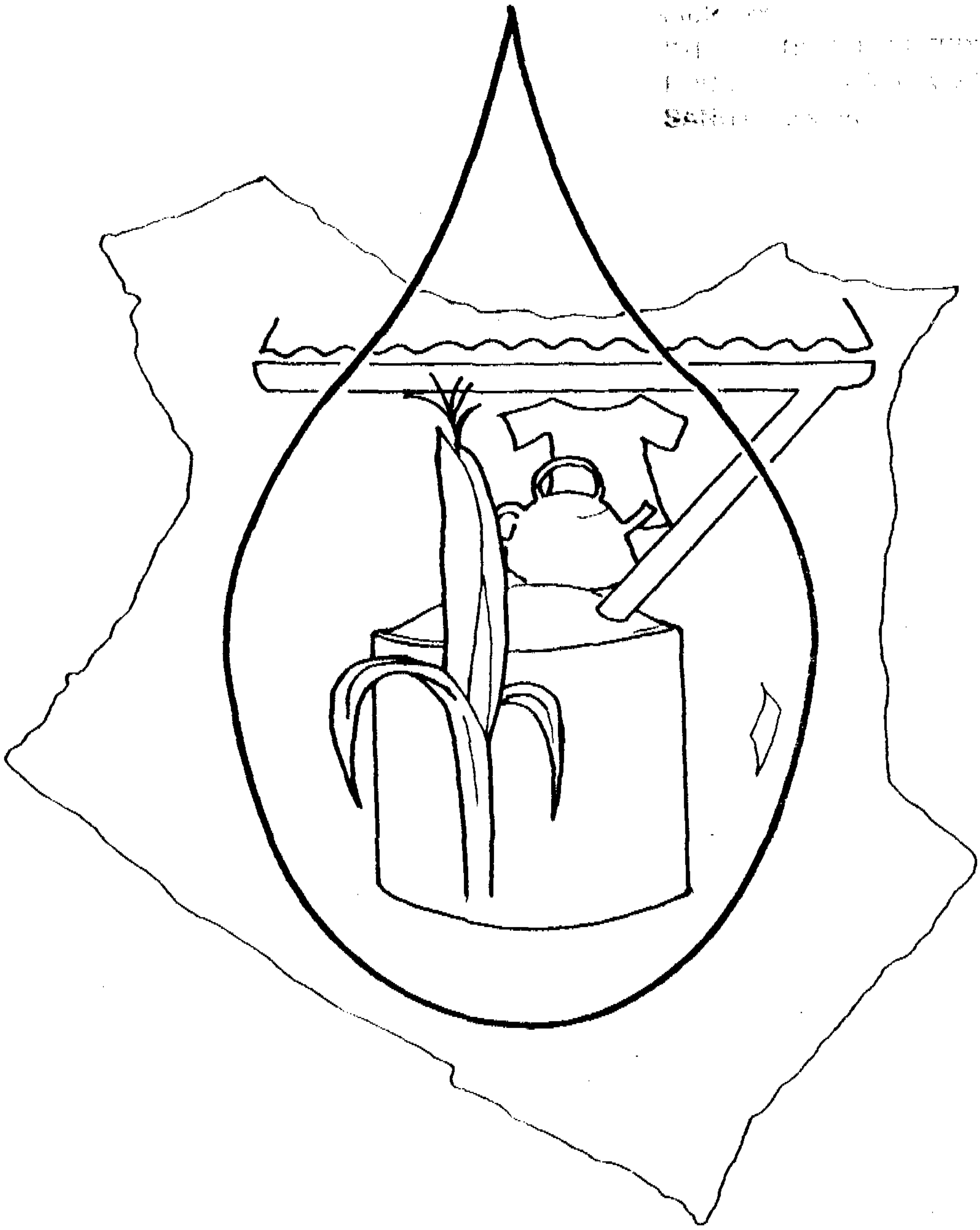
PROCEEDINGS OF THE FIRST NATIONAL WORKSHOP ON

RAINWATER HARVESTING

AT NAKURU ON MAY 28TH - 29TH 1991



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IRCSA

Diocese of Nakuru

PROCEEDINGS OF THE

FIRST KENYA NATIONAL WORKSHOP ON

RAINWATER HARVESTING

At Nakuru on May 28[TH] - 29[TH] 1991

ORGANIZED UNDER

The International Rainwater Catchment Systems Association

BY

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WELCOME REMARKS BY JOHN MBUGUA
Kenya National Representative of IRCSA

On behalf of the workshop organizing committee I wish to welcome all of you to this workshop. A Special welcome is extended to:

Ministry of Water Development official from the headquarters Mr S. Getanda.

UNICEF Kenya country office : Mr Hubert and Mr S Makondiego

IRCSA International Secretary Mr J Gould
Africa Regional Representative Mr E Nissen-Petersen

Representatives from various ministries:
Ministry of Water Development
Ministry of Agriculture
Ministry of Health
Ministry of Development and Reclamation of Arid and Semi-Arid and Wastelands (sent their apologies)

Representatives from various Non Government Organizations: including AMREF, KIOF, INADES, 7 CPK Dioceses, AIC and KENGO.

I will ask the secretary of the International Rainwater Catchment Systems Association (IRCSA) to introduce the association later and will give us the objectives of the association.

However concerning this workshop our goals are:

a) To promote rainwater harvesting technology and disseminate information about it.
b) Link those working in this field so that information and experiences can be shared.

The rationale behind rainwater harvesting technology is that it has proved to be an effective alternative for an urban as well as rural water supply both in developed and developing countries. In developed countries rainwater may supplement public water supplies where as it may be the only alternative in rural areas of developing countries where groundwater is unfit for human consumption or calls on technology beyond the rural's economic and organizational capacity.

While planning this workshop the organizing committee looked into the objectives set out for the 5th International Conference on Rainwater Cisterns Systems to be held in August 1991 in Taiwan, and suggested our Nakuru Workshop could adopt them as guidelines.

These objectives are:

1 To identify problems, constraints research priorities and needs of rainwater cistern catchment systems for providing a safe palatable and cheap water supply.

2 To report on recent advances and technological development to monitor rainwater quality on a long term basis.

3 To develop operational guidelines for efficient management and maintenance of rainwater cistern and catchment systems.

4 To report on positive and negative experiences in transferring of technology to the rural areas of developing countries.

5 To explore potential applications other than domestic water supply to enhance further promotion of rainwater cistern and catchment systems.

I am sure our workshop is not able to achieve all the above objectives, although they are all relevant. Nevertheless it being our very first workshop of its kind, I hope it will yield valuable information for the future. At least we have now met and we will get to know one another, share information and also arrange more inter-visits to each others organization's projects. Many of us are already encouraged by your participation and makes us feel we are not alone in this technology. We have supporters at all levels: Government, multilateral and bilaterals, private and volunteer organisations and finally and not least religious organisations.

Finally, before I call upon Mr Getanda to address us and open this workshop I want to express special thanks to our Bishop, Rt Rev Stephen N Mwangi of CPK Diocese of Nakuru for hosting the IRCSA country office and all the support he has accorded to us during this workshop's preparations.

And now Mr Getanda you are welcome.

OVERVIEW OF MINISTRY OF WATER DEVELOPMENT INVOLVEMENT IN RAINWATER HARVESTING

By Mr Samuel Getanda (Engineer MoWD HQ)

The Ministry of Water Development spends a large percentage of its development vote on planning, designing and implementation of piped water schemes both in urban and rural areas. This is largely because of its public nature and requirements that it serves the public as opposed to establishing roof catchment projects which tend to serve individual, institutions or small communities.

However, in dry and semi-arid districts of this country the Ministry spends substantial amount of funds on developing pans and dams which store rain water for livestock consumption under the Livestock Programme. This is in addition to developing other types of water supplies.

In other districts the major role the Ministry plays is largely on propagation of the idea of roof catchments to the public during District Development Committees, leaders' meetings or barazas. The District Water Engineers are well staffed with qualified personnel who can assist individuals, institutions and communities that want to establish rain water harvesting facilities - by providing designs, skilled labour (artisans) and supervision of such constructions.

NGOs and other Donor Agencies establishing rainwater harvesting facilities work closely with our Ministry staff at field in providing hydrological data, designs and actual implementation.

District Development Committees being the co-ordinators and decision makers on what project to establish are the ones who decide on what type of project the Ministry can fund. If any district proposes a rain water harvesting project then the Ministry will fund such a project.

The Ministry also collaborates with other ministries like Agriculture when dealing with soil conservation and irrigation activities where rainwater can be stored in dams and also Ministry of Public Works when roads are under construction where runoff and storm water is stored in check dams. The water can then be available for livestock consumption during dry weather and also control water from causing soil erosion.

Thank you.

THE INTERNATIONAL RAINWATER CATCHMENT SYSTEMS ASSOCIATION (IRCSA)

By Mr John Gould (IRCSA Secretary)

Background

The establishment of the International Rainwater Catchment Systems Association (IRCSA) was agreed at the 4th International Rainwater Cistern Systems Conference held in Manila, 2-4th August 1989.

Professor Yu-Si Fok was elected President of IRCSA at that meeting and was asked to draw up a constitution and proceed with preparations to establish the association. It was also agreed by the conference that Chairpersons of the Organizing Committees of the International Rainwater Cistern Systems Conferences should automatically act as Vice-Presidents of IRCSA. Prof. Fok has invited a number of individuals to fill key IRCSA positions until these can be formalized at the 5th International Rainwater Cistern Systems, to be held in Keelung, Taiwan between August 4-10th, 1991, when IRCSA will be officially launched.

Objectives of the Association

1 To promote Rainwater Catchment Systems Technology and encourage dissemination of information about it.

2 To attempt to link all those working in this field so that information and experiences can be shared.

3 To draw up a set of international guidelines regarding the use on Rainwater Catchment Systems Technology.

4 To support the contribution of the series of International Rainwater Cistern Systems Conferences.

5 To produce a Quarterly Rainwater Catchment Systems Bulletin.

For further information or enquiries about the International Rainwater Catchment System Association please contact:

Prof. Yu-Si Fok, Dept. of Civil Engineering, Univ. of Hawaii, 2540 Dole St, Honolulu, Hawaii 96822, USA.

Mr John Gould, 43 Miller Avenue, Canterbury, Kent, CT2 8NY, UK.

Kenya Country Representative:
Mr John Mbugua, CPK Diocese of Nakuru, P.O.Box 56, Nakuru, Kenya.

For further information or enquiries about the 5th International Rainwater Cistern Systems Conference please contact:

Mr Show-Chuyuan, Dept. of River and Harbor Engineering,
National Taiwan Ocean Univ., Keelung,
Taiwan 20224 Tel: 886-32-622192 ext 736
Fax: 886-32-620724

UNICEF

By Mr S Makondiege (Project Officer, UNICEF Kenya)

UNICEF stands for the United Nations Children's Fund.

Primary Objectives (1989/93)

1 To support the Government's long-term and short-term plans and commitments to improve the well-being of disadvantaged children and women.

2 To reduce child and female morbidity, mortality and vulnerability to disease.

3 To achieve the global goals for child survival, protection and development to which Kenya is committed.

The World Summit for Children (New Delhi Statement 14 Sept 1990)

This endorsed a number of development goals for the year 2000 (see the Appendix for the full statement)

1 Universal (widespread) access to safe drinking water.

2 Universal (widespread) access to sanitary means of waste (excreta) disposal.

3 Eradication of dracunculiasis (Guinea Worm Disease).

Implementation costs and estimated population (US$ 000)

	89/90	90/91	91/92	92/93	93/94	Total
% Imp	8.1	10.6	27.1	27.1	27.1	100
Inputs Community	503	694	1855	1950	2047	7,049
G of K	1236	1298	1363	1431	1503	6,832
UNICEF Gen. Fund	517	520	520	520	520	2,597
Supp.Fund	983	1480	3781	4368	4887	15,500
Sub-Total	1500	2000	4301	4888	5407	18,097
Gr Total	3240	3992	7519	8270	8959	31,979

Population Served

	89/90	90/91	91/92	92/93	93/94
No of Water Sources	236	310	788	789	789
Population	25,163	33,022	84,093	84,186	84,186
				TOTAL	310,651

STRATEGY

Theme of Government 6th National Development Plan: "PARTICIPATION FOR PROGRESS" with emphasis on:

- Basic Needs
- District Focus Strategy
- Disadvantaged Groups
- Less Development Areas

The actors must be active, these are the Community, Government of Kenya and External Support Agencies.

This requires Community Based Projects, which must be: Affordable, Acceptable, Replicable, Sustainable, and Simple.

Assistance to individual projects should be given through moral/technical support.

RAIN WATER CATCHMENT SYSTEM

The advantage of this system for collecting water is its Simplicity, Cost-effectiveness, and Replicability. The main limitations are the Rainfall (prolonged droughts) and having a large enough catchment made out of an appropriate material.

These limitations can be overcome through the expansion and extension of the storage facilities, and improving the catchment by ensuring it is of a suitable surface material.

APPENDIX

THE NEW DELHI STATEMENT

THE NEW DELHI STATEMENT IS AN APPEAL TO ALL NATIONS FOR CONCERTED ACTION TO ENABLE PEOPLE TO OBTAIN TWO OF THE MOST BASIC HUMAN NEEDS - SAFE DRINKING WATER AND ENVIRONMENTAL SANITATION

THE STATEMENT WAS ADOPTED BY 600 PARTICIPANTS FROM 115 COUNTRIES AT THE GLOBAL CONSULTATION ON SAFE WATER AND SANITATION FOR THE 1990s HELD IN NEW DELHI, FROM 10 TO 14 SEPTEMBER 1990. ORGANIZED BY THE UNITED NATIONS DEVELOPMENT PROGRAMME AND HOSTED BY THE GOVERNMENT OF INDIA, THE CONSULTATION WAS CO-SPONSORED BY UN STEERING COMMITTEE FOR THE INTERNATIONAL DRINKING WATER SUPPLY AND SANITATION DECADE AND BY THE WATER SUPPLY AND SANITATION COLLABORATIVE COUNCIL.

NEW DELHI, INDIA, 14 SEPTEMBER 1990

Copies of the New Delhi Statement and related information on the Global Consultation should now be addressed to: Eirah Gorre-Dale, Co-ordinator, Communication & Information on WSS, UNDP, Palais des Nations, CH-1211, Geneva 10, Switzerland.

ORGANIC FARMING IN KENYA

By Mr J W Njoroge (Director, Kenya Institute of Organic Farming)

The Kenya Institute of Organic Farming (KIOF) began operating in 1986 in response to requests from small groups of farmers who were requesting help to improve their methods and thereby their yields. KIOF promotes the basic elements of composting, double digging , water conservation and biological pest management to farmers in their own communities. The groups are visited by the technical training staff every four to six weeks. In between, field promoters from the area work closely with the farmers at their plots.

Farmers find it useful because they recognize the economic and health benefits. Many subsistence farmers cannot afford to pay for expensive inputs of fertilizer and pesticides. Yet the continued use of hybrid seeds makes the crops very susceptible to attack by fungus and pests. By adopting organic farming methods, the plants have become healthier and more resistant to attack by pests and fungal diseases. The farmers learn to compost which is obviously cheaper than fertilizer. Furthermore, it adds nutrients and enhances the micro life of the soil.

Deep cultivation is another practice that KIOF promotes. This practice breaks the hardpan which has developed from continuous shallow cultivation and persistent soil erosion. By breaking the hardpan, plants benefit from deeper penetration of the roots, aeration of the root zone, and better retention of rain water. As a result many farmers have become self-sufficient in vegetable production on slopes and in "kitchen gardens" next to the house which heretofore were only located in bottom land or near water sources such as streams.

Farmers are taught crop rotation, plant spacing and selection of plants for interplanting. Experimentation and rotations are encouraged on a small scale for different combinations of plants to control pests.

Animal "bomas" or sheds, using bedding of organic material can be cleaned periodically providing basic materials for composting.

Liquid manure is a common and easily obtainable way to add nutrients to the crops. The process is similar to that using nitrogenous chemical fertilizers. Farmers are taught how to develop these manures by collecting urine and fresh animal dung in a container and adding water. The liquid cures into a valuable fertilizer in about ten days. It is then applied at the root zone after diluting with equal parts of water.

Another practice that KIOF promotes is working with biological pest management or botanical pesticides,KIOF has provided a list of local plants that have insect repelling qualities. Among these are common weeds such as <u>Targetes minuta</u> (Mexican marigold) <u>Urtica spp</u> (dioica nettle), others are well known food crops such as chilies, onions, and garlic. Others are grown as cash crops such as pyrethrum and tobacco. Some of these plants such as Mexican marigold, nettle, chilies, pyrethrum and tobacco are made into a tea by soaking the leaves and leaf stems and flowers in water for a period ranging from three to seven days. The tea so made can be diluted with equal parts of water,and soft soap added to create a bond with the leaves of the plants on which it is sprayed. These teas provide protection against most common garden pests, such as caterpillars, aphids, slugs, mites and hoppers. Some teas especially the marigold and nettle also discourage blight and other fungal diseases in vegetables.

Other aspects of the program aim at improving the general environment where the plants are growing. Simple agroforestry techniques provide shade, wind breaks and nitrogen fixing. They can provide fodder also fruit. Techniques for simple contouring, such as the A-frame, control erosion and help retain water.

Recently, KIOF has recognized that water is a limiting factor in Agriculture. For subsistence organic farming, a continuing availability of water between rains is critical. In the districts of Murang'a and Machakos, northeast of Nairobi in Kenya,small self-help farmers groups working with (KIOF) are building water harvesting containers using local materials to reinforce the concrete encasement. The farmers' groups provide labour and local materials. A small grant provides the purchased materials. The group works cooperatively making the 10 foot high (3 meters) basketry that provides the basic structure for the concrete container. One container for each family, located near the kitchen garden, will collect rain water from the roof and store it for use in both use and garden.

Starting with a very small number of groups in 1987, the work of KIOF now extends to some 3,000 farmers in six districts of Eastern and Central Kenya. In order to make the training intensive and real to the farmers, KIOF has set up a network of promoters drawn from successful organic farmers. The promoters are paid a small sum to serve as support for the farmers.

Although initially KIOF sought out groups doing agricultural projects, now groups seek help from KIOF for information and training. This is the result of the demonstration of the specific benefits of low or no cost inputs and higher yields. KIOF uses visits to successful subsistence farmers by new groups as a way of stimulating response and exchanging ideas and information among farmers.

RAIN WATER CATCHMENT FOR FUTURE GENERATIONS

By Mrs T.N.Makanyama (Ministry of Agriculture, Nakuru)

The Ministry is charged with the responsibility of producing adequate and appropriate food for the population.

Objective To ensure that the country is self sufficient in food for its growing population and to have surplus for export.

This comes in form of guidance on Agricultural technology i.e. production of improved seeds, irrigation which are passed to the extension worker and they later teach the farmers and work with them so as to achieve the above. As an individual, one has to be well fed. It is my belief that agriculture plays a very important role in maintaining primary health care.

Basically, these activities are mainly channelled in most cases through the women groups or individual members. Our role with these farmers is to uplift their standards of living both in the rural and urban families through efficient use of available resources by engaging in Agriculture, Livestock and home management activities.

In order to achieve the above objective, water is necessary for growing crops and keeping livestock. Most of our people live in rural areas where they depend mostly on rain water as opposed to their counterparts in the urban centers who have got tap water. Hence to be able to sustain growth of crops of crops, and grass farmers require to plant crops during the beginning of the rainy season. During this season, water has to come down in the form of rain. It can be beneficial or hazardous. Therefore it has to be collected, channelled into reservoirs or retained where it is better use.

This can be done in the following ways:

1 Soil and water conservation. When it rains, water has alot of effect on the soil. If
   a) Terraces are made, water can be retained and used for crop growing.
   b) Use of cover crop on the terrace bank is necessary so as to retain the terrace e.g. Napier grass or other grasses.
   c) On steep slopes (land) we recommend tree and grass planting to avoid erosion by surface water.
   d) Agroforestry reduces the velocity of the rain water.
   e) Other methods of soil and water conservation are retention ditches, unploughed strips, trash lines biological measures.

2 Roof Catchment. This is mainly for rural farmers where by they make structures to catch rain water. These are appropriate technology devices such as metal tanks concrete, cut stones and adobe. The water is mainly used for domestic purposes e.g. cooking, bathing, cleaning, washing clothes & utensils, and sometimes irrigating the families kitchen garden hence enabling the family to have crops grown all around the year and in turn provide a balanced diet to the family. By use of storage water tanks, energy and time used to look for the water are saved and

instead the farmer would use it in a more productive way in the farm. This roof catchment has enabled the farmers to improve their mode of houses by having corrugated iron sheet roofs which has in turn improved their standard of living. This stored water is later on used when the rains are not there since we have dry spells. To date we have a total of 135 women groups with a 5644 membership, 46 groups of which have completed a total of 1156 tanks.

This mode of rain catchment has advantages in that:

a) The families have access to clean, safe water for all the household needs.
b) Durability of the tanks is certain with proper handling.
c) It supports other domestic activities eg. feeding of livestock.
d) Since the woman is the overall worker of the home, when water is readily available to her, she can do alot in the house as most of the household chores revolve around the use of / access to water, hence uplifting their standard of living.

3. Dams, Rivers and Lakes. Nakuru district used to have large scale farms which had dams constructed by the previous owners. These were used for collecting and conserving water for domestic use and irrigation. In both wet and dry season. Some are still in existence.

In areas where there is a problem of poor drainage (stagnant water) the ministry has a responsibility in ensuring that the water is drained by channelling it in dams for use in irrigation and livestock as well as making the land arable for growing crops eg. Kihingo in Njoro division. This covers an area of 300 hectares. There is an expansion potential of another 500 ha.

When rainfalls, the water table at the rivers and lakes is raised. This sustains the farming and life around it through sustainable irrigation in both wet and dry season.

On some rivers, irrigation is done on a small scale and is not expensive in that it uses gravity to take the water from source to the farm without using pumps. Operational costs are minimal as much of the work is done by the community around. An example of this is Lari-Wendani development project in Mbogoini division. It covers an area of 38 ha. but the scheme has no room for expansion now. Lake waters can also be used for overhead irrigation eg. Lake Naivasha where horticultural crops are grown for food and export.

Other areas that the ministry addresses itself to is on rivers and streams. It ensures that they are protected by pegging so that there is not much encroaching by people around it to avoid silting and cultivation along the river banks.

This is done by encouraging the people to plant trees and grasses along the river banks and water sources so that evaporation is also minimal hence conservation of water.

Other aspects that contribute to water catchment for future generations is by improving the environment. This is done by encouraging people to plant trees during the rainy season on bare land catchment areas, public grounds, schools, hospitals, shows, towns and along the roads which can be used as a source of fuel wood and timber as well as attracting rain.

In conclusion, the earth that we are living in is not ours but we have borrowed it from the future generation who are the children. So we must leave it better than we found it.

KENGO'S ROLE IN RAIN WATER CATCHMENT FOR FUTURE GENERATIONS

By Mr David E O Owich (District Team Leader KENGO - Nakuru Resource centre for environment and Development)

ABSTRACT

With increasing human, livestock population and growing Cultural demands there is increasing pressure on all natural resources including forests, land and water.

Their development is an essential prerequisite for the alleviation of food shortage and energy crisis in Africa.

It is obvious that the unity of drainage basin simply is the collection of water over the catchment and its flow through one mouth into a reservoir. In other words, the water within the geographical area of a particular basin constitute a critical resource basis and, therefore, a most useful conceptual unit for establishing a legal regime and for organising co-operation and collaboration for land and water resources development, utilization and conservation.

Water resource planning and development can be rather complex. An integrated river basin development, besides being an evaluation of both surface and ground water resources, is a survey of all the natural resources of the basin. These resources include land resources, human resources, animal resources, economic, social and environmental conditions. Because these resources are interrelated, a multi-disciplinary approach is essential to achieve integrated water resource development. It is imperative therefore to evaluate the characteristics of water resources in Africa in order to assess the benefit that will accrue from harmonious and integrated water development planning.

In drought - prone areas, surface water resources are limited because of loss by rapid run-off from flash floods and evaporation. The development of both natural and human resources in these areas depends on whether conjunctive water use planning can be adopted. The conjunctive water use is a planning concept in which both surface and ground water resources are evaluated planned and developed. Since the use of surface water will likely cause a deterioration of ground water or vice versa, planning of total water resources in a drainage basin is imperative.

Data collection and eventual analysis may be accompanied by an evaluation of biophysical processes and Technological, social and economic considerations. The main purpose of development is to improve the standard of living of the people within the area. It is commendable to solicit their participation on development of their locality at an early stage i.e at the point of intervention in the community Based Development strategy.

INTRODUCTION

Trees are by far the best ground cover to stabilize soil, increase infiltration and protect steep slopes from erosive rainfall. Their role in the infiltration and runoff of rainfall in a rain water catchment cannot be over emphasized. The interaction of these trees with other variables in soil conservation practices are basically geared to increasing infiltration and conservation of water, nutrients, and top soil and increase in groundwater recharge.

Conversely, there are three main physical criteria which have a dominant influence on the hydrological characteristics of the catchment. These are geology, altitude and precipitation. Both rainfall and potential evaporation are strongly correlated with altitude although rainfall is less so in the drier areas. Soils, landforms and drainage networks results from the interaction between geology and climate and may also be altitude dependent. A fourth major criterion of course, is land use or land management which can seriously affect infiltration storage characteristics. The water balance and soil erosion of a catchment.

Rainwater catchment Techniques; The advocacy of the conservation of protected forest areas as a strategy in our extensions programmes has a far reaching effect in the hydrological cycle and the water balance especially so when natural regeneration and enrichment planting is promoted and actually effected in these catchment areas.

While it is unnecessary to detail the many physical process involved, it is useful to examine the broad outline of the cycle so that its interdependence with soil conservation can be seen. Given that the input to this crucial processes are infiltration and runoff which have to be maximized and minimized respectively. How these are interrelated is set out in Table 1 and it can be seen that the soil conservation practices are basically geared to increasing infiltration and conservation of water.

INTERDEPENDENCE OF THE HYDROLOGICAL CYCLE AND SOIL CONSERVATION

TABLE 1

Process/Key Factor	Guidelines for Conservation Optimization
Rainfall	Protection of soil by complete ground cover.
Erosivity	Reducing reflectance
Frequency/Duration	Weather modification
Infiltration	Maintenance of high organic content.
Soil permeability	Prevention of compaction by overgrazing. Breaking up or surface crust and hard pans.
Surface Horizon Depth	Prevention of physical removal by terracing and improving ground cover.
Topography	Terracing to reduce slop length.
Storage Soil moisture	Maintenance of soil depth, structure and humus content
Groundwater recharge	Maintenance of High infiltration rates.
Evaporation	Use of aerodynamically short crops where effect is critical to water balance.
Interception losses Open-water Evaporation	Monomolecular films on reservoirs,covered storage and efficient irrigation systems.
Transpiration	Clean weeding
Streamflow	Increasing infiltration, decreasing slope and protection of impermeable areas i.e roads, paths, school play grounds.

The fundamental reason why agroforestry systems are perceived to improve soil properties is the protection a tree cover gives the soil against surface compaction, runoff and erosion.

Agroforestry system can contain one or more such covers (also referred to as canopies):

(1) a tree-top canopy
(2) a ground cover provided by annual crops or pasture
(3) a surface-litter layer produced by the vegetation when any or all of its components are fully established.

The onset, duration and thickness of ground cover of each type varies widely in agroforestry systems.

There is sufficient evidence that fully developed tree canopies reduce runoff and erosion losses and consequently increases infiltration rates. Kang et al (1985) reported that the addition of Leucaena prunings in a Maize alley cropping system substantially increased moisture retention of the topsoil.

Other than agroforestry practices enhancing rain water catchment, the other techniques employed in rain water harvesting are;

1. Cutoff drain system (Retention ditches)
2. Rough stones mulching.
3. Perforated tins drips system.
4. Bottled water drip system.
5. Bamboo moisture arresting system.
6. Trough basin system.
7. Sunken bed rain water harvesting.
8. Polythene sheet-water harvesting.
9. Runoff harvesting.

GENERAL

Essentially, the land use management strategy forms the best basis in rain water catchment. To enhance high infiltration rates and avoid erosion, management strategies should maintain the densest possible vegetation cover consistent with current land use.

This will help to:

Stabilize the soil and reduce flow velocity,

Provide protection against raindrop erosion,

Absorb the energy of raindrops and wind and thereby reduce particle detachment

Provide shade for the soil thus reducing the rate of moisture loss.

The above is best realized in Agroforestry systems which incorporates the same within the land-use pattern, soil farming processes would then continue unabated enhancing soil-nutrient status and ensuring acceptable storage and subsequent release of moisture to the plants and preventing excessive water loss from runoff. Involving the community in the re-structuring and suitably re-formulating the agroforestry systems, future generations would then be educated to understand better the scientific basis for sustainable and productive land use.

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D.B. THOMAS E.K. BIAMAH A.M. KILEWE L. LUNDGREN B.O.MOCHOGE	1986	Soil and water conservation Kenya.
ESTER SULBERTI	1987	Professional Education in Agroforestry.
JEAN-LOUIS CHLEG HUGUES DUPRIEZ	1988	Land & Life Vanishing land and water

INADES - FORMATION KENYA

By Stanley Riungu (INADES-Formation Kenya)

INTRODUCTION

Inades-Formation Kenya is a Non-Governmental Development Agency duly registered in Kenya as a non-profit making company limited by guarantee in the year 1978.

It is part of Inades-Formation Africa with headquarters in Cote d'Ivoire (Abidjan).

OBJECTIVES

The main objectives of Inades-Formation Kenya National office are:

> "To provide a service of non-formal education and training to grassroot farmers and to adults involved in development and post literacy education".

To support the above objective and preference of being functional, Inades-Formation does the following:

1 Writes educational materials (including audio-visual means) in the field of Agriculture where water catchments and reservations are emphasized.

2 Writes materials on Management for groups and Development workers

3 Writes materials on Perspectives in Development.

4 Intends to start a women programme very soon where materials on the following topics will be developed:
   Project management, Project Choice, Starting a small business and Basic planning.

5 Conducts face to face workshops and practical demonstrations on all the above topics.

6 Conducts correspondence courses in Agriculture, Management and Development (PID).

INVOLVEMENT IN WATER CATCHMENT

Inades-Formation Kenya does not carry out a separate programme on rainwater catchment but does the following:

- Advice the farmer on various methods of rainwater catchments and reservations.
- Make visual aids and drawings in the teaching materials on rainwater catchments and protection

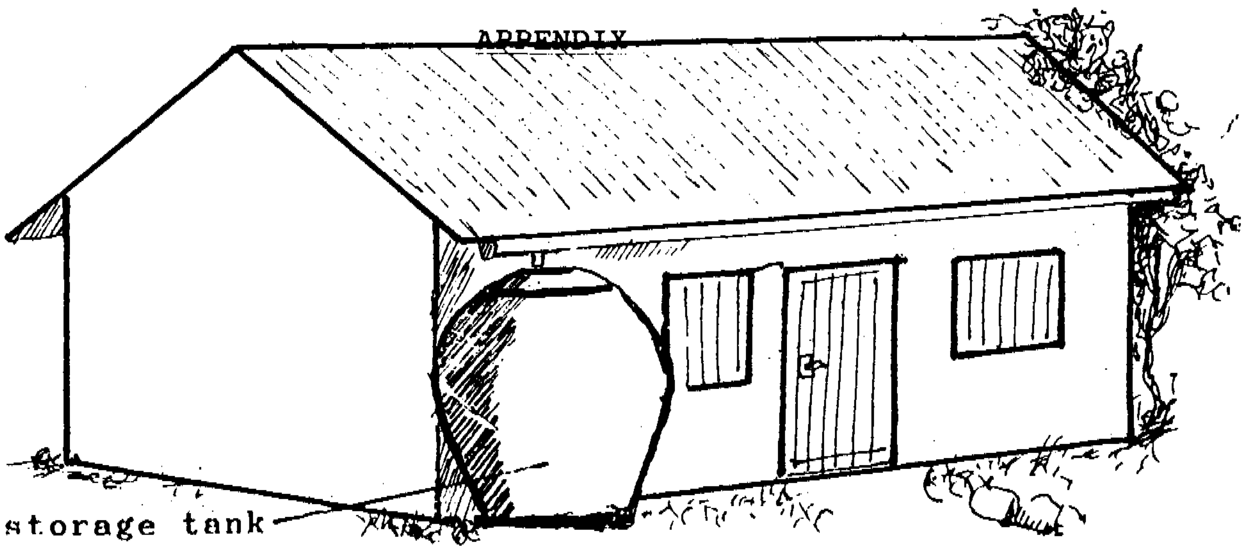
The following methods of rainwater catchments were presented on overhead projector during the workshop (These can be seen in the Appendix):

- Roof catchment by using ghala tanks
- Dams catchment and their maintenance
- Dug wells catchments

- Contour bunds for crops/trees in dryland areas
- Rock catchments
- Semi-circular micro-catchments
- Crops irrigation from a dam

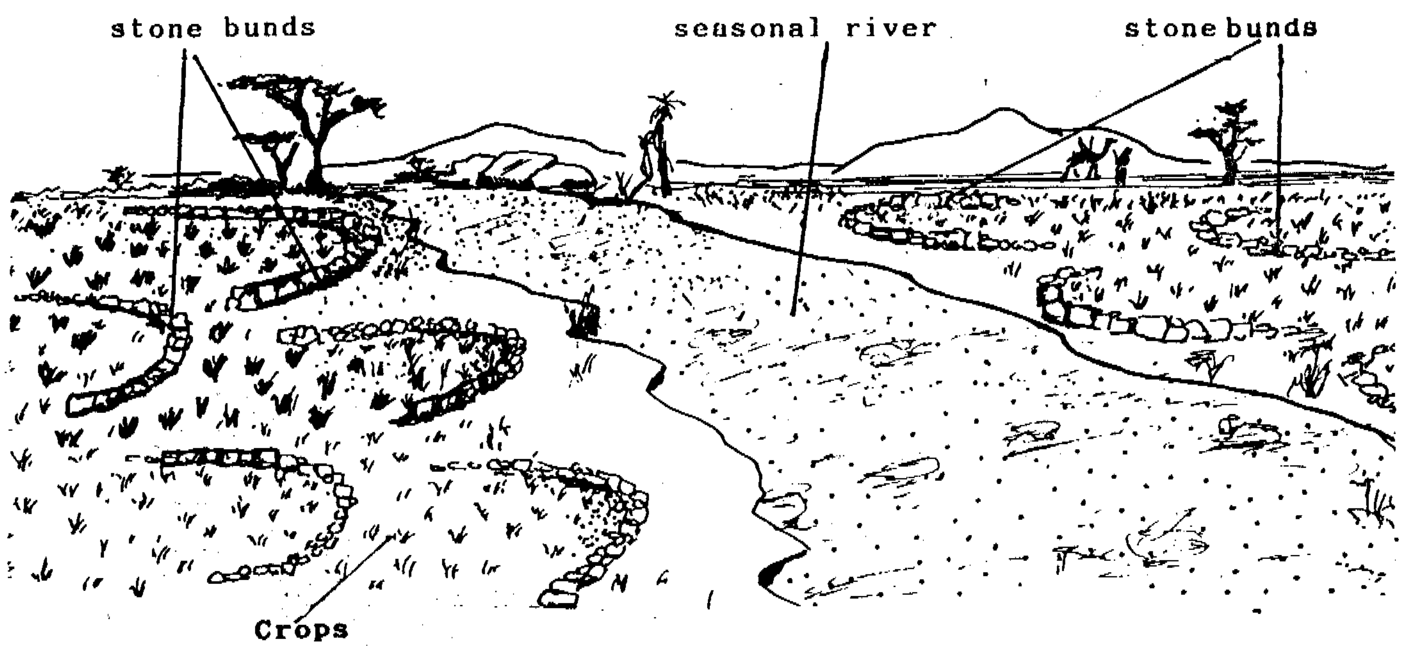
Inades-Formation Kenya emphasizes various ways of catchments because when teaching agriculture, the basic requirements is water, either from the rain or any other source.

APPENDIX

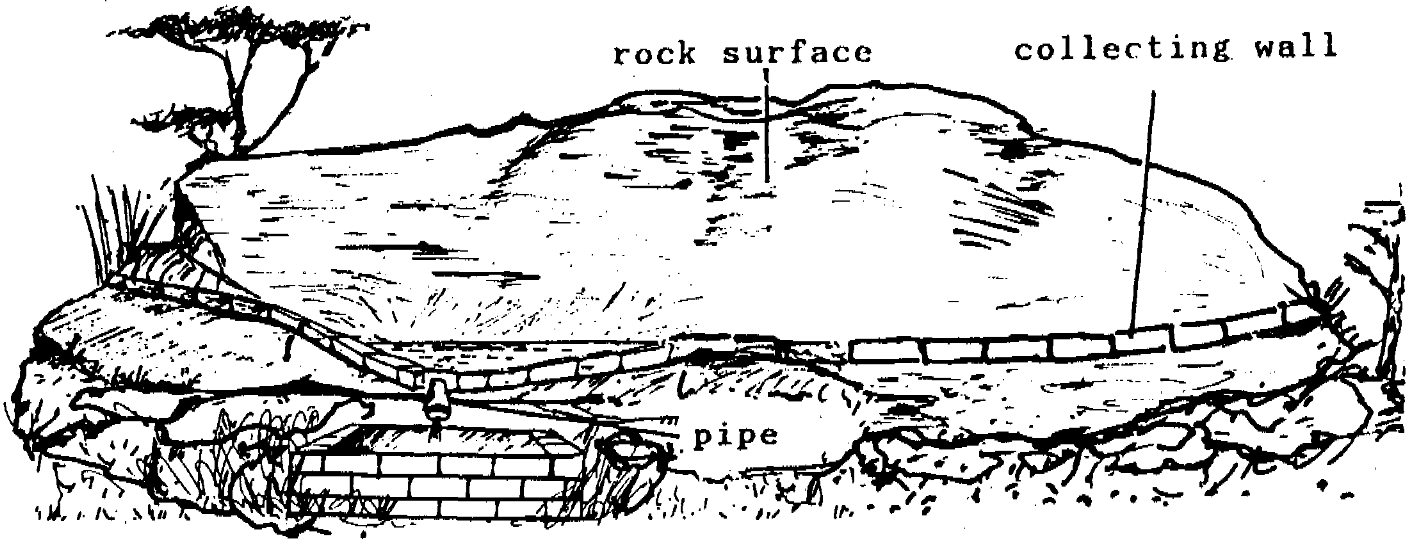


Roof catchment

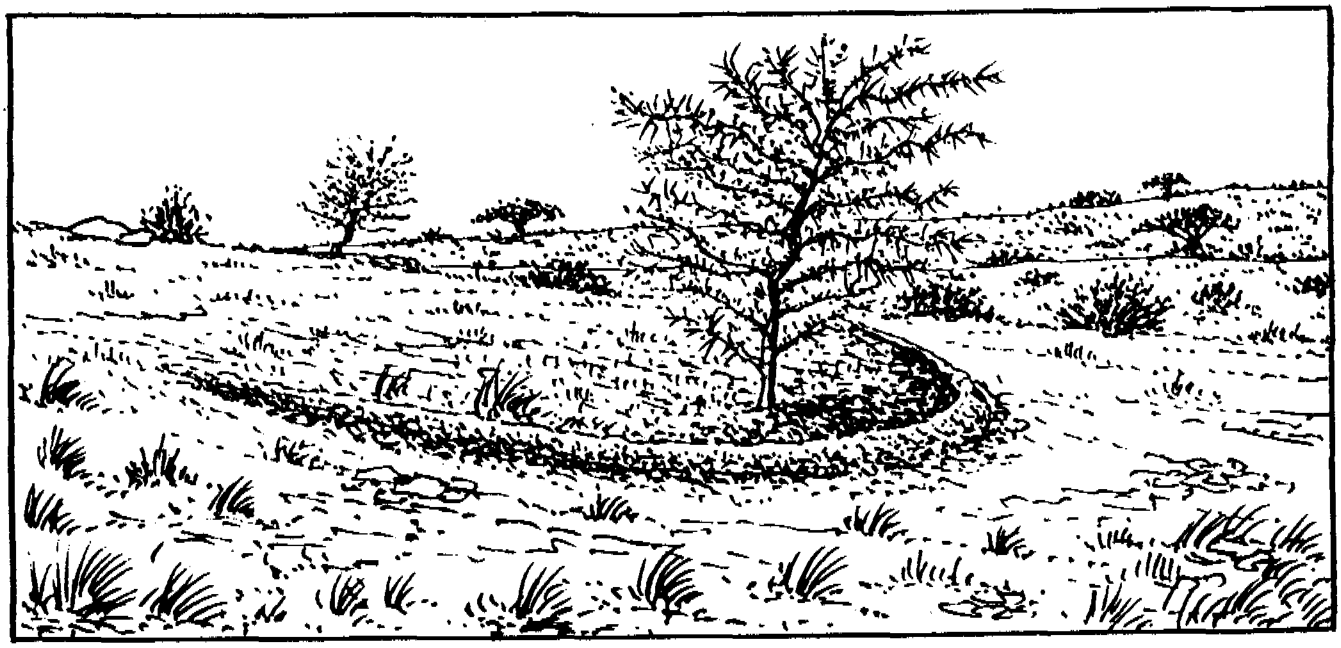
Dug wells *catchments*



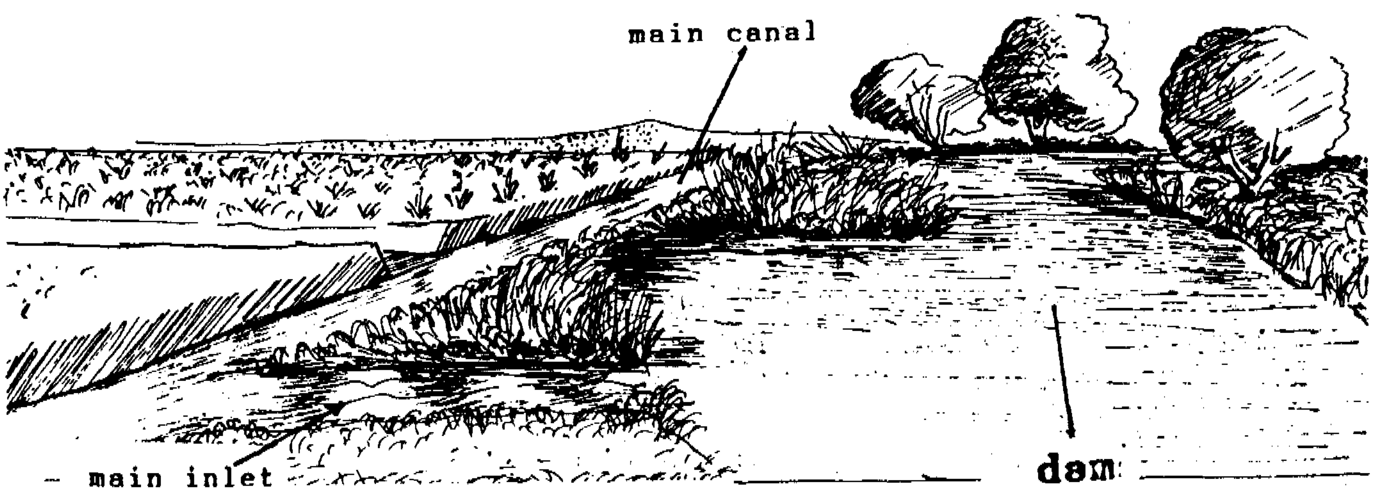
Countour bunds



Rock catchment



Agroforestry in Dryland *Semi-circular microcatchments*



How to irrigate crops from the dam

AMREF

By I O Oenga (Public Health Engineer)

AMREF stands for African Medical and Research Foundation.

AMREF runs NETWAS (Network for water and sanitation) in Kenya.

Objectives

Training
Information
Small Community Projects
Applied Research

Funding for AMREF comes from International and bilateral donors.

The Technologies practices by AMREF are: Shallow wells, hand pumps, gravity, spring protection, rainwater harvesting (domestic), and sanitation (on-site)

RAINWATER CATCHMENT

1 Ferrocement Tanks

Important aspects are:
Construction Procedure
Strength versus Size
Cost Variations
Roof (Slope to increase strength of the wall / roof joint)
Cover is important
Downpipe (must have a screen on it)
Gutters (Brackets may be made of wood as well iron)
Tank Sizing (Rainfall, area versus storage, Demand versus storage, cost)

2 Mbati Mould Tank

Limitations are:
Size is fixed
Mould needs to be moved from site to site
Mould has a high depreciation rate

3 Water Jar

Size is small and needs to be used in areas where there is lots of rain

4 Rough Stone Tank

Appropriate in places with lots of rough stones

5 Ground Surface Runoff

Can be used for crop or livestock, using surface open pans or rectangular tanks.

COMMUNITY PROJECTS

In Kebwezi have a shallow well / handpump project, and in Gelegele a ferrocement and sanitation project. There is a gravity system project in Subukia using mbati mould ferrocement tanks for the brake pressure tank and storage tanks.

There are currently demonstrations in:

Kenya	Mogotio, Mazeras, Murag'e, Maseno, Mambrui, Mita Syam, Thange etc
Tanzania	Masasi, Mpwapwa
Uganda	

Dissemination is done through training Institutions, in-service training for field workers, the AMREF diploma course and practical attachments from MTC, KEWI, VON, Kenya Polytechnic.

AMREF collaborates through the various relevant government ministries and with NGO's.

WATER

The water budget is very important for the rainwater catchment system to have any impact on the health of the people.

When considering the cost and quality of the water surface runoff is adequate for crops and livestock. However for human consumption, for acceptable quality the catchment area must be clean and the storage proper.

Is this the ultimate or a step in the overall development?

THE DIOCESE OF NAKURU RAINWATER HARVESTING PROJECT

By John Mbugua (Water Engineer)

ABSTRACT

The C.P.K. Diocese of Nakuru Rainwater Harvesting Programme started in 1984 with a goal of introducing sustainable, affordable, replicable and acceptable water supply projects within the 6½ administrative districts the Diocese covers, these are Nakuru, Nyandarua, Narok, Baringo, Samburu, Kericho and the western half of Laikipia. During this period of 6 years a number of areas and target groups have been identified and mobilized. To date the programme has 132 groups made up of 90% women who are also responsible for their group management. The total number of tanks constructed are over 3,000 and sizes vary from 500 gallons capacity to 30,000 gallons. Through the programme over 30,000 people have safe water supplies at their homes and hundreds of cattle now have adequate water. The challenges have been in areas of research, documentation, quality monitoring and promotion of rainwater catchment systems in areas outside domestic use such as agriculture.

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1. INTRODUCTION

The C.P.K. Diocese of Nakuru Rainwater Harvesting (RWH) programme covers an area which was occupied by former white settlers. The settlers developed various water resources to suit their own interests. The technologies were chosen based on already available operation and maintenance capacity. After independence the lands were bought and sub divided into small holdings which were occupied by the new African settlers. The water systems collapsed because the new settlers found the technologies strange and to some it was a symbol of colonialism. As a result little attention was given to their operation or maintenance.

This situation posed a great challenge. After critical analysis of social cultural and economic dynamics it was determined the RWH was an acceptable and affordable. After a year and in some places even two years the projects started and proceeded on to completion.

2. RATIONALE

Rainwater technology was accepted mainly because of its simplicity, affordability and clearly defined individual responsibilities during construction and thereafter during operation and maintenance. Another reason was that individual benefits were clear. This programme was introduced at a time when failure and collapse of many piped water systems was occurring and also at a time when government expenditure on the public sector was being cut back and many donors had started accepting the role of NGOs due to their success at the grass roots with appropriate technologies.

3. IMPLEMENTATION

3.1 Non Technological Aspects

3.1.1 Institutional Options

Through a number of ways villages heard about the rainwater programmes and came for technical advice. Then the programme officials organized a baseline survey and a series of community meetings for dialogue. This then was followed by visits organized to expose members to similar areas like theirs where various activities related to RWH was going on. Such visits were by far the most effective mobilization strategy. Various trainings were planned to improve management skills, organization, human resources, and confidence building. During these training sessions the role of women in the development of rainwater technologies was taught and encouraged throughout project planning and implementation.

3.1.2 Main Target

The Nakuru RWH programme has the poor as its main target. But this group happen to be also most difficult to deal with because:

a) The poorest of the poor do not like joining community groups
b) They lack the required group member monthly contributions
c) They shy away and fail to join others in group activities
d) Some rich members stand as barriers to development of the poor
e) The poor lack confidence in themselves

f) Communication barriers sometimes exist between the facilitating agent and the poor

Target groups were located in the identified project area. The group gathered members who faced water shortage and could form a cohesive group. The group sizes depended on a number of factors including economics, geographical location and degree of awareness created by the external facilitator. Generally our groups range from 15 to 80 members; with large groups the members further sub divide into small units of 12 to enable easy labour management.

3.1.3 Labour

Tank construction requires skilled and unskilled labour. In order to minimize on cost all unskilled labour plus some of the skilled labour is done on a voluntary basis by the group members. The group then recruits a village artisan who is trained or approved by the programme to carry out the skilled work.

3.1.4 Finance

i) Community

The groups agree on monthly meetings to contribute money and to plan future actions, but the group meet also weekly to work on their projects. Some groups have agreed to meet after the construction of 2 or 4 tanks in order to cast ballot papers to find out whose tank will be built next. Some groups have also fixed that when it is a certain member's turn the member will contribute about ten times the monthly contribution to boost the group's account, in order to build more tanks, and in order to reduce the waiting period.

ii) External Support

The programme in addition to contributions on mobilization and technical help it encourages construction by contributing 50% of materials needed and cannot be obtained locally like cement or iron reinforcing. This input is very carefully planned to avoid fights, or group collapse; something that has happened when too much money has been given without proper planning.

3.2 Technical Aspects

3.2.1 General

Tank size, tank material, roof material, gutter sizes, gauge, fixing, gutter gradient are all important technical aspects. There are a number of formulae to determine tank sizes but whatever the circumstances careful planning is done so that the optimum size of tank that is cost effective is selected. Tank materials is usually chosen with minimum utilization of locally available material. The programme has used five different tank materials, more than ten different tank sizes, and about six different shapes. Some are built above the ground, some in the ground, or a combination of both.

The need for standardization has become necessary in order to generate quality and to reduce technical supervision. The standard sizes and design that the programme has decided upon are in Table 1.

TABLE 1

Type of Tank	Size	
	Gallons	M^3
Masonry	3,000	13
Masonry	5,000	20
Sub Surface - Polythene Lined	20,000	90
Sub Surface - Chicken wire	20,000	90
Water Jar	500	2
UNICEF Ferrocement	5,000	20

However within our programme area the Ministry of Health and the Catholic Diocese of Nakuru are facilitating construction of ferrocement tanks of uniform capacity e.g. 10 m^3 or 20 m^3 or water jars of 3.6 m^3 capacity. One short coming of these projects is the rigidity in that even where stones are available cheaply ferrocement tanks are still the only available tank with eternal support. In such circumstances sustainability is at risk and the degree of participation is minimized. In one instance the ferrocement tank cost about Kshs 15,000 including the external assistance while a masonry tank of the same size cost Kshs 5,000.

The programme under review has approached the community with an open approach and technology options so that after a series of meetings the community itself will identify the most appropriate tank materials and sizes with a little but adequate technical support from the programme officials. In Baringo, an area with a very hot and dry climate, the Ministries of Health and Water Development have abandoned ferrocement tanks because of failure (mainly due to bad curing) and are now building reinforced stone tanks.

The process of selecting a RWH technology is done carefully through community meetings and dialogue. Some of the questions often asked are 1) are rainfall pattern and roof size and material suitable for rainwater catchment if yes 2) can people afford the storage tanks necessary for rainwater catchment?

The Nakuru RWH programme has dealt with the first above questions in a number of ways. There is often not any rainfall data or accurate data especially in thee dry areas which were formerly ranches. This makes designing tanks of optimum size difficult if not impossible.

However in dry areas construction of large sub surface water cisterns receiving water from surface run off from roads paths or non cultivated fields have successfully been introduced. These have adequately responded to the flash storms and lack of adequate roofing among the majority of rural poor. However the water collected have limitations in quality and the water is usually used for non drinking purpose like kitchen gardens and livestock. A number of families have also been known to use the same water for cooking and washing after using some well known vegetations or aluminium sulphate to coagulate and then by passing the water through a piece of white cloth. The programme officials advice the community to use the water as tea, coffee or some soup but not to drink water directly.

The main problems found with these tanks have been drawing the water and secondly the high evaporation rate. At present the water is drawn from the tanks by walking down a 'home-made' ladder into the tank and collecting the water with a small container. This is very dangerous and most people can not swim and only a small quantity of water can be collected at a time, which makes irrigation difficult. To overcome this the programme is manufacturing and selling a very simple 'Rower' pump to get the water out. It works by sucking the up to the pump and then out. All working parts are above the surface so maintenance is very simple, it also has very few moving parts. The pump has been very successful, and with them costing only Kshs 800/= there is a high demand. The problem of evaporation is talked about in the next section.

About the second question of affordability of storage tanks, care is taken to maximize on villager or family labour and materials nearest to the family. This explains why we have such wide selection of tanks such as masonry, rubble stones, surface or hemispherical sub surface tanks. Thus it is possible to choose the cheapest alternative and most appropriate for a particular location.

3.2.2 Roofing

Roofing is essential for any tank which is used for domestic use. Without a roof algae will grow in the tank, insects will breed in it, animals and birds will contaminate it, and there will be a high evaporation rate.

Alot of people do not roof their tanks as they do not see a direct benefit. Through education and dialogue it is possible to persuade people the importance of roofing.

Presently iron sheet roofs are common due to their simplicity to put on, and often it is the only type of roof people know how to construct. The programme has decided to adopt the position that all tanks used for domestic use ought to be covered by a ferrocement roof. This decision was taken after the preliminary results from a small number of water tests. It is found that by using a ferrocement roof no animals (especially lizards) or insects can enter the tank thus reducing the likelihood that there will be any contamination. Also insects can not enter and thus the tank can not become a breeding ground. However it is important that the roof seals all the way around with the wall, the manhole fits properly, and the water inlet and overflow have a well fitted fly screen over them.

The large sub surface tanks not used for domestic use do not need such a good roof. What is required is a roof which will reduce the high evaporation rates. Trials are now under way with a wooden and wire lattice work over the tank and then growing a flowering creeper which does well in the area.

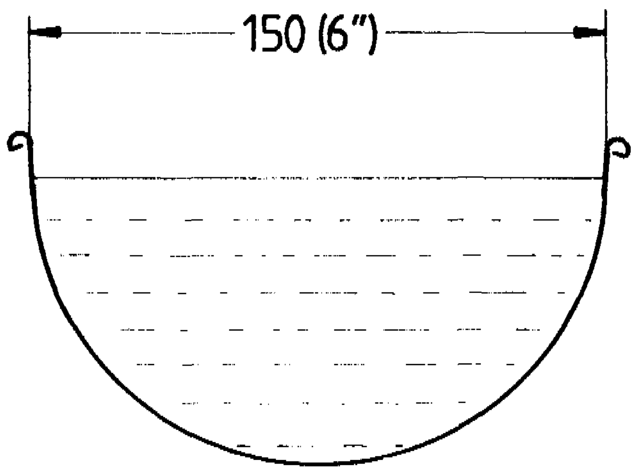
3.2.3 Gutters

Nakuru RWH programme has adopted specific sizes and shapes for gutters, shown in Figure 1. Although the community has not taken this seriously. It is common to find tanks that were built and

FIGURE 1

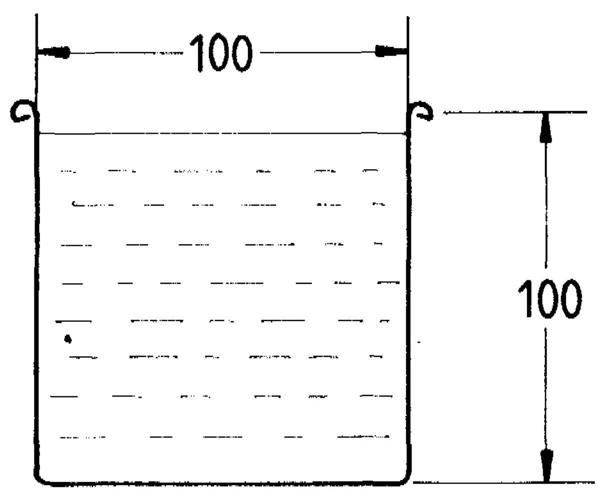
SEMI - CIRCULAR GUTTER
Made from 26 Gauge GI sheet (Kenya Bureau of Standards Approved)

Area = 91.2 cm^2



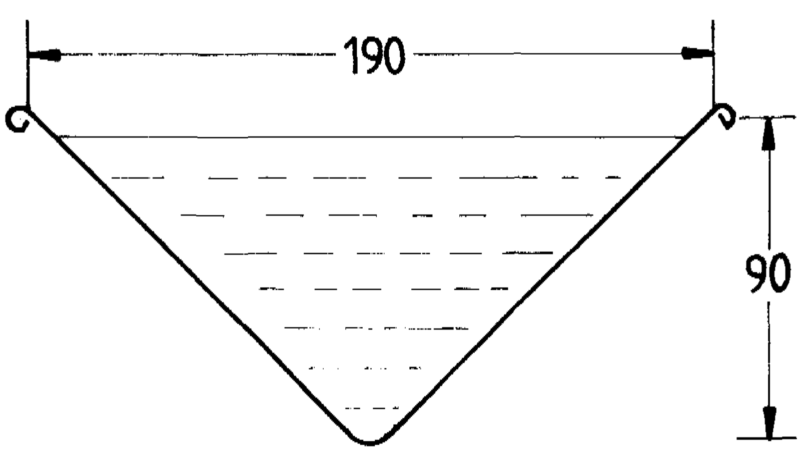
SQUARE GUTTER
Made fom 26 Gauge G.I. sheet

Area = 100 cm^2



TRIANGULAR GUTTER
Made from 26 Gauge G.I. sheet

Area = 85 cm^2



for a year there has not been any gutters or only $^1/_{10}$ of the gutters that could have been installed.

The following criteria, based on experience acquired, is followed in the choice of gutters size, shape and fixings:

1 Gutter must be large enough to channel water from heavy rains without overflowing.
2 The shape should be such that the gutter is not too shallow to allow overflow
3 The gutter should not be too narrow otherwise the water from the roof may shoot over the gutter and be lost.
4 The gutter should be placed at a uniform slope to prevent water from pooling and overflowing, e.g. 0.8 cm/m or 1 cm/m which is 1%.
5 The gutter must collect all of the water running off the" roof during heavy rainstorms. To achieve this the gutter by 1".
6 Number of supports depends on type of materials but should be at least 50-60 cm apart.

However the optimum gutter sizes will obviously vary with the intensity of local storms and area covered by the roof. For our programme area a study on such things would be very useful to provide some guidelines.

Roof materials is a great concern. The programme has tried unsuccessfully to tap water from grass thatched roofs or other organic materials. But of even greater concern is a number of brick and painted G.I. materials which are being manufactured in the market. Health impact of the pollution from these surfaces is still yet to be established.

3.2.4 Collection Efficiency

The programme has identified that some farmers treat a tank as a symbol of status and therefore forget its purpose. This is evident by some farmers who forgot to put enough gutters of adequate size or correct slope. However this short coming has come out clearly and is currently serious challenge and the water department is working out a training strategy to overcome this shortage.

Making the proper gutter sizes in the market is another constraint and the programme is planning awareness creation among the community so that the farmers refuse size of gutters that arenot appropriate. Also various fixing materials to achieve proper gutter slopes are being introduced.

3.2.5 Quality

i) General

Both quantity and quality of water supplied to community is of great concern to our Nakuru RWH Programme. The programme area has serious shortages of both quantity and quality. While it has been possible to make more water available attempts to improve quality and to maintain high standards has not been easy. However health education to improve kitchen and domestic and even personal hygiene has been incorporated in the programme. As this touches on culture and traditions care is taken so that cleanliness culture could be incorporated in our people without interfering with the existing culture.

ii) Quality Analysis

The Nakuru RWH Programme a year ago acquired a mobile water laboratory equipment which is capable of analysing pH, conductivity, turbidity, Dissolved Oxygen, over 12 minerals and using its two incubators, which run off 240 volts mains electricity or off a 12 volt or 24 volt battery, coliform bacteria, E.Coli, and Faecal Streptococci can be cultured. From the results it is possible to know whether any contamination comes from animals and birds or humans. In this way it is possible to identify the way the tank is being contaminated and so action can be taken to cure it (eg fitting a first flush mechanism); and once cured the tank is chlorinated to disinfect it. It is then hoped it will not be reinfected once the chlorine level has fallen to a non-effective level.

iii) Treatment

On several occasions the programme is called upon to help sort out problems such as

a) Water from the tank producing bad taste, odour or colour
b) The water is found to contain small larvae.

The programme then responds in a number of ways that include washing the tank to remove settled materials or drawing off water at a higher point to exclude the polluted settlement and finally testing the water and if necessary chlorine is administered.

For treatment a solution of 70% chlorine is prepared by mixing 100 grams to a litre of water (or for 65% chlorine 107 grams to a litre). Using a table developed by the programme (see Table 2) and based on experience the right dose is applied (between 1 and 5 mg/l). After an hour a test of residual chlorine is done so that a level of over 0.2-0.5 mg/l is present.

3.2.6 Monitoring and Control

i) General

The Nakuru RWH programme has drawn up this schedule of activities for its staff to facilitate quality improvements.

Jan - Feb	Cleaning tanks, checking for cracks and repairing faults in gutters or tanks, cutting any trees overhanging tanks or roofs to avoid birds resting directly above the tanks.
Mar - April	Clean gutters and roofs, repair them and ensure first flush mechanism are in position and working.
May - June	Evaluate tank performance and catchment effectiveness.
July - Aug	Check water quality by use of the portable laboratory, maintain the ventilated improved pit latrines and evaluations.

TABLE 2

Water Vol. /m³	Concentration in mg/l							
	0.5	1.0	2.0	5.0	10	20	50	100
1	7	14	28	71	140	280	710	1420
2	14	29	57	140	290	570	1430	2860
3	21	43	86	210	430	860	2140	4300
4	29	57	110	290	570	1140	2860	5710
5	36	71	140	350	710	1430	3570	7140
6	43	86	170	430	860	1710	4300	8570
7	50	100	200	500	1000	2000	5000	10
8	57	110	230	570	1140	2290	5710	11.4
10	71	140	280	710	1420	2860	7140	14.3
12	86	170	340	860	1710	3430	8570	17.1
15	110	210	420	1070	2140	4290	10.7	21.4
20	140	290	570	1420	2860	5710	14.3	28.6
30	210	430	860	2140	4300	8570	21.4	42.9
40	290	570	1140	2850	5710	11.4	28.6	57.1
50	360	710	1430	3570	7140	14.3	35.7	71.4
100	710	1420	2860	7140	14.3	28.6	71.4	143
150	1070	2140	4290	10.7	21.4	42.9	107	214
200	1420	2860	5710	14.3	28.6	57.1	143	286

The figures in the table are the amount of chlorine solution in ml (shaded area in litres) that is needed to produce the particular concentration for a particular volume.

Sep - Oct Train on water conservation and usage, water budgeting to avoid loses and wastage.

Nov - Dec Preparation of water tank and V.I.P. constructions.

4. RESEARCH

The Diocese of Nakuru RWH programme identified the research needs of the programme. The nearby Egerton University was approached who jointly with the author developed a research proposal for which finances are still being sought. However with limited funds from the programme a number of samples have been taken and analysed

4.1 Questionnaires

The research proposal intended to carry out some study in areas of social economic conditions of those already practicing RWH through a questionnaire. The questionnaire is broken up into various sections and parts.

Part I — This was to bring in size of household, size of land and the production of the land.

Part II — This part aims at obtaining information on group dynamics such as reasons behind the group formation and its social aspects.

Part III — SECTION A This was aimed at rainwater technology and questions focussed on type, size, shape, cost and capacity of the tank plus its performance.
SECTION B This looked into the attitude towards tanks and awareness of other designs, shapes etc.
SECTION C This asks about the water quality and the tank water's effect on health and agriculture.

Part IV — Here sanitation issues are discussed, so that the number of people with a form of sanitation, those without and how many had improved theirs is found out.

Part V — This was devoted to socio-cultural issues. Questions here were concerned with cultural attitudes and taboos that affect various sources of water and its use.

There then other shorter questionnaires for the Government Administration Officials, Agricultural extension workers (from government and NGOs), Community Health Workers (from government and NGOs) and Artisans. These questionnaires are for getting a wider perspective on RWH technology and how it affects agriculture and health in particular.

These results will give information into the acceptance of the RWH, its benefits, its problems, its effect on the homestead socially and economically, the success of certain designs, and alot of other information.

4.2 Water Testing

The second part of the research involves testing the tank water where the main questionnaire is being asked. The tests are for microbiological organism only (Coliform, E.Coli, and Faecal Streptococci). These results in conjunction with the questionnaire answers will be able to give results relating water quality with tank size, materials, roofing of tank, gutters etc.

5. SANITATION

The CPK Diocese of Nakuru RWH Programme has integrated sanitation activities. For every tank construction there must be an improvement or construction of a pit latrine. To date out of 3,000 tanks constructed there are over 2,000 pit latrines dug or improved by installing a vent pipe, clearing the compound and path leading to the latrine. Inside the latrine moisture on the slab is avoided by keeping a container of ash which is sprinkled around after use. The Ministry of Health instead insist on using a concrete slab something that is not compatible with financial ability of most people. Families argue that their own houses are not made of concrete floors and are even grass thatched. But when materials used for latrines is compatible with materials in the houses and owners financial capabilities then latrines are improved.

Of equal importance is health education. Full health and economic benefits can only be realized when safe water and adequate supplies are complimented by sanitation facilities, kitchen and domestic hygiene and health education.

6. CONCLUSION

The programme has achieved many of its objectives. Many lessons have been learnt. Most notable of these is the importance of the non-technological components relating to the sustainable delivery of water services. For example finance and technology are not the major constraints to acquiring water for all, but rather the social and political dynamics among the target groups. Financial inputs should be administered carefully to avoid a 'dependency syndrome'. Any intervention should develop self-reliance and confidence. Therefore the choice of technology should be made with extreme care.

Rainwater resources have a great impact on the daily lives of the majority of people in the project areas. Energy and time saved can result in more time for productive activities that help counter poverty, hunger and disease among the rural communities in Kenya.

Community participation not just lip service is necessary in project planning and must be encouraged. Communities must make a commitment with a view towards accepting ownership and responsibility for the project. Efforts are needed to prepare communities before implementation and to avoid short term goal fulfillment. Quality not quantity and programme sustainability must be the main objectives. Community participation through education using the mass media and schools is necessary. Community involvement requires considerable resource inputs (finance and time) and budgets must be properly allocated and used. A bottom-up and top-down approach should complement each other coupled with institution building. More research is needed in some areas of rainwater technology such as optimum tank sizes, roof materials, gutter sizes, water quality; also better information dissemination is required.

RESEARCH INTO RAINWATER CATCHMENT SYSTEMS

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INTRODUCTION

Historical Development

Rainwater has been collected from roofs and other surfaces and stored for domestic purposes for thousands of years. The use of rainwater cisterns (tanks) in Roman times is well documented, Kovacs (1979), Crasta et. al. (1982); and archaeological evidence from the Negev desert in Israel indicates that rainwater has been stored for both agricultural and domestic purposes since at least 2000 B.C., Evenari (1961). Rainwater harvesting is still being practised in the region today and crops are cultivated in areas with little more than 100mm of rainfall annually.

Archaeological and documentary evidence from around the world shows that rainwater catchment technology has been used in various locations on almost every continent for centuries, Pacey and Cullis (1986), Hasse (1989), Fok (1989).

The Main Types of Systems

The three main types of rainwater catchment systems (classified according to the nature of their catchment surfaces) are roof, ground and rock catchments, Figure 1-3.

Roof Catchment Systems : these are the most common type of catchment used for harvesting rainfall. The system consists of three main components a roof which acts as a catchment surface, a gutter and downpipe, and a tank.

Ground Catchment Systems : these are cheaper than roof catchments and are normally employed where suitable roof surfaces are not available. The main advantage with using the ground as a catchment surface is that water can be collected from a larger area (this is particularly advantageous in areas of low rainfall). Ground surfaces are not normally as efficient for collecting rainwater unless covered with cement or some other material to reduce their infiltration capacity. This may, however, increase costs of the system.

FIGURE 1

Roof catchment system

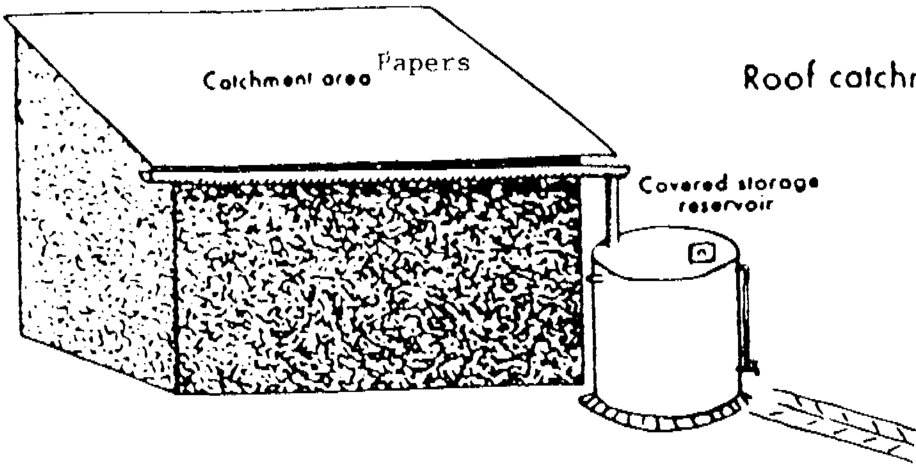


FIGURE 2

Ground catchment system

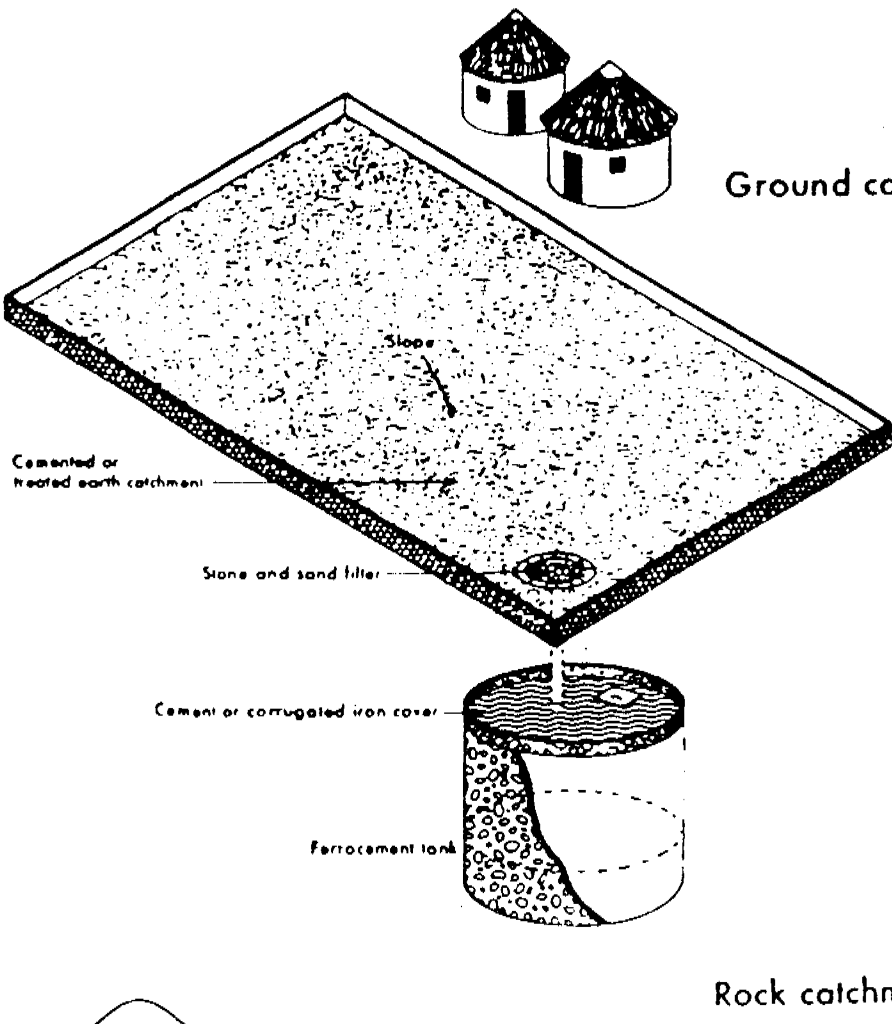
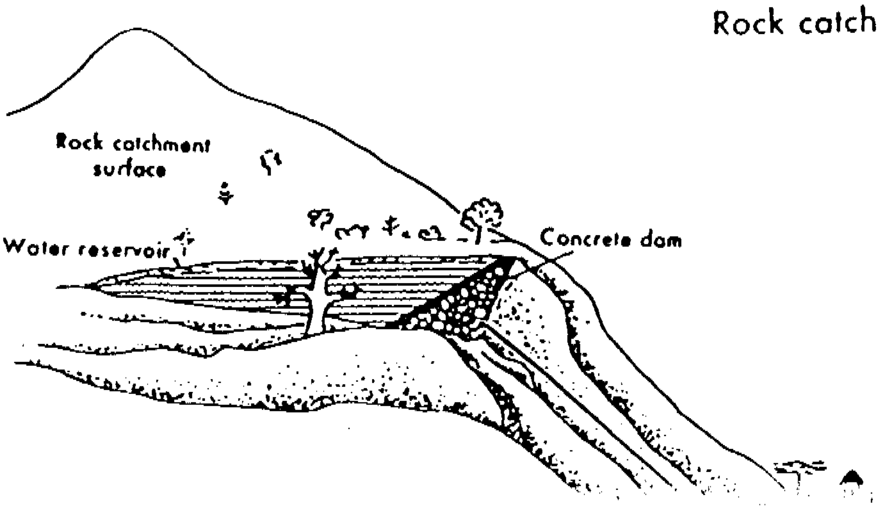


FIGURE 3

Rock catchment system



Rock Catchment Systems : these are generally constructed for communal supplies in areas where unjointed massive rock outcrops provide suitable catchment surfaces. The runoff is channelled along stone and cement gutters constructed on the rock surface into reservoirs contained by concrete dams. If the dams lie above settlements, water can be supplied to standposts through a gravity fed pipe network. A detailed discussion of rock catchment systems is provided by Visscher and Lee (1990) and Nissen-Petersen (1982).

Rainwater Tank Design

The storage tank is the most expensive part of any RWCS and determining the most appropriate capacity for any given locality will critically affect both its cost and the amount of water it is able to supply. In general, larger tanks are required in areas with marked wet and dry seasons, while relatively small tanks may suffice in regions where rainfall is relatively evenly spread throughout the year. Although smaller tanks will be affordable to a greater number of people, large tanks generally provide economies of scale (Pacey and Cullis 1986).

Field experience has shown that a universally ideal tank design does not exist, (Latham and Gould 1986). Local materials, skills and costs, personal preference and other external factors may favour one design over another. Nevertheless there are a number of crucial requirements common to all effective tank designs these are:-

a. A solid secure cover to keep out insects, dirt and sunshine.
b. A coarse inlet filter.
c. An overflow pipe.
d. A manhole, sump and drain for cleaning.
e. An extraction system that does not contaminate the water Eg.Tap/Pump
f. A soakaway to prevent spilt water forming puddles near the tank.
g. A functional and water tight design.
h. A maximum height of 2m to prevent high water pressures.

Additional features might include:-

i. A device to indicate the amount of water in the tank.

j. A sediment trap, tipping bucket or other foul flush mechanism.

k. A lock on the tap.

l. A second sub-surface overflow tank to provide water for livestock etc..

Modelling Techniques for Storage Tank Size Determination.

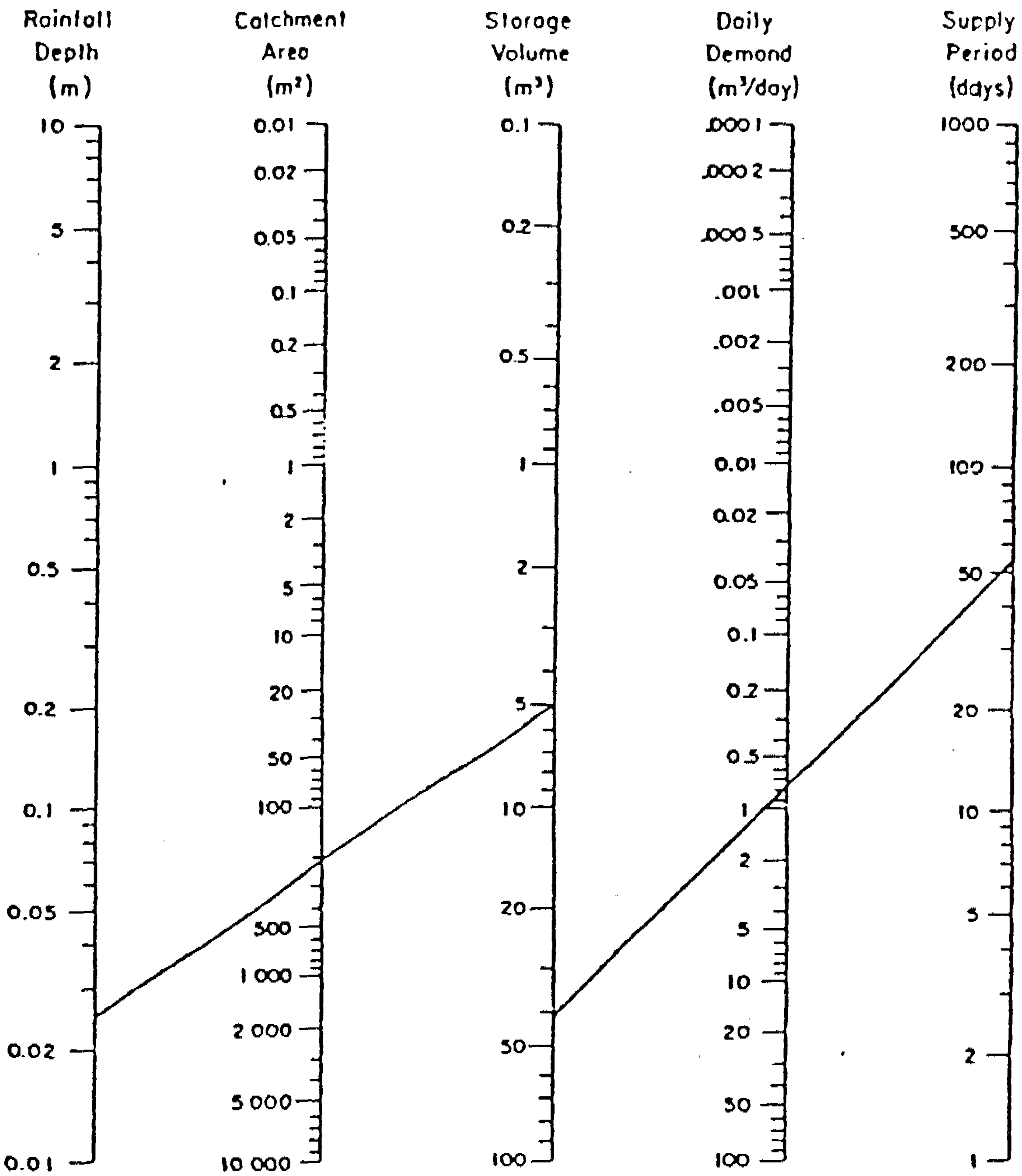
An important element of tank design is determining the storage capacity required to meet a given demand. In locations where rainfall is abundant and catchment areas large, tank volumes can be easily estimated by multiplying the daily water demand by the longest expected period between rainfall events in days. For example, at a locality where dry spells of more than 20 days are rare, for a household with a daily demand of 100 litres of water, a 2000 litre (2m3) tank should suffice. In the rare event of a dry spell longer than 20 days the household would either need to reduce daily rates of water consumption as the water level in the tank diminished through rationing or turn to other sources of supply.

Since, abundant rainfall spread relatively evenly throughout the year is not common in most parts of the world, especially those suffering from water shortages, tank designs are often required to maximize the available water storage to ensure water is available during long dry seasons often lasting for several months. Clearly in regions where prolonged droughts may occur from time to time such as Botswana, the cost of providing sufficient storage and catchment area to meet household water demands at all times may be prohibitive. Nevertheless, in such localities, water is often at a premium and RWCS are often feasible even if they cannot provide a 100% guaranteed constant level of supply at all times.

Use of Alignments Charts

These can be use make quick and accurate estimates of potential rainwater supply from a given roof, if the rainfall and catchment area are known. An example of such a chart is shown in Figure 4 after Fok (1989).

FIGURE 4 ALIGNMENT CHART FOR DETERMINING REQUIRED STORAGE VOLUME AND DURATION OF RAINWATER SUPPLY



(After Fok 1989)

The Graphical Method

The simplest method to estimate the most appropriate storage tank capacity for maximizing supply is to represent roof runoff and daily water consumption graphically, Figure 5.

Statistical and Computerized Methods

For more accurate determinations of the storage requirements for meeting a given demand with a given probability mass curve analysis is required. A clear and easy to follow explanation of this statistical approach is given by Schiller and Latham (1982).

The use of computer models designed along the same principles provide a powerful tool for simulating future rainwater supplies and anticipated storage requirements on the basis of past rainfall data. An accurate and lengthy rainfall record is essential for this method. Using computers calculations for the reliability of different levels of reliability of supply can also be included and plotted in a graphical form. A detailed discussion of computerized methods is given by Latham (1983).

The use of graphs produced using computer models, with roof area and tank volumes on the two axis and sets of curves representing the range of annual rainfall values within a given region can provide an effective tool for estimating the most appropriate storage tank capacity. This approach is being widely used by the government of South Australia as part of a technical advice package offered to householders (Govt. of S Australia 1987, 1990). An extension of this approach was considered in a study by Wall and McCown (1989) in which a water budgeting program was used to analyze rainfall data from two contrasting stations in Kenya and Australia, cost curves for determining the economic optima for different roof area and tank volume combinations were included in the analysis.

Construction

The involvement of local communities is especially essential in the construction phase of the project as this will ensure that the skills required for future maintenance, repairs or further construction are developed within the community. The community and individual recipients should also be involved in discussing the pros and cons of different types of designs; e.g. surface/sub-surface, ferrocement/concrete ring, tank/jar.

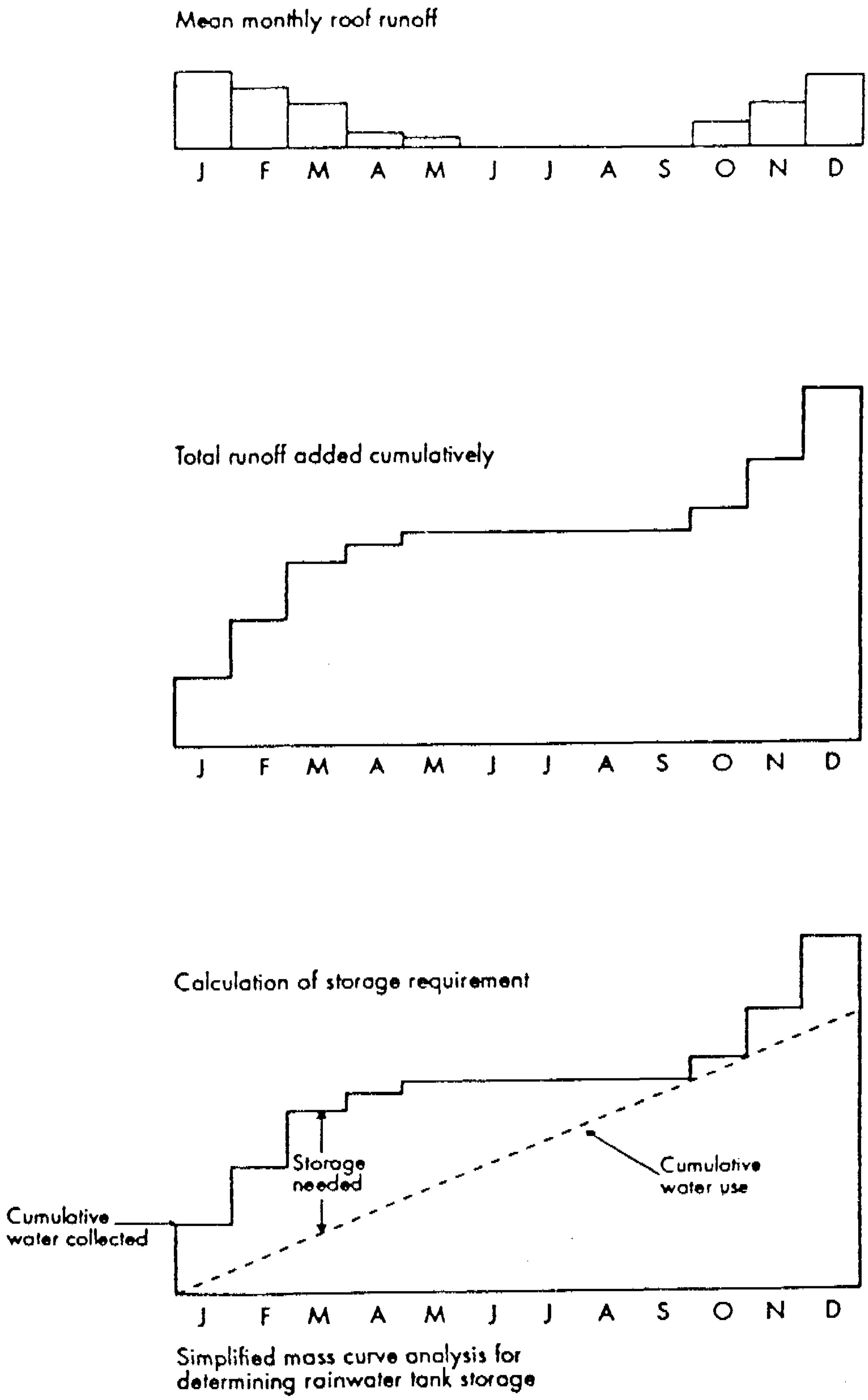


Figure 5 — **Simple step-by-step approach for determining storage requirement for maximizing rainwater supply**

1. Cement Jars

This design is ideal for small tanks and can be used for tanks up to 2m3 with wire reinforcement or up to 0.5m3 without it. The construction procedure involves the use of a reusable formwork. This can be made using a hessian sack filled with sand, straw, sawdust, rice husks etc.. for smaller jars up to 0.5m3. For jars bigger than this, either a basketwork or specially made cement block formwork, made from about 90 curved bricks, can be used. The formwork is placed on a precast wire reinforced circular base 3cm thick and up to 1m in diameter, a 5-7mm of 1:2 cement/sand mortar is then carefully plastered onto the formwork. Steel wire is then wrapped around the jar at about 10cm intervals and a further layer of plaster applied. A neck is produced at the top of the jar using two concentric metal ring moulds the smaller of which can be used to cast the cover. In Thailand, around 10 million 1-2m3 jars of this type were constructed during the 1980's, at a cost of only $25 per 2m3, excluding labour.

2. Ferrocement Tank Designs

There are a number of different ferrocement designs available and large tanks up to 200m3 or more can be built with this method, (Watt 1978).

The Wire Framed Ferrocement Tank design is particularly good for tanks with capacities between 2m3 and 10m3 but can be used for tanks up to 16m3 in size. The construction consists of making a frame out of steel reinforcing bars and wire mesh. This is then placed on a sturdy reinforced concrete foundation and plastered from both inside and outside simultaneously. The materials required for a 10m3 include 22 bags of cement, 40 steel reinforcing bars (9.15m x 9mm), 30m x 0.9m of 12mm welded wire mesh, 3 cubic metres of sand. This design has been developed through cooperation between IDRC and Khon Kaen University in Thailand and is currently being implemented in the Philippines, (Appan et al. 1989). A considerable amount of work into ferrocement and other designs has been conducted in Thailand, Vadhanavikkit and Viwathanathepa (1986), Vadhanavikkit and Pannachet (1987) .

3. Other Surface Tank Designs

Apart from variations on the above designs there are also numerous others fibre-glass, metal, asbestos/cement, PVC etc... Perhaps the most common of these are the various brick tank designs. In Thailand an interlocking cement brick design has been developed but field testing has revealed leakage problems. Tanks built in East Africa using another design with interlocking concrete blocks compacted with a vibrator have, however, so far have fared better.

Conventional tank construction methods, using copious reinforcement and adhering to strict engineering standards, may result in 'over-designed' structures. Although these are extremely robust and the risk of failure is negligible the tanks are very expensive.

4. Ground Tank Designs

A number of different designs exist, but where carefully constructed, ferrocement has proved to be the most effective and economical. In semi-arid environments where the sub-soil is dry throughout the year, it is possible to dig a cylindrical pit of appropriate size, put in a concrete base and plaster the sides. Chicken wire can then be attached before adding two more layers of plaster each, at least 2cm thick with a 1:3 cement/sand mix and finish with a layer of waterproof cement. A cover is essential and can be made of corrugated iron or ferrocement. The ALDEP ground tanks in Botswana (Ainley 1984) use this design in conjunction with traditional mud/dung threshing floors as catchment aprons.

An alternative design, using a similar construction technique is the hemispherical tank developed in Kenya. The shape maximizes storage volume while minimizing the material requirement for the tank and a 3m deep tank with a radius of 3m has a volume of more than 50m3. The stages of construction for a 78m3 version is described and illustrated by Lee and Petersen (1989).

It is essential, for ground catchment tanks, that some kind of sediment trap and course filter is used to prevent unwanted debris entering the tank. When two or more tanks are built together and the second and subsequent tank is filled from the overflow of the first, very clean water can be collected. The catchment surface needs be protected from contamination, however, by fencing it off and the water in the tank protected with a sealed cover and ideally a handpump if it is to be used for consumption.

Other Technical Considerations

Gutters and Downpipes

A carefully designed and constructed gutter system is essential for any roof catchment system to operate effectively. A properly fitted and maintained gutter-downpipe system is capable of diverting more than 90% of all rainwater runoff into the storage tank, the remainder being lost through evaporation, leakage, rain splash and overflow. In design calculations it is usually better to assume a runoff coefficient of 0.8 (i.e 80% of precipitation as collected runoff) for roof catchments, considerably lower values apply for ground catchments. All too often both individuals and projects overlook the importance of guttering. This frequently results in only the runoff from part of the roof area being utilized. It is common in both Africa and Asia to find situations where only a small fraction of roof area has been provided with guttering for directing runoff into large storage tanks. In other instances gutters have not sloped in the direction of the tank and downpipe or have rusted through and not been repaired, Gould (in press).

Even where roofs have well constructed and maintained gutters, if they are too small, considerable quantities of runoff maybe lost due to overflow during torrential storms. In many tropical climates intense convectional rainfall accounts for a large proportion of total annual rainfall. A useful general rule is that 1cm2 of guttering is required for every m2 of roof area, (Hasse 1989).

Gutters and downpipes can be made of a variety of materials, wood, metal, plastic and bamboo. Those made from organic materials will require more frequent replacement. The regular maintenance of gutter systems is essential, they should be checked at least annually and leaves and other debris removed. Overhanging branches should be removed where possible as these not only drop leaves into the gutters, but provide ideal havens from which birds and small animals can defecate onto the catchment surface.

Foul Flush and Filter Systems

Although not absolutely essential for the provision of potable water in most circumstances, when effectively operated and maintained foul flush and filter systems can significantly improve the quality of roof runoff. If poorly operated and maintained, however, such systems may result in the loss of rainwater runoff, through unnecessary diversion or overflow and even the contamination of the supply. In very poor communities where the provision of even a basic roof tank represents a substantial upgrading of the water supply, the addition of an elaborate foul flush mechanism to the catchment system would add unnecessary expense and complication to the system and could even risk jeopardizing its effective use.

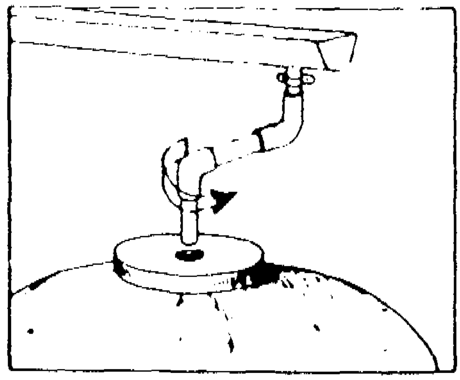
In some locations where roof surfaces are subjected to a significant amount of blown dirt and dust, or where particularly good quality water is required a foul flush system can be very effective. Numerous ingenious devices have been developed and these have been reviewed by Michealides and Young (1984). Some examples of these devices are illustrated in Figure 6.

Operation and Maintenance

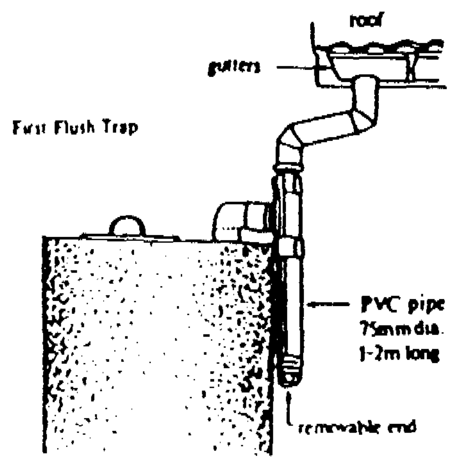
The simple operation and maintenance of rainwater catchment systems is one of the most attractive aspects of the technology. The amount of maintenance required by a basic privately owned household roof catchment system is limited to the annual cleaning of the tank and regular inspection of the gutters and downpipes and the removal of any leaves, dirt or any other matter which may have accumulated there. In seasonal climates where roof surfaces may become dirty and dusty in the dry season, the cleaning or sweeping of the roof before the first major rains may be advisable. Roof tanks with tipping buckets, sediment traps or foul flush mechanisms may require more attention. Some tipping bucket systems need to be reset after each rainfall event, failure to do this may result in future runoff running to waste.

The operation and maintenance of communally shared roof or ground tank supplies is considerably more difficult than for privately owned tanks, Pacey and Cullis (1986). Ideally one person should be responsible for overseeing the regular cleaning and occasional repair of the system. Roof tanks at schools where young children have access to the supplies may suffer water losses from a tap left dripping and padlocks are often needed to ensure careful control over the supply. Serious problems such as cracked or leaking tanks need to be repaired quickly. Ferrocement designs have a distinct advantage over commercially available metal tanks in this respect, since they can be relatively easily repaired.

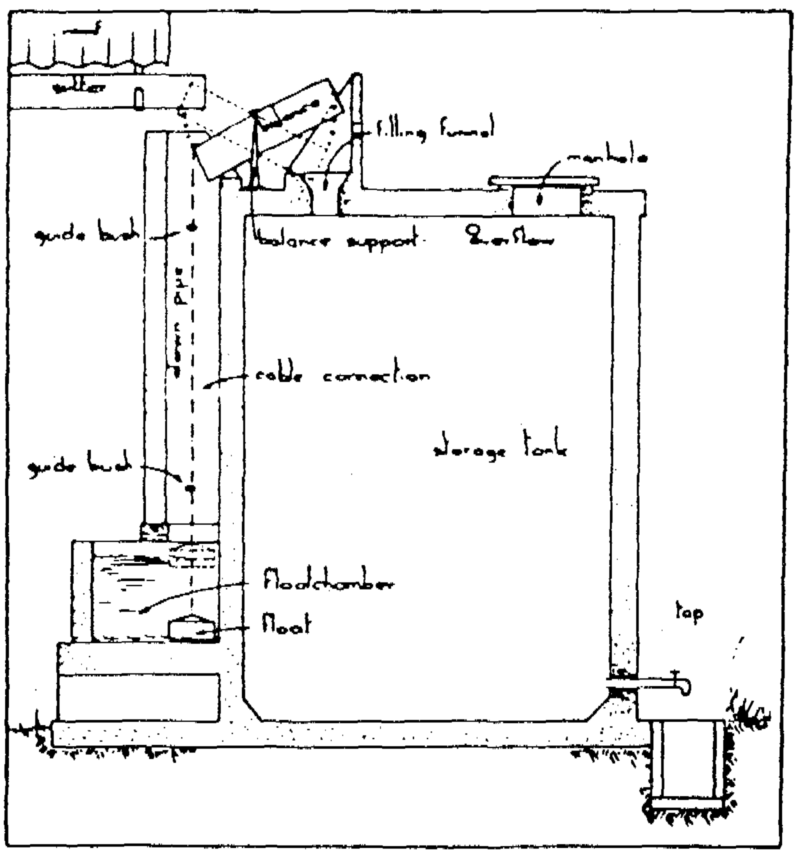
FIGURE 6 EXAMPLES OF FOUL FLUSH SYSTEMS



Adjustable downpipe fitting (after ITDG, 1984).



Foul Flush Trap developed at Khon Kaen University, Thailand



First flush device for Campagne Citernes cistern, Togo (after Government of Togo, 1987).

The operation and maintenance of ground catchment tanks also involves the regular cleaning of the tank and catchment surface. Where water is extracted by a pump additional care and maintenance will be required. One aspect of ground tanks which requires particular attention is the risk of animals and young children falling into the tanks, either during construction or if the tank cover is not sufficiently robust. Proper fencing of both the tank and catchment is therefore recommended. Keeping animals and young children off the catchment surface should also help to reduce the risk of serious contamination of the supply.

Research Into Water Quality

Although stored rainwater may not always meet W.H.O. drinking water standards it frequently does, and generally speaking it is of a far higher quality than most of the traditional sources and many of the improved water sources found in the developing world. Contrary to popular myth rather than becoming stale with extended storage its quality often improves, as bacteria and pathogens gradually die off, (Wirojanagud et al. 1989).

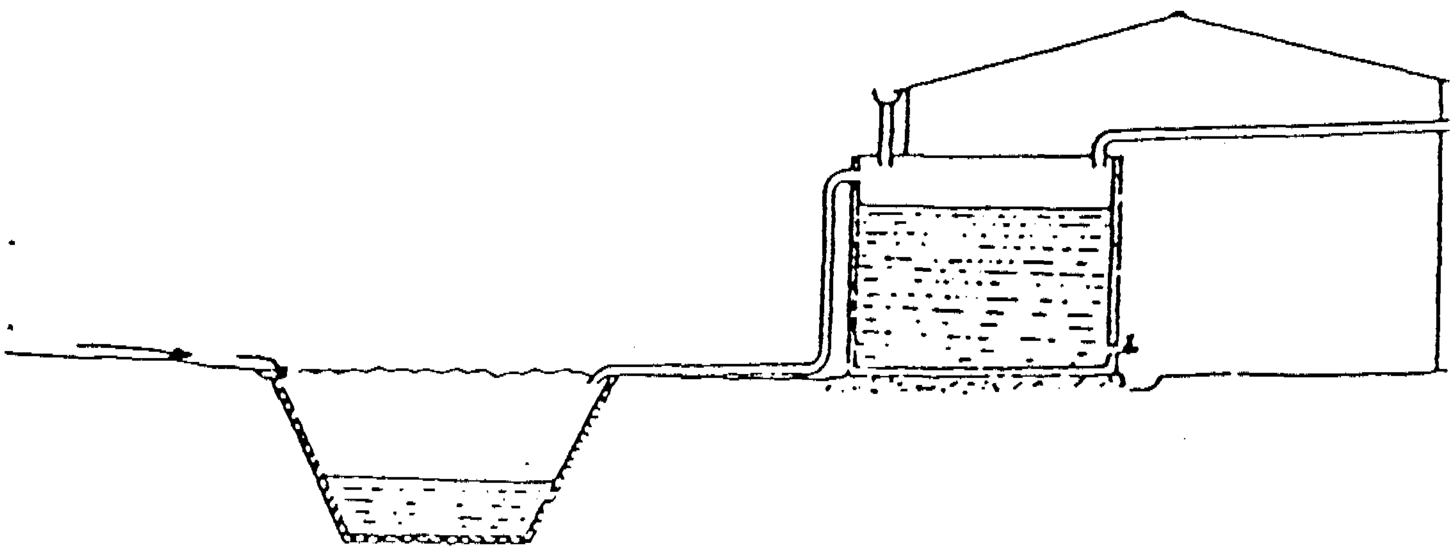
Roof catchment tanks can provide good quality rainwater clean enough for anyone to drink, so long as the design features listed above are incorporated. A clean impervious roof made from non-toxic material is essential, lead and asbestos roofs should be avoided as should any covered with lead based paint. Roofs should also be free from over-hanging trees since these provide sanctuary for birds and other animals which could defecate on the roof and thus contaminate the rainwater runoff. Koplan et al.(1978) have postulated that an outbreak of a rare form of salmonellosis in Trinidad was caused in this way. Since accounts of serious illness linked to rainwater supplies are few, it would appear that slight contamination of roof runoff from an occasional bird dropping on the catchment surface does not represent a major health risk. Nevertheless, taps on roof tanks should be at least 30 cm above the base of the tank as this allows any debris entering the tank to settle on the bottom where, provided it remains undisturbed, it will not affect the quality of the water. Ideally, tanks should be cleaned annually if possible. In a major study of the quality of stored rainwater in Thailand by Wirojanagud et. al. (1989) which examined bacteriological, pathogenic and heavy metal contamination, samples from 189 rainwater tanks and jars were tested as well as 416 of both roof and gutter runoff. Only 2 out of 89 rainwater tanks and none of 97 rainwater jars sampled contained pathogens. The heavy metals analyzed included Cadmium, Chromium, Lead, as well as Copper, Iron, Magnesium and Zinc. None of these exceeded WHO standards with the exception of Magnesium and Zinc which are considered to only effect the aesthetic quality of rainwater. Nevertheless, bacteriological analyses revealed that only 40% of 189 rainwater jars sampled met with WHO drinking water standards. Despite this finding it was still concluded that potentially rainwater is the safest and most economical source of drinking water, since, generally only serious bacteriological contamination has major health implications. Improvements in the hygienic collection and handling of the rainwater, sanitary practices and the use of disinfection techniques where necessary were recommended.

Pinfold et. al.(1990) have argued that any systematic attempt to ensure water from rainwater jars meets WHO quality guidelines would be both problematic and expensive, with negligible health benefits. It is suggested that a more realistic approach should involve incremental improvements maximizing the cost-effectiveness of available resources. Disinfection of stored rainwater through chlorination is also discouraged, due to its impracticality when dealing with so many discrete supplies and the dangers of health risks from over chlorination.

Rainwater Catchment Systems Research in Southern Africa

Following the initial research work into low cost ground catchment tanks in the region, ITDG (1969), further research was conducted by Farrar in the early 1970's which examined rainwater catchment systems throughout Southern Africa, this study included the diagram shown in figure 7, Farrar (1974). One interesting finding from this work from this work relates to the construction of over 200 ferrocement roof tanks by the Hlekweni Rural Training Centre in Matabeleland, Zimbabwe, Farrar and Pacey (1974). Most of these tanks were still operating effectively when the author visited this centre in 1983. The tanks were built using a cylindrical corrugated iron formwork as outlined by Watt (1978), Fig. 8.

The tanks were initially subsidized although the aim of the project was to become economically self-sustaining. Despite the fact the ferrocement tanks were cheaper than the commercially available galvanized corrugated iron tanks of comparable volume, when the subsidies were removed, few people could afford the tanks and demand



gure 7 ...Combined Roof and Ground Catchment System (After Farrar 1974) slackened dramatically. Although the project was still producing some tanks in the early 1980's, a cheaper design using locally produced and discarded building bricks had been adopted.

In 1983 the Botswana Technology Centre (BTC) became actively involved in a rainwater catchment systems research project. This work examined the feasibility of the widespread introduction of both roof and ground catchment systems in Botswana for supplementary water supply in rural areas, Gould (1985, 1987). A computer model for determining the most appropriate storage capacities for given catchment areas was run using rainfall data from 10 different locations spread throughout the country. Different tank designs were examined and compared and the bacteriological quality of stored rainwater analyzed.

The study concluded that rainwater collection was clearly a viable technology for supplementary or drinking water supply in all but the extreme S.W. corner of Botswana. Due to the high cost of the large storage tanks required, however, subsidies from government or other sources were recommended as essential for encouraging the spread of the technology. The construction of large ferrocement roof tanks at primary schools and clinics lacking reliable good quality water supplies was proposed. A storage capacity equivalent to 40% (0.4) of the total annual runoff was calculated to be the most appropriate for eastern Botswana. This would yield a supply equal to 70% (0.7) of the roof runoff with 95% reliability, thus maximizing rainwater supply while attempting to reduce the storage tank costs.

Following this research the Botswana Technology Centre (BTC) spearheaded a campaign aimed at introducing and promoting the spread of ferrocement roof catchment tanks. This involved the construction of demonstration tanks at the new BTC centre, the running of training courses, the loan of formworks and the publication of a booklet giving construction details, Wilkinson (1984).

Although commercially available 2.25, 4.5 and 9 cubic metre galvanized corrugated iron roof tanks were being used at some schools, clinics, missions and by wealthy householders with large corrugated iron roofs, the life expectancy and capacity of these tanks was limited. Due to the large storage volumes needed to ensure a continuous supply even in the long dry season, BTC recommended the construction of $20m^3$ tanks using a design based on that of Watt (1978). At least 60 of these tanks have been constructed both for roof catchment and storage of water at boreholes.

According to relevant correspondence in BTC files the success of the ferrocement tanks built to date has been somewhat variable with figures quoting as many as 50% suffering from some degree of leakage, especially where tanks have been allowed to dry out. The Ministry of Local Government and Lands (MLGL) have also been peripherally involved in the construction of ferrocement but have mainly constructed a more expensive reinforced brick design, Visscher and Lee (1990). Extensive technical and other details of all these designs with reference to there construction in Lobatse is given by Hasse (1989). Although he gives a very thorough and well illustrated account of the construction techniques for both reinforced brick and ferrocement tanks, his guidance on rainwater tank volume determination is somewhat limited.

CONCLUSION

Further Research Requirements

Following the recent study of rainwater harvesting in five African countries by Lee and Visscher (1990) recommendations were made for more applied research in the following areas: community participation; women's involvement; the true cost of systems; community-spread financing; national finance support systems; actual impact measurement (especially on women and health); and non-ferrocement roof catchment technologies. The need for improved monitoring of the use, maintenance and water quality of systems was also stressed for the purpose of providing guidelines and improvements.

In many parts of Asia the research needs are similar although in more prosperous countries such as Thailand the emphasis is no longer on implementation and financing of programmes, but on improving water quality through better operation and maintenance of systems and improved hygiene education.

In other parts of the world, research needs vary according to each location, although particular areas of concern at present include the problem of mosquito larvae in tanks, the influence of industrial atmospheric pollution on rainwater quality and the possibilities for using rainwater supplies in urban areas for non-consumption purposes, as part of a dual-supply system, (Bullerman and Klein 1989).

Information Transfer

No clear unified system yet exists for the effective flow of information on rainwater catchment technology either within most countries or between them. At the international level a loose association of interested organizations liaise to some degree and each assist in the dissemination of information. The most active of these at present is the Water and Sanitation for Health (WASH) Project based in the U.S. which networks more than 500 individuals and projects interested in rainwater catchment technology around the world and produces a regular bulletin 'Raindrop' available free of charge to all network members. The WASH project also has a stock of over 300 publications on rainwater catchment technology, copies are available on request.

Other organizations actively involved in providing information on developments and issues related to rainwater catchment systems include; the IRC International Water and Sanitation Centre in the Hague; the Intermediate Technology Development Group based in the U.K. through there quarterly Waterlines publications, technical briefs and other publications; and the newly formed International Rainwater Catchment Systems Association (IRCSA). The contact addresses of these and other organizations actively involved in disseminating information on RWCS is given in Appendix 1. A series of International Conferences on Rainwater Cistern Systems has also provided a useful forum for the information exchange between researchers and project managers, details of future conferences can be obtained by contacting IRCSA.

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APPENDIX 1

CONTACT INSTITUTIONS

1. The International Rainwater Catchment System Association, c/o Prof Fok. Univ. of Hawaii, Dept. Civil Eng., 2540 Dole St., Honolulu, Hawaii 96822

2. W.A.S.H., 1611 N.Kent Street, Room 1002, Arlington, Virginia 22209, USA

3. I.D.R.C., Box 8500, Ottawa, Canada K1G 3H9.

4. International Reference Centre, P.O.Box 13190, 2509 AD, The Hague, The Netherlands

5. WaterAid, 1, Queen Anne's Gate, London SW1H 9BT. Tel 01-222 8111

6. The Botswana Technology Centre, P/Bag 0082, Gaborone, Botswana.

7. The Mutomo Soil and Water Conservation Project, P.O.Box 125, Mutomo via Kitale, Kenya.

8. The Capiz Development Foundation, P.O.Box 57, Roxas City, Philippines.

9. The Faculty of Engineering, Khon Kaen University, 40002, Thailand.

10. Approtech Asia, P.S.D.C, Magallanes Cor.,Real St, Intramuros, Manila 1002, Philippines.

11. UNICEF, Technology Support Unit, P.O.Box 44145, Nairobi, Kenya.

12. ENSIC, Environmental Sanitation Information Center, Asian Institute of Technology, P.O.Box 2754, Bangkok, 10501, Thailand.

13. I.T.D.G., Myson House, Railway Terrace, Rugby, CV21 3HT, U.K.

RESEARCH IN RAINWATER HARVESTING: A REFLECTION ON THE RESEARCH PRIORITIES IN KENYA

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INTRODUCTION AND JUSTIFICATION FOR RESEARCH

In this paper we focus our attention to the probable aspects of rain water harvesting research that would be of priority in the 1990s for Kenya. The paper also tries to emphasise the need to develop extension strategies that would be utilised in order to educate the Kenyan Public on the findings from the research. Finally, the paper concludes by highlighting the problems that may be faced when carrying research in this area.

It has now become common sense knowledge to us all that adequate water supply is one of the basic needs of life. However, it is often lacking in developing countries, particularly, in the arid and semi-arid parts. Due to the increase in human population, and coupled with the Kenya Government policy of settlement, people have now settled in the marginal areas, which are characterised by low rainfall. These areas are now under increasing pressure from both human and animal populations for the provision of adequate water supply. Generally speaking, the levels of water system coverage in Kenya as a whole is relatively low. They vary widely from as low as 14% in North Eastern Province to 20% in Central Province with 15% on average, for rural coverage. The unserved population was estimated at the end of 1986 to be 14 millions (6). This suggest that serious attention must be given to alleviate this problem.

Although rainwater harvesting is a relatively new technology in Kenya, and has now been taken as probable solution to the provision of water, very little research has been done on the plansibility of this alternative. In many parts of Kenya even where severe draught and food shortage are frequent, majority of the people do not conceive rainwater harvesting as an immediate solution, to their water problem. Although the Government and non-Government Organisations (NGO), have tried to encourage, the inhabitants of such regions, to engage in rainwater harvesting, the rate of construction of improved water supply systems is still slower than the target originally set under the International Drinking Water Supply and Sanitation Decade (1981-1990). Also those schemes already completed are not in satisfactory operating conditions.

Various reasons have been raised to explain this dilema, for example, lack of sufficient funding and trained personnel to operate and maintain water systems (12). A number of water projects here in Kenya have employed water harvesting technologies without reference to a study on the most appropriate technology for the areas or the communities. These speculations may help us in understanding the problem, but there is still urgent need to carry out a study on what may be influencing the success of such endeavours. Also, no study has been conducted to evaluate how those who have succeeded in establishing a rain-water harvesting system, have utilized the water (8). The key requirements for an appropriate solution is that, the technology should be selected in the light of local circumstances, with particular attention to the human material, their socio-cultural set-up and maintenance. The type of technology chosen should be that which would serve reliably and economically for many years under local conditions.

Also, studies have not been done before the introduction of any type of technology, so as to understand the social structure within which the technology has to be implemented and maintained. That is, in most cases there has not been communication between the experts and the members of the community. On the type of rainwater harvesting technology presented vis-a-vis their traditional methods. Such a study would enhance the understanding of the peoples' attitudes and traditions; economic capability and their level of acceptability of the new forms of technologies. These would then lead to the development of more appropriate water facilities which are affordable and easily maintained. They would also assist government planners and community development officials in establishing strategies for educating the communities concerned on the appropriate technologies to be introduced.

From the foregoing argument and observation there is an indication that there is some underlying problems that seem to impend the rate at which the communities in Kenya are able to accept and utilise the rain-water harvesting practices. There are definitely some pertinent questions which have not yet been answered so far in relation to rain water harvesting e.g:

1. What are the Rain Water Harvesting practices and their relationship to the rainfall patterns of the areas concerned?
2. What are the beliefs, perceptions, and attitudes among the people towards the existing Rain Water Harvesting technologies?

3. What are the socio-cultural structures of the people and its influence on the acceptability and use of the water harvesting technologies that are not indigenous to the area?

4. How have the existing water harvesting practices influenced the health and agricultural production in an area where they are being practiced, and which of them are most appropriate?

5. What type of rain water harvesting designs that have been developed in Kenya i.e. either at household or community levels? Have they been appropriate in terms of cost affordability and maintenance and have they been documented?

6. What may hinder the possibility of incorporating the rain-water harvesting aspect in our town housing designs? Would this conflict with the Local Government Bye-Laws!

7. At what stage would the introduction of a certain rain water harvesting technology be most vulnerable, and what factors are associated with this?

Such underlying issues could surely form a research agenda for Kenya. Moreover, after independence in 1963, large number of families, particularly, from Central and Westen Kenya rural communities engaged in uncontrolled migration to the formerly white settled areas. This led to creation of settlements where there were no adequate centralized water systems. Attempts by the government to alleviate water problems in these settlements have been unsuccessful in meeting the communities water demand, due to limited resources, lack of control of settlement patterns of the people, and the mismanagement of the available centralized water resources. Thus, rainwater harvesting becomes the most viable alternative, aimed at meeting a demand for a given quantity of water at a minimum cost, maximum hydrologic reliability, maximum quality, and with minimal sensitivity to organizational or administrative failure. Among the few studies that have been done on rainwater harvesting in Kenya i.e. (7), (9), (10), (5), none seem to have concerned itself to the analysis of the achievement of the above objectives. There is then, need for a study to evaluate in general the performance of the various water projects in the Kenyan rural areas in order to reveal the challenges for development of rainwater harvesting among the groups concerned.

Although various lessons could be learnt from the number of studies done on rain water quality elsewhere in the world e.g. (1), (2), (3), (4), etc. more studies, specifically for Kenya are required, as well as establishing an extension mechanism for disseminating the knowledge gained from the other societies dealing with rainwater harvesting. Also, no studies have been conducted to survey the existing rainwater quality control measures that our Kenyan rural communities practice, nor is there an indication of attempts to try and educate them on the findings from studies done elsewhere.

Current Lessons and challenges for the development of Rainwater Harvesting in Kenya

As has been implied so far in this paper, the rain water harvesting as a water resource has an increasingly bright future in Kenya. Previous studies of its application has suffered because of very few studies in this area, and also, due to whatever work done, being in isolation from other similar endeavours, from other parts of Africa or elsewhere. However, very recently, renewed emphasis is being put on this topic by researchers, governments and NGO's and it is now clear that rainwater harvesting is a unique area of applied science that incorporates a wide range of fields, e.g. hydrology design, construction, water treatment, environmental pollution, and economics. It is therefore, necessary that future developments in rainwater harvesting should involve collaborative efforts by experts from the related disciplines, in order to resolve the problems from a multivariate standpoint. Lessons from issues such as: the viability of runoff in farming in Kenya with respect to improved crop production and their economic performance to the rural households; improvement of sanitation and the general livelihood of the rural people and environmental protection, are yet to be learnt, since no serious attempt has been made to this end. Thus, a study to attempt to reveal the lessons from the current water harvesting practices and the challenges thereof, is long overdue, in order to assist the government and NGO's in formulating their water harvesting related policies. Such lessons would also allay the anxiety of the desperate peasant farmers in our arid and semi-arid rural Kenya.

In summary, it has been noted from the foregoing brief literature review that, studies on various aspects of rainwater harvesting in our rural Kenya are lacking, and where they occur, no serious indication has been shown of their findings having been translated at policy level in order to lead to a renaissance in the prospects for runoff farming and improved sanitation practices. Also, lessons and future challenges for development in these areas are not clear due to lack of rigorous studies having been carried out.

Furthermore, there exists very little documentaion from evaluation projects carrid out by donor agencies or NGO's that may have funded projects on water harvesting in rural Kenya. What is available is budgets of the proposed projects and accounting of the expended monies. Thus, those interested in rainwater harvesting should try and conduct research in order to fill all the above gaps indicated, and in addition, some of the salient issues cited above should also be taken into consideration in the design of such studies.

Problems of carrying out Research in Rainwater Harvesting in Kenya

The above would have been incomplete without the mention of the problems researchers are likely to encounter. The two major problem that comes directly to mind are:

i). except for bodies such UNICEF and IDRC, very few others are willing to fund studies in this area, and

ii). there exists very limited documentation on what have been going on in Kenya, about rain water harvesting,

hence difficult to identify what to concentrate on as a priority. Definitely, there are other minor problems that one may encounter, such as negative attitude towards researchers by the local people due to unforeseen immediate pay - off from the findings of such researchies.

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The Pwani Community Rainwater Catchment Project - A Case Study

The Pwani community is situated about 15 km west of Nakuru Town in Kenya. People were settled there in 1974. Each household own a 2.5 acres of land. Its on this piece of land where the average family practices a subsistence type of mixed farming. The rainfall figures are between 600mm-800mm per annum. Pwani experiences a drought at least once in 3 years.

The Diocese of Nakuru (C.P.K) Rural Development Programme (Christian Community Services) entered in Pwani community in 1987. After a thorough community participatory survey the community's felt needs were critically analyzed and prioritized. Water was right on top of the list. It was a very serious problem. Women would travel an average distance of 8km round trip to the nearest borehole daily (took up to 6hrs) to collect only 30 litres of clean water for the family! Men, on the other hand would travel the same distance with their cattle and sheep for water. Others used bicycles and donkeys to collect water. How could this poor community with their meager resources be helped to come out of this problem? What was the most appropriate approach and what was the most appropriate technology for them? The project personnel were reluctant to decide for the Pwani community due to earlier technical mistakes they had experienced in other areas.

After holding several meetings in the field with the community a village committee was appointed by the local people to attend a one week seminar on rural development and community leadership. During this week the committee resolved to go back and mobilize their people to form self help groups (SHGs) to build surface water tanks to tap rain water roofs. The following local resources were to be used: Quarry stones, sand, a local transporter, local skilled artisans (after some training by the Development Agent - C.P.K) Any other manual work was provided for by the respective members of the group. Each group set a specific date in the month when they met. Every group member was involved in deciding the amount of money for monthly contributions (some groups would increase their contributions after a good crop yield) With this formula, the 1st group was formed with 72 members. By the time they had completed the first 10 tanks or so more groups were formed with varying membership and monthly contributions. The capacity and shape of the tank also varied: some with 2500 gallon, others with 4000 gallons. Some tanks were round,others square. The local artisans trained others and there was a multiplying effect. Today after a good 3 years, there are 21 self help groups with a total membership of 1,002 local people. These together have today completed over 700 surface water tanks. Out of all this the development agent has only assisted (in terms of materials not cash) about 25% but with very close interaction with community members on technical issues. All administrative issues in the groups are handled by the central village committee and the specific group officials. It is this self Government that we have consistently empowered through frequent meeting, training, education tours etc. Currently each tank costs between Kshs.4,500-6,500 minus labour charges. All the 21 SHGs put together contributes over KShs.90,000 per month. This money has very good accountability since materials are bought immediately the money gets collected, thereby avoiding any room for misappropriation.

In addition to surface water tanks, individual farmers are excavating their own shallow ponds manually to harness surface run-off for use either by their livestock or in micro-irrigation work in their kitchen garden. This is a better and economically way of soil and water conservation.

We have found that once a group meets its water needs that is not the end of the road. Some have entered into phase two of their project depending on the most pressing need of the individuals in each group. The following activities have been undertaken: Income generating projects such as zero-grazing, bee-keeping, improved houses, or compost making and "double digging" technology for improved food production.

However, with the tank work, there are a few technical problems to be addressed to such as guttering systems, proper roofing to curb dirt and evaporation rate, the proportionality of the tank's size in relations to rainfall figures and size of the catchment and other sanitary measures. All the same, one thing is clear: the Pwani community have today got a break through in the earlier water problem. We in the Diocese of Nakuru have learnt alot from this case project, that the local people must be involved and that they must take the initiative in solving their own problems.

Joseph M. Ndegwa
PROJECT OFFICER-RODA/PWANI PROGRAMME

BREAKDOWN OF PWANI COMMUNITY SELF HELP GROUPS AS IN APRIL 1991

Rainwater Harvesting Workshop

	Name of Group	Started	Tanks Built	Total No. Expected	Type of Tanks	No. of Fundis	Mabati Tanks Roofed	Remarks
1.	Miharati	7/7/87	72	72	Square 10x10ftx5ft (3000 gal)	1	72	Zero-Grazing - 7 today.
2.	Mwiloti	8/88	56	86	" " "	1	None	
3.	Metha	10/88	45	70	" " "	1	None	
4.	Kiriko	9/88	48	86	" " "	1	"	Individually some have roofed to be refunded.
5.	Witeithie Wone Mai	17/3/88	47	48	" " "	1	"	
6.	Senedet	10/90	48	73	" " "	1	"	
7.	Wendo	1/91	2	47	" " "	1	"	
8.	Mucii ni Mai	8/90	8	56	" " "	1	"	
9.	Rukungu	8/89	35	35	" " "	1	"	Roofing starting
10.	Murango	18/8/88	66	73	" " "	1	"	
11.	Kihoto	9/90	7	69	" " "	1	"	
12.	Amani	-	33	33	Iron Sheet GI	-	"	New Posho Mill, Zero-Grazing project, Heifer project.
13.	Umoja	1982	30	30	Adobe block cylindrical	-	"	Zero-Grazing,(15 ready), Goat project finished.
14.	Kuga na Gwika	4/88	Bee-Keeping project 115 hives			Individual are members of other water project		
15.	Matigari	11/89	56	72	Square	1	-	Low cost housing - 4 ready.
16.	Thayu	12/89	13	86	Square	1	-	-
17.	Mahua	11/90	11	48	Square	1	-	-
18.	Guthera	6/89	VIP latrines (19 VIPs) Today			Members 48		
19.	Kiambiriria Mwiteithia	2/8/89	38	40	Square	1		-
20.	Murera		Cattle dip		Individuals are members of other water projects			
21.	Youth		Poultry + Tree Nursery			-	-	-

RECOMMENDATIONS

i) Design of Rainwater Catchment Systems

SIZE

1 Consumers should be educated on ways of preserving water because it is a very rare commodity.

2 Advice people to use ground catchments for non domestic requirements instead of depending on the roof catchment.

OTHER ASPECTS OF DESIGN

3 Sensitize our Engineers and policy makers to start thinking of rainwater as a possible water source.

4 Applied research to be done in relevant areas (gutters, slope etc), and to then be put into practice.

5 Sensitize our people to look at tanks as a means but not as a status symbol.

MATERIALS FOR TANKS

6 It is difficult to recommend any material because several of them have failed due to various reason. Materials available should be used where possible.

ii) Livestock and Crop Production

1 Too much emphasis on roof catchment provision for other methods for rainwater harvesting should be looked into in the future.

2 There is a need for collaboration of a cross-section of all disciplines.

3 Management strategies to maintain good vegetation cover within the farm environment to improve on water retention capacity.

4 Need for educating the farmers on Rainwater harvesting techniques, and creating awareness of the need for rainwater harvesting for livestock and crop production.

iii) Water Quality and Health Aspects

GROUND WATER CATCHMENT

1 Water from ground runoff should not be used for drinking unless treated, otherwise it can be used for other purposes.

2 The source should be adequately covered to control mosquito breeding.

3 To reduce the risk of accidents they should be adequately covered or fenced off.

4 Where a large surface water point is the only source simple natural filtration eg a shallow well can be provided to

improve the quality near to the source.

ROOF CATCHMENT

5 To control contamination the tank should be covered with a sealed roof and any opening should be screened to prevent any insects, animals and any organic matter entering.

6 Roof catchment surface and gutters should always be maintained in a clean state by removing overhanging branches or trees and letting the first rain run outside the tank.

7 Collection of water from roofs of the following materials should not be recommended:
   a) Asbestos cement
   b) Lead based painted sheets or tiles

GENERAL RECOMMENDATIONS

8 Catchment areas in the vicinity of where pesticides are used should be avoided.

9 Regular monitoring of the water quality, catchment and tank conditions is recommended, especially for institutions where there are many users.

(See Appendix for the WHO Guidelines for drinking water Quality Volume 3 DRAFT for Household Rainwater Collection in relation to Health)

iv) <u>Social, Economic and Community Aspects</u>

COMMUNITY

1 Advocacy through institutions, social groups, should be encouraged by the government and external support agencies (ESA)

2 Locally developed and potential skills should be retained through job opportunities (by the community).

GOVERNMENTS

3 Greater (increased) number of government officials to appreciate the technology and spread the knowledge.

4 Promote and organise workshops / seminars to enhance the application of this technology at community or regional levels.

5 Develop acceptable, affordable, replicable and sustainable system's.

6 Develop and promote research

EXTERNAL SUPPORT AGENCIES

7 Emphasis human resource development - develop skills and expand such skills.

8 Assist Communities that need help.

9 Encourage rain-water harvesting at household level.

10 Work together with other agencies so as to create a multiplier effect within the communities

11 Promote widespread distribution of storage facilities
Many Smaller Tanks Are Better Than One Large Tank

v) General Recommendations

1 Rainwater harvesting should be started and encouraged in urban areas.

2 There ought to be more research on the subject, with the research findings getting through to the extension staff in the field.

3 There ought to be a survey of what is being done in Kenya

on Rainwater Harvesting, and by who.

4 Such a workshop as this should take place annually or biannually but be longer and with a more specific theme.

APPENDIX

(this is an extract from: The Surveillance and Quality Control of Small Community Water Supplies, World Health Organization Guidelines for Drinking Water Quality, Volume 3, DRAFT 1991)

Household Rainwater Collection

Rainwater collected from clean house roofs can be more microbiologically safe than water from untreated household wells. However, when rain falls after a long dry period, collected rainwater may carry significant amounts of contamination and debris which have accumulated on the roof and in the gutters. For this reason, it is recommended that the water running off the roof for the first 10-20 minutes of a storm be discarded. There are many devices for diverting this initial flow to waste.

Additional precautions to improve the quality of the collected rainwater include maintenance of the roof and gutters and diligent cleaning at the beginning of every wet season. There should be some form of mesh between the guttering and the downpipe to prevent entry of coarse debris, but this precaution needs to be accompanied by an assurance of regular cleaning of the screen to prevent blockage. It is worth noting that the worst fouling of roofs occurs when they are situated under trees in which birds roost. In areas where malaria is endemic care should be taken to avoid creating mosquito breeding sites.

The condition of rainwater storage tanks is crucial. They should be completely covered and well-maintained. Organic debris should be prevented from entering by fitting a fine mesh on all openings to the tank. Water should be drawn off by a tap located a little above the base of the tank.

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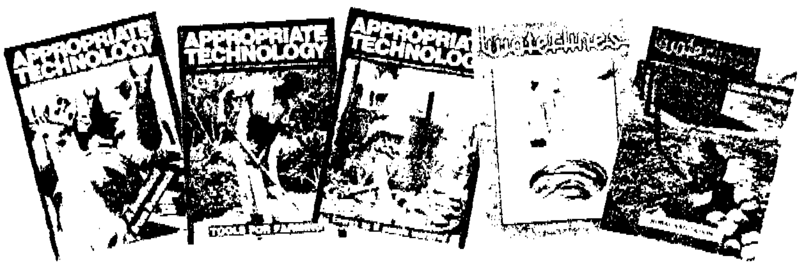

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Community Participation in Water Supply and Sanitation: Concepts, strategies and methods
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This collection of articles from the *Waterlines* and *Appropriate Technology* journals covers the areas Sources of Water, Abstraction, Pumping and Distribution, and Training and Maintenance, and is an excellent training guide.
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Describes how cylindrical water storage tanks of up to 150 cu m capacity can be built using wire-reinforced cement-mortar. Covers design and planning; costs; standard, recommended and alternative construction methods, and other information.
118pp. 1978. (ITP). 011FWT. ISBN: 0 903031 51 5. £4.95.

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Guidelines for Drinking-water Quality Drinking-water quality control in small-community supplies Vol 3

For use by countries as a basis for the development of standards which, if properly implemented, will ensure the safety of drinking-water supply. This book deals with small-community supplies, particularly in rural areas.
130pp. 1985. (WHO). 013GDWQV3. £7.25.

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OUT OF PRINT

A practical and well ... manual for all those seeking to prov... drinking water and hygienic sanitat... low-cost hand drilled wells in a rural environ...
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Hand Pump Maintenance in the Context of Community Well Projects
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Shows how to make a simple, cheap, pump suitable for small holding and garden use, a pump which can raise water from unlined (or lined) wells up to 4 metres deep. A simple clear text, with line drawings, show how common materials can be used.
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† **Laboratory and Field Testing of Handpumps** Goh Sing Tau

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Land Husbandry: A framework for soil and water conservation NEW T.F. Shaxson and others

This manual should prove valuable for a broad spectrum of interests; from soil conservationists attempting to raise the awareness level of policymakers, to project leaders attempting to explain problems and solutions, to nonconservationists.
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Making the Links: Guidelines for hygiene education in community water supply and sanitation Marieke T. Boot

Written for community hygiene promoters, planners, technicians, and survey staff, this book discusses the main water and sanitation related diseases and how they can be prevented or reduced, as well as community hygiene education.
82pp. 1984. (IRC). 013MTL. £5.95.

Manual for Rural Water Supply

This is a highly detailed construction and maintenance manual, with many scale drawings for the planning and execution of drinking water projects.
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A Manual on the Hydraulic Ram for Pumping Water S.B. Watt

Contains details of how to make and maintain a small hydraulic ram on a suitable site, whilst Part Two takes a more technical look at ram performance and design considerations and also contains a useful bibliography.
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60pp. 1989. (CIIR). 013TTW. £3.50.

The Operation and Maintenance of Small Irrigation Schemes Peter Stern

Written in conjunction with *'Small-scale Irrigation'*, *this manual deals with the problems of operation* and maintenance at sources of supply, the conveying of water, its distribution, and also advises on drainage, health, and general management problems.
48pp. 1988. (ITP). 011TOAMOSIS. ISBN: 0 946688 74 5. £5.50.

The Participation of Women in Water Supply and Sanitation: Roles and realities Christine van Wijk-Sijbesma

This state-of-the-art survey, produced jointly with UNDP, is based on practical experience drawn from 800 sources, and describes ways of involving women in the planning, implementation, maintenance, evaluation, health education, and agency support.
200pp. 1985. (IRC). 013POWIWSAS. £15.95.

Rain Catchment and Water Supply in Rural Africa: A manual E. Nissen-Petersen

A simply written guide to obtaining a regular water supply using only locally available skills.
96pp. 1982. (Hodder and Stoughton). 013RCAWS. £2.50.

Rainwater Harvesting: The collection of rainfall and runoff in rural areas Arnold Pacey and Adrian Cullis

This book emphasizes the importance of social, economic, and environmental considerations when planning and implementing projects. For rural development workers, it aims to fill the gap in existing literature on the gathering and storage of water.
224pp. 1986. (ITP). 011RH. ISBN: 0 946688 22 2. £8.95.

Rainwater Reservoirs above Ground Structures for Roof Catchment Rolf Hasse

Developing countries demand the utilization and development of all possible sources to ensure the supply of water. This recommended book gives information on water catchment and choice of reservoir types, material testing, and tank installation.
102pp. 1989. (Gate/Vieweg). 013RRGS. £13.50.

Rural Sanitation: Planning and appraisal Arnold Pacey

This document is written for hospital staff and community development workers in Third World countries who are planning to start sanitation or hygiene improvement programmes.
68pp. 1980. (ITP). 011RS. ISBN: 0 903031 72 8. £4.50.

Rural Water Supplies and Sanitation: Blair research bulletin (NEW)
Peter Morgan
Brings together the latest information concerning practical, realistic and appropriate solutions to a fundamental problem — how to establish and maintain clean water supplies in areas without access to reliable sources
360pp. 1988. (Macmillan). 013RWSAS. £8.99.

Sanitation without Water: Revised and enlarged edition
Uno Winblad and Wen Kilama
Deals with drop latrines and pour-flush latrines. Shows how to design, build and operate better latrines. The emphasis is on simple measures that people can carry out with limited resources. For health workers, architects, engineers and planners.
174pp. 1985. (Macmillan). 013SWW. £3.95.

Septic Tanks and Aquaprivies from Ferrocement S.B. Watt
This book describes the potential of ferrocement as a construction material; gives details of how septic tanks and aquaprivy waste treatment and soil disposal units are designed and constructed; and gives details of other low-cost sanitation options.
108pp. 1984. (ITP). 011ST. ISBN: 0 903031 95 7. £5.50.

Simple Methods for the Treatment of Drinking Water Gabrielle Heber
Shortage of clean drinking water is one of the reasons for disease and child mortality in Third World countries. This manual shows simple methods and equipment for the treatment of water and gives basic technical information.
78pp. 1986. (GATE/Vieweg). 013SMTODW. £9.25.

Slow Sand Filtration
L. Huisman and W.E. Wood
This book describes the 'biological filtration' or 'slow sand filtration' process — a simple, inexpensive and reliable method of water purification that has proved effective under widely differing circumstances.
112pp. 1985. (WHO). 013SSF. £7.95.

Slow Sand Filtration Caretakers Manual
J.T. Visscher and S. Veenstra — Revised Edition
A practical manual covering step-by-step technical aspects of the slow sand filtration process, community involvement, operation and maintenance, and cleaning and resanding.
80pp. 1986. (IRC). 013SSFCM. £6.50.

Small Scale Sanitation
R. Feachem and A.M. Cairncross
An extremely useful introduction to a range of sanitation techniques, with abundant detail on smaller systems from pit privies to sewerage systems.
54pp. 1988. (Ross Institute). 013SSS. £3.50.

Small Water Supplies
R. Feachem and A.M. Cairncross
A guide to small-scale water supply, with sections on water sources, pumping, treatment, storage, and purification.
78pp. 1978. (Ross Institute). 013SWS. £4.00.

Small-scale Irrigation Peter Stern
This excellent, clearly illustrated book has been written for those working with farmers on development and extension in rural areas who do not have much access to the technical know-how needed for developing irrigated agriculture on a small scale.
176pp. 1979. (ITP). 011SSI. ISBN: 0 903031 64 7. £6.95.

Solar Water Pumping: A handbook
Jeff Kenna and Bill Gillet
A 'state of the art' survey, with guides to costs and criteria for choice of pumping methods.
132pp. 1985. (ITP). 019HOSWP. ISBN: 0 946688 90 7. £12.50.

Surface Irrigation: Systems and practice
Melvyn Kay
Practical information on methods of applying water, land preparation, open channels, structures, and pipelines for both large and small-scale irrigation schemes, as well as the common problems of irrigation, and ways in which these can be overcome.
152pp. 1986. (Cranfield Press). 013SI. £12.50.

† **Tank Irrigation in Semi-Arid Tropical India: Economic evaluation and alternatives for improvement** (NEW)
M. Von Oppen and K.V. Subba Rao
Presents the findings of a survey of 32 tanks and related farm data from the Andhra Pradesh and Maharashtra states, reviews the history and development of irrigation, and discusses the economics of existing tank irrigation.
38pp. 1987. (ICRISAT). 012TIISATI. £4.00.

† **Water Disinfection by Solar Radiation: Assessment and application** A. Acra and others (NEW)
Basic information on solar energy, its transmission and distribution, and on the monitoring of UV radiation. With reviews of the two main water disinfection methods, and detailed results of experiments with the solar and halosol disinfection systems.
70pp. 1990. (IDRC). 018WDBSR. £6.00.

Water Pumping Devices: A handbook for users and choosers Peter Fraenkel
A detailed and practical review of the options available for pumping and lifting water, especially for irrigation, on a small scale, with the costs and general suitability of the different technical options.
196pp. 1986. (ITP). 011WPD. ISBN: 0 946688 85 0. £12.95.

Water Resources: Issues and strategies (NEW)
Adrian T. McDonald and David Kay
Examines complex management challenges derived from the interaction between man's control agencies and the water cycle. Successful water resource management can provide a basis for political stability, economic growth and improved living conditions.
284pp. 1988. (Longman). 013WRIAS. £11.95.

The Water Sellers: A co-operative venture by the rural poor in Bangladesh
Geoffrey D. Wood and Richard Palmer-Jones
The Water Sellers analyses an innovation in rural development whereby groups of landless labourers in Bangladesh are assisted to invest in irrigation equipment and to provide an irrigation service to farmers.
Water for irrigation, as the second most important rural means of production, can in effect be

owned by the landless if they can obtain pumpsets and make agreements to supply farmers. Farmers can be interested in such a service when their holdings are so fragmented and dispersed that any mechanized irrigation technology becomes too lumpy for fragmented plots, and when co-operative arrangements among farmers fail.

A Bangladeshi NGO, PROSHIKA, has undertaken this programme since 1980 — supporting landless groups with consciousness raising activity, skills training and credit. The initial incredulity of the irrigation community has now been overcome, and the model is slowly being adopted more widely both for irrigation and other agricultural services.

The Water Sellers consists of a close examination of the project experience from a policy, institutional, economic and financial perspective, including implications for NGOs as development organizations.

274pp. Forthcoming 1991. 011TWS. ISBN: 1 85339 084 4. £14.95.

Water Treatment and Sanitation
H.T. Mann and D. Williamson

A handbook of simple methods for rural areas in developing countries. This corrected and revised impression includes a new appendix on planning in developing towns.

96pp. 1982. (ITP). 011WTAS. ISBN: 0 903031 23 X. £5.95.

† Wood and Bamboo for Rural Water Supply: A Tanzanian initiative for self-reliance
K. van der Huevel

Describes a 9 month project using wood and bamboo water pipes for water supply. Well-illustrated and with detailed technical information.

76pp. 1981. (Delft University Press). 012WAB. £7.00.

The Worth of Water: Technical briefs on health, water and sanitation
NEW

With an introduction by John Pickford

Brings together a series of short and highly illuminating introductions to many of the main technologies and processes in the field of village and community level water and sanitation, ranging from household water storage to public standposts.

136pp. 1991. (ITP). 011WOW. ISBN: 1 85339 071 2. £8.95.

WOMEN'S ISSUES

Forward From Nairobi: Strategies for the future
M. Haslegrave

Designed to assist NGO's in deciding how they will be involved in implementing the Nairobi *Forward-Looking Strategies For The Advancement Of Women*. It summarizes the basic concepts of the original document, keeping close to the original text.

12pp. 1987. (Marianne Haslegrave). 013FFN. £1.50.

Gender Roles in Development Projects
Edited by Catherine Overholt and others

Aimed at students and fieldworkers, this collection of technical papers and case studies shows the roles that women play in development projects, and the ways in which women's needs and activities may be better incorporated into development planning.

332pp. 1984. (Kumarian). 013GRIDP. £19.00.

No Short Cuts: A starter resource book for women's group fieldworkers
N. May

Designed primarily for outsiders working with women's groups, this clear and practical book covers four main areas : how field workers can support women's groups, women's group organisations, women's group activities, and resources.

56pp. 1987. (Change). 013NSC. £5.00.

Rural Development and Women in Africa

This book recognizes that rural development is inconceivable without the active participation of women, and yet their interests and needs are not always taken into account. The case studies conclude that development strategies should be reconsidered.

158pp. 1986. (ILO). 013RDAWIA. £8.80.

Women and the Transport of Water
Val Curtis

The haulage of water is one of the most arduous and time consuming tasks of rural women, and this paper looks at the scale of the problem in general and in particular in Kenya, suggesting ways in which improved methods of transport could help.

64pp. 1986. (ITP). 011WATTOW. ISBN: 0 946688 42 7. £6.50.

† Women Taking Hold of Technology

A collection of newsletters produced by the International Women's Tribune Centre, on women and technology. Includes information on specific technologiess, details of resource organizations in the AT field, and listings of relevant publications.

40pp. 1984. (IDRC). 018WTHOT. £7.50.

Women Working Together: For personal, economic and community development
Suzanne Kindervatter

More than 40 proven participatory learning activities. A resource for field workers, adult educators, extension agents and group leaders, it enables women to organize for a variety of development efforts. Adaptable for literate or pre-literate groups.

100pp. 1988. (OEF International). 013WWT. £10.00.

† Women's Issues in Water and Sanitation: Attempts to address an age-old challenge
K.P. Pilipino

Documents the results of a seminar held in the Philippines in 1984, by reviewing women's past efforts in water supply and sanitation activities and presenting abstracts about ongoing research.

200pp. 1986. (IDRC). 018WIWAS. £6.00.

AGRICULTURE AND FORESTRY

† **Farming System Principles for Improved Food Production and the Control of Soil Degradation in the Arid, Semi-Arid and Humid Tropics: Summary proceedings of an experts meeting, 20-23 June 1983** ICRISAT (NEW)

The main objectives of the meeting were to identify areas of farming systems research and development which have potential to significantly increase food production and promote soil conservation for selected agro-ecological zones.
44pp. 1986. (ICRISAT). 012FSPFI. £2.75.

† **Irrigated Forestry in Arid and Semi-Arid Lands: A synthesis** F.B. Armitage

Irrigation is a specialized and complex process only recently applied to forestry. This book examines the processes involved, the uses of irrigation, past experiences and the benefits of integrating tree plantations with irrigated agriculture.
160pp. 1985. (IDRC). 018IFIAASL. £6.00.

Tools for Organic Farming
Edited and introduced by George McRobie

Large-scale capital intensive farming is being increasingly questioned, in both developed and developing countries. This book lists small-scale and relatively inexpensive tools for organic farmers, wherever they are in the world.
80pp. 1989. (ITP). 011TFOF. ISBN: 1 85339 009 7. £5.95.

Training and Visit Extension in Practice
Edited by John Howell

A collection of papers focused on the role, management and performance of agricultural extension services using the *Training and Visit* system. Includes an examination of the impact of this system in such countries as Zimbabwe, Somalia, Zambia and India.
108pp. 1987. (ODI). 013TAVEIP. £4.95.

Vanishing Land and Water: Soil and water conservation in dry lands
J.L. Chaelq

Clearly written and well illustrated guide with methods to promote soil and water conservation.
117pp. 1987. (Macmillan). 013VLAW. £4.95.

The Vegetable Garden in the Tropics (NEW)
Agrodok 9 AGROMISA

An introductory guide to growing vegetables on a small-scale in the tropics. It examines which tools to use, how to prepare a site ready for planting, improving the soil, sowing and propagation, how to harvest and disease control.
56pp. 1981. (AGROMISA TOOL). 013VGIT. £3.50.

The Previous publications are extracted from Books by Post 1991, Intermediate Technology and are all available from:

Intermediate Technology Publications Ltd,
103-105 Southampton Row,
London WC1B 4HH, UK.

All the books can be bought and sent through the Post

The Following Books are related to Rainwater Harvesting, They are not available through anyone dealer.

The Addresses have been included where known of the publications.

Proceedings of the Third International Conference on Rainwater Cistern Systems (14-16 January 1987)
Khon Kaen University, IDRC 1987

A Workshop Design for Rainwater Roof Catchment Systems - A Training Guide
D.Edwards, K.Keller and D.Yohalem
WASH Technical Report No 27, WASH 1984

Standing Ferrocement Water Tank - Construction Manual
UNICEF Technology Support Section, P.O. Box 44145, Nairobi, Kenya

Ground Catchment Ferrocement Water Tank - Construction Manual
UNICEF Technology Support Section, P.O.Box 44145, Nairobi Kenya

Rainwater Catchment Ferrocement Tanks - Workshop Report (17-20 February 1987 at Limuru, Kenya)
World Neighbors and Oxfam

The Introduction of Rainwater Catchment Tanks and Micro-Irrigation to Botswana
ITDG 1969

Water Harvesting in Five African Countries
M. Lee and J. Visscher
IRC 1990

Water Harvesting for Crop Production - Report of Farm Trials and Extension Work from CPK Isiolo Ext. Centre
Stephen Burgess 1990

Evaluation of Rainwater Quality Heavy Metals and Pathogens
W.Wirojanjanagud and all
Khon Kaen University, IDRC 1989

The Bacteriological Examination of Drinking Water Supplies 1982
HMSO 1983

Guidelines for Drinking-Water Quality Volume 1 - Recommendations
WHO 1985

Guidelines for Drinking-Water Quality Volume 2 - Health Criteria and other Supporting Information
WHO 1985

Concrete and its Chemical Behaviour
M.S. Eglinton
Thomas Telford Ltd, 1987.

Practical Design of Masonry Structures
ICE
Thomas Telford 1987

Taarifa Fupi 1 - Utunzaji Wa Maji Kwa Matumizi Ya Nyumbani
Oswald E Kasaizi
Waterlines, IT Publications

Construction Manual for Reinforced Cement Water Tank 2.4 M^3
T. Holmes
Saradidi Water Project, P.O. Box 33, Nyilima via Kisumu

Harvesting Rainwater In Semi Arid Africa

Manual No 1 - Water Tanks With Guttering and Hand-Pump
Manual No 2 - Small Earth Dam Built by Animal Traction
Manual No 3 - Rock Catchment Dam with Self-Closing Tap
Manual No 4 - Shallow Wells with Bucket Lift
Manual No 5 - Sub-Surface and Sand-Storage Dams
Manual No 6 - Spring Protections

Authors : E. Nissen-Petersen and Dr. M. Lee 1990

How to Build A Cylindrical Water Tank With Dome - A Photo-Manual
by E. Nissen-Petersen, KIDP/DANIDA 1990

All the above manuals are available from ASAL Consultants Ltd,
P.O.Box 867, Kitui, Kenya

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