
4. The physico-chemical parameters can be tested easily by using available field kits.
5. The main problem with the quality of stored water in DRWH lies with its bacteriological quality. The following are the main issues:
    - Dust from the soil, and droppings of birds and animals can also be the source of contamination by the above bacteria.
    - In any case where first flush eliminating devices are absent, all the indicator bacteria are generally present in water samples in numbers beyond what is acceptable by any standards. Higher temperature reached by a metallic roof due to solar heating may lead to reduction in bacteria.
    - From the health point of view it is important to clean the gutter from time to time and ensure that water does not stagnate. This leads mosquito breeding.
    - Tree hanging in the vicinity, definitely enhances the possibility of contamination due to increased access of the roof to birds and animals.
    - On storage, generally due to limitation of nutrients, bacterial count falls. Different indicator bacteria under study decay over 7-20 days depending on the initial amount of bacteria, nutrient availability and other storage conditions.
    - Increase of temperature due to sun's heat or exposure to UV radiation of sun, reduces and ultimately eliminates bacteria. However, exposure to sunlight in the presence of nutrients can lead to algal growth, especially when the storage is open.
    - Mosquito breeding generally occurs if mosquitoes are already available in the vicinity of storage. Water quality deteriorates with the breeding of mosquito. The only way to prevent mosquito in the tank is by covering the openings by appropriate screens.

Thus the basic conclusion from the study, substantiated by actual experimentation under the project are that DRWH must be designed, taking the following into consideration:

1. Convenient first flush device must be integrated. Roughly the first flush to be may be taken to be 2 mm rainfall and the volume is obtained by multiplying this by the area of the roof.
2. Storage must be tightly lidded and all entry points must be closed by a mesh to prevent entry of mosquitoes and eggs.
3. It is preferable to allow the water to stand for some time before drawing. The bacterial count is more at the bottom. Hence the water may be drawn from a higher level, e.g. withdrawing water from an over flow system may be useful. Thus, instead of one tank of large capacity, more tanks in a series may be used, but increase in total cost has to be considered.
4. Some rapid testing methods like H_2S test methods are useful in the field for indicating presence of biological contamination. The safest methods of treatment are exposure to UV & boiling.

7. TECHNOLOGY – DOMESTIC WATER STORAGE

It is difficult to understand why certain technologies prosper over others. There are many examples of situations where inferior technologies thrive whilst the ideal (in the eyes of the technologist) is shelved or dropped in the dust bin. The reasons are often political or market driven, rather than technology driven and a good salesman can be a wonderful asset. In the case of developing countries, technologies which are well-suited to improving the lives of rural poor are also overlooked on occasions. Again, there are a variety of reasons, the main reasons usually being a poor access to knowledge and information, traditional cultural practises and a lack of political will. Small-scale RWH is one such technology that has been largely overlooked by the majority of poor rural households in LDC's. In countries where the technology has been embraced (Thailand being the most prominent example), great benefits have been seen and large steps taken in alleviating the daily drudgery faced by householders in the task of meeting their water needs.

7.1. Requirements of a domestic water storage tank

Any vessel used for storage of potable water in a domestic context should have certain attributes. These are investigated below in some detail:

Strength.

Any tank that is to store water must have sufficient strength. Water pressure inside the tank creates stresses, which, if not dealt with properly, can cause the tank to fail, which could in turn lead to serious damage of the tank and injury to persons and /or damage to surrounding buildings. Ideally a full engineering analysis should be carried out for any new tank design and tests carried out to confirm the findings. In practise, tanks are usually designed and built, based on previous experience with the material being used and/or previous experience with similar vessels. A good safety factor is usually incorporated in such cases. In Section 2 the shape of tanks was discussed. Existing tanks come in a number of common shapes. The relative merits of these shapes are discussed in Table 7.1

Impermeability.

A water vessel should obviously be impermeable. This is achieved in one of a number of ways, depending on the material from which the tank is made. Some materials are inherently water proof e.g. corrugated steel sheets or fibre glass, and require no (or little) treatment to provide an impermeable barrier. Traditional materials, such as masonry and brick, are usually dealt with by applying an internal render of sand and cement, which can be treated with a water proofing agent or given a final coat of 'nil' (cement slurry). Ferrocement technology uses this concept by applying a cement slurry onto the wall of the tank when complete. Modern plastics may allow low-cost linings to be produced although little has been done in developing countries to

Table 7.1: Relative merits of some common tank shapes

Tank shape or type	Stresses	Material usage and construction
Cuboid	Stresses are unevenly distributed and difficult to calculate	The ratio between material usage and storage capacity is lower than for a cylindrical and doubly curved tank. Construction is quite simple
Cylindrical	Stresses are more evenly distributed and are easier (though trivial) to calculate	There is an improvement in the material use to storage capacity ratio (a saving of 7.5% given a good height to diameter ratio) Construction becomes more difficult with traditional materials e.g. bricks
Thai Jar Style (doubly curved tanks)	Stresses are ideally distributed if the proportions of the jar are correct	Material usage to capacity ratio is very good (savings of up to 20% over a cuboid) but construction can be very difficult, often relying on specialised moulds.

develop a suitably sized off-the-shelf solution. Other modern materials, such as bituminous paints, suitable for use with potable water supplies, are slowly becoming available on the market in LDC's.

Durability

of storage tanks is a critical question. Engineering techniques for determining the durability (through accelerated ageing) are expensive and so the only way to properly 'test' a new technology is usually to apply the test of time. This is problematic when we are looking for a useful life of 20 – 30 years. Little information seems to be available on existing tanks and their useful life spans. The experience in Thailand (documented in Section ??) shows how some unsuitable technologies can be widely disseminated before major flaws appear. In the Thai case more than 50,000 bamboo reinforced mortar jars were manufactured, many of which failed due to termite and fungal attack on the bamboo.

Sufficient storage capacity.

This topic is discussed in far more detail in other sections of this report. Many techniques are available in the RWH literature for determining the ideal size of a tank for full water coverage throughout the year, but none exists for determining the size with modified consumption (during the wet season for example), or for partial coverage.

Maintenance of water quality.

A good storage vessel should maintain and improve the water quality. This is achieved in a number of ways:

- a good fitting, light-proof cover will prevent debris, animals or humans from entering the tank and prevent light from causing algae growth
- water quality can enhanced by putting water into the tank and taking it out of the tank at the correct location – low-level tank entry and floating off-takes are devices designed to aid this approach
- good sanitary conditions around a tank will prevent disease being spread
- water extraction should be such that the water is not contaminated while being drawn
- filters improve water quality are discussed in a following section

No increase in health risk.

Sometimes, with all good intentions, a water tank can become a serious health hazard. This is particularly the case when mosquitoes are allowed to breed in the tank. This can be avoided by sealing the tank well and preventing the mosquitoes entering and breeding by covering any openings with mosquito gauze.

7.2. Tank size – ideal tank size vs. affordability

Tank sizing techniques usually only consider the optimum size for a tank based on the rainfall available, the size of the catchment area, and the demand on the system. Little consideration is usually given to the affordability of the tank. It is assumed that the customer will be looking at capturing all the water from the roof or enough to meet all their demand. But in some cases, people will be happy with *some* water from their roof. In many cases, the customer may not be able to afford a tank suitable for catching the optimum amount of water. In such cases the tank size is determined by the tank cost and so, in this tank case, we need to maximise capacity for a given (low) cost.

Below, in Table 7.2 we have classified *domestic* tank sizes into three distinct groups – small, medium and large scale.

Affordability is a strong function of tank size and tank design. The smaller the tank the cheaper it will be and the cheaper the construction materials and labour costs, the cheaper the tank will be. For increased affordability we are therefore looking at small-scale, locally produced RWH systems that use local materials. Local manufacture and use of local

Table 7.2: Tank scale classification

Scale of domestic tanks	Description
Small-scale	Any tank or jar up to seven days storage or up to 1000 litres
Medium-scale	A tank up to several weeks storage or between 1000 and 20,000 litres storage
Large-scale	Any tank with several months of storage or above 20,000 litres storage capacity

skills are design issues, and have been given great consideration during the design process described in Sections 7.4 and 7.8. Affordability is a function of a number of socio-economic factors and is decided at the household level.

As an indication of actual costs for a number of different tank types, a cost analysis of commonly available small and medium scale factory made tanks has been made, and compared with locally manufactured tanks. This is shown in Table 7.3 and shows the actual costs while Table 7.4 shows the cost per litre storage.

As expected, economies of scale show the cost per litre dropping as tank size increases. Also, as expected, factory made tanks are generally more expensive than locally manufactured tanks. The general advantage of off-the-shelf, factory-made, plastic tanks is convenience, a good range of sizes and usually a guarantee of quality. The disadvantage is the high cost. The advantage of the GI sheet tanks is again off the shelf availability, but the quality is dubious with the manufacturer claiming a 15 year life and local contacts stating a more realistic figure to be 2 – 3 years. The usual mode of failure is that the base of the tank rots out and the usual method of repair is to surround the base with concrete. The cost is much lower than that of the plastic tanks. They are manufactured primarily on the outskirts of Kampala and some of the major Ugandan towns by micro-

Table 7.3: Cost comparison between 'imported' and locally made tanks in East Africa (all cost figures in £ Sterling)

Tank size (litres)	Plastic Tanks [2]	GI Tanks [3]	PBG Tanks [4]	F/C jars and tanks	Brick jar 5	Plastic tube jar [6]	Tarpaulin tank [7]
100	20						
250	36						
500 – 600	62			28[5]		21	
750	88				33		
1000	115						
1500	158						
2300 – 2500	219	72					
3000	289			79[1]			
4000	379	88					
5000	463	100					
6000	590	132					40
8000	747	147					
10000 – 11000	976	159	155	264[1]			
12000		207					

Notes:

1. Costs take from 'Rainwater Catchment Systems for Domestic Supply' Gould and Peterson (1999). Costs are from 1998 and converted from Kenyan Shillings at a rate of 113.7 (15/8/2000)
2. Costs from price list, Poly Fibre (U) Ltd, P O Box 3626, Kampala, Uganda - cost of filter and tap not included. Factory made, spin moulded, plastic tanks.
3. Costs from price list, Tank and tanks, PO Box 1219, Kampala, Uganda. Cost of filter and tap not included. These tanks are made from curved galvanised iron sheets which are riveted together and soldered to make them waterproof. Estimated useful life 15 years (by manufacturer) or 2 to 3 years (by local contact). These tanks are also available in Kampala or Masaka (2 hrs drive from Mbarara).
4. Partially below ground tank. Design by DTU. Approximately 10 have been built in SW Uganda of between 5,000 to 20,000 litres. Cost is for 10,800 litre tank not including handpump (approx. £10 extra), based on costing exercise carried out June 2000.
5. Cost based on actual construction cost during study, July 2000. Cost includes tap and filter. See Section 7.8 for design detail and full cost breakdown.
6. Cost based on actual construction cost during study, July 2000. Cost includes handpump and filter. See Section 7.8 for design detail and full cost breakdown.
7. For detail see http://www.eng.warwick.ac.uk/DTU/cs/cs20.html. Costs based on actual construction costs, July 2000.
8. All costs (other than Note 1) were converted from Uganda Shilling prices converted at a rate of 2509 Shillings to the pound (15/8/200)

Table 7.4: Cost comparison – pence per litre storage capacity of tanks in East Africa

Tank size (litres)	Plastic Tanks [2]	GI Tanks [3]	PBG Tanks [4]	F/C jars and tanks	Brick jar 5	Plastic tube jar [6]	Tarpaulin tank [7]
100	19.6						
250	14.5						
500 – 600	12.5			5.6		3.4	
750	11.8				4.4		
1000	11.5						
1500	10.5						
2300 – 2500	9.5	2.9					
3000	9.6			2.6			
4000	9.5	2.2					
5000	9.3	2.0					
6000	9.8	2.2					0.7
8000	9.3	1.8					
10000 – 11000	9.8	1.6	1.4	2.4			
12000		1.7					

entrepreneurs, who sell small numbers of tanks. They also make gutters and downpipes from flat GI sheet. These tanks are found throughout Uganda, but not in very great numbers.

The figures given for the locally made tanks and jars are taken from the work carried out during the study (and documented in Section 7.5), as well as from the RWH literature for the region. It can be noted that the costs are generally lower than for the plastic tanks but in line with the GI tank costs. The expected useful life for the majority of the locally-made tanks is much higher than that of the GI tank. It is also noted that only one size is quoted for each of the small jars – this is because the costing exercise was only done for the work carried out under the study. Similar economies of scale would be expected for larger jar sizes using similar materials, but the design would need to be reconsidered. The aim of the small jars is to provide systems for poor rural households who don't have sufficient money to purchase the larger tanks.

The tarpaulin tank, developed by the Rwandan refugees in Uganda uses a 5m x 4m polypropylene tarpaulin, which is fitted inside a lined pit with walls of poles and mud built up to about 1m around the pit. The outhouse-like building is roofed with corrugated iron sheet (see Figure 7.1). The simple design and use of predominantly local materials make this tank extremely cheap for the given, maximum 6000 litre, storage capacity. The cost per litre storage is only 7% that of the plastic tank of the equivalent size. Tarpaulins and corrugated iron sheet are available locally

Figure 7.1: A Figure 7.1 – The tarpaulin tank. Note the inlet into the side of the tank and the door at the front for scooping water

7.3. Choice of tank type

The type of tank that may be chosen will be dependent upon a number of factors:

- space availability will determine the maximum dimensions and whether the tank will be above or below ground
- soil conditions determine whether a tank can be built below ground – rock causing excavation difficulties and sand being liable to subsidence during excavation

- the choice between factory made or locally made tanks is usually a function of wealth
- for low cost tanks (as defined above) the material and construction technique is usually dominated by what is available locally and what is affordable.
- subsidies, often give as part of tank building programmes, can influence the type of tank that will be bought or built
- there are many other factors that influence the choice of tank

7.4. Materials for tank construction

The fundamentals of design for sustainability suggest that where possible, local skills and materials are used for manufacture. This should be carefully considered when designing RWH systems, particularly in rural areas of developing countries. A

Table 7.5: Advantages and disadvantages of a variety of tank types

Tank type	Advantages	Disadvantages	Comments
Plastic tanks	Off the shelf convenience Quality assured Wide range of sizes	High cost Central manufacture High tooling costs Local skills ignored Transport costs extra	Factory made in large numbers
GI tanks	Off the shelf convenience Reasonable initial cost Moderate range of sizes Low tooling costs for the manufacturer Open to local manufacture	Doubtful quality Transport costs extra	Made by micro-entrepreneurs in the major towns
PBG tank	Reasonable cost Good range of sizes available Low tooling costs Suitable for local manufacture Local skills enhanced Use of many local materials Transport costs embodied in material cost	Quality only assured through good workmanship Water extraction device required to prevent contamination of water	DTU design. To date approximately 30 or 40 tanks have been built in SW Uganda by local artisans.
Locally manufactured small jars	Use of many local materials Use of local skills Low tooling costs – suitable to local artisans Transport costs embodied in material cost Suitable for poor rural households Suitable for incremental adoption	Limited range of sizes for given design Quality only assured through good workmanship	DTU designs dealt with in Section 7.8 These are new designs that have been prototyped and are currently under survey.
Tarpaulin tank	Very low cost Uses skills available to most rural farmers Uses only local resources (except tarpaulin and GI sheet) Very few tools required Significant storage capacity for small farms for irrigation or livestock Suitable for poor rural households Quality assured if new tarpaulin is used	Maximum size dependant on tarpaulin size Some problems at present with termites eating poles and tarpaulin Water extraction device required to prevent contamination of water	Tank developed by refugees in East Africa using UNHCR tarpaulin and now built in some number by ACORD and IVA / UNIFA in SW Uganda.

careful study of locally available skills and materials should be carried out before the design process begins. This can vary from dramatically from place to place, depending on natural resources, the range imported goods and tools and local building techniques (which are usually closely linked to availability of natural resources). Local knowledge is invaluable during such a survey. For the work described in Section 7.5, such a study was conducted and the findings are listed below in Table 7.6 and 7.7

Table 7.6: Resources available close to the site at Mbarara town

Local resources		
Item	**Availability**	**Comments**
Sand	Good quality sand is difficult to find in the area. The sand used was transported 30kms from the Oruchinga Valley. Sand of poor quality is available within one km.	Transport is needed and this costs up to *six* times the sand cost for the 30 km trip. Loading and offloading costs need to be considered – can be as much as the cost of the sand. Bulk purchase (4 tonne loads) is cheaper than buying small loads.
Aggregate	Available locally – about 5 kms from site	Again transport is needed and is costly. Loading and offloading to be considered. The stone is quarried and broken locally by hand.
Stone	Available locally at site.	Stones suitable for foundations and masonry work were available from previous work at the site.
Bricks	Good quality bricks manufactured about 40kms from the site. Poor quality bricks are manufactured locally.	There are the same concerns with transport and loading. The bricks are of reasonable quality but dimensionally irregular. Special (angle ended) bricks were needed and this had to be arranged in advance – a mould was supplied and the special bricks were made and burnt in the next available batch.
Wood / timber	Poles for building and for making ladders and scaffolding are available locally	We could harvest these from the site, as they were growing on the land. Sawn timber is available in town or sometimes locally if trees are being felled and sawn by local farmers.
Materials available in the local market place (a selection)		
Item	**Unit**	**Comment**
Cement	Bag 50kg	Used for most of our construction work
Chicken wire 1/2"	Roll (30 x 0.9m)	Used for ferrocement work
4mm mesh	Roll (30 x 0.9m)	Useful for sieves and for ferrocement work
Rebar 8mm	13m length	Reinforcing and cover manufacture
Rebar 6mm	13m length	Reinforcing and cover manufacture
Welded mesh	2 x 1 m sheet	For concrete reinforcement
Binding wire	kg	For tying rebar and other uses
Barbed wire (double strand)	Roll (600m)	Used for our rammed earth work
GI and plastic pipes and fittings	Wide variety of sizes and components available	Water extraction
Sisal rope	Roll	General purpose
Nails	kg	General purpose
Water proof cement	kg	For tank linings
Fencing staples	kg	General purpose
Plastic sheet (250 micron)	87cm wide roll – bought by the metre	For plastic tube tank – quality in local market is dubious as ends get easily scuffed
Tarpaulins	5m x 4m	For tarpaulin tank – available in some hardware shops or possibly from lcoal agencies dealing with refugees
Timber	Any size to requirements	General purpose (not accurately cut)

Table 7.7: Skills available close to the site at Mbarara town

Skill	Comments
Local pole and mud construction	Known to, and practised by, most rural farmers
Brick laying and rendering	Widely used and known to most masons
Stabilised earth technology	Not known locally
Stone masonry	Known to some masons but not widely practised
Ferrocement tank construction	There had been some previous training in the area, so a number of masons had been exposed to the technology. One local mason was very experienced and did good quality work.
Carpentry	Several carpentry workshops in town with a limited range of power tools available (thicknesser, planer, power saw, pillar drill, etc). Most carpentry shops specialise in furniture making. The quality of the work varied enormously. Local village carpenters have no power tools and have limited skills. Accuracy of work is generally low. Lathe work can be done but not very accurately.
Metal work	Welding equipment is available in town, but quality of work is not high at most workshops. No turning or toolmaking equipment available. Angle iron and flat bar available locally but few other profiled sections.
Other	A wide range of services are available in Kampala, 4 hrs drive from Mbarara

7.5. Tank trials at Kyera Farm, Mbarara, as part of this Study

A technical study was undertaken as part of the Feasibility Study to allow the study team to build and assess a number of small-scale RWH systems suitable for local manufacture in the region. The study was carried out at Kyera Farm, a training centre in organic farming techniques and rainwater harvesting techniques, based 8kms south of Mbarara, in SW Uganda. During the study 3 types of small storage vessels were investigated, namely:

- a cylindrical brick jar of 750 litres
- a ferrocement jar of 500 litres
- a partially below ground plastic-lined tank of 600 litres

(Technical drawings of each of the designs is given in the Appendix II. Sizes given are approximate)

Figure 7.2 The plastic tube tank

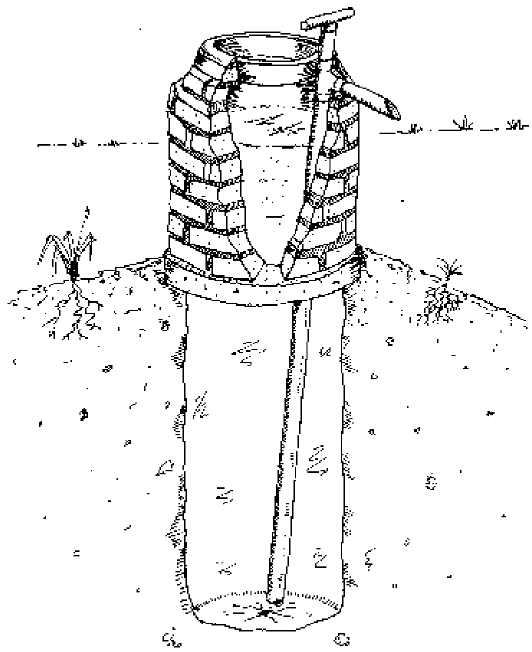


Figure 7.3: The brick jar

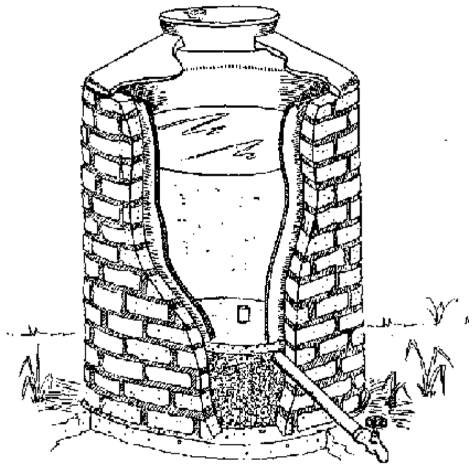
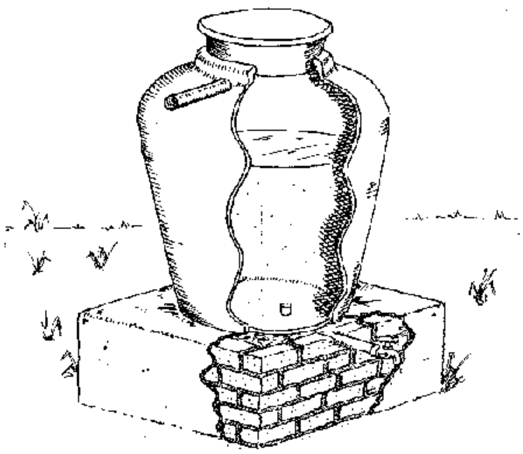


Figure 7.4 The ferrocement jar



The aim of this study was:

- to test three designs of small storage vessel (one well established and two new designs)
- to build prototype / demonstration RWH systems at Kyera Farm to assess the skills and materials required for each of the designs, and their suitability for local manufacture
- to make improvements to the design based on early experiences with the prototypes
- to investigate the use of RWH on grass roofs
- to build a number of systems in the local community to allow a survey to be conducted – the survey will look at the technical suitability of the systems, as well as the use of the jars by householders and the benefits and savings brought about by the RWH system
- to carry out a full costing for each of the RWH systems

7.6. The designs

The design of the jars was undertaken using the principles set out earlier in this chapter.

In the case of the ferrocement jar, the design was taken from the RWH literature (Watt, 1978) and adapted slightly to suit local conditions. The size of the jar was increased from 250 litres, as suggested by Watt, to 500 litres. A tap was incorporated, and the jar set on a plinth, to allow water to be extracted without contamination. Chicken wire was added to the cement jar described by Watt, to give added strength and a combined cover and filter was incorporated to help improve and maintain water quality.

The cylindrical brick tank was developed as it was seen to be a tank, which very closely matches local skills, materials and known building techniques. Brick manufacture is common in the area and brick building techniques well known. The jar is cylindrical, which, as described earlier in this section, reduces stresses and gives a good material:capacity ratio.

The plastic lined tank was developed as a new innovation, specifically aimed at reducing costs. It is an adaptation of a larger partially below ground tank developed by the DTU in Uganda. The tank was designed in such a way that plastic tubular sheet, available in the local market, could be used to line a hole dug to a suitable diameter. The above ground section of the tank is made of brick. The handpump used with this tank was designed during the project and generated considerable interest, enough to warrant a short training course for local NGO technical staff.

It was decided that three designs should be developed, in order that a choice would be available to local artisans and to their ‘customers’.

Further information and design drawings are given in Appendix II

7.7. Small tank costs

A detailed costing of the small RWH storage vessels was undertaken and a breakdown of the costs are given in Appendix III. A brief summary of the costs is given in Table 7.8 to allow for easy comparison

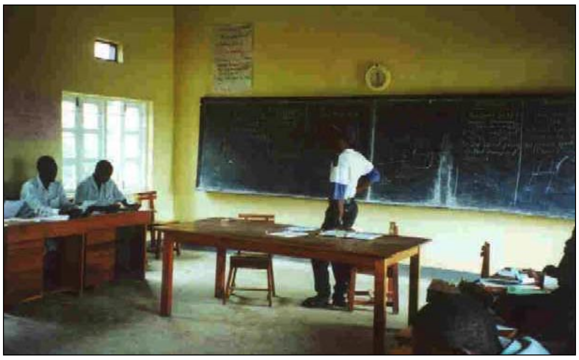
It is worth making a few general comments on the data presented in Table 7.8 and in the tables in Appendix III.

1. Cement is a major expense. A bag of cement costs 3 times the daily wage of a mason. For the jars constructed the cost of cement is dominant – 42% of the material cost for the f/c jar, 45% for the brick jar and 24% for the plastic tube jar. Reducing cement content can significantly reduce cost.
2. Irregular brick size increase cement content as extra mortar is used to fill the gaps. It is worth carrying out a quality control exercise at the brick manufacturing plant.
3. Water extraction can be made cheaper in most cases, but then there is the increased risk of contamination.
4. Further cost reduction exercises should be carried out e.g. reducing f/c wall thickness through proper experimentation, possibly omitting chicken wire from f/c tank, using more locally available materials such as wood poles and mud. It is worth bearing in mind that the jars constructed at Kyera were demonstration/ prototype jars and were constructed to a high standard.

7.8. Training

As part of the study, training was given to eight masons, 4 taken from the local community and 4 taken from a pool of masons who work closely with a local farmers organisation (IVA, Mbarara) who are already building RWH systems. The training was for a period of 6 weeks and was primarily 'on-the-job' training, with instruction being given by the project technician and with a classroom component included at the end of the period to re-cap on the work undertaken during the training. Feedback from the masons on the practical implications of the designs was absorbed and often changes implemented directly as a result of suggestions.

Figure 7.5: Classroom sessions for the masons gave opportunity to reinforce the techniques being taught as well as allowing the masons to discuss concerns and make suggestions



A series of Photo Manuals for the construction of these small RWH systems have been developed based on the work carried out at Kyera Farm. They can be found on the DTU Web Site at http://www.eng.warwick.ac.uk/DTU/rainwaterharvesting/workingpapers.htm or obtained directly in hard copy from the DTU.

A pump training course was arranged as a result of high levels of interest shown by people attending the programme seminar. This course in Low-cost Handpump Manufacture was run over a two-day period on the 22nd and 23rd August 2000 by Vince Whitehead, a Warwick mature student (and experienced machinist) who is working at Kyera Farm voluntarily during his summer break.

Table 7.8 Cost comparison between the jars constructed at Kyera

Type of jar	Size (litres)	Cost (USh)	Cost per litre storage capacity (USh)
Brick jar	750	83,000	110
Ferro-cement jar	500	70,000	140
Plastic tube jar	600	51,500	86

8. TECHNOLOGY – OTHER DRWH SYSTEM COMPONENTS

8.1. Roofs

For domestic rainwater harvesting the most common surface for collection of water is the roof of the dwelling. Many other surfaces can be, and are, used: courtyards, threshing areas, paved walking areas, plastic sheeting, trees, etc. In some cases, as in Gibraltar and Zimbabwe for example, large rock surfaces are used to collect water which is then stored in large tanks at the base of the rock slopes.

Most dwellings, however, have a roof. The style, construction and material of the roof affect its suitability as a collection surface for water. Typical materials for roofing include corrugated, galvanised, iron sheet (GI Sheet), asbestos sheet; tiles (a wide variety is found), slate, and thatch (from a variety of organic materials). Most are suitable for collection of roofwater, but only certain types of grasses e.g. coconut and anahaw palm (Gould And Nissen Peterson, 1999), thatched tightly, provide a surface adequate for high quality water collection. The rapid move towards the use of GI sheets in many developing countries favours the promotion of RWH (despite the other negative attributes of this material).

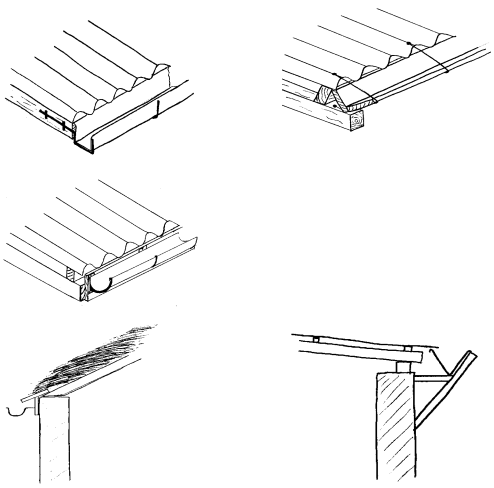
Some work was carried out during the study to investigate the possibilities of using grass roofing for DRWH. Guttering was installed on one grass roof that had been constructed with a plastic membrane beneath it – this helps to prevent UV degradation of the plastic. The grass was loosely thatched and found locally. The plastic sheet guttering that was installed is shown in Figure 8.1. It is designed to capture all the water falling on the thatch and passing through to the plastic sheet. It is fixed using two long poles, one suspended below the eaves and one on top of the thatch. It can also be designed to be demountable from the upper surface, such that it can be 'put away' under the eaves when there is no rain. Again this helps prevent degradation due to sunlight. A follow up survey will look at the longevity of the plastic guttering and the taste, odour, colour and palatability of the water captured. The survey will run until February 2001.

Figure 8.1: Plastic sheet guttering

8.2. Gutters and downpipes

Guttering is used to transport rainwater from the roof to the storage vessel. Guttering comes in a wide variety of shapes and forms, ranging from the factory made PVC type to home made guttering using bamboo or folded metal sheet. In fact, the lack of standards in guttering shape and size makes it difficult for designers to develop standard solutions to, say, filtration and first flush devices. Guttering is usually fixed to the building just below the roof and catches the water as it falls from the roof. Some common gutter shapes and fixing methods are shown in Figure 8.2.

Figure 8.2: Gutters and fixings



8.3. Water filtration

Again, there are a wide variety of systems available for treating water before, during and after storage. The level of sophistication also varies, from extremely high-tech to very rudimentary. The simple trash rack has been used but this type of filter has a number of associated problems: firstly it only removes large debris; and secondly the rack can become clogged easily and requires regular cleaning.

The sand-charcoal-stone filter is often used for filtering rainwater entering a tank. This type of filter is only suitable, however, where the inflow is low to moderate, and will soon overflow if the inflow exceeds the rate at which the water can percolate through the sand. Settling tanks and partitions can be used to remove silt and other suspended solids from the water. These are usually effective where used, but add significant additional cost if elaborate techniques are used. Many systems found in the field rely simply on a piece of cloth or fine mosquito mesh to act as the filter (and to prevent mosquitoes entering the tank).

Post storage filtration include such systems as the upflow sand filter or the twin compartment candle filters commonly found in LDC's. Many other systems exist and can be found in the appropriate water literature.

8.4. First/ foul flush systems

Debris, dirt, dust and droppings will collect on the roof of a building or other collection area. When the first rains arrive, this unwanted matter will be washed into the tank. This will cause contamination of the water and the quality will be reduced. Many RWH systems therefore incorporate a system for diverting this 'first flush' water so that it does not enter the tank.

There are a number of simple systems that are commonly used and also a number of other, slightly more complex, arrangements. The simpler ideas are based on a manually operated arrangement whereby the inlet pipe is moved away from the tank inlet and then replaced again once the initial first flush has been diverted. This method has obvious drawbacks in that there has to be a person present who will remember to move the pipe.

Other systems use tipping gutters to achieve the same purpose. The most common system uses a bucket that accepts the first flush and the weight of this water off-balances a tipping gutter which then diverts the water back into the tank. The bucket then empties slowly through a small-bore pipe and automatically resets. The quantity of water that is flushed is dependent on the force required to lift the guttering. This can be adjusted to suit the needs of the user.

Another system that is used relies on a floating ball that forms a seal once sufficient water has been diverted. The seal is usually made as the ball rises into the apex of an inverted cone. The ball seals the top of the 'waste' water chamber and the diverted water is slowly released, as with the bucket system above, through a small bore pipe.

Although the more sophisticated methods provide a much more elegant means of rejecting the first flush water, practitioners often recommend that very simple, easily maintained systems be used, as these are more likely to be repaired if failure occurs.

8.5. Water extraction devices (handpumps for sub surface tanks)

There are a number of designs of handpumps currently being investigated at Warwick and in Uganda for the extraction of water from below ground tanks. The findings are published as a DTU Technical Release (TR-RWH09 The Manufacture of Direct Action Handpumps for use with Domestic Rainwater Harvest Tanks)

8.6. Treatment of rainwater for potable supply

A number of post storage treatment techniques are recommended. Boiling water is the most commonly recommended, but it is seldom practised. Ceramic candle filters are easily purchased in most major towns in Africa, but their cost is often prohibitive. A technique that is being widely recommended currently is solar disinfection or SODIS. This technique requires only clear glass or plastic bottles that are filled and then placed in the sun for one day. More detail is given in Appendix VII. It is also worth remembering that in many cases contamination takes place during secondary storage or during water handling, due to unsanitary conditions.

9. MECHANISMS OF DISSEMINATION

9.1. Candidate mechanisms for dissemination

Any programme of disseminating a new developmental technique should be built upon evidence that the technique

- has a reasonable chance of meeting important and basic needs in a sustainable way, *and*
- requires an input of 'outside' effort to overcome specific obstacles to its adoption, *or*
- deserves to have its adoption accelerated.

Many useful innovations in the Target Area in recent years have occurred without any non-commercial promotion – the widespread uptake of burnt bricks and iron roofing sheets for housing, bicycles for transport, and plastic jerrycans for water are good examples.

Domestic roofwater harvesting is increasingly practised in the Target area by a minority of better-off householders, and during the last 5 years metal gutters have appeared for sale in many hardware shops. However it has been perceived as too expensive for poor rural households. Recent research has however demonstrated that, properly installed, DRWH *can* be economically viable for all but the very poorest households – in part because of the increasing commonness of hard roofing mentioned above. The payback time of a VLC system is around 1 year. Because RWH is relatively 'capital-intensive', it may need linking to micro-credit programmes or other means of spreading its cost over between 6 and 24 months.

Large (institutional) RWH systems require considerable care in construction and have been the subject of governmental or NGO training programmes for some years [FAKT & KRA, 1997]. Smaller domestic RWH systems have also been promoted, on the basis of their potential to reduce water-collection drudgery, their prospect of providing a focus for women's groups and the absence of familiarity and relevant skills.

Any promotional programme, once it has established that there are benefits in a technology being taken up more widely, can select its activities from the following list:

1. provide a continuing subsidy to make the technology affordable to the target group;
2. provide a temporary subsidy to accelerate take up and cover learning risks;
3. supply micro-credit to facilitate adoption of viable but capital-intensive techniques;
4. improve, adapt and test the technology;
5. train suppliers (especially where these are local artisans);
6. organise the provision of key tools or materials not yet available locally;
7. inform potential users (and producers) of the existence of the technology;
8. provide an independent source of quality control;
9. influence governmental or aid policies to facilitate take-up.

Moreover the promotion may be a primary objective or a secondary one – many technologies are disseminated as part of developmental programmes whose primary purpose is to generate employment, redress gender discrimination, empower citizens, improve health, protect the environment and so on. This can lead to considerable conflict in priorities.

Finally the promotion may be intensive or extensive. *Intensive* programmes have a high level of interaction with a small group, usually defined by socio-economic and geographical criteria, and a low 'multiplication factor'. *Extensive* programmes aim to reach a large group by means that have a large multiplication factor. They are necessarily more narrowly focussed and may employ such techniques as politics and advertising to benefit or reach its large and widely-located target group.

9.2. Regional experience of promoting DRWH

There is a surprisingly large number of organisations active in promoting *domestic* RWH in the Target Area, some of whom have been active for over a decade. Moreover other sources indicate a steady growth in 'commercial' DRWH – e.g. the attaching of tanks to middle-class houses by their owners. The formation of the Uganda Rain Water Association in 1998 and the recognition of the technology by Government are further pointers to its growing popularity. It would seem that the proportion of households operating DRWH systems is rising steadily, perhaps by as much as 1% per annum.

However the Study Area as shown on the map in the Introduction of this report, namely S Uganda, NW Tanzania and E Rwanda has a total population of over 6 million and therefore contains about 1 million homes. Against this figure, the perhaps 2000 DRWH systems installed by the combined efforts of the organisations in table 15 above represents but a tiny impact – say 0.2% penetration. Even if the seeds planted by training were to multiply vigorously, it seems unlikely that the number of DRWH systems disseminated by NGOs etc will catch up those in the private sector. In those same households the (purely commercial) penetration of ($100) iron roofing probably exceeds 60% and of ($50) bicycles perhaps 25%.

It is clear from the reports from active RW organisations in Appendix VI, and from the discussions at the Mbarara Seminar which concluded the Study, that non-commercial propagation of DRWH is extremely constrained. Not only is RWH generally treated as part of intensive rather than extensive interventions, but it also reported to be highly and permanently dependent upon availability of external subsidy. Repeatedly it was reported that it is too expensive for most of the population to purchase. The fraction of system hardware costs (i.e. *excluding* training and promotional costs) provided by beneficiaries in the interventions reported varied from about 10% to 70%. Thus there appears to be no sense that these interventions are for 'kick starting' a technology that is ready to run on its own.

One conclusion could be that DRWH, even in its very-low-cost (say $40) form is not affordably by the great bulk of its potential recipients. It is only a technique in a long-term programme of government-funded or Agency-funded provision of better water supplies for those too poor to do other than collect from 'free' natural sources. It may often cost less per household than such alternatives as protecting more springs and wells, or extending gravity-flow schemes, but it is not sustainably affordable. Thus either (a) DRWH should continue to be extended under substantial subsidy – perhaps over 50% of the organisational and material costs of each installation – at the rate that the availability of such subsidy affords or (b) it should be deemed to have failed to affordably meet water needs and aid should be devoted to other more deserving ends.

An alternative view – hardly a conclusion – is that DRWH should be just left to commercially trickle down from higher-income to middle-income households in locations where other water sources are inadequate.

A further option is to strive to reduce both the cost of individual systems and the cost of promoting/supporting them, so hat far more poor households can be reached with a given financial resource. Moreover the threshold of affordability could also thereby be changed so that all but the poorest say 30% of households could access water in this way without outside subsidy.

This Feasibility Study indicated that VLC systems are often financially justified where the 'opportunity cost' of householder time is over say $1 per day.

Table 9.1: Organisations in the region working in RWH

Name **of Organisation**	**Area of Operation** **Country /** ***District*** **county / town** **U=Uganda** **T=Tanzania** **R=Rwanda**	**Type** **of org'n** **Commercial** **Gov't** **Internat'n NGO** **Local NGO**	**RWH type** **Domestic** **Institution'l** **VLC**	**Tech-niques** **Credit** **Demonst'n** **Insallation** **R & D** **Subsidy** **Training**	**Start with RWH** **(approx. year)**
ACORD Uganda	U/*Mbarara,* Oruchinga Valley	I	D,I,V	C,T,S,R,D	1995
ARUCED	U / *Kabarole* Mwenge / Kyenjojo	L	D,V	T,R,I,C	1997
BRATIS	T / *Biharumulo*	L	D,I	T,D,S	1996
JUDEA	T/ *Bukoba*	L	D,V	T	2000
KARADEA	T / *Karagwe*	L	D,V	T,S,I	1987
Lutheran World Federation	R / *Kibungo* & *Gitarama*	I	D,V	C,S	1996
N Kigezi Diocese WATSAN Progr'm	U / *Rukungiri*	L	D,V	I,T,S,D	1991 ?
Rakai Dep't Water Dev't (Gov't Uganda)	U / *Rakai*	G	D,V	T,S,D	1995 ?
Uganda Nat'n Farmers Association UNIFA / IVA	U/ *Mbarara*	L / I	D,V	T,S	1998 ?
Uganda Rain Water Association	U	L	D,I	D	1998
Uganda Rural Dev't & Training Org (URDT)	U / *Kibaale*/ Kagadi	L	D,V	C,T,R,D,I	1996
Kigezi Diocese Water Project	U / *Kigezi*	L	D,V	I,T,S	1994 ?

10. CONCLUSIONS: PROSPECTS FOR EXTENSIVE TAKE-UP OF DRWH IN THE GREAT LAKES AREA

This Feasibility Study was undertaken to assess whether 'very-low-cost' domestic roofwater harvesting has the potential for extensive take up in the Study Area. It found that 'informal' DRWH, using bowls or sometimes 200 litre drums, is already widely practised and that rainwater collection goods like gutters and GI tanks are on sale in many trading centres. Moreover a large (>65%) and growing fraction of households have at least one roof of GI sheets suitable for RWH.

A number of NGOs have been active in promoting DRWH amongst the rural poor in the Area.

However it seems unlikely that their efforts have yet affected more than about 0.2% of the region's households, far fewer than the number practising DRWH because they can afford its full cost. These NGOs generally hold that for poorer households DRWH can only be accessible if it is strongly subsidised. The activities of NGOs and local government have made the DRWH option far better known and acceptable than a few years ago. Moreover DRWH has been used in a few cases to carry interventions aimed at enabling women to achieve greater status, skills and confidence.

Modelling using rainfall data from various locations in the area indicated that a water store of capacity about 600 litres would enable most households to draw 65-75% of their annual water from such stores, but would still need to collect the remainder from point sources like wells. This relief from water-carrying would be almost total in the wet seasons (about 2/3 of each year) but rather slight in the driest months when carrying distances and queuing times are at their longest. The average annual saving in distance walked corresponds (in this hilly terrain) to a mean time saving of about 700 hours per household per year, worth perhaps $70 at a realistic 'opportunity cost' for time. For households having to pay cash for their water carriage – at typically $0.1 per 20 litres – the benefits would be somewhat greater but at the expense of the income of professional carriers.

At present water consumption per capita is about 13 litres per day. With DRWH this is likely to rise significantly, but only in the wet seasons.

Six hundred litres of storage, including a domestic handpump in the case of underground storage, was shown to be achievable at a cost of around $50 to which might be added $10 for guttering and a downpipe. Three designs of small tank and four designs of simple handpump were developed, tested, demonstrated and used for training. However the cheapest of the stores (a partly underground polythene-lined store) has yet to satisfactorily pass endurance trials.

From this data, and from the various assumptions made, it appears that counting reduced walking time as the sole benefit, the 'payback time' for investment in VLC DRWH is about 1 year. This is an acceptable but not outstanding figure, indicating broad economic viability provided that promotion costs do not exceed say $10 per household. The availability of suitable credit would make take-up much easier for the poorest households. For households that are particularly poorly located with respect to point sources the payback period may be as low as 6 months. The benefits accrue more to women and school age children than to men.

No conclusive data was collected in this Study concerning the health or safety impacts of greater DRWH usage, although studies elsewhere indicate that they should broadly be more positive than negative.

Overall it was found that DRWH could bring considerable benefits to the majority of households in the Study Area, is likely to continue to expand into higher-income households and has considerable potential for adoption by low-income households if artisan training and either credit or modest subsidy can be provided.

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APPENDICES

APPENDIX I
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APPENDIX IV
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APPENDIX VI
Partners in DRWH – organisational profiles

APPENDIX 1: PARTICIPANTS AT THE RWH SEMINAR, MBARARA, 19TH – 21ST JULY 2000

List of participants by name

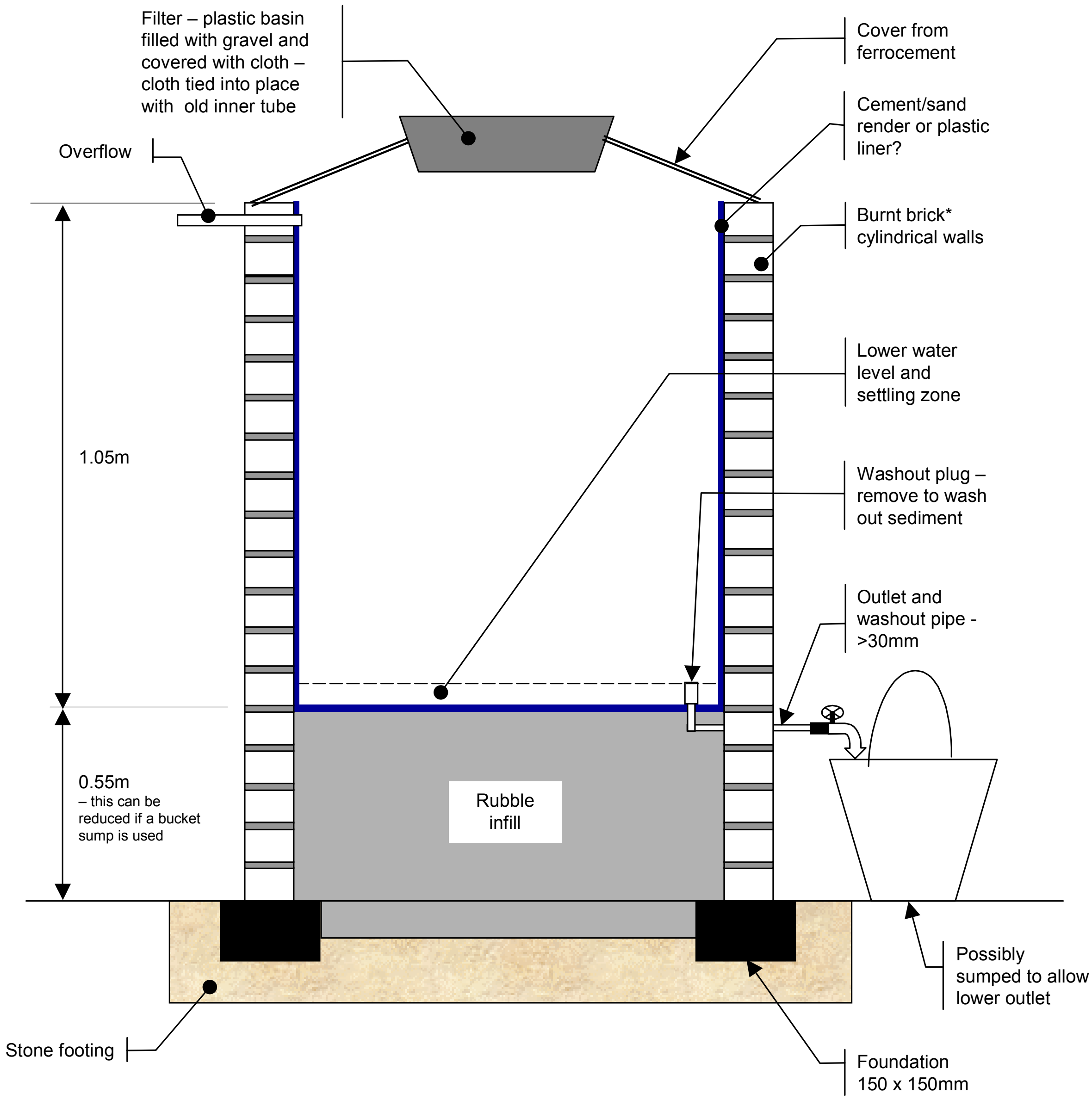
	Name	Organisation
1	Mr Angelo Nzigye	Biharamulo Rural Appropriate Technology and Innovations Society (BRATIS)
2	Mr Byaruhanga Moses	Uganda Rural Development and Training Programme (URDT)
3	Mr Nirere Sam	Uganda Rural Development and Training Programme (URDT)
4	Mr Victor Turyamureba	Uganda Rural Development and Training Programme (URDT)
5	Mr Oswald Kasaizi	KARADEA
6	Mr Mugisa Kimarakwija	ARUCED
7	Mr Charles Rwabambari	ACORD
8	Mr Edward Ahimbisibwe	Kyera Farm
9	Mr Timothy Tibaijuka	JUDEA
10	Ms. Caritas Mukankusi	Lutheran World Federation (LWF)
11	Mr Ssemanda Edward	Rakai District Water Development Department
12	Mr Bariyo Rogers	Mbarara University of Science and Technology (MUST)
13	Mr Turyaramya Moses	IVA Mbarara
14	Rev Eric Kamutera	North Kigezi Diocese
15	Mr Kaleega William	DWD, Mbarara / Uganda Rainwater Association (URA)
16	Rev George Bagamahunda	Kigezi Diocese Watsan Programme
17	Mr Swithen Nyakaana	DWD Mbarara
18	Dr Terry Thomas	Development Technology Unit
19	Mr Dai Rees	Development Technology Unit

List of organisations participating in seminar

Organisation	email	physical address	Contact person	Tel / Fax
Uganda				
ACORD (Oruchinga Valley Project - Mbarara)	acordug@uol.co.ug	PO Box 1394, Mbarara, Uganda	Charles Rwambambari (Water)	T 256 41 256 41 267667 / 267668 F 267669 (Kampala)
URDT	urdt@swiftuganda.com	PO Box 24, Kagadi	Mr Byarushanga Moses Mr Victor Turyamureba Mr Sam Nirere	T 256 0483 22820/1
ARUCED		PO Box 1028, Kyenjojo, Kaberole district	Mr Kimarakwija Mugisa	T 256 (0) 483 22756 F 256 (0) 483 22636 (Fort portal post office)
Department for Water Development – Rakai		PO Box 1, Rakai, Uganda	Mr Ssemanda Edward	
Uganda Rainwater Association (URA)	wesw2.dwd@imul.com	DWD Kampala	Kimanzi Gilbert (DWD Kampala) Kaleega William (DWO Mbarara)	T 077 500602 (Mob) 220374 / 220560 (Office)
North Kigezi Diocese WATSAN		PO Box 23, Rukungiri	Rev Kamuteera Eric	T 256 486 42230
Kigezi Diocese WATSAN	kdwd@imul.com	PO Box 3, Kabale	Rev George Bagamuhunda	T 0486 23940
Kyera Farm		PO Box 1577, Mbarara	Mr Edward Ahimbisibwe	
DWD Mbarara		PO Box 704, Mbarara	Mr Swithen Nyakaana	T 256 485 21011 Mobile 256 077 594518
MUST	highland@imul.com	PO Box 1410, Mbarara	Mr Barigi Rogers	T 0485 20642
IvA (Mbarara)	rottiers@africaonline.co.ug	PO Box 1592, Mbarara, Uganda	Mr Moses Turyaramya	
Tanzania				
BRATIS	drdp-biharamulo@twiga.com	PO Box 79 Biharamulo, Kagera, Tanzania	Mr. Nzigi Angelo	T 028 255 222634 F: 255 66 23222 (via post office)
Karagwe Development Association (KARADEA)	ndeki@unhcr.ch	PO Box 299, Karagwe, Kagera	Exec Sec. Oswald E. Kasaizi	T 255 66 22541/22971 F 255 66 22541
JUDEA – partner org of IvA (Bukoba)	mayawa@twiga.com	Bukoba	Mr. Timothy Tibaijuka	
Rwanda				
Lutheran World Federation (LWF)	lwf-rw@rwandatel1.rwanda1.com	B. P. 2831, Kigali	Ms. Caritas Mukankusi	
UK				
Development Technology Unit	dtu@eng.warwick.ac.uk	DTU, School of Engineering, University of Warwick, Coventry, CV4 7AL, UK	Dr Terry Thomas (Director) Mr Dai Rees (Researcher)	T 44 24 76522339 F 44 24 76418922

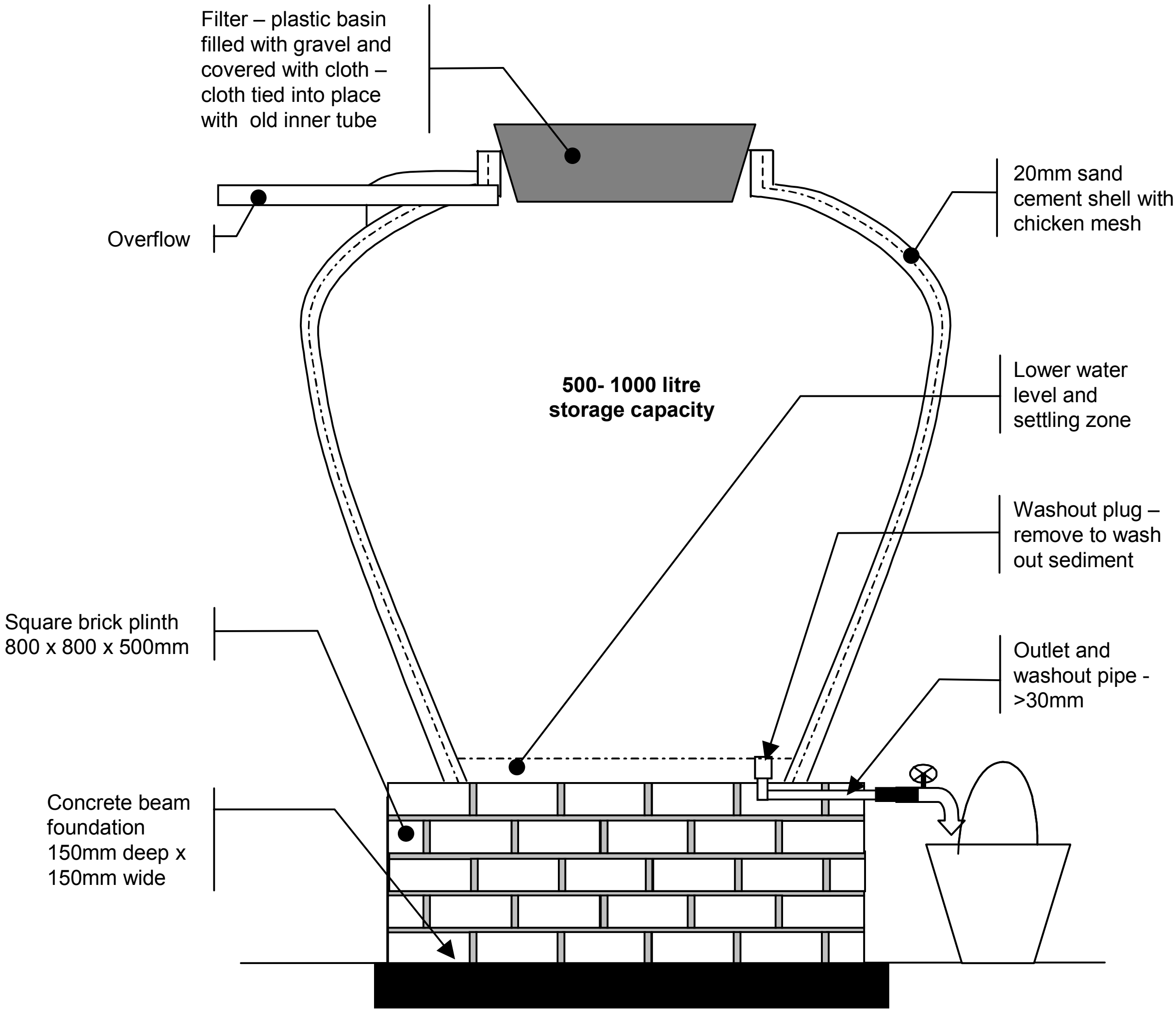
APPENDIX II: DESIGN DRAWINGS (VLC RWH SYSTEMS)

Brick jar – 750ltr



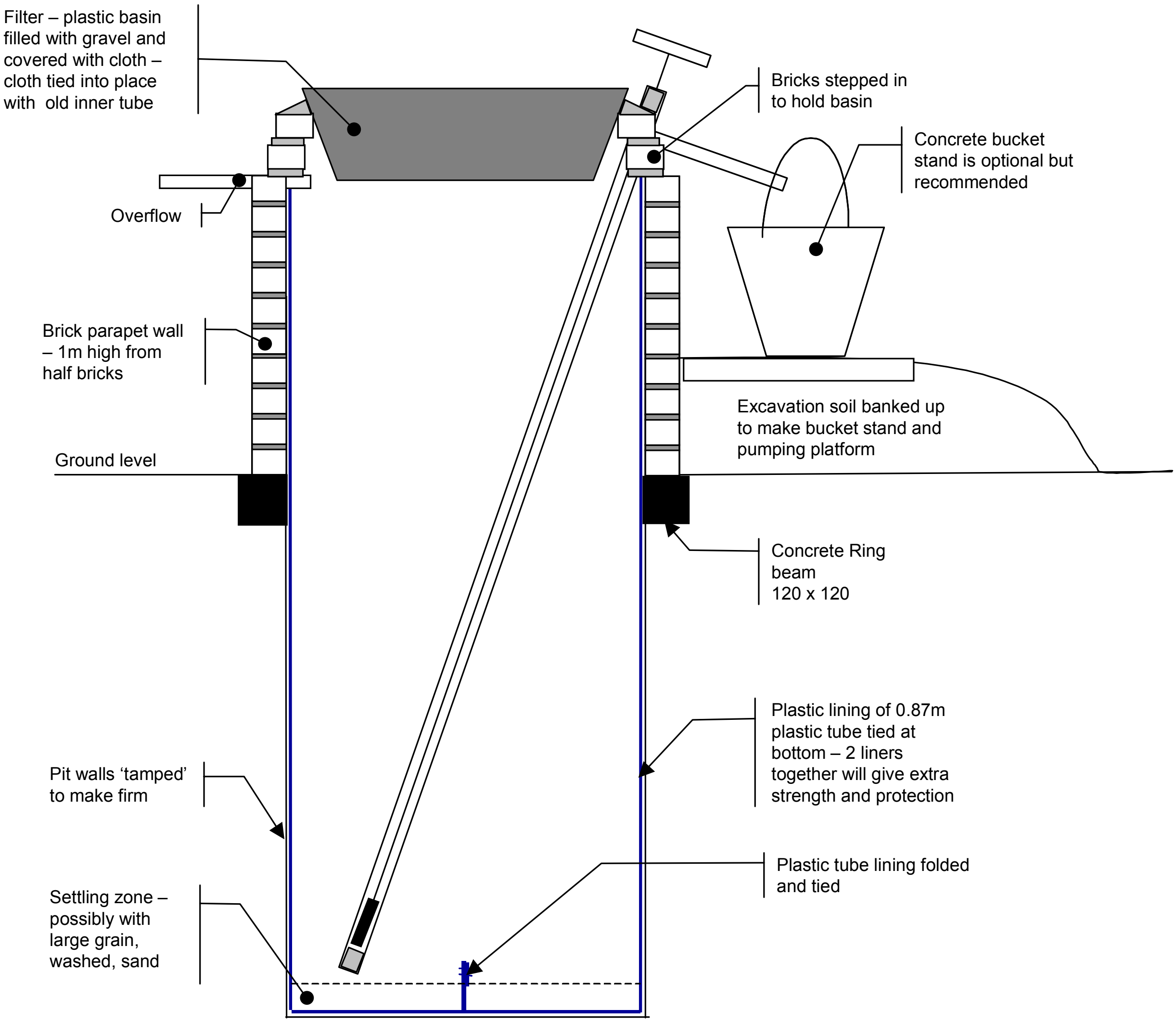
Notes:
- Number of courses – 21* * Burnt brick size – 225 x 100 x 75mm
- Number of bricks per course - 14
- Total number of bricks - 294
- Shaping of bricks or using half bricks
- Cover - conical from ferrocement
- Good stone footing under foundations – 100mm deep
- Size of tank will be about 750 litres useful storage capacity
- If drainable bucket sump is possible then infill section can be reduced, reducing number of bricks for construction

Ferro-cement jar – 500ltr



Notes:
- This version of the ferrocement jar uses a polypropylene sack mould that is filled with sawdust / rice or coffee husks and is then rendered. It uses an optional single layer of chicken wire. The level of skill required (based on recent experience in Kyenjojo) is quite high. Size is about 500 – 1000 litres depending on size of mould (dimensions below for 500 litre mould).
- There are a number of alternatives: using block moulds, wooden moulds, making cylindrical tanks using a number of different mould types,
- We could possibly simplify the design by using a collapsible cylindrical or octagonal mould. This would be easier to handle and transport

Plastic tube tank –600ltr



Notes:

- This a small version of the tube tank and could be developed to give a storage of say 600 litres or so.
- A handpump developed for use with this tank is very low cost and very low maintenance.
- This version uses a tube of plastic sheet which is turned up and tied (0.87m flat tube is available on the market). Two layers of plastic offer extra protection against leakage. The 0.87m (flat) plastic tube gives a diameter of 0.55m. This is the internal diameter of the tank.
- The capacity for each metre of depth is 230litres. Digging inside the pit can be difficult, but is aided by using a long bar and a long handled hoe. Depths of 2 metres can be reached this way, and with the 1m of parapet wall this gives a capacity of 600litres.
- The sand in the bottom prevents damage of the liner should someone enter the tank and aids cleaning (the settled matter can be scraped from the sand.
- The tank will be monitored for the following: damage, durability, cleaning, repair, replacement.

APPENDIX III: SMALL JAR COSTS

Ferrocement jar costs

Item	Unit	Number required	Unit cost	Total cost	Total US$	Total £
Cement	kg	68.5	300	20,550	13.70	9.26
Sand	kg	245	20	4,900	3.27	2.21
Aggregate <50mm	kg	40	25	1,000	0.67	0.45
Bricks	no	100	42	4,200	2.80	1.89
Rubble	kg	75	0	0	0.00	0.00
Chicken mesh 0.5"	m	3.2	1,667	5,334.4	3.56	2.40
GI Pipe 1"	m	0.5	4,200	2,100	1.40	0.95
GI Elbow 1"	no	1	1,500	1,500	1.00	0.68
PVC Pipe 1.25"	m	0.5	1,667	833.5	0.56	0.38
Tap 0.5"	no	1	5,000	5,000	3.33	2.25
Reducer 1" – 0.5"	no	1	1,500	1,500	1.00	0.68
Basin	no	1	1,000	1,000	0.67	0.45
Labour (skilled)	days	2	5,000	10,000	6.67	4.50
Labour (unskilled)	days	4	3,000	12,000	8.00	5.41
	Material costs			47917.9	31.95	21.58
	Total cost (including labour)			69917.9	46.61	31.49
	Cost per litre stoarge			95.84	0.06	0.04
	Cost per litre storage (incl labour)			139.84	0.09	0.06

Notes

1. Mould cost not included - cost of mould is approximately 6000 Ush and may last for up to 10 or 15 jars depending on care taken during manufacture
2. Larger sizes of jar - say up to 1500 litres - can be achieved by experimenting with the mould size
3. Wall thickness is approximately 20mm but varies due to bag shape. Keeping the wall thickness of the f/c to the suggested thickness helps keep cement costs down.
4. Sawdust is obtained from local sawmills (sometimes at a small cost)
5. The volume of the jar is obtained by using a bucket of known volume and counting the appropriate number of buckets of sawdust
6. The jar can be made without the plinth, but water extraction is then difficult - dipping with a container can then be practised. This would significantly reduce the cost of the jar
7. Some transport costs included (i.e. for sand, aggregates and bricks)
8. Cost of bucket slab not included
9. Omitting the tap reduces cost but contamination is more likely to occur

Brick jar costs

Item	Unit	Number required	Unit cost	Total	Total US$	Total £
Cement	kg	92.5	300	27750	18.50	12.50
Sand	kg	390	20	7,800	5.20	3.51
Aggregate <50mm	kg	40	25	1000	0.67	0.45
Bricks	no	300	42	12,600	8.40	5.68
GI Pipe 1"	m	0.5	4,200	2,100	1.40	0.95
GI Elbow 1"	no	1	1,500	1,500	1.00	0.68
PVC Pipe 1.25"	m	0.5	1,667	833.5	0.56	0.38
Tap 0.5"	no	1	5,000	5,000	3.33	2.25
Reducer 1" – 0.5"	no	1	1,500	1,500	1.00	0.68
Basin	no	1	1,000	1,000	0.67	0.45
Labour (skilled)	days	2	5,000	10,000	6.67	4.50
Labour (unskilled)	days	4	3,000	12,000	8.00	5.41
	Material costs			61,083.5	40.72	27.52
	Total cost (incl labour)			83,083.5	55.39	37.43
	Cost per litre storage			81.44	0.05	0.04
	Cost per litre storage (incl labour)			110.78	0.07	0.05

Notes

1. Some transport costs included (i.e. for sand, aggregates and bricks)
2. Cost of bucket slab not included
3. No mould required
4. The tank size can be increased slightly by increasing diameter, but tests should be carried out to determine the strength of the jar.
5. Omitting the tap reduces cost but contamination is more likely to occur
6. Where the ground slopes suitably, the plinth height can be reduced, thus reducing cost

Plastic tube tank costs

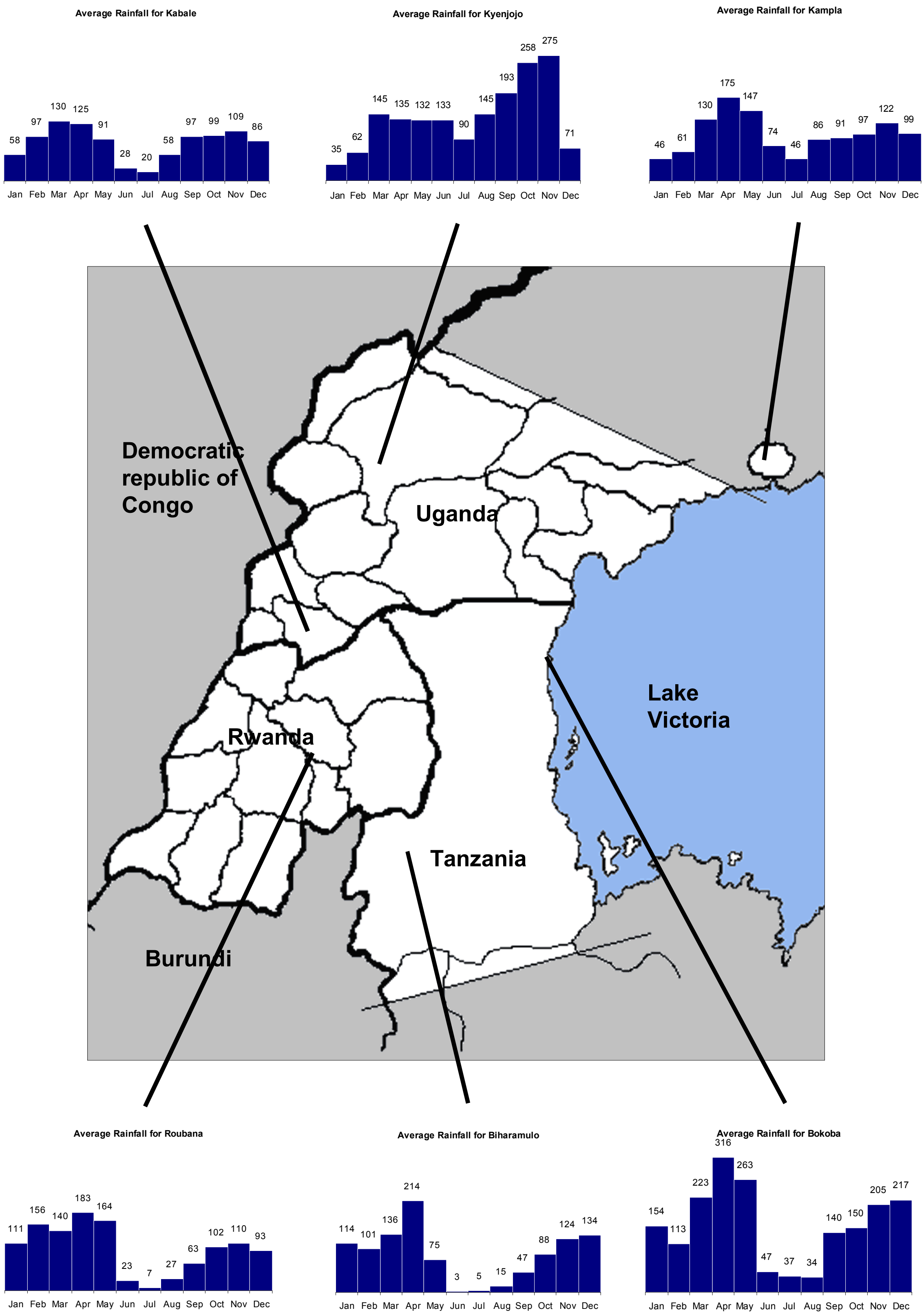
Item	Unit	Number required	Unit cost	Total	Total US$	Total £
Cement	kg	33	300	9,900	6.60	4.46
Sand	kg	136	20	2,720	1.81	1.23
Aggregate <50mm	kg	20	25	500	0.33	0.23
Bricks	no	115	42	4,830	3.22	2.18
Harold pump	no	1	15,000	15,000	10.00	6.76
PVC Pipe 1.25"	m	0.3	1,667	500.1	0.33	0.23
0.87 flat plastic tube	m	6	1,000	6,000	4.00	2.70
Basin	no	1	1,000	1,000	0.67	0.45
Labour (skilled)	days	1	5,000	5,000	3.33	2.25
Labour (unskilled)	days	2	3,000	6,000	4.00	2.70
	Material costs			40,450.1	26.97	18.22
	Total costs (incl. labour)			51,450.1	34.30	23.18
	Cost per litre storage			67.42	0.04	0.03
	Cost per litre storage (incl. labour)			85.75	0.06	0.04

Notes:

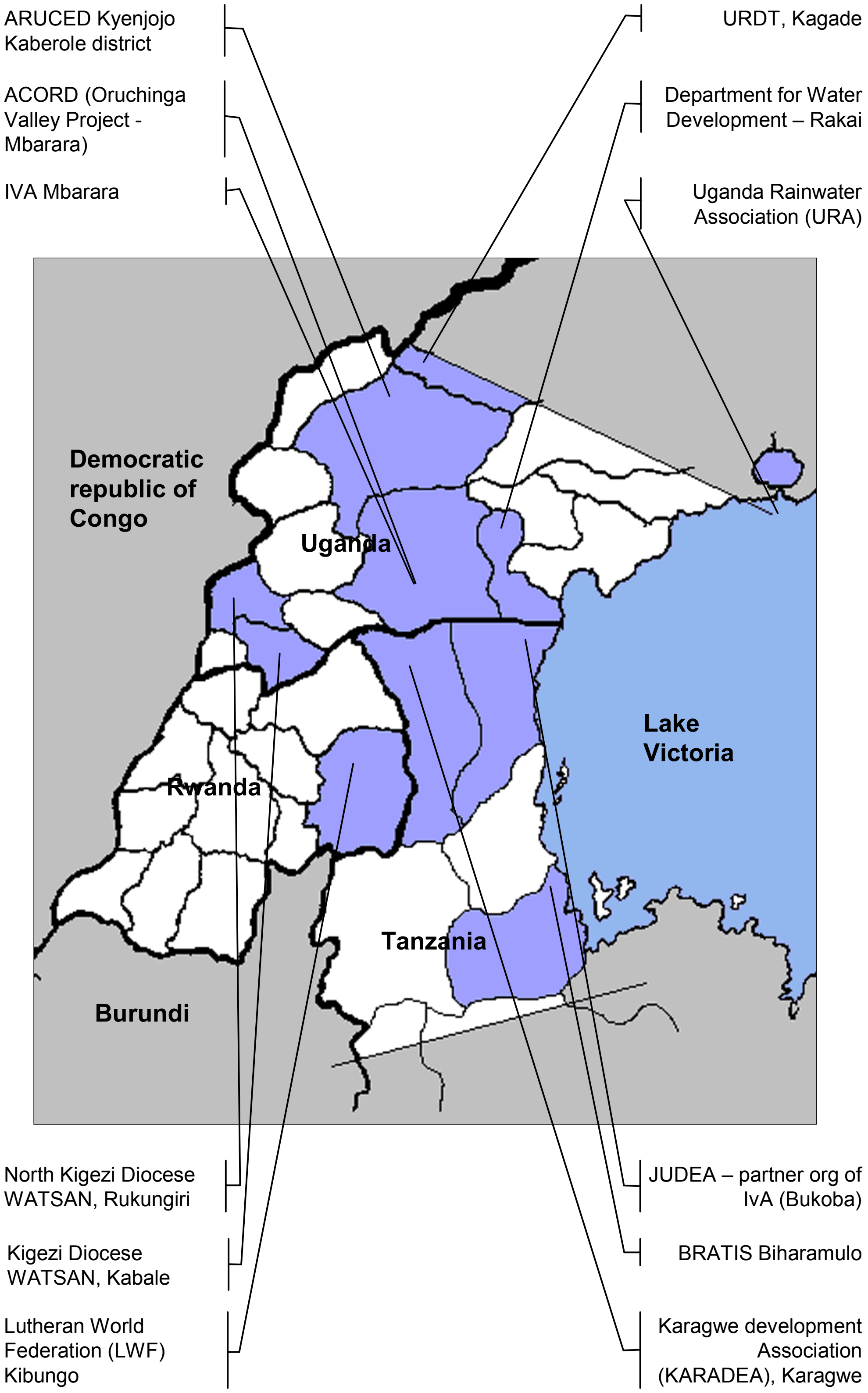
1. Diameter of Jar is 54cms
2. Diameter of polythene sheet is 55cms
3. The ring is cast at 54cms
4. Some transport costs included (i.e. for sand, aggregates and bricks)
5. Cost of bucket slab not included
6. The handpump can be omitted but water is then more prone to contamination and the lining is more likely to be damaged

APPENDIX IV: MAPS

1. Map of the Target Area showing average annual rainfall



2. Distribution of organisations



APPENDIX V – MINUTES OF SEMINAR HELD 19TH & 20TH JULY 2000 AT MBARARA

The two-day Seminar was held at the Pelikan Hotel, Mbarara, Uganda

Timetable for the seminar

DAY 1

9.00 a.m. - Opening address - Kimanzi Gilbert - DWD

9.05 a.m. - Self-introductions by participants

9.15 a.m. - Dr. Terry Thomas - Introduction to the Seminar and its objectives

9.45 a.m. - Mr. Swithen Nyakaana - the findings of the Feasibility Study - a brief overview

10.15 a.m. - Break for coffee

11.00 a.m. - Presentation - the experience in Rukungiri (North Kigezi Diocese) - followed by discussion

12.00 a.m. - Presentation - the experience in Karagwe (Karadea) - followed by discussion

1.00 p.m. - Break for lunch

2.00 p.m. - Presentation - the experience in Rakai (DWD) - followed by discussion

3.00 p.m. - Break for coffee

3.30 p.m. - Presentation - the experience in Rwanda (LWF) - followed by discussion

4.30 p.m. - End of Day 1 Activities

DAY 2

7.30 a.m. - Breakfast

8.30 a.m - Field visit 1 - **UNIFA** (Tarpaulin Tank)

10.00 a.m. - Field visit 2 - **Kyera Farm** - (Small jars, Partially below ground tank, Ferrocement tanks, Experimental Rammed Earth tanks, Grass roofs). *Tea will be served at Kyera Farm*

12.00 p.m. - Return to Mbarara

1.00 p.m. - Lunch at Pelikan Hotel

2.30 p.m. - Mr Dai Rees - technical issues related to small-scale RWH - followed by discussion

3.00 p.m. - Discussion - small-scale RWH Technology

3.30 p.m. - Break for coffee

4.00 p.m. - Time for reflection and comments

5.00 p.m. - End of Seminar

1. Mr Kimanzi was unable to attend the Seminar and the opening address was made by Dr Terry Thomas, who warmly welcomed all participants.

2. Dr. Terry Thomas, Director, DTU, University of Warwick, UK. Introduction to the seminar - background, aims and objectives.

Contents of the presentation:

- Types of Roofwater Harvesting and our focus today
- Small systems
- DTU Roofwater Harvesting Programme
- Key Questions

Dr Thomas discussed the following issues:

- Institutional vs Domestic RWH – and how the bias often been toward large institutional RWH by the funders
- ASAL vs Humid zones – Dr Thomas pointed out that the focus of past RWH programmes has tended to be in arid regions and for full coverage through RWH
- Total, partial, seasonal or casual. Dr Thomas outlined these 4 ‘styles’ of RWH and briefly discussed the relative merits of each.
- Water for people, cattle or gardens? During this study we are concerned mainly with water for people, possibly with a small surplus for animals or the garden.

- Our focus today. Dr Thomas pointed out that we are focusing on domestic, humid zone, partial or seasonal, for poorer people
- "The fifty thousand shilling system". Is this system achievable, and is it affordable and attractive to the poor of the region?

Dr Thomas then spoke about the law of diminishing returns and the relatively good return from a small scale system (e.g. a five day supply of water can give 70% of total water needs, wheras a 100 day supply may only give 95% coverage).

Dr Thomas spoke briefly about the DTU roofwater harvesting programme.

- Dr Thomas then presented some key questions to the participant, questions that he hoped would be answered during the course of the Seminar:
- How does RWH compare with other sources in terms of…….. cost and effort?, ...reliability?,.... water quality - (actual and perceived)?.... ease of installation?….. general image?….. permanence?
- How much can "most" people afford to spend on water supply?
- The practicalities of multi water sourcing?
- Who are best suppliers of domestic RWH systems - householders, fundis, self-help groups, industry, local ngo's, local government?
- What are major constraints to the use of RWH?

Mr. Swithen Nyakaana, DWD, Mbarara (and Social Scientist employed to carry out the Feasibility Study). An overview of the findings of the Feasibility Study to date.

Mr Nyakaana presented the findings of the feasibility study to the participants. He emphasised that there is a need for RWH in the region and that the technology is feasible, both technically and economically. Some of the factors for choice of RWH system include:

- Relief and topography
- Soil texture
- Existing water facilities (e.g. ponds, pans, valley tanks, wells, boreholes, etc.)
- Quality of water
- Demand
- The availability of hard catchment surfaces (usually in the form of corrugated iron (mabate) roofing (figures quoted were Uganda 60 – 80%, Tanzania 40 – 60%, Rwanda – no figures available)
- Maintenance costs are low
- Time saving

He pointed out that RWH is:

- practised locally and the skills required are readily available
- known to local people as a viable alternative water supply
- suited to the area in terms of climate
- suitable to individuals or community groups

The identified constraints were noted:

- Transport and communication are poor and expensive
- Some skills need improving
- There is insufficient choice of technology available
- Information is not readily available in the area – there is inadequate extension service

The Rev Eric Kamutera of North Kigezi Diosece (NKD, Rukungiri, Uganda) then shared the experiences of his organisation with the group.

Rukungiri is situated between 2000 and 3000 above sea level. It is a densely populated area with 200 people per km^2 and an average annual rainfall of 1500mm, falling between March and June and then between September and December. Recently the climate has been erratic and changeable. Rev Kamutera stated that RWH has great potential in the region and already 5000 homes, of the 100,000 or so homes, has DRWH. Water collection in the area is very difficult as the terrain is hilly and very muddy in the wet season. Most of the homes in the area have hard roofs. Since 1992, NKD have been promoting cement jars, ferrocement jars and ferrocement tanks in the region. They have worked closely with Water Aid (who funded the RWH programme) to promote the 250 litre jars, working closely with women's co-operative and women's groups. The aims of the water programme have been threefold:

- to provide wholesome water for drinking (the beneficiaries were advised to conserve the water for drinking purposes only)
- to reduce the burden of women and children
- to supplement existing sources

Some of the systems built have been communal, some for individual homes. There have been some management problems with the communal systems. The average family size is 6 – 8 people.

The constraints faced by the programme were noted as:

- limited funds
- limited storage capacity of the tanks
- problems with management of communal systems
- poor design or lack of choice (particularly covers, inlets and construction quality – some tanks failed due to poor construction)

Local initiative resulted in larger jars – up to 5000 litres) being constructed. These were reinforced with chicken wire and steel bars.

Rev Kamuteera recognises the limitation of their top down approach to RWH dissemination and recently the Uganda Rainwater Association (URWA) has been training women's groups in the area. NKD are convinced that RWH is a serious alternative for rural water supply in their area.

Mr Ssemanda Edward from Rakai District Department for Water Development (Uganda) presented the experiences of their work in RWH.

The rainwater programme in Rakai started in 1997 when a group of women from Kenya trained two groups form Rakai district in the skills of water jar construction and also in self expression and confidence building techniques. The two groups then built a tank for each of the group members using funds from a revolving credit scheme. The Twekembe group now builds tanks for profit as well as being involved in other profit making activities such as jam making and baking. They have trained a further 17 women's groups. The Katuntu group have trained groups from 3 other Districts and some are going to Zambia in September to train women there.

The water situation in Rakia District is difficult. It is a dry area (compared to neighbouring Districts) and the groundwater is highly mineralised. The main water sources in the area are ponds and swamps.

The appraoch taken by Rakai DWD was to 'give' only what was essential – i.e. cement on occasions, but to encourage people to rely on their own resources to supply other materials and labour. To date 300 jars (500 litre) and tanks (2500 litre) have been built in one county, with as much as 30% coverage in some areas. The cost of the jars is approximately 160,000 Ugandan Shillings (£72) and the tank 220,000 Ugandan Shillings (£100).

Please see the report titled 'Rakai Women's Groups Involved in Rainwater Harvesting Activities – Women Leading the Development Process in the New Millenium' (distributed during Seminar).

Next Mr Charles Rwabambari took advantage of some spare time to present the work of ACORD, based in the Oruchinga Valley, south of Mbarara.

The ACORD programme started in the Oruchinga Valley in 1987 with the objective of improving the standard of living of the people and improving household income. The programme identified water as one of the key problems in the area and has developed a programme based on hand augered wells and RWH (Rock catchment, tanks and dams).

However, donors were not keen to support RWH activities. After a visit to the 1993 IRCSA Conference in Nairobi, ACORD staff arranged a visit for a local women's group to the Laikipia region of Kenya. The women in this region had earlier received training in tank construction and were willing to train their Ugandan sisters. The experience is documented in a video titled 'Mvua ni Maji' – Rain is Water.

The implementation method used by ACORD is that for every domestic tank constructed by the group, ACORD provides funding for another tank to be built.

Problems faced by the organisation include:

- inflation
- drought

- no clear government policy on household water security
- poor communication
- dependency on imported materials
- low priority on rural water supply by the authorities

The opportunities include:

- economic improvement in recent years
- benefits of RWH easily seen
- skills are readily available in the region
- RWH provides a better quality of water
- simple O & M
- reduction of burden on women and children

Future work includes:

- continued support for community initiatives
- further improvements in household water security
- further networking with other organisations in RWH

Mr Oswald Kasaizi of KARADEA was next to share his experiences of RWH in the Karagwe District of NW Tanzania.

KARADEA was started in 1987 with the objective of solving community problems. Their location is the remote area of NW Tanzania and they serve an area 6700 km^2 where there is an annual average rainfall of 1000mm (bimodal). They started with 10 integrated projects, provision of water being one of these. The terrain is hilly and water is a serious problem. In 1990 their RWH programme got underway with the construction of 1400 litre jars. RWH was seen as being affordable and managable. A British VSO volunteer who was working with KARADEA at the time helped to start the programme. A 50% subsidy for tank construction was provided by VSO initially but later the tanks were sold at cost price. Meetings in the communities were arranged and women were targeted. Water committees were established with a 75% female balance. Initially things were slow and attendance at meetings was poor, but eventually word got around about the benefits of RWH and things took off. Fundis (male and female) from the villages were trained. Eventually 5 workshops were set up for semi-centralised manufacture (the finished jars [500kg] were transported to site from the workshop on donkey carts for up to 10kms). Selling jars was difficult in this low-income region due to the 100,000 TSh cost, and so a rotating fund was established to help promote the technology. People paid an initial 25,000 and the remainder was then repaid into the fund over a one year period.

Problems faced:

- transport
- very high cement costs (almost 3 times the price of cement in Dar es Salaam)
- competition with other organisations
- low income in the region
- lack of hard roofs in the region

Solutions

- rotating fund established
- subsidised sale of mabate sheets
- external funding sought from Government and NGO's

In 1996 / 97, after the return of the Rwandan refugees from the area, an international NGO copies the KARADEA example but jars were given to beneficiaries. KARADEA could no longer sell jars and so started producing larger ferrocement tanks (10 – 25m^3). These have also been successful.

To date it is estimated that about 600 individuals households have RWH jars. AT the KARADEA HQ water from their numerous tanks is sold for income generation! RWH is seen as being a very promising water supply option but pressure is needed on Government to promote RWH and to alter policies favourably.

The final organisational presentation was given by Caritas Mukankushi of the Lutheran World Federation (LWF), Kibungo, Rwanda.

Rwanda is a country of 8 million people, and 23,000 kms^2 (pop density of 350 / km ^{2}). LWF works with refugees and also in the resettlement camps, where the returned refugees (returnees) are now living. Generally Rwanda is well endowed with springs, and so spring protection and gravity systems are common. But the area where LWF is based do not have these springs. Danida has funded the drilling of boreholes in the area. RWH is limited to the returnee settlements in the arid Kagera National Park. The technology used is a 1200 – 1800 litre ferrocement jar which is built onto a bamboo basket mould. The tank is for individual household supply, uses 200kg of cement, has a wooden cover and costs between US$220 and US$250. LWF realise that the cost is high.

Identified constraints

- High cost – the community cannot afford to purchase the tanks themselves
- Limited rainfall
- Limited skills
- Poor information dissemination

After field visits to both the premises of the Uganda national Farmers Association (UNIFA) and Kyera Farm Training Centre, there was a presentation by Mr Dai Rees of the DTU, titled 'Technical issues related to small-scale Domestic RWH'. The content of the presentation is outlined below:

- What is small-scale RWH?
- Why small-scale RWH?
- The benefits of small-scale RWH
- Reverse economies of scale
- Actual benefits to the user - a study in Kabarole District
- Some low-cost technologies for small-scale RWH - experiences at Kyera Farm

Firstly Mr Rees described what he sees as being small scale RWH

- Storage capacity of 500 - 1000 litres
- Provides several days storage for a typical household (but not inter-seasonal storage)
- Suitable for partial water supply
- Used in conjunction with other water sources e.g. distant spring or borehole
- Suitable for humid climates with evenly distributed rainfall
- It is low-cost and therefore affordable by poorer families

He then looked at why small-scale RWH is well suited to the region:

- Low-cost and therefore more affordable
- Suitable for local construction by artisans, women's groups, farmers groups, etc.
- Suitable for regions with evenly distributed rainfall pattern e.g. SW Uganda, Rwanda, NW Tanzania
- Adoption can be incremental – people buy more capacity as and when it can be afforded
- A significant supplement to existing sources - say providing 50 - 80% of total domestic water supply

He then looked at the sensitivity of annual coverage to roof area, daily demand and tank size, using rainfall figures for Mbarara to demonstrate the point and also using figures form a recent study carried out in Kabarole District (Uganda) where a number of small systems have been built by the DTU and ARUCED.

Mr Rees then went over the costs and designs of for the small RWH systems that had been seen at Kyera Farm earlier in the day (and are shown elsewhere in the Report document).

Finally Dr. Thomas led a discussion as to the future of the DTU's involvement in RWH in the region. He particularly tried to ascertain what the participants saw as being the most suitable dissemination strategy for the region for the proposed dissemination programme for which the DTU hope to secure funding. The discussion homed in around two differing strategies, namely a product based, market orientated approach or a more traditional developmental approach as exemplified by the Rakai experience. The participants were divided as to which may be the 'best' option and different organisations felt drawn to one or other (or both) of the strategies. It was generally agreed that it would be interesting to proceed with both approaches and to monitor the outcome.

APPENDEX VI - PARTNER ORGANISATIONS IN DRWH

North Kigezi Dioceses:

Organisation location: Rukungiri district in SW Uganda

Visited by Swithen Nyakaana May – July 2000

Population: Rukungiri district = 390,780

The organisations main activities:

The North Kigezi Diocese WATSAN is a water and sanitation organisation. It is funded through its religious background and aims to improve people's development. People apply for support from the church in various fields: Water and sanitation, primary health care, farming and tree planting. The organisation has majored in water supply improvement and advancement of H/H water technology. The organisation is funded by the church and has worked in partnership with Water Aid U.K.

Administrative structure:

The organisation is divided into two sections, the management and the extension team. The management is composed of the co-ordinator, spring supervisor and the hygiene and sanitation group leader, and these are supported by the Water Aid representative. The extension team is composed of the water-jar officer, senior fundi (mason/craftsperson), sanitation senior fundi, sanitation/hygiene educator, driver/mobiliser and the contractors (fundi's). There are 10 people in the team; 3 of these are women and they deal with the software within the programme. The target group is organised by the local councils, chiefs, religious leaders, opinion leaders, CBO's and NGO's.

Topography and physical features:

The area is hilly with some very steep hills (around 250) separated by narrow valleys. The valleys have seasonal rivers but few springs. The people live in these areas because the soils are very fertile; crops grow well though there is a problem of lack of markets. This is attributed to bad roads and steep terrain. The problems faced due to these features are shortage of water, bad roads, little income due to poor markets, a burden of carrying water loads on the steep terrain. The water that is available from seasonal rivers is often dirty. The soils are loamy/clay, stony and volcanic soils. The hill slopes have stones of varying sizes. The grounds are very stable, pits are unlikely to collapse, so unde ground tanks can be constructed. In the valleys, there are some sandy pits, the sand is mixture of clay and silt. The sand is not currently used for tank/jar construction.

Rainfall: 800-1000mm

The area experiences rainfall mainly in two phases March to May and Sept to Dec. There are some trace rains in late July and August.

Economic activities and major crops:

Rukungiri is mainly a subsistence farming area, the crops grown include, banana (grown for food and beer brewing) maize, rice, beans, millet and potatoes. Most of the crops are eaten by the H/H.

Major H/H expenditures:

The main expenses for H/H's include, school fees, health services, agricultural implements, paying for labour charges, building houses, water jars, clothes, drinks, food and dowry payments.

Purpose for intervention in RWH

The purpose of the organisation's intervention with RWH is to focus on areas with people in the Rift Valley & other hilly areas with either no springs or only unprotected springs. The organisation intends to promote RWH as a technology, because there is a lot of potential due to widespread hard roof coverage (70% - 85%) and sufficient rainfall (800-1000mm). RWH will reduce water shortage and amounts of water loads being carried by women & children from the valleys.

Achievements of the organisation

The organisation focused on training women groups in jar construction in the sub-counties of Bwambara, Kihiihi, Kambuga and Nyarushanje. The total number of group members trained has been forty but most of the group members have failed to use the skills due to lack of money. It takes a very long time for the group to collect money among themselves, due to low incomes. The women groups are constructing 800 l tr jars costing USh.120,000/-.

The organisations approach is basically training and demonstrations. The groups being assisted are those that have been in existence for some time. The group selects a site for the demonstration and the community takes responsibility for managing the facilities. The organisation has a sanitation component, so group member are required to ensure that latrines are available.

Agency's opinion about effectiveness:

- The organisation supports the promotion of small water tanks/jars. The beneficiaries have expressed the need for training in the construction of Ferro- cement tanks.
- The organisation lacks external support as Water Aid no longer work in the district.
- The organisation has learnt that technology development requires a strong economic base from the beneficiaries.
- The organisation has trained groups in jar construction but it feels there is need to make improvements in making jar covers also guttering is a problem.
- RWH is not only an alternative water source but can also be an income generating activity, especially to women groups…

  Example: Mrs. Mungereza was asked what she has benefited from her membership of a water group.

  > *"I call upon fellow women to join the groups, at first people thought it was time-wasting. But now, after constructing my 3000 ltr tank in addition to 350 ltr water jar. In the previous rain season, I sold water & got USh.80,000/-; I was about to sell all the water but I reserved some for my H/H. From the money, I have bought home utensils. My husband and has promised to support me in constructing another tank".*

- The organisation, looks at the people as poor, so there is need for subsidies to these people so that they can get started.
- The organisation is seeking support from donors, because the water problem is still on.

Observation:

- The groups could benefit from being informed on ways of disseminating existing technologies, e.g. phased construction can help the beneficiaries rather than advocating big tanks, as they claim to being poor.
- The organisation has emphasised the promotion of above-ground tanks/jars and underground tanks have not been demonstrated, however the inclusion of the latter could have given the beneficiaries another possibility to choose from.

ACORD

Organisation Location: Orichinga valley, Mbarara district

Visited by Swithen Nyakaana in May–July 2000

Population: Mbarara District = 930,772

ACORD started in southern Sudan in the early 1950's in war torn areas by inter-agencies response to people's problems. The organisation was initiated by Oxfam to solve people's problems by relief and community rehabilitation by initiating income-generating activities. The other partners in funding include Britain, France, Europe, Canada & Belgium. ACORD has many branches in Africa and one of which is in Mbarara.

ACORD Mbarara operates in the southern part of Mbarara District bordering Tanzania. The project offices are in the Oruchinga Valley. The organisation operates in the three sub-counties of Kabingo, Ngarama and Kikagati.

Administrative structure:

ACORD Mbarara has two main sections, management and extension team and employs 20 staff. They work in different sections, i.e. management, field staff & support staff, and cover credit/micro-finance, agriculture, water & Sanitation, HIV (STD) and gender issues. The communities they work with are organised under the local council (L.C) system; other leaders include Chiefs, elders, religious leaders and community based organisations (CBO).

Topography and physical features:

The area is quite hilly with very few natural water sources. The hill slopes are covered with stones and rocky outcrops. The area experiences water shortage, poor communication, limited health facilities, lack of markets due to bad terrain and limited extension services.

Rainfall

890mm

Economic activities in the project area:

The basic economic activity is subsistence agriculture. Banana growing is the main H/H income earner. Other activities include keeping animals, growing beans, & groundnuts, brick making and stone sales Some people in the area salary earners.

Purpose of intervention and opportunities for RWH

The organisation started by assisting refugees & distributing seeds but this was gradually phased out. A self-reliance participatory methodology took root and people started requiring other services such as support for income-generating activities. The purpose for the organisation's intervention in RWH was to improve the quality and quantity of water for H/H and sanitation and hygiene.

The target group was the population with water stress in the three sub-counties of Kabingo, Ngarama & Kikagati. These are the areas where H/H experience water shortage most of the time because the area has limited natural water sources. A limited number of individuals have tried out their own water ponds. There has been an increase in the population as many people have been migrating to the areas but the water sources remain scarce, this is one of the reasons behind the organisations intervention.

The availability of hard roofs in the area is 90% the catchment area the average H/H is 54m2. People have started income generating activities. They are ranked rich = 17%, medium 65%, poor =15% and destitute = 3% so the money can be channelled to technology development

Impact:-

- Some women have started home gardens and zero grazing.
- H/H have built individual tanks
- The trained artisans have got employment
- RWH has been considered as a supplementary water source.
- H/H with tanks collect less water from more distant sources

Achievements of the organisation

ACORD supported the communities by training interested groups in demonstration tank construction, which includes providing transport for all materials. The capacity of the demonstration tanks are generally 6m3. A ferrocement design of about 4 m3 and a much cheaper, partly-underground, tarpaulin design have been developed and promoted. In the case of the former, a group of 9 women build and share tanks until there is one at each household. A few much larger community systems have been built in plateau areas. Where ACORD has trained, the skills are now available and people have initiated low cost tarpaulin tanks, and the people have a spirit of working together. The average H/H tank cost USh.400,000/- to USh.600,000/-, 48 tanks have been constructed after the demonstrations.

Specific problems of water collection and availability of water

Women and children mainly carry out water collection, though the children have been noted as the ones that collect the most water for H/H. During serious droughts men are hired to transport water from more distant permanent sources (springs, gravity fed systems).

The people expressed problems with accessing water, lack of finance, high charges for skilled labour. The cost of a 6 m3 tank is USh.150,000/-. There is a high transport charge for the sand: 7 tons of sand cost USh.20,000/- but with transport this becomes Ush.100,000/-

Agency's opinion of effectiveness

Training: Identified groups should be trained by use of demonstrations at the beginning of the project, and tours conducted to view new technologies. This is seen as a valuable method of awareness creation. It creates economic empowerment, reduces costs for the project, the multiplier effect is high and the skills remain within the community.

Subsidy: Quick project implementation and enhances group participation which creates a sense of ownership.

Private water provision (RWH): To benefit the poor the provision should be through group formation by selecting a feasible technology, then the poor can plan for the tank size according to their economic base.

Organisations Future plans: Continuity and sustainability:

To train artisans & pump mechanics, involve government structures (e.g. LC5s) & District extension staff, train groups in accountability and group dynamics and give the groups a chance to originate the choice of the technology. As a multiplier mechanism, locked up information can be disseminated via seminars and inter-agency forums to form a common front.

Observations

- For a project to succeed there is need to first initiate and sensitise the communities/target group to initiate income-generating activities, then invest in the technology development.
- Training, demonstration and subsidising costs makes the technology advocated far simpler and awareness takes root in a short time.
- The organisation has mainly one type of technology, this being the ferro-cement tank. The community may still miss a more favourable option, which could have a higher adoption rate.

The organisation has put a limit in terms of tank size which it can subsidise (i.e. 6m3). This may have been a problem to the target group by not giving them chance to choose the type and size of tanks to build.

Rakai District Water Development

Organisation Location: Rakai district

Visited by Swithen Nyakaana, May – July 2000

Population: Rakai District = 383,501

The organisations aims and activities:

The organisation deals basically with rural water development and is under local government control. The partners in funding are SIDA and Rakai District Administration.

Administrative structure:

The organisation is composed of water staff, health assistants, community development assistants, drivers and a secretary. As a means of dividing out the extension activities, the department employs a district water officer, county water inspectors, sub-county health assistants, and sub county community development assistant as well as drivers and secretaries.

Due to the nature of the work there are few women involved in the hardware section, though one women is in the field of community development. The communities are organised under the leadership of LCs, religious leaders, opinion leaders, cultural leaders, NGOs and CBOs.

Topography and physical features:

The area has gentle and steep hills (15°-25°) with no rivers and few swamps. The valleys have seasonal water bodies due to ground run off. These ponds provide water for both domestic and animal use. The main problems faced due to the physical features are poor road networks because of the hilly terrain and a lack of clean and soft water. A notable feature of the District is that its soils are highly mineralised. Any water in contact with soils is either salty or changes colour owing to this mineral contents: thus little groundwater can be used.

The soil texture varies depending on the area, i.e. silt in valleys, hilltops have murram with graded stones and sandy /clay in other places. Some areas have under-laying rocks at 3m deep. The ground and soils are stable which favours underground tank construction. The sand from the valleys is used for the mud rendering of house walls but is regarded as of poor quality.

Rainfall: 800-1000mm

The area experiences two rainy seasons, one in March-May and the second in August-December.

Economic activities in the project area:

Mainly subsistence farming with banana plantations (grown for both food and beer), coffee, potatoes (Irish and sweet), maize, beans, animals (hens, goats) and brick making.

Purpose for intervention in RWH

The purpose for the organisation's intervention in relation to RWH was to promote an alternative source of water for H/H's and reduce walking distance to collect water. It also aimed at tapping water before it touches the ground as this would prevent it becoming so highly mineralised. The target group for the organisation's intervention is H/Hs and women in particular.

The organisation basically deals with training. The women are required to form groups, and then apply to the Chief Administrative Officer; then the District Water Officer assesses what the group requires. Demonstration training for the group is conducted on site with selected group members. The philosophy in all the steps is participatory and the technology being promoted is on jars and Ferro–cement tank construction. The groups requested specific training skills for constructing bigger tanks of 3000-6000 ltr. Underground tanks have not been tried out though it is hoped that the cost may be much less. However, there is need to analyse the effect of cement on the highly mineralised soils.

Achievements of the organisation

The training in tanks of bigger capacity, using welded mesh as a mould has already been done. The welded mesh is provided by the organisation after which the training is left with the community. Most of the jars constructed by the women groups are of size 1500 ltr, they cost USh.250,000/-. The bigger ferro-cement tanks of 7000 ltr cost Ush.510,000/-. The communities note that the ferro-cement tanks are are cheaper per litre than jars.

Women groups have been empowered and they are constructing RWH facilities on their own. The three women groups in Rakai have constructed tanks on the H/H and have been given a chance to organise and plan for what they want, other than being guided by the support agency. Women groups have become more group oriented after seeing that group formation makes things easy.

Specific details:

Rolf Winberg a representative for SIDA's E Africa office in Nairobi responded to the people's call in relation to the mineralised water problem. Through the District Water Office, womens group representatives and some staff members travelled to Kenya to train in rainwater jar construction. After the training, the women formed three womens groups and started constructing water jars.

Agency's opinions for effectiveness observations

- Communities should be supported and guided to identify their needs, then they should be given a chance to organise themselves.
- There is need to integrated sector in development in order to achieve high adoption rate in the technology being advocated for.
- In development, there is no need to form parallel bodies when working in the same area. There is need for integration and support to each other.
- Dissemination of skills and training is the best tool to be handed over to communities if they are to work on their own with minimum external support.
- Women are the basic elements to faster change. So to every intervention there is need to involve the most affected persons, they know their problems better.
- Let the groups start from where they are with their limited resources. As their income base stabilises, they will demand more complex

facilities which will suit them at that particular time.

- Private water provision is more feasible when done at H/H level, this develops a sense of ownership

Observations

- Demonstrations make participants more involved and they can see their potential benefit; this leads to strong groups, and it encourages other new members. The people tend to demand more services, which leads to building capacity in the target group (planning and implementation).
- Empowerment starts with skill dissemination, which leads to self-reliance in both decision-making and a demand for more needs or support.
- Credit schemes were found more effective when beneficiaries raised the funds for the scheme themselves
- Subsidies to target groups activates group formation and a sense of ownership is developed. This further creates competition among the group members and the adoption rate is high.
- Provision of key components helps the group to access non-locally available materials commodities. The organisation's presence is felt.
- Construction in phases: communities should be encouraged to start where they are by building small tanks. The demand for others can be met by continuous construction of other small tanks with in the limits of their economic base.
- Sustainability: the basic strategy for this involves training, involving local leaders on ground and the beneficiaries, should use their own resources to multiply the technology.
- Technology development: for the technology to develop there is need for other income-generation activities by the potential adopters of it. RWH as a programme on its own is difficult to adopt or develop when the income base is very low. Technology development can be hindered by several factors, lack of extension services and/or lack of markets/income. There is need to work in an integrated way by involving other agencies that deal in those particular fields.
- Many people have abandoned tank construction due to fear that the sand is bad and the structures would crack. So, there is need to support the communities with transport facilitates so that cost of this critical raw material can be lowered.
- Most people are negative when looking at communal water structures, because such structures often end up in the possession of individuals.

  Case Study: "A communal water tank of 30m3 was constructed at the chiefs' house because it had the biggest catchment in the village. After one year the chief made a fence around his home and bought dogs, the people then abandoned the tank". This showed that the group lacked any laws to guide them in case one of them lacked trust from fellow members.

KARADEA (Karagwe Development Association).

Organisation Location: Kagera Region of NW Tanzania, bordering Uganda & Rwanda

Visited by Swithen Nyakaana, May – July 2000

Population: Not known

The organisations aims and activities

The association was initiated by both the community and the donors, A British volunteer Alice Morris strengthened the project with a grant from Britain. The grant at the start was used in conducting sensitisation workshops, and for training fundis in water jar construction. Sweden gave aid to the association with the intention of improving peoples living standards by providing clean water.

KARADEA's objectives include "the emancipation of women" and it contains 31 women groups. Its activities, as reflected by its organisational sections as listed below, include administering three loan funds, seminars for women and help to orphans RW jar construction has been undertaken for 13 years. Although for 2 years high cement costs and the temporary intervention of a new (refugee-support) NGO providing free jars interrupted this activity.

Administrative structure:

KARADEA has the following sections: Water, Health & Nutrition, Solar, Finance, Appropriate Technology, Education & Research, Women's Development, Afforestation and Youth Development. The water section is sub divided with technicians and a water contractor who work on a part-time basis. They have an annual general meeting with the board of directors, the executive secretary, and heads of department. There are more women than men on KARADEA's staff because the programme is intended to assist women in easing their problems.

Communities are organised under village leaders, opinion leaders, religious leaders chief and NGO's. The most active person in mobilisation for the development programmes is the Village Executive Officer.

Topography and physical features

Generally the whole region is quite hilly.

Rainfall = 1000 mm

The region receives two rains, one in February–May and the other in September-December.

Economic activities in the project area:

The main income generating activities is subsistence farming. Most of the products are consumed at H/H level; these are beans and maize. Ground nuts, bananas, tomatoes and coffee are the main cash crops.

Purpose for intervention in RWH

The organisation recognised that access to water was very limited and in 1987, with assistance from Sweden and Britain (under Alice Morris), training artisans in jar construction was initiated.

Achievements of the Organisation

They introduced plastic bags of 1000 ltr, after some time it was discovered that they were prone to damage by termites. The bags were finally rejected by the communities. After the training the jars were bought by the individual beneficiaries. There is still a demand for services from the project by the community. Beneficiaries then started applying for assistance, the organisation would make costs for them depending on the distance from the head officer or nearby workshop, the beneficiaries would prepare the platform (the seat for the jar). The organisation provides transport for the jar from the workshop and makes/provides gutters. People are allowed to pay in instalments: contracts are made specifying when to fulfil the payments.

The common technology is the sand/cement (mortar) jar of 1400 ltr costing TSh.5,000/-. Some people have started constructing ferro–cement tanks and underground stone masonry tanks.

The quality-control advantages of manufacturing jars in specialised workshops have been offset by the difficulty of then transporting them (fragile and heavy) across difficult terrain. At one stage donkey-cart transport was introduced into Karagwe solely for this task. As a means of reducing transport distances, five workshops branches have been established. These are managed by the beneficiaries some of whom are employed in the workshops. Branches make reports to the heads of departments and the executive secretary. Every department makes reports on the activities conducted.

The organisation promotes training for both staff and beneficiaries. Two approaches are used to train staff, an expert is called in to train specific sections or staff are taken to selected institutions.

Agency's opinions about effectiveness:

- Training: the beneficiaries, artisans and staff involved in new technologies are a means of creating more awareness.
- Demonstration: the organisation does not use H/H demonstrations, but shows models in public places or jars are taken to exhibitions/open shows.
- Establishment of branch workshops: to reduce contact distance for the beneficiaries and organisation.
- Formation of groups and water committees: as a means of empowering the community. Phased jar construction by individual H/Hs ownership, as a means to meet people's water needs, in

small bits, by building jars in sequences with time.

NB: Very few H/H can construct tanks large enough to meet the whole water needs of a H/H. The common and affordable tank size for a H/H, depending on funds, is 5.6m3 = (4 jars of 1400L). These can be built one after the other. Beneficiaries need assistance in obtaining materials that are not available locally. The organisation success is partly dependent on providing other inputs i.e. transport, skills and supervision).

Observations

- For a programme to succeed there is a need to integrate technology development with other income-generating activities. Very few technologies can be adopted when the income levels for the beneficiaries are very low. Improvements to extension services and markets could lead to technology development
- Many households have more than one water jar. It has been noted the beneficiaries do not feel the total cost when jars are bought at different times.
- Children collect more water in the H/H than the men or women. Both men and women control the funds in the H/H, yet it is the children that suffer from collecting water. Children have no say on the funds to be invested on RWH.
- Jars and tanks may take a long time to buy when the H/H has many children as income is directed to higher priorities i.e. school fees.
- Portable water jars may be a problem when they are carried to areas that are very hilly.
- Jars are not made by individual H/Hs due to concerns that:

  1. It can reduce the quality of the jar constructed
  2. The cost for transporting sand is very high.
  3. There is a need to subsidise the jars to the community and the people's income is very low.

BRATIS (Biharamulo Rural Appropriate Technology Innovation Society)

Organisation Location: NW Tanzania.

The organisation is located in Biharamulo district N W Tanzania. Five other districts, Ngara, Muleba, Geita, Kahama and Kibondo surrounds Biharamulo. The organisations area of operation is Busenga, Husahunga and Nyakanazi. The head quarters are in Katooke and the other office in Biharamulo town.

Visited by Swithen Nyakaana, May – July 2000

Population: not known

In the initiation of the organisation the target group was not involved, they only benefit from the organisation through awareness creation and training. The organisation started as a voluntary youth group under the Caritas Church organisation (Diocese of Rulenge). After 3 years it become independent and registered in 1995. Mr. Angelo Nzigiye and the youth group initiated the organisation. The partners in funding are comprised of the Tanzania team, the District Council, and subscription by members. 50% of the funds are generated by executing tasks in construction and carpentry workshop

The organisations aims and activities

The broad objective is to animate communities to participate fully in their own social and economic development and aims to establish an organisational infrastructure among disadvantaged people.

Administrative structure

The organisation has a board of six directors, management committees and co-ordinator departments of carpentry, agriculture, entrepreneurship and technology.

Educated women often go to the bigger towns in search for better pay, as gender issues are not viewed as important topic at present. The organisation employs people of low cadre and trains them on the job.

The organisation's activity co-ordination is done through reporting and meetings are intended for planning and ironing out differences. The executive meetings are conducted every Monday while the Board and General Assembly meet every year. Each department reports independently and the reports are then co-ordinated to formulate policy on how the organisation is run.

The communities where the organisation operates are organised by village leaders, religious leaders, opinion leaders, traditional leaders and NGO's

Topography and physical features.

The organisation's area of operation has undulating gentle hills covered with stones and boulders; there are valleys and swamps, which serve as water sources for the area. The soils are fertile with natural vegetation. Firewood is scarce in the area and there are water shortages in the dry periods. Swamp water is dirty, some of the sources are on hills and in the valleys. Soil varies depending on the location: in the valleys there are clay/sandy, on the hills there are the red laterite soils and red loamy soils. The area has large rocky outcrops and the soil stability varies with the location. Sand in the area is available and is used for building constructions.

Rainfall

Not known but likely to be over 1000 mm per year, with 1 long and 1 short rainy season..

Economic activities in the project area:

The major activities are agriculture and the main crops are maize, beans, like coffee, sweet potatoes, keeping goats and cows. Other sources of income are charcoal manufacture, brick making, salary earners, carpentry and tailoring.

Purpose for intervention in RWH

The purpose for intervention in RWH was that there was a limited number of water sources available. The low amount of 10L/ per person/day was seen as another valuable reason for RWH intervention.

The organisation's aim is to try out RWH technologies for the beneficiaries to appreciate, adopt and practice (multiply). The main problems are that few people have hard roofs, 50% of 40-50m2 and the technologies appear to be costly. The target groups for the intervention were the villagers and areas with acute water shortage. This would help women suffering from the drudgery of water collection. It is the institutions that have taken up the technology by contracting the organisation to put up large tanks of 43m3 and some institutional VIP latrines.

The entrepreneurship department conducts the economic assessment for the area and determines the beneficiaries' contribution. The organisations approach is in sensitising the community on RWH. Identifying and training the artisans on the selected affordable technologies (jar/tanks). However, the adoption rate is still very low as the target group claims the technologies are very expensive.

Agency's opinions about effectiveness:

- The organisation has no intention of ending its services because the problems in water are still on and the youth groups still need support, so the programme should continue trying to resolve the problem, lack of support and funding are limiting factors.
- The organisation aims at assisting H/H by constructing small jar/tanks of ferro-cement and under ground tanks. Due to low costs.
- As a means of multiplying the technology. The beneficiaries, should is to participate in training to become artisans, the organisation is to give technical advice.
- On information services, the organisation has set up training centres where the youth go to seek advice and new technologies. The organisation has formed a networking forum for local NGOs.
- The organisation supports the idea of public demonstration, but if the first structure fails the idea being demonstrated does not take root. Unfortunately most demonstration systems in public places lack ownership and therefore good maintenance.
- Training the users in system construction may not be economical, when the trainees do not use the skills attained. The better approach is the training of artisans, as skills and employment are created and the multiplier effect is noted when there is the availability of funds. This is further developed if the group's activities are

subsidised, this creates a higher chance hat the technology in question is adopted.

- Most beneficiaries have failed due to lack of key components for RWH. There is a need for the provision of key components & services to be brought nearer, giving a reduction in cost/litre. For example tools and equipment such as moulds could be hired.
- As a means of reducing cost/litre at the time of construction, water provision for the poor should be implemented though group formation and subsidy
- The organisation has started income generating activities, promotion of improved bananas, making tiles – as a means of uplifting H/H income.

Observations:

- According to the organisations approach, if the target group is to benefit and adopt the intended technologies there is need for group formation, subsidy provision and credit scheme association as a means of empowering the individual H/H to construct their own water structures.
- The organisation may have good intentions and approaches in reaching the target group, but with limited funds and support this is difficult. The intended objectives may take long to be realised. Like wise, if the target group has financial constraints, the message and ideas sound beneficial but implementation remains a problems.
- HESAWA (Health through sanitation and water) had different approach in the same area, its approach is more towards donation. (The beneficiaries are required to contribute local materials for a 20m3 structure). This has been a hindering force for BRATIS to succeed. The beneficiaries look at BRATIS's requirements as expensive in comparison to HESAWA.

  CASE STUDY: NGO's with very similar activities may complement each other or compete, to the extent of displacing each other from either the area of operation or the technology".

- According to the beneficiaries' claims, the best tank size to meet the H/H water needs, may be constructed in the phased approach (one jar after another) up to the capacity of (4 to 6 m3).
- The organisation has started on projects intending to raise people's income, (introduction of new banana species, making roofing tiles, carpentry. Many technologies fail due to low income in the target group. No new technology can develop before the target groups' brains are trained and changed towards the new approaches. (Specific training).
- The organisation intends to network with other NGO's but there has cropped up a problem of extra payment to the focal people that run day-to-day activities. This has led to the need for the formation of a secretariat for NGO's.

  NB: (In collaboration there is need to avoid too demanding partners).

JUDEA. (JUhudi DEvelopment Association)

Organisation Location: North west of Tanzania bordering Uganda.

Visited by Swithen Nyakaana, May – July 2000

Population: Not known

JUDEA is a rural development NGO in Bukoba, Tanzania, it focuses on poverty alleviation and improving the living conditions in the rural communities. The organisation was initiated by Mzee Ishengoma and registered under co-operative organisations involving individual partners. The organisation was started on the basis of the individual annual subscription of 5000 TZS, and an entry fee of 2000TZS as the basic funds for the organisation. The Belgians (IVA and VIC) have given support to the organisation. IVA supports agriculture and VIC support JUDEA in under taking drilling. The administrative structure for the organisation is the chairman, the executive committee and the general meeting.

Administrative structure

JUDEA is an organisation initiated and run by retired people, mainly professionals.

Topography and physical features/soils:

The area where the organisation operates has gentle undulating hills, valleys, swamps and rivers. The soils are mainly loamy lateritic and murram. The ground is stable and favours underground tanks.

Rainfall: 1900 mm per annum

Economic activities in the project area:

The economic activities in the area are mainly agriculture or subsistence farming. The main cash crop in the area is coffee. Other crops include beans, bananas & maize etc.

Purpose for intervention in RWH

JUDEA wants to promote RWH as a source of water supply and assist elderly people of Sawata & Sadiawazee Tanzania, by constructing H/H water jars tanks to reduce water stress. The target group for the organisation is the mostly the elderly H/H,s but women and children are a focus as well. The criteria used in choosing areas to benefit from the RWH programmes are those areas that have water stress, no alternative water sources, those with hard roofs and where the people are willing to form groups and contribute.

Agencies opinions about effectiveness

- As the organisation has not fully participated in RWH system building, many of their ideas are waiting to be turned to reality.
- The organisation intends to introduce and promote water jars of 500 ltr to 1000 ltr, and encourage underground tank technology using tanks of capacity 2000 to 7000 ltr.
- The organisation does not intend to end the programme, it wishes to continue but the organisation lacks founders and financial/technical support.
- The organisation has a limited number of staff, due to lack of funds. It intends to establish a training scheme and open up a workshop for water jars, and public demonstration on low cost technologies as a means of awareness creation.
- Though the organisation has not implemented RWH activities, suggestions on possible means on approach & dissemination of RWH technology were noted.
- Group formation, mobilisation and sensitisation for RWH and create a structure, which creates awareness and strengthens RWH as a technology.
- The communities need to be introduced to simple techniques, affordable and with in their financial reach.
- As a tool to promote RWH, there is need to form a collaborative NGO body and implementing agency in RWH to form a common front in promoting the technology.
- Government and community based organisations need to have documented policies regarding the approach & extension to support the dissemination of RWH technology.

Observations

- The organisation has a vision to support the elderly and the poor who have no capacity to contribute towards the services they require. The group would require a grant for the organisation to achieve its goal.
- The other population if mobilised and sensitised would take up the organisations idea because water is a problem to most H/Hs.
- HESAWA (HEalth through SAnitation and WAter) has been operating in the region, so the sensitisation required is not new, and the organisation needs to introduce the feasible technologies and train the target group on implementation.
- The composition of the organisation may cause a rejection by potential groups, as there may be a bias towards elderly people only. There is need to integrate other players in the organisation. The youth and women can play a good role in community mobilisation and sensitisation.
- There is need for both the organisation and target group to train or visit other areas implementing RWH so that the organisation can gain awareness of available technologies. Skilled labour and raw materials could be considered.

IVA + Uganda Nat Farmers Association, Mbarara District

Organisation Location: IVA has its office in Mbarara town, S Uganda.

Visited by Swithen Nyakaana, May – July 2000

Population: Mbarara district = 930,772

IVA is a Belgium farmers alliance service similar to UNFA. The organisation provides funding to support farmers in Mbarara. The organisation works through UNFA members, UNFA members contact the office for technical support /skills development.

The organisations aims and activities

IVA operates throughout the whole of Mbarara district. They use a bottom-up approach when executing the extension, IVA has its representative up to parish/cell level and deals with the grass root farmers.

Administrative structure:

The organisation has a project management team composed of two Europeans and two Africans. The support staff comprise of agricultural teams and a secretary. The target groups are organised through committees, groups and the leaders include LC chiefs, opinion leaders, religious leaders and NGO's.

Topography and physical features:

The organisation's area of operation varies considerably, it therefore deals with hilly areas, valleys without or limited natural water source, valleys with a flat basin, steep hills with rocky out crops like those in Rugaaga S county. The hillsides are used for both crop production and as grazing land. Water sources are few and far between in the hilly regions.

The soils are of a variety, black soils, sand loamy clay soils are found in the valleys, while stony, murram, soils found on the hillsides are very compact and difficult to dig, but may be suitable for underground tanks. IVA operates in one of the areas with the best sand pits (Nyeihanga). This sand is good in jar/tank construction.

Rainfall: 890mm

The rainfall in Mbarara district occurs in February-May and Sept-December with some light occasional rains in July.

Economic activities in the project area:

The income generating activities include banana plantations, coffee growing, animal keeping (cattle, goats, hens and rabbits) sand extraction, charcoal etc.

Purpose for intervention in RWH

The organisation conducting a needs assessment survey in the area which showed a water shortage. Many areas have no or limited natural sources of water. In the survey it was noted that most of the water sources are located in the valleys, with ponds and springs being used for both animal and human use. From this survey IVA felt that they could meet people's needs by introducing RWH systems.

Achievements of the Organisation

In the course of one year 10 groups have been formed and 8 ferro-cement tanks have been constructed. The organisation carries its activities out through UNFA members, at the parish level people are mobilised to form water groups, when groups are formed and contribution accepted two agreements are made one for the group and the other between the group and the organisation. Then group member selects local builders and a demonstration training session is conducted.

Agencies opinions about effectiveness

- IVA promotes training the beneficiary groups as a means to create skills in the target groups. This is done on public demonstration.
- Prior to technology development there is need to create income for the target group so, that the funds from their produce is again put into the new technology development.
- As an entry point there is need for group formation, this encourages the group to access financial support and funds are easily generated for an activity.
- The organisation encourages the idea of inter-agency collaboration, this increase information

flow and there is a gain from sharing the experience and/or technical assistance.

- The communities should not be limited on a particular tank size or technology, the people know their problem best and how to solve them e.g. the organisation demonstrates; on 3000 ltr tank costing USh.400,000/- but the communities now are constructing 5000 ltr tanks.

Observations

- As IVA deals with UNFA members and those that are not members do not have access to the organisations services.
- If UNFA fail to deliver then IVA will also be regarded as having failed.
- H/H with a regular (but low) income could improve themselves through a RWH programme. It has been noted that most of the H/H with rainwater tanks are those that who have benefited form UNFA programmes. Therefore technology development requires external financial support, this can be generated locally or through subsidising.

LWF (Lutheran World Federation) in Rwanda

Organisation Location: The organisation has its country office in Kigale.

Visited by Vince Whitehead, July 2000

Population: Not known, but population or Rwanda is currently 7.3 million and population densities are generally high

LWF is a worldwide religious organisation and deals with humanitarian assistance. It started in 1946 as a world service provider by the federation of Lutheran churches. The partners in funding include the Federation of Lutheran churches of Europe, North American and Australia. The organisation operates especially in areas of Rwanda to which former refugees and IDPs have recently returned, including in the Ndego II sector of Kibungo, Kigarama Departement and in Gitarama Departement. The population served is between 6000-7000 people but the number is increasing, as there are more people returning home.

Administrative structure

LWF consists of a director, a programme co-ordinator, and three project managers there are thirty-two staff in total. Nine out of the thirty-two staff are women.

Topography and physical features:

Much of this area of Rwanda is characterised by high hilly regions and isolated steep valleys. Many of the peaks are rock-strewn, with little vegetation. Lower down the slopes are a mixture of rocky outcrops and lateritic soils. Erosion from the rains regularly causes deep ruts in the unmetalled roads. The occasional hurricane has been strong enough to take the CI sheets off houses. The soils are very stable and favour underground tanks; in the area there are some rocky outcrops.

Rainfall: About 1000 mm

The area experiences rain from February-May and October-December. The Kibungo district was suffering a serious drought during the time of the visit.

Economic activities in the project area:

The main economic activities in the area are the selling of agricultural produce and animals (goats, hens).

Specific details

In Ndego II, people were walking 6 km twice day collect water; the round trip took about two hours on foot and one hour on a bicycle. The water sources in the area include lakes and shallow wells (the wells were protected by NCA, Norwegian Church Aid). Water collection is done by women and children. In drought seasons some people hire others for water collection. In the communes hard roof coverage is 100%, each with a catchment area of only 15-20 m2.

Purpose for intervention in RWH

In Rwanda as a whole, gravity piped water schemes are common. However they are not easily applicable in the specific target areas of LWF. Rainwater harvesting has not been developed much in Rwanda, but the potential of assisting returnees is high. All the roofs in the communes are new and made from corrugated iron, which is an ideal solid catchment area for RWH. Also because of the six month long drought season there is a desperate need to alleviate some of the problems faced with extreme water shortages. Many of the tanks currently built are very costly and have limited capacity, which seems insufficient to assist them through the dry season.

Achievements of the Organisation

Some of the work in building tanks has been built on experience of the returnees from Tanzania seeing the Umutara tanks. The tanks were made from a basket of reeds covered with cement mortar and placed on a stone foundation. The inside of the tank is rendered with waterproof cement. Communities are required to organise them selves via meetings and to provide sand and stones. LWF provides cement, guttering and skilled labour. The organisation has provided credit not specifically for RWH, but to micro-financing and agricultural schemes. There has been very little capacity building through training. One training session for masons was conducted with twelve men and one female being trained in house construction.

Agency's opinion about effectiveness

- The organisation provide materials as a gift to returnees at the beginning, this is now being scaled down and will probably be on a oan basis in future.
- The involvement of CBOs in spring protection, shallow well and gravity flow scheme development. Water committees are formed and representatives are selected. Representatives come together and build up larger bodies for all water system management.
- The communities in Mugesera district were shown video's on RWH by women's groups from Kenya and other realisation developmental communications.
- On the means for collaboration, high demands from the returnees have initiated collaboration from UNHCR/ECHO. This has been used as a methodology to all developmental programmes. The beneficiaries put forward a request for the services they require rather than donors giving them what the donors wish to give.
- The organisation suggests starting with water tanks of small capacities (1.5 or 2 m3) for H/Hs; the more prosperous H/Hs can construct 5m3 water tanks.
- The organisation intends to create local capacities to take over the responsibilities after five years. The idea is still on trial to see if CBO's can look after themselves.

Observations:

- The organisation has had little dealing with RWH technology in the past, but it has a strong need to initiate the advancement of RWH in its region of operation.
- Some tanks in the community for returnees that were observed in the National Parks cost around RFr.20,000 (about \$50) - the high cost was because of the high cement content, transport cost and for a technicians services.
- The area where the organisation is operating is still faced with new returnees and their resettlement, so the technology to develop at the beginning may require a push from the implementing organisation. The returnees have very little to offer and have very little material possessions, they lack any real land security during early resettlement and their contribution may be hard to mobilise.
- Depending on the distance from the existing permanent water sources (lake, gravity flow scheme) the idea of RWH can still be promoted as a jar or tank as an asset for a particular H/H giving water 'on the step'.
- The organisation needs to sensitise communities & train artisans from their area of operation on the new, available & affordable technologies in the region. Tours visits, and demonstrations could be the basic tools in disseminating the information about RWH technology.

Kigezi Diocese: Kabale

Organisation Location: Kabale

Visited by Swithen Nyakaana, May – July 2000

Population: 417,218

Kigezi Diocese Water Project is a church initiated project and aims to ease people's water shortage problems. The partners in funding at present are Tear Fund, Irish Embassy, DFID and the beneficiary- communities. The role of the beneficiaries' community is supplying locally available materials.

Administrative structure

Water Project staff comprises a programme co-ordinator (water engineer), an assistant water engineer charged with construction and an accountant. The organisation has a health component. There are four female co-ordinators responsible for monitoring/ functionality. The construction section consists of masons who build water jars/tanks, spring protections, san plats, and other constructions. The technicians are involved with the plumbing, pipe laying and tap-stand fixing. Higher cadre officers do the supportive supervision. Within the communities are organised through the LCs, opinion leaders, religious leaders and NGOs.

Topography and physical features:

Kabale District is high, cool and very hilly. Population density is very high and for many years Bakiga have been emigrating to other parts of Uganda, There are no significant rivers; springs are located down in the valleys and near to Kabale town there is the picturesque Lake Bunyonyi. The soils are very fertile for crop production, the though the area suffers soil erosion. Cultivatable land is covered with many stones, which makes tillage difficult. The soil is composition of inteharaea(?), murram, sandy/silty soils, and sandy loamy. Many stony grounds are porous, the ground is stable and could favour the use of ground tanks. Sandpits are located in the valleys; the sand is used in building construction.

Economic activities in the project area:

Economic activities in the area are basically subsistence farming, with crops of sorghum, beans, Irish potatoes, sweet potatoes, & millet.

Rainfall: 1000-1200 mm.

The area experiences two rainy periods of March to May and September to December.

Specific details

Most H/H experience water shortage, as springs are usually quite distant. There are long dry spells and small containers are used for RWH. A jar of 350 ltr costs USh.90,000/-. The water shortage is overcome by collecting water from distant places: lakes and permanent springs. RWH is practised by few H/H. Women and children collecting water from springs may be queuing up to an hour during the peak times, walking time for the round trip may be 1.5 hours, which is over steep terrain. Missionaries introduced gravity flow schemes as a means of reduce the amount of time and walking for water. Though gravity flow water routes are determined by the terrain, people who live uphill quite a distance away from a source have their water problems not solved but reduced. Those that have tried out RWH have faced such difficulties as scarcity of money buying sand and transportation of materials to site, skilled labour.

Purpose for intervention in RWH

The purpose for the organisation's intervention is to minimise water-borne diseases, to reduce time spent in water collection and to introduce new low-cost technologies for H/H water supply. The target group is the rural community at both institutional and H/H level, but focussed on relieving the water burden of women and children.

Achievements of the Organisation

The organisations entry point is at the parish level. The mobilisation and sensitisation is done by software on how the contributions are shared. Benefitting H/Hs are required to provide only 'local materials' i.e. earth mortar, while the project provides skilled labour, cement, moulds and gutters. Beneficiaries pay only USh.7000/- (out of a total cost of USh.90,000/-) for a 350 ltr jar. An average H/H can make 350 ltr last for 6 days. The organisation requests a payment for training artisans.

As a means of sharing their experience the organisation collaborates with the District Water Office (Health), LCs, churches, EU, DFID, Irish Embassy, women groups, Tear Fund, Rotary clubs and the government. This has helped the organisation in sharing experiences on new technologies, identified resourceful people and avoided the double counting of RWH structures.

Agency's opinion about effectiveness.

- The communities in the area of operation are poor so there is need to identify low cost technologies within the reach of the low-income base. Even a USh.50,000/- jar seems too expensive for the communities.
- Subsiding should be looked as the only means of encouraging people to start RWH.

Observations:

- The project contribution is very high, though some H/H do not seem to have picked up the donations. With more sensitisation many H/H are now welcoming the RWH technology.
- The organisation has not trained many artisans in the area. For all the works done, the project staff provides the skilled labour. For one to be trained he is required to pay for the training. The community solely depends on the project's skilled labour.
- The organisation has promoted water jars only where people have been looking at small structures. There is need to introduce new technologies, i.e. underground tanks, which are potentially lower cost per litre.