

**Proceedings of the  
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Catchment Systems Conference**

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# 1 URBAN RAINWATER CATCHMENT ISSUES

## PAPERS

### 1.1 Runoff Absorption Potential of Roofing Materials

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#### Introduction

About 48% of the land area in Singapore is being utilised as water catchment. The water abstracted is not sufficient for the increasing demands in a rapidly growing industrial society. Consequently, about 60% of the water is imported. Hence, ways and means are being looked into to harness more water from the rest of the land area in which 86% of the urban population lives in high-rise buildings. The potential catchments being looked into are the roofs of high-rise buildings wherein the water collected at the roofs is of a high order (Appan, 1997) and will also reduce considerably the energy costs. The rooftops are primarily flat and, in some cases, pitched roofs have different types of roofing tiles. Being in a sub-tropical region, where radiated heat can reach very high levels throughout the year, it is envisaged that during tropical downpours, considerable amount of the rainfall is absorbed by the roofing material resulting in a loss in the runoff. The main objectives of this paper are to:

- to review a few absorption standards for roofing materials and study some of the roofing material used locally
- to establish a relationship between heat generated by radiation and the equivalent temperature
- to set up an experiment to study the amount of water absorbed in different roofing materials for the worst condition of a thunderstorm and
- to draw conclusions and make recommendations for further research

### 1.2 Water Harvesting in an Industry – Bangalore, India

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#### Introduction

Bangalore, the capital of Karnataka State in South India, is located at an altitude of 921 MSL on the Southern edge of the Deccan Plateau. It is a rapidly growing city known as the Silicon Valley of Asia.

The current population of 6 million is expected to reach 7 million by 2011. Industries, especially software and automobiles, are flocking in. The water supply infrastructure is under severe stress and groundwater levels are dropping alarmingly. Due to pressure on land, lakes and tanks are being filled up and converted to real estate. This phenomenon makes ground water recharge more difficult thus depleting ground water further

### **1.3 The Quality and Major Influencing Factors of Runoff in Beijing's Urban Area**

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#### **Introduction**

Beijing is faced with dual pressure brought on by the shortage of water resources and water environment pollution. To cope with this situation, it is important to study the quality of the average annual runoff of about 200 million cubic meters in the urban area (Che, 2001).

We analyzed and studied the quality of the natural rainfall on roofs and roads during the rainy season 1999-2000. The study shows that the pollutants quantity of natural rainfall was relatively low and the water quality was basically fine. The rainwater on roofs and roads showed serious pollution, mainly organic pollution and suspended solid pollution. This article, therefore, focuses its analysis on the two COD and SS indexes

### **1.4 Urban-related Water Issues at Local Level: Case Study “Caduti Della Resistenza-Ater” Neighbourhood, Padua, Italy**

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#### **Introduction**

Water planning, within the context of overall landscape planning, should not be defined only within the plan's strategy, but also via the identification and definition of specific sectorial issues: a new approach to protection of the surfaces associated with water utilisation; collection and non-conventional treatment of wastewater; the possibilities for water conservation during distribution and use; protection and valuation of water bodies and related territories, taking account of landscape characteristics and the growing awareness of the local population. All the above is being translated into concrete action in the illustrated case study “Caduti della Resistenza-ATER” Neighbourhood, Padua, Italy

## 1.5 Ecological Storm Water Management of Large Settlements

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### Introduction

Until the mid-90s, all storm water was treated as contaminated surface runoff and diverted away in drainage systems. Drainage took precedence over infiltration. However, with the amendments in the state water laws, the water resource management objectives became reversed, and decentralised infiltration began to take precedence over drainage.

Storm water management in urban areas is basically subdivided into that for private lots and that for public property, including streets, public squares, parks, or other open areas. It is primarily carried out through retention, reuse, and infiltration. Drainage of storm water as wastewater can now be seen as outdated. Storm water management intended to relieve the sewer network, infiltration to enhance groundwater recharge, and on a limited scale, the storm water collection for reuse, are finding increasingly more application in modern development projects.

## 1.6 Internet Survey on Local Governments Subsidizing Rainwater Utilization

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### Introduction

Recently, the internet has been so popularized that we use it very easily almost everywhere, such as offices, home, etc. As users of the internet increase in number, the information available on websites increases. With such a background, internet surveying is considered to be a new and very useful method, because it can economically conduct a survey on many subjects in a short period and in addition, it can quickly process the data for totals.

In urban areas, inhabitants often suffer from water shortage, exhaustion of ground water and floods caused by the excessive coverage of ground surfaces by artificial structures, concrete buildings, paved road, etc. One solution to these problems is to introduce facilities which store rainwater and promote rainwater penetration. Rainwater utilization facilities are very useful in preventing urban flooding, saving water and the conservation of ground water, therefore public buildings have been equipped with them. In order to increase their effect, rainwater use facilities need to be diffused further and be spread to private offices and houses. However, people hesitate to install them until they are sure of

obtaining benefits commensurate with their expense. Thus, subsidies for installing rainwater use facilities have been offered by local governments to promote their further diffusion.

In this research an internet survey, concerning the availability of subsidies for rainwater utilization facilities, was conducted on local governments with websites.

## **1.7 Rainwater Harvesting in an Urban Context:Case Study of Bangalore City, India**

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### **Introduction**

Rainwater harvesting has gained tremendous interest among academics, institutions, media and lay people especially in the past few years all over India. While rainwater harvesting has a broad generic description in the rural context as water collected mainly for agriculture purpose in dry land and tank irrigated area, rooftop rainwater harvesting has a clearer definition as water collected from rooftops chiefly for domestic consumption. In this paper rainwater harvesting refers to the process of collecting, filtering and storing water for urban use. Collecting can be from rooftops and also at urban micro-watershed level in lakes and tanks Storing can however mean actual storage in tanks and sumps or recharging groundwater either through open wells or deep bore wells.

## **1.8 Quantitative and Qualitative Improvement in Groundwater by Artificial Recharge: A Case Study in Jawaharlal Nehru University, New Delhi**

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### **Introduction**

Soil properties and land use patterns are *the* major contributing factors to the hydromorphogeology of a particular area. Information on existing land use is required for the formulation of policies and programmes for sustainable development (Kale, 1992). Humans transform the land for different activities-and quantifiable information on the dominant activities is necessary to develop future plans (Rao,1995). A knowledge of past human activities on the site may also be useful.

In order to choose good positions for check dams (to replenish groundwater) on the JNU campus, historical monuments and other urban features of the JNU have been analysed by satellite imagery ( Mishra et.al 1996, Shokhi, 1992, Catanese, 1972). The same data was helpful in locating former brick kilns in the recharge areas of JNU new campus for groundwater replenishment. Repeated heating and cooling in the brick kilns were responsible for changing the soil texture of the JNU campus ( Mukherjee 1997<sup>1</sup>). Multispectral and multitemporal data from SPOT, IRS- 1A, IRS- 1B and IRS -1C

satellites when integrated with land use, geological, geomorphological, hydrogeological and magnetic data, have potential for identifying suitable areas for constructing check dams. Check dams' sites have been selected in the places with high spectral reflectance (low soil moisture) in satellite data. Interception of surface runoff by check dams across drainage at appropriate locations is one method for artificial recharge ( Map-1).

In general J.N.U. area lacks sufficient surface water bodies and palaeochannels to sustain rich ecosystems. The very thin soil cover in this area does not support the use of dug wells. Groundwater occurrence is restricted to the deep-seated fracture zones. For the selection of artificial recharge areas, the radiance values of pixels in near-infrared region were studied. Due to high recharge the soil moisture as well as vegetation densities were low in the inferred check dam sites. Lineaments pass through the check dams, which were selected on the basis of their low spectral reflectance and low magnetic values over the weathered ferruginous quartzites. Low magnetic values were noticed in lineaments on ferruginous quartzite (Mukherjee 1997<sup>2</sup>). Selection of check dams were based on the points inferred by magnetometer showing low magnetic values and interconnected lineaments (a magnetic survey was carried out around the J.N.U. campus in 1996 using the US instrument Proton Precession Magnetometer Geomatrix G-816/826 A).

Groundwater levels had gone down in this area, but increased after the artificial recharge. Eco-conservation in this campus is being restored by plantations of specific species in suitable area.

## 1.9 Rainwater Utilization of Quake Disaster Area Rebuilding Programs in Taiwan

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### Introduction

Utilizing rainwater harvesting in schools brings two major benefits. The most direct and substantial benefit is the saving in water and electricity bills. The educational benefit is that students learn to appreciate water resources and make water saving a habit and contribute to its spreading. School reconstruction works in the disaster areas must be planned as a whole and it is compulsory to include a rainwater catchment system. This is in fact much easier than a reconstruction design of an existing building. All data must be accurately calculated and all measurements must be estimated by professionals in order for every rainwater catchment system to achieve its ultimate economic effect.

## 1.10 Use of Rainwater in Australian Urban Environments

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### Introduction

Over the last decade the concept of Ecologically Sustainable Development (ESD) has become widely adopted by all levels of government in Australia. While there are a large number of rural initiatives, one of the more radical ESD innovations is Water Sensitive Urban Design (WSUD) in urban areas. These innovations include the integrated management of rainwater, stormwater, potable water and wastewater such that resource consumption is reduced and flooding is managed using natural hydraulic processes (Newman and Mouritz 1995).

Clearly **rainwater** (rainfall which is directly collected as the roof runoff from buildings) and **stormwater** (rainfall which runs off all urban areas) have a major role to play in substituting and/or supplementing reticulated urban water supply from centralised water supply facilities. In this paper we describe initiatives in Australia which use rainwater and/or stormwater at three levels – individual house, cluster housing and suburban scale.

## POSTERS

### 1.11 RWH as EST in Mysore Development

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### Introduction

The urban development of Mysore has a projected area of 150 Sq. Km. Mysore receives an average rainfall of 750mm per annum and has 170 rainy days. An estimated total rainfall of 135x10<sup>9</sup> litres per year has been calculated where 10% is runoff and 10% is evaporation and infiltration losses. An estimated 295 litres per capita per day can be supplied in Mysore, if all the rainwater is used for Mysore domestic requirement.

Further, Environmental Sound Technologies [ESTs] encompass technologies that have the potential for significantly improved environmental performances relative to other technologies ([www.unep.or.jp/estdis/maestro/setup2.html](http://www.unep.or.jp/estdis/maestro/setup2.html)). As a case study, the ineffective use of ESTs in Mysore urban development is reported ([www.vishalcomputech.faiethweb.com/mlan](http://www.vishalcomputech.faiethweb.com/mlan)). Based on ESTs database and best practices else where, a home page of PSF. ([www.psf.4t.com](http://www.psf.4t.com)) on RWH as an EST for urban development is proposed for local utilization at domestic, industries, and service sector.

## 1.12 Sizing of Rainwater Storage Tanks in Urban Zones

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### Abstract

Rainwater harvesting systems have been used for centuries. In many developing countries, their use is essential because of the scarcity of water resources. In spite of the fact that most of this technology is focused mainly on rural zones, their use in urban zones is not only convenient but necessary, mainly in those regions where the conventional sources of supply are scarce, distant or exploited. In the urban areas, the use of large-scale roof rainwater harvesting offers a high potential for alleviating water constraints to the domestic demand; also, they can be cost effective. The objective of this work is to show, on one hand, that significant volumes from a rainwater harvesting system could be obtained if we use the roofs of large buildings in urban centers; on the other hand, a technical-economic analysis is done to evaluate the size of the rainwater storage. Under this approach, the temporal variability of the rainfall is considered by modeling the mass balance equation for the storage tank. The approach maximizes the water input and minimizes the construction costs of the cistern. This method is illustrated for an urban zone of the City of Queretaro, Mexico.

## 1.13 Large-Scale Dry Sanitation Programs –Preliminary Observations and Recommendations from Urban Experiences in Mexico

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### Introduction

Dry sanitation is a modern adaptation of the ancient practice of managing excreta without the use of water, and therefore without sewage. It implies: a) waterless toilets; b) the on-site treatment of excreta; and c) the production of a safe and effective soil amendment. Its benefits include saving large quantities of water, reducing water pollution, reducing the volume of excreta, killing off pathogens, and retaining nutrients that can later be applied to agricultural crops.

Dry sanitation has been implemented in rural areas of many countries and urban areas of some. Urban populations have different needs compared to rural settlements. Because of their high human

population density, urban areas require greater support infrastructure for the success of this technology.

Large-scale dry sanitation programs have the potential to address a variety of problems that urban areas face today: increased needs for water supply; dwindling sources of water; lack of economic resources to adequately treat domestic wastewater; lack of resources to provide water and sanitation services to rapidly growing urban and peri-urban populations; and public health risks due to lack of adequate water and sanitation provision.

Mexico has a large number of dry sanitation experiences, including some of the largest-scale urban experiences in the world. A study of the strengths and weaknesses of these experiences can provide insight on successful dry sanitation implementation, not only in Mexico, but in other countries as well. This document reports preliminary observations and recommendations based on 15 months of field research in 6 urban sites in Mexico. Research focused on program implementation opportunities and barriers. Programs varied with respect to their degree of continuity, user adoption, and strategies they had developed to address various aspects of program implementation.

Many program weaknesses were due to inadequate planning and lack of understanding of the set of steps necessary to carry out a dry sanitation program. Most programs began operating with little or no information from other experiences, information that might have saved them precious time, effort and resources. This Report has been prepared to help practitioners who are designing or already implementing large-scale urban dry sanitation programs. It reviews some of the frequent pitfalls and makes recommendations that may lead to greater program effectiveness.

## **2 RAINWATER CATCHMENT IN HUMID AND ARID REGIONS**

### **PAPERS**

#### **2.1 Potential of Rainwater Cistern Systems for Bluefields, Nicaragua**

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#### **Introduction**

Bluefields, located on the east coast of Nicaragua, has a current population of approximately 38,000, which is expected to increase by the year 2024 to approximately 96,000.

There are currently 5,340 dwellings and 249 other buildings in Bluefields; these numbers are estimated to increase to 18,900 dwellings and 630 other buildings by 2024.

Current water sources are:

- an unreliable public supply that serves about 7 percent (about 2,700 persons) of the population
- shallow wells, of limited capacity and uncertain quality, that serve most of the population outside of the downtown core
- private water vendors, who provide in the downtown core a drinking water supply that is considered to be reliable in terms of quantity and quality, but very expensive
- collected rain water, which is used for cleaning and laundry by an estimated 20 percent of the population (about 7,600 persons), but only a small percentage of this use (in larger dwellings, schools, hotels) is in buildings that have gutters and rainwater storage.

There are no known examples of use of rainwater as a potable supply in Bluefields.

## **2.2 Water for Bukora and Ndego: Water Security Issues in Rwandan Resettlement Villages**

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### **Introduction**

Following cessation of the war in Rwanda and the genocide in 1994, providing shelter for returnees was a top priority. New land areas with limited water resources had to be used for the resettlement schemes of refugees coming back from neighbouring countries. In this paper we are concerned with 2 resettlement areas near Rusoma on the border to Tanzania:

- Bukora, with a total of 1.500 households. So far 369 houses have been equipped with rainwater harvesting systems.
- Ndego resettlement area has 1349 households, out of which 988 have rainwater harvesting systems.

All in all we have 1.357 households with a rainwater harvesting system of about 3.000 households in total

## 2.3 Securing Domestic Water Supplies for Rural Bangladesh Through Combined Systems

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### Introduction

Despite having access to abundant rainfall (albeit seasonal), readily accessible groundwater and large river systems, many households do not have access to an adequate supply of potable drinking water in today's Bangladesh.

Water that is clean, clear, with chemical and bacteriological qualities recognised by WHO as being suitable for human consumption is frequently unavailable. Historically these serious and widespread shortages can be attributed to high population growth rates and densities, combined with low disposable household incomes.

In concerted attempts to address this situation, sustained efforts to exploit groundwater were initiated in the early 1970s with the help of international support. By the mid-90s, groundwater reserves were made accessible on a nation-wide scale through the widespread provision of handpumps and tube wells.

However, in 1993 the discovery of naturally occurring arsenic in some aquifers began to emerge. By 1996, the extent of the problem became apparent: approximately 20 million persons were now consuming drinking water with arsenic levels above the WHO guideline value of 0.01mg/litre.

In the light of this water quality crisis, various stakeholders have initiated arsenic mitigation measures in different ways. In this context suitably harvested rainwater represents an acceptable alternative to overcome and supplement the scarce and over-stressed potable water supply situation.

In some regions where families and communities are experiencing severe water shortages, collected rainwater may even represent the only source for potable drinking water.

## 2.4 Post-evaluation of a Rainwater Harvesting Project

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### Introduction

Because of aridity, the loess plateau in northwest China, the massif areas in north China, the karst mountain areas in southwest China as well as China's coastal areas are lacking water resources. The total water-deficient area is about 2 million km<sup>2</sup> with a population of 260 million. The cultivated land encompasses 26 million ha and 34.2 million people are short of drinking water.

As a small-size water conservancy installation, rainwater storage and harvesting facilities are a simple, low-cost and effective way to solve the water problem. It is evident that the development of such facilities is important for people living in water-deficient areas. to improve their production and living conditions.

Rainwater utilization has a long history in China and since the 1980s it has been developed rapidly all over the country. According to incomplete figures, more than 4.64 million small and mini-sized rainwater storage facilities, including various cisterns and ponds, have been built. Every year 1.35 billion m<sup>3</sup> rainwater were stored, providing potable water for nearly 24 million people and 17 million livestock. At the same time more than 1.5 million ha farmland has been brought under irrigation. The benefit is remarkable.

This evaluation will be carried out looking at the rainwater harvesting facilities and their influence on solving the shortage of drinking water in the countryside. We also want to point out the success of the project: promoting the local economy and social development, as well as taking a look at the existing problems, thus providing an objective and scientific basis for a demand analysis and a plan for future projects.

## **2.5 Value of Rainwater for Domestic Use in the Uphill Settlements in Sri Lanka**

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### **Introduction**

Although Sri Lanka's climate is in the Monsoon zone and therefore with ample water resource in its wet zones, recent studies show that there are wide temporal and spatial variations of water availability and demand. If the current trend of water use efficiency continues, there will be a severe scarcity of water in several districts of the country in the near future (Amarasinghe et. al, 1999). In addition, 43% percent of rural population are deprived of safe water for drinking purpose (UNDP, 2000). Scarcity in water availability will be more aggravated with the economic development and implementation of free market policies, where demand for water for industries and domestic use will increase. Therefore the envisaged water crisis will be a significant constraint for the country's socio-economic development.

The community Water Supply and Sanitation Project (CWSSP) was an innovative project started in 1993 and aiming to establish an alternative system of water supply and sanitation delivery in rural Sri Lanka. The project was implemented based on the needs and aspirations of the people through community initiated projects. The project mainly used the following technologies to achieve domestic water security at household level. These include, Gravity Water Supply Systems, shallow dug wells, hand pumps/bore holes and pumped pipe systems. However, these conventional technologies were not suitable to supply safe water for the communities living in uphill settlements. In hilly areas the ground water table is very deep and most springs and wells dry out quickly during the dry season. In addition to the uphill areas, some places in the dry zone of Sri Lanka also have water problems for domestic use, particularly those areas where groundwater sources are not reliable throughout the year and the available water has problems of salinity, hardness and high concentration of other elements.

A technology for systematic rainwater harvesting (RWH) was proposed and successfully implemented in the uphill areas and dry zone of Sri Lanka by CWSSP with community participation and contribution. The difficulties and time involved in fetching water, uncertainty in available water, rising costs in water fetching and low quality of available water sources provided a greater incentive to beneficiaries to adopt rainwater harvesting technology. The main components of the rainwater harvesting systems are catchment surface for water collection (mainly domestic roof), gutter system for water delivery and a tank for water storage. Although Sri Lanka is a country with an annual average annual rainfall of nearly 2000mm, spatial and temporal variations in rainfall make it necessary to adopt a technology for systematic collection of rainwater.

## 2.6 Rainwater Harvesting with Subsurface and Sand Dams

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### Introduction

Ethiopia has a yearly surface water potential of 110 billion cubic meter coupled with an estimated groundwater resource of over 2.6 billion cubic meter. One way or another these water resources are derived from a yearly rainfall. The great diversity in geography associated with high rugged mountains, flat topped plateaus, deep gorges and the extreme variation in altitude ranging from an area of below sea level to peaks reaching over 4,500 meters result with high variation in annual rainfall ranging between 200 to 2000 mm per year.

The present coverage of water supply of the country is about 17%. Given the current population of about 60 million accompanied by annual growth rate of over 3% with incompatible economic development, it is unlikely that substantial improvement in the water supply coverage will be attained within a foreseeable future.

Even though rainwater harvesting ranks high on the priority list as a cheap possibility to alleviate the severe drinking water shortage, roof water catchment is not popular in the country, particularly in the rural areas, since the vast majority of the residential houses have thatched roofs, not suitable for rainwater collection, and the high costs of the water storage facilities.

Ponds are the most prevalent means of rainwater harvesting in rural areas of Ethiopia. In the Gambella region for instance, over 30% of the water supply for drinking purpose comes from ponds. They are also very common in the arid and semiarid parts of the country where alternative water sources are not available. These ponds are planned, constructed and managed by the communities.

Besides its high turbidity and bacteriological load, the water stored in the ponds is not available all year round due to water loss through seepage, sediment deposit and evaporation. Apart from natural self-purification, the ponds do not have any sort of water treatment facilities and improved water abstraction mechanisms. Due to the unsanitary situation around the ponds, they create conducive breeding areas for mosquitoes as well as for spreading of water borne diseases.

## 2.7 Rainwater Modeling in Arid Regions (A Case Study in the North of Tunisia)

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### Introduction

The art and science of hydrological modeling has been replete with computer programs, which will help solve certain classes of hydrologic problems. Hydrological models have been in existence for a long time. However, with the advent of the digital computer, methods in water resources modeling became highly sophisticated and in turn were accompanied by a proliferation in complex terminology. In fact, hydrology, which was developed before the introduction of technologies allowing for the collection and processing of spatial information, is poorly adapted to the efficient use of the full potential of remote sensing and GIS. The empirical methods development for the estimation of peak (flood) discharge and annual contributions, barely use spatially distributed information, and generally only in a statistical form. A significant work of development of new hydrological methods was developed to evaluate and calculate the hydrological assessment on a catchment area.

## 2.8 Rainwater Harvesting for Drought Proofing

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### Abstract

Women are trying to fight the severe water scarcity in the dry desert region of Gujarat, which is experiencing the third consecutive and worst drought year and has also been affected by a devastating earthquake. One of the campaign's major outcomes was the construction of almost 200 household and about 70 community level roof rainwater harvesting structures in the districts of Kutch, Banaskantha and Surendranagar. The women's ingenuity led to the development of area-specific tank designs. According to the geographical terrain, the design and material used in the tanks of each district varies.

Roof rainwater harvesting tanks are meant to harvest all the water that flows from the rooftop of each house in water tanks. This method is a re-introduction of traditional ways of harvesting water in the villages but improvised through technical methods. These tanks are an important resource for collecting water during monsoons at an individual/ household and community levels and maintaining it through proper chlorinating process. Depending on the size of the household, tanks with various capacities were constructed. The tanks provide drinking water for at least 6 to 8 months.

## 2.9 Multiple Sourcing and Water Security

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### Introduction

Having plentiful water does not necessarily mean that water needs are satisfied. In a tropical country like Sri Lanka, where the annual average rainfall is approximately 2400mm, wide spatial and temporal variations deny adequate water distribution to approximately 40% of the people living in the rural areas. Sri Lanka receives a typical bimodal pattern of rainfall with two distinct peaks in April and November. The Northwestern arid zone with less than 800mm of rainfall coupled with saline ground water compounds the problem of water availability for household use. In contrast, the Central wet zone receives more than 5000mm of rainfall, but geographical location of most settlements hinders access to household water in required quantities at times of need. Hence, settlers in both these areas have to look for other alternatives to satisfy their household water requirement. Use of multiple sources of water is one option often practiced by most rural people to satisfy their water requirement. However, uses of multiple sources of water incur considerable opportunity cost of time. Introduction of institutionalized rainwater harvesting has been the latest addition to the list of multiple sources used by the rural poor in Sri Lanka.

This paper attempts to highlight the practices of using multiple sources of water to satisfy household water security in two communities in the Northwestern and Southeastern arid zone and Central highlands. Use of multiple sources of water in the former case is mainly due to scarcity of good quality water, while in the later case hilly terrain and settlement locations deny access to adequate water at household level.

## 2.10 Promotion of Rainwater Jars Through Informed Choice (A Laos Case Study)

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### Introduction

About 85 % of Laos' 5 million people live in the countryside. The National Center for Water Supply and Environmental Health (**Nam Saat**) in the Ministry of Health is responsible for rural water supply and sanitation. The provision of water supply and sanitation services in a sustainable manner to the rural population living in remote parts of the country under difficult socio-economic conditions remains a major challenge.

Nam Saat initiated the development of the national Rural Water Supply and Sanitation (RWSS) Sector Strategy in 1994, using a Lao-led, step-by-step, participatory process. The national *RWSS Sector Strategy and the Guideline National Framework* was launched in November 1997. With assistance from its supporting partners UNICEF and World Bank Water and Sanitation Program – East Asia and

Pacific (WSP-EAP), Nam Saat started the application of the Strategy through the implementation of a number of pilot projects supported by Sida, the World Bank, JICA and various NGOs.

The main objective of these pilot projects was to ensure a smooth transition from past practices/ approaches to more community focused, demand driven and sustainable intervention, with a special focus on the capacity development of Nam Saat staff at all levels.

## 2.11 Roofwater Catchment for the Rural Poor

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### Introduction

This paper concerns the use of domestic roofwater to supply households in the rural areas of low-income countries. It focuses on communities where rainfall is sufficient, roofing is suitable for domestic roofwater harvesting (henceforth DRWH), and where existing point water sources are so widely spaced that fetching water from them is a considerable household burden. The paper is illustrated by data from East African areas where these conditions apply and where incidentally a very complete evaluation of rural water economics was made in the mid 70s (White, Bradley, & White, 1972 – which showed the over 10:1 increase in per capita consumption that can occur when convenient piped water replaced fetched water).

The primary benefit of DRWH in the scenario we are addressing is the time-saving, or more rarely money-saving, obtained by reducing the fetching of water. A secondary benefit is the increase in water consumption that follows any reduction in marginal water costs. The situation has a strong seasonal aspect, since in the dry season the cost of water from point sources rises, due to the failure of more local sources and increases in queuing times, while the yield of DRWH systems falls. There are consequent changes in water consumption.

The main design choices in DRWH concern the size and type of tank used, the area of roof guttered, the water-management strategy and any phasing of construction. This paper addresses these options mainly from an economic standpoint, using a mixture of field data collected in 2000 and modelling. It is based on activities undertaken under two 4-partner DRWH research programmes (one EU-funded and the other DFID-funded) and under a smaller programme funded by the Laing Trust and by Warwick University. The support of these sponsors is gratefully acknowledged. Further details may be found in Rees & Thomas 2000, DTU website & RHRG website.

## POSTERS

### 2.12 Potentials of Rainwater in a Southwestern Nigerian Community

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#### Introduction

The great importance of water to sustaining life on earth cannot be over-emphasised. In many South Western Nigerian communities, three main sources of water – surface water, ground water and rainwater are usually available. However availability is one thing, usability is another. In the case study – Akufo, a village of about 2000 inhabitants located on longitude  $3^{\circ} 49'E$  and latitude  $7^{\circ} 31'N$  in South Western Nigeria, the rainwater source has particularly lent herself to ready exploitation. Many of the community 's streams are highly polluted and disease-causing. Rainwater was thus a viable option considered in the design of a water supply scheme for the community (Coker, 1999). Ostroot and Ramos (1972) had asserted that rainwater can constitute a veritable source of potable water if it could be hygienically harvested and stored. Similarly, a study on small community water supply in Europe, Asia and Africa by Huisman et al (1981) confirmed the increasing resort to rainwater for potable use on a global level. This paper, further illustrated with a poster, presents the tremendous potential usage of rainwater in a typical Nigerian rural community.

### 2.13 Promoting Rainwater Utilisation in Oruchinga, Uganda

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#### Abstract:

There are enormous latent potential possibilities for rainwater catchment in rural settings of Uganda and elsewhere in the world, which have not been exploited.

Water is increasingly becoming scarce both in quality and quantity in most low-income communities in the face of increasing population. Only 17.3% of the local population of Oruchinga valley has access to clean and safe water. This situation needs to be checked otherwise efforts to poverty eradication and improvement of standard of living of people in low-income communities will not achieve the desired goal. Women and children will continue to be victims of this circumstance.

This paper puts forward a case how ACORD has supported a rainwater development programme in Oruchinga valley in Mbarara District in south-western Uganda.

Methodology shift to household rainwater harvesting has created better access to potable, clean and safe water. Water is slowly becoming increasingly available for domestic use and agricultural production purposes.

This resulted from a SMART partnership of good collaboration between needy women groups, ACORD - Uganda, FAKT (Consult for Management, Training and Technologies) and Bread for the World (BftW) of Germany. The funding of rainwater harvesting and sanitation pilot project in Oruchinga valley by BftW has created a competitive and enthusiastic atmosphere among the groups undertaking the project.

More savings groups for rainwater harvesting and utilisation have emerged and are running their min-water harvesting projects on the rotational basis.

Benefits by participating women groups are manifold in terms of decreasing women and children labour, saving time and energy, increasing agricultural production and household hygiene and sanitation.

Lessons learnt from this pilot project indicate that, there is need to re-examine the current approaches in order to reach many poor unreachable. Addressing peoples felt needs; demands involving them throughout the process of project preparation, decision-making, technology choice, implementation and monitoring and evaluation. This is a core pre-condition to sustainability, replicability and increased management. Subsidies to these rainwater-harvesting groups have a positive role to play.

The donor community needs to flexibly and positively support household rainwater promotion and utilisation to achieve the World Health Organisation (WHO) global objective “water for all” where the poorest of the poor will benefit.

## 2.14 Rainwater Harvesting Techniques for Rural Houses

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### Abstract

Kiteto District Arusha region is one of the semi – arid and arid areas in Tanzania. WaterAid (UK, NGO)Tanzania, Kiteto programme has been working in this area since 1997 to improve rural water supply, hygiene promotion and sanitation. WaterAid Kiteto programme is working together with local NGO known KINNAPA and Kiteto District Council (KDC) under tripartite partnership.

Currently, this WaterAid /KINNAPA /KDC programme is implementing six borehole schemes. The big challenge that the programme faces is to locate the borehole sites. According to the hydrogeological studies it was noted that water is found in fault and not in sand aquifers which is very difficult to locate them. Also their recharge is minimal due to little amount of rainfall in a year (400mm – 600mm). Even the cost is high compared to the rural communities’ income especially, when considering the issue of operation and maintenance costs.

Therefore the programme started to opt to other alternative technologies for water sources such as improvement of traditional wells and harvesting rainwater. The rainwater harvesting technologies include sand dams, small dams, underground tanks and roof catchment for domestic uses. Responding to this it is planned to conduct training to the mobilization team regarding the rainwater harvesting technologies. Thus the paper wrote by the Project Engineer WaterAid Kiteto is aimed to build the

capacity of the TUWI team to disseminate Rainwater harvesting technologies particularly for roof catchment (starting with Ndaleta village).

## 2.15 Opportunities for Water Management in Arid and Semiarid Zones of Mexico

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### Introduction

Two thirds of Mexican territory is arid and semiarid, where crop production is seriously affected by the quantity of available water. In order to obtain the biggest amount of dry matter for the same amount of water, under dryland conditions of Mexico, several technical possibilities were tested to increase the available water to the ground level.

## 2.16 Cost-effective Dimensioning of Artificial Rainwater Harvesting Storage Systems

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### Abstract

The existence of water harvesting systems in India have a long history like *gardabands* in Baluchistan, *kundis* in the Thar desert of Rajasthan or the *temple tanks* in Southern India. Although a wide range of experience is available the development of the society makes it necessary to revise these systems according the new requirements. Beyond any doubt the cost-effectiveness plays nowadays an important role and has to be considered as one of the factors for rainwater harvesting systems dimensioning [1].

The use of artificial storage facilities within a rainwater harvesting system (RHS) requires exact calculations regarding their storage capacity depending on its intensive costs. Annual amounts of rainfall have to be statistically evaluated to estimate the probability of maximal rainfalls as well as long dry periods. The size of the artificial storage is to be chosen either by collecting the maximum of rainwater or to adjust it according the requirements of the user.

This approach lacks a practical use in subtropical countries and includes a high risk factor for the consumer's supply due to the complicated rain patterns. The variation of amount of rainfall and rainfall intensities in the range of several 100 % and unpredictable time range for droughts

complicates approaches for a consumer friendly cost-benefits. In comparison to moderate climates artificial storage systems have to be considered as buffer capacities for droughts.

An approach based on statistical tools like probability of rainfall, return periods, storage equation shall make it possible to dimension a rainwater harvesting system which are more cost-effective.

## **2.17 Economic Analysis of Rainwater Harvesting for Agricultural Production in Selected Semiarid Areas of Tanzania**

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### **Introduction**

The most important characteristics of semi-arid areas are the factors, which limit availability of soil moisture for plant growth. In addition, the occurrence of dry spells during the growing season is a critical problem to plant growth. The focus on Semi-arid areas is important in Tanzania because of over dependence on agriculture in low rainfall areas, poverty problems and high number of livestock. Rainwater harvesting (abbreviated as RWH) is justified in semi-arid area.

In the semi-arid areas RWH has become important for agricultural production. The most commonly used practices involve the diversion of flood flows from gullies into crop fields and reservoirs. Two main crops, rice and maize are produced in semi-arid areas using RWH techniques. It is estimated that more than 54% of paddy rice produced in Tanzania is cultivated in the semi-arid areas of Shinyanga and Mwanza. In these areas water is the scarcest resource followed by labour, good land for cultivation and financial capital.

The poster demonstrates the economic viability of RWH for crop production in semi arid areas. The introductory part gives pictorial and graphic presentation of the area of Tanzania, the proportion of that which is semi-arid, current use of RWH and the existing potential for expansion.

## **2.18 Rainwater Harvesting in Grand Turk**

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### **Introduction**

Grand Turk, the capital of Turks and Caicos Islands, with an area of about 18 km<sup>2</sup>, is a “very small” island. This is the factor that determines the complexity of its water resources management.

It is obvious that sustainability must be the goal of water management in small islands and for this the principles for improving water management endorsed at conferences on water and the environment in Dublin and Rio de Janeiro (GWP, 1998) must be taken into account.

In Grand Turk rainwater is the main source of water supply and is widely developed at the household and community level. It is one of the treasures in water management in the island that is being carefully preserved (Pérez Monteagudo et al, 2000a).

Almost all buildings and houses have their own rainfall collection system composed by roof catchments, gutters and cisterns. A roof frequently also covers these cisterns for catchment purposes.

## **2.19 Rainwater Harvesting for Survival and Development**

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### **Introduction**

The “Integrated Pastoral Development Project (IPDP) Mbarara” aims at enabling 900 settler families to sustainably satisfy their basic needs from their own resources within 6 years. The Mbarara Local Government (MLG) and “Gesellschaft für Technische Zusammenarbeit (GTZ)” are in charge of project implementation from the Ugandan and German side respectively.

The ultimate objective for the implementation of watershed management measures during the 3 phases of the project, is to have settled communities with sufficient water for both production (livestock use) and domestic use. This objective was achieved using a gender sensitive, participatory extension concept.

## **2.20 Rainwater as a Supplementary Source of Water Supply in Nigeria**

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### **Abstract**

Over the years, the Federal Government of Nigeria has made appreciable investments towards development and management of water supply using large centralised and conventional water supply systems. For certain reasons, the demand for safe drinking water service continues to overwhelm the delivery. Though for centuries, people across Nigerian urban and rural areas have harvested rainwater for household, livestock and agricultural uses but lack of promotion had limited its wide acceptance especially in urban centres. The study looks into rainwater availability, rainwater catchment, storage tank capacity and rainwater quality.

Major data used for the work include an average of 35 years rainfall pattern based on yearly rainfall intensity for 18 Nigerian cities and major towns obtained from Nigerian Meteorological Centre records. The variations and distribution of rainfall in the cities and towns studied were plotted. Permanent roofs for rainwater harvesting were also assessed. Moreover, the issue of rainwater quality was also considered.

It appears that the average yearly rainfall in Nigeria during the period examined varied from 1070mm to 2400mm, that is, 1.07 to 2.40m<sup>3</sup> of rainwater was available per m<sup>2</sup> of catchment area each year for the development of a rainwater based water supply system. A study of suitable permanent roofs for rainwater harvesting shows that over 75% of urban households and about 20% of rural households have suitable roofs.

A rainwater availability mass curve and cumulative consumption / demand of total rainwater revealed a shortfall of 0.32m<sup>3</sup> in the dry periods and an excess of 0.22 m<sup>3</sup> during rainy season. Hence, for full utilisation of rainwater potential, a storage tank capacity of 0.54 m<sup>3</sup>, that is 33% of the cumulative rainwater is required for an uninterrupted water supply at a constant rate during the year.

## **2.21 Introduction of Rainwater Harvesting Technology in a Rural Community in Nigeria**

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The annual drought in the northern parts of Nigeria has been accepted as inevitable, and rural communities are generally resigned to their fate in this season because they believe there is nothing that can be done about it. The brunt of the drought is borne by women and children who have to make dawn trips to the nearest river in search of water for domestic use because the wells and near-by streams have gone dry.

The introduction of Rainwater Harvesting in one of the communities where Fantsuam Foundation serves was greeted with surprise - the whole scheme seems so logical we all wondered why we had never thought of it before. After the novelty of the idea has become more generally accepted and widely discussed, the technical details needed to be understood and put to work. Financing the cost of materials and labour required for the water storage became a challenge for the community. This poster presents the outcome of the innovative use of microcredit loan to the community for financing a pilot project for harvesting rainwater

## 2.22 Rainwater Harvesting Technologies Practiced in Zambia

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### Introduction

Though Zambia receives an annual average rainfall of 1,000 mm, 30% of the rural population and 67% of the urban population have no access to adequate clean drinking water (Study of the water Supply and Sanitation sector, 1991). This has substantially lowered the standard of life for many people. High mortality and morbidity due to diarrhea diseases and parasitic infections are particularly critical in many densely populated squatter compounds and rural areas.

Rainwater harvesting technology, as a rural water supply option for households where other water supply options are not technically and financially feasible, has recently been introduced in Zambia. Demonstration structures are being constructed, and agricultural extension workers and farmers being trained.

This poster presentation illustrates the current traditional and modern rainwater harvesting technologies practiced both in rural and urban areas of Zambia.

## 2.23 Rainfall Harvesting From Pretreated Catchment Areas

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### Abstract

Rainfall harvesting from roofs and backyards has been practiced in Jordan for many years. However, this practiced has been decreases due to limited rainfall and spread of public water supply system. Rainfall can be captured from building roofs, courtyards and playground areas. Collected water is stored in underground storage tanks and cisterns. In a larger scale, rainfall harvesting can be achieved using pre-treated catchment and micro catchment areas to increase the efficiency of runoff and maximize the amount of collected rainfall. The objective of this research is to quantify the efficiency of various surface treatment methods and its effect on rainfall collection.

A laboratory experiment was conducted to estimate the runoff efficiency using four surface treatment methods, two-rainfall intensities, two-rainfall duration and two soils. Surface treatments were, wax treatment, plastic cover and compaction plus a control. The two soils used in the experiments were sand and loam soil. Results indicated that soil compaction had the highest runoff efficiency followed by plastic cover, wax treatment and natural soil. The runoff efficiency of sandy soil with rainfall intensity of 3 mm/min and 10 min duration rainfall for compaction, plastic cover, wax treatment, and

natural soil were 79, 64, 45, and 20%, respectively. The corresponding efficiencies for clay soils were 82, 71, 74, and 65%, respectively. It has been concluded that little physical treatment of soil surface such as compaction can enhance rainfall collection from backyard and natural playgrounds and helps in increasing water supply in rural areas.

## 2.24 Rainwater Catchment Systems in Latin America

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### Introduction

At present time, there are available many alternative technologies for freshwater augmentation and soil conservation in Latin America and the Caribbean, many of them generated by Inca, Maya, and Aztec cultures, it is necessary to rescue them and combine them, when it is possible, with modern knowledge in order to establish technological options for all diverse social, cultural and economical conditions. Most critical global issues in arid and semiarid areas are reversing desertification, preventing soil erosion and increasing production. Rainwater catchment systems mean a reinterpretation of ancient techniques developed in the Middle East and America but forgotten by modern science and technology.

Rainwater catchment systems (RWCS) for water resources development, desertification control, flood water harvesting, recharge of aquifers, recreation and sustainable agriculture, represent efficient technologies for sustainable development. However, there is an urgent need for promoting massively RWCS as real alternatives to solve severe problems of water scarcity and soil conservation. Rainwater provides water for drinking, domestic, recreative, industrial and agricultural purposes. Water crisis and land degradation are problems of management which have social, economical, and ecological impacts.

These technologies should be widely used; however, only few countries are paying attention to them, they are the following: U.S. Virgin Islands, Honduras, Costa Rica, Guatemala, El Salvador, Nicaragua, Argentina, Brazil, The Turks and Caicos Islands, Bahamas, Chile, Venezuela, Jamaica, Colombia, Dominican Republic and Mexico. This paper describes some of RWCS in the region used for domestic and agricultural purposes, they include water collection from rooftops, soil conservation, runoff management and „in situ“ catchment for agriculture purposes. In those countries where the government has established subsidies, community participation is high because these technologies are well accepted, because they are inexpensive and effective; however, there are serious economical and social challenges to solve in order to use RWCS in a massive way, mainly in isolated and poor communities so, It is urgent to develop and apply an integrated water resources management program to stop the chronic and growing water crisis which will provoke wars if adequate measurements are not taken by the governments in this region. Water and soil management represent strategies to prevent and combat land degradation in the region.

## 2.25 Rainwater Harvesting in Nigeria: Prospects and Problems

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### Introduction

Rain water harvesting has become a world wide practice to meet the increasing demand for fresh water. In Nigeria it is widely practiced mostly in the southern part as the rainfall is widespread for over 8 months in a year with mean intensity of 180 to 225 cm. Rain water harvesting is practiced at individual level, household level, community level and occasionally at Local or State government level to augment the dwindling water supplies to urban centers. This study describes the magnitude of rain water harvesting in selected communities in peri-urban areas obtained from a house to house survey, their behavioural practices in harvesting, storage and usage of the rain water, the quality of such waters and design of a sustainable system in one of the study areas.

## 2.26 A Methodology to Tackle the Growing Scarcity of Domestic Water Supplies in India

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### Introduction

Artificial recharge of groundwater and rainwater harvesting are two diametrically opposite methods of effective utilisation of rainwater. Groundwater recharging aims at suppressing surface runoff and evapotranspiration to maximise infiltration for making as much rainwater as possible to become groundwater. Rainwater harvesting on the other hand aims at suppressing infiltration and evapotranspiration to maximise surface runoff for storing as much rainwater as possible in natural or artificial containers for some direct use. The overlap between the two terms arises from the practice of using the water that overflows from the container used in rainwater harvesting for recharging groundwater.

## 2.27 Rainwater Harvesting for the Poor - Project Management

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### Introduction

Some of the results of the 9<sup>th</sup> Rainwater Conference in Petrolina, Brazil (1997) and other studies in relation to project management for Rainwater Catchment Systems have been:

- Participation of the beneficiaries from the beginning is essential
- Top-down management usually does not work out
- The applied technique ought to be accessible to the participants of the project
- There is a necessity of affordable Rainwater Catchment Systems for the poor

Learning from past experiences this paper aims to demonstrate the possibility and the outcomes of realising these calls for **application of accessible technology, community participation/management, and affordability**. Basis for this case study is the author's experience with a project for the construction of cisterns in Northeast-Brazil.

## 2.28 Rainwater Utilization in the Coastal Area of Southeast China

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### Abstract

In the coastal area of Southeast China, owing to the uneven distribution of rainfall and the high population density as well as the pollution of surface and groundwater, the exploitable water resources per capita is low and the seasonal water shortage occurred frequently. Effective rainwater utilization has been taken seriously. The paper gives an introduction to the rainwater utilization in the rural area of Yuyao municipality.

1. Effective use of rainwater in the paddy area: The irrigation technique for paddy land with shallow submersion and without submersion. Because the surface runoff, under ground seepage loss and evapo-transpiration were reduced, the rainwater utilization efficiency was raised. The irrigation water amount and the consumed energy were reduced by 2000~5000 m<sup>3</sup> and 90~220 kWh per hectare, respectively while the yield of paddy was increased by 350~750 kg per hectare.

2. Rainwater utilization in the dry farming land

In the Xiaolu village, the rainwater harvesting and irrigation project has been built from 1999 to 2000. In the 100 ha cultivated land, 100 km long ditch for storing rainwater was excavated with storage capacity of 27000~40000 m<sup>3</sup>. The water source is reliable and the quality is very good. The sprinkler and drip system was built to irrigate the vegetables and fruit trees, of which the products are with no pollution and well known as "green food".

## 2.29 Rooftop Rainwater Harvesting Systems in the Tropics: Two Case Studies

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### Abstract

In the realisation of water resources projects, development experts and engineers (who frequently carry out feasibility studies) generally give the preference to centralised systems and focus their attention on technical aspects. Yet, technologies used in conventional/centralised water supply systems more often than not are not sustainable, and make *engineering services costly and often unaffordable* by both governments and rural communities of developing countries. Consequently, despite intensified investments of governments in large schemes, the socio-economic situation have been steadily worsening, and catastrophic *water scarcity* have been spreading in semi-arid regions of Africa, Central and North America, and the Caribbean – affecting domestic water supply, food production, the agro-industry, employment and health.

In the face of local (ecological, socio-political, economic and technological) constraints in developing countries of the Tropics, decentralised rainwater harvesting/watershed management systems have proven most appropriate – particularly in absence of the huge capital necessary for centralised systems. The importance and appropriateness of the *conservation of flood runoff in rural areas* of developing countries, as opposed to the conventional exploitation of rivers, is the more significant, that water harvesting measures are much less costly than large dams schemes, and can be spread over time, when labour and time is available during the dry season. They can therefore be afforded without threatening the countries' economy through debts. Besides, the necessary capital is almost fully used to create work in the country itself, since the technical measures can be implemented and managed by the communities themselves. Furthermore, local capacity can be developed, while the low-level and low-cost technologies necessary are well known or understandable by *rural* people – having been developed by indigenous people themselves, as a *sustainable* adaptation of irrigated agriculture to the agro-climatic conditions prevailing in their difficult environment.

Similarly, in *urban areas* of humid and semi-arid regions, *rooftop rainwater harvesting* is being increasingly considered to compensate for shortage of domestic water supply due to scarcity of water or deficient centralised supply systems.

The short paper/poster will illustrate *two case studies of rooftop rainwater harvesting*:

1. in richer city households in Haiti; and
2. in a project for poorer households in a rural town of Nigeria.

## **2.30 Investigating the Feasibility of RWH Under Semiarid Conditions: Benefits of Computer Simulation in Adding Value to Field Experiments**

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### **Abstract**

Agricultural production in semi- arid areas depends on direct rainfall, which is highly variable with respect to both time and space. Significant variation in the temporal and spatial distribution of rainfall usually results in serious shortage of soil-water available to plants and thus poor crop and livestock production. To overcome this problem, feasibility of RWH was investigated in representative areas of semi- arid lands in Tanzania. Analysis of rainfall characteristics was done in these areas to reveal different rainfall variability parameters (i.e. start and cessation of rainy season, duration of season, total rain, and rainy days). The results revealed that rainfall was low and highly variable with CV varying from 20% to 50% during long rainy season and 42 –50% during the short rainy season. It was also found that in some areas, dry spells of 15 days may occur during both the short and the long rainy season with probability 30%.

Though efforts have been made through experimental research to investigate RWH options, meaningful extrapolation of results has been a big problem. A twin-track approach was used in this project, where experimental work was linked to the development of simulation model (PARCH-THIRST) designed to assess how any particular RWH innovation is likely to perform. The potential of the model to overcome problems of spatially and temporally extrapolating experimental results and delivering results of direct relevance to farmers and extension services is presented in this paper. The results of simulation, shows that the model proved to be reliable in prediction with high accuracy. Performance of cropping systems with and without RWH is demonstrated on the basis of scenario simulations. The twin-track approach introduced additional requirements into the experimental effort in the short-term in order to provide all the data necessary for developing the model, but it can be concluded that this burden was worthwhile due to added value for the work as it makes research better and more efficient. It provides more complete understanding and more accurate predictions than it would be the case for field research alone unless it was continued over a long period and replicated on a large number of sites.

## 2.31 Challenges and Prospects of Rainwater Harvesting in Rural Communities in Eastern Nigeria

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### Background

Freshwater is a precious but limited resource. Only about 0.007% of all earth's water is available for human use. If the earth's total reserves were compared to one gallon, (including snow and ice) fresh water will make up less than half a cup and readily accessible fresh water would just be about two drops.

Competition for those drops is increasing exponentially. By present estimates, about thirty-one countries, accounting for under 8% of the world population about 400 million people face chronic water shortages. Each year some 90 million people are added to global population and nearly every country will experience a per capita reduction of available water resources during the next three decades

Water scarcity on such a colossal scale in the age of space exploration, biotechnology and microchip is an economic embarrassment and a moral outrage.

The implication of the global water crisis has impacted on the capacity of third world nations to deliver contextual issues of development in areas of food security, health care delivery and poverty alleviation.

The challenges that face Africa seem most daunting. The annual rate of population is already high and there are doom day expectations that growth will stay high the foreseeable future.

The situation in our continent is exacerbated and complicated by prolonged drought in arid and semi arid zones, conjugated high population pressures and a rapidly growing competition for water in the agriculture and industrial sectors.

## 3 RAINWATER: QUALITY ISSUES

### PAPERS

#### 3.1 Microbiological Quality of Rainwater in Selected Indigenous Communities in Central Australia

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##### Introduction

Environmental factors, such as the poor quality of drinking water, are considered to be one of the major causes of poor health in remote Aboriginal communities (Hearn et al. 1993). The provision of safe drinking water supplies in those communities is therefore of great importance.

The Anangu Pitjantjatjara Lands covers 160,000 square kilometres in the north-western corner of South Australia and contains approximately 3000 people in nine major communities and about 70 homelands. It is an arid region, and the communities rely heavily on groundwater. High salinity, together with the concentrations of nitrate, fluoride, boron and other elements frequently exceed the Australian Drinking Water Guidelines (Fitzgerald et al., 2000). The region receives on average approximately 270 mm/yr of rainfall although it is highly variable and ranges from 50 to 739 mm/yr. Even though almost all houses have rainwater tanks, most tanks are not large enough to reliably serve as the sole drinking water supply, however they represent a valuable additional water source of superior chemical quality.

#### 3.2 Towards Water Quality Guidance for Collected Rainwater

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##### Introduction

Traditionally surface water and (shallow) ground water have been used as sources for drinking water. In harsher environments societies have developed ways of securing sufficient good quality water by developing techniques for digging deeper and collecting water in underground drains (*qanats*) or by constructing run-off water collection systems to fill surface reservoirs (tank, *wewa*, *hafir*, etc..).

In recent years exploitation of water resources has focused on providing water for food production, and water supply for domestic and industrial purposes. Population growth, intensification of agriculture and growing urbanization have led to water stresses in locations that used to self sufficient in water. Quantity and quality of water for all human purposes are becoming compromised and many countries are now developing strategies to conserve and protect water.

Households and communities all over the world have from time immemorial collected rainwater for their daily needs. *Dying Wisdom*, published by CSE in New Delhi in 1995 as a result of an extensive journey across the Indian Sub-continent, beautifully describes the intricate ways in which people secured their livelihood through harvesting and protection of rainwater. On the other hand, public health concerns and technological developments of the last 150 years have combined to provide many people with safe and convenient water supply facilities near their home. This will have pushed rainwater harvesting to the background as a water supply option.

Unfortunately, the Global Assessment of the Water Supply and Sanitation Sector, 2000, has to report that in 2000 only 82% (4.9 billion) of the world's population is served with some form of improved water supply. The diagram above shows that for the combined population of Africa, Asia, Latin America and the Caribbean some 21% is not served.

Chances are that many of those not served, and even a good number of those served by an improved supply, will practice some form of rainwater harvesting to secure or augment domestic supplies.

In view of the stress on available water sources and because many people will have no alternative, the use of rainwater for a variety of domestic purposes is likely to grow rapidly. Not all collected rainwater will be used for drinking and cooking. But for the part that is, it would be useful to develop guidelines with respect to safeguarding its quality. WHO intends to include guidance on the quality and storage of collected rainwater as a source of drinking water, in its next update of the Drinking Water Quality Guidelines scheduled for 2003.

### **3.3 A Diary Study Of Gastroenteritis And Tank Rainwater Consumption In Young Children In South Australia**

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#### **Introduction**

Tank rainwater is an important source of drinking water in South Australia. More households (42%) use tank rainwater as their main source of drinking water than use public mains (40%) (Heyworth et al.1998). The community preference for consumption of this untreated water supply has highlighted the need for policy on its safe use. The longitudinal study reported here, the tank rainwater diary study, was undertaken to provide epidemiological data in support of a risk assessment of tank rainwater consumption.

An earlier prevalence study of 9,500 children, indicated that there was a slight, but non-significant, increase in risk of gastroenteritis associated with consumption tank rainwater in rural South Australia. This longitudinal study was undertaken to investigate more fully the temporal relationship between risk of gastroenteritis and exposure to tank rainwater.

### **3.4 Health Implications of Widespread Use of DRWH: Mosquito Control**

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#### **Introduction**

Mosquito borne diseases like malaria and dengue are of primary concern, especially in tropical countries. It is well known that the availability of stagnant water generally leads to mosquito breeding. Hence in considering health issues related to DRWH, the risk of mosquito breeding and consequent spread of diseases borne by them need to be evaluated. Measures have to be taken to minimise the risk. Under an EU sponsored project, special features required for reducing the risk of mosquito breeding in DRWH design, were studied.

Denying access to water is universally effective in controlling breeding of all mosquito species. Preventing stagnation of water on the gutter and putting up suitable barriers for barring the entry of adult mosquito into DRWH are most useful, but not always feasible. If, in spite of preventive measures, mosquito enters the storage tank, appropriate measures for deterring ovi position and larval growth have to be considered. Accordingly, the following three aspects were examined:

1. Barriers for preventing the approach of adult mosquitoes to water in DRWH.
2. Quality of water and other parameters which discourage or encourage ovi-position and larval growth.
3. Treatment of water in storage for control of breeding.

Some of the results are discussed herein.

### 3.5 Bacteriological Quality of Water in DRWH

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#### Introduction

In spite of the fact that RWH is an age old traditional practice for collecting water (Dying Wisdom, 1997), certain research inputs are needed for reviving the technology to suit the modern habitats. In this paper the results on the following aspects are presented:

1. Comparison of testing procedures for bacteriological quality: correlation between H<sub>2</sub>S strip test and MPN.
2. Effect of roofing material on water quality from four different types of roofs, with and without tree hangings over them.
3. Co-relations between bacteriological quality of water and amount of roof washings collected in flushes.

### 3.6 Solar Disinfection of Water:(A Case Study from Kenya)

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#### Introduction

The Water Supply and Sanitation Project being implemented by the Christian Community Services, works with rural self help groups to improve their access to clean, safe, domestic water. Operating in the North Rift area of Kenya in Uasin Gishu District the groups are building household rainwater

catchment systems, protecting shallow hand dug wells and using rope and washer pumps. This provides for water supply, but one important issue is how to ensure the water is safe. As the objective is to improve the health status of the community, environmental hygiene and sanitation training and awareness raising has been undertaken in order to reduce the risk of waterborne disease transmission, (Faecal – oral cycle ).

Rainwater, collected in the roof catchment tanks, is a good source of safe water provided precautions are taken to maintain cleanliness of the RWCS. Other sources have the risk of contamination by pathogens that cause diseases, particularly the rivers, unprotected shallow wells and springs that are a common source of water in the area. The community members report a high incidence of diarrhoea, and even typhoid, suggesting that a contamination problem exists.

Currently the community members treat their water by settlement, storage and disinfection by boiling but due to time pressure and the effort involved in collecting firewood and boiling water the practice is often neglected leading to a high incidence of waterborne diseases.

An alternative method of water disinfection, SODIS, Solar Disinfection of water has been promoted with some of the groups to provide safe, household drinking water. This paper reports the experiences from these groups.

The technique of SODIS has been researched and reported widely ( Acra et al., 1984; Wegelin et al., 1994; Lawand et al.,1988; Sommer et al., 1997). The following technical details are taken from a series of Technical notes; ( EAWAG/ SANDAC, 2000 ).

### **3.7 Rainwater Treatment Technology for Affordable, Quality Drinking Water**

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#### **Introduction**

The final resolution of the 9<sup>th</sup> International Rainwater Catchment Systems Conference, held in Brasil in 1999, stated that greater attention needed to be placed on improving the quality of rainwater. Up until then efforts were concentrated only on the catchment of rainwater.

The Second World Water Forum, held in 2000 in the Hague, confirmed that view, stating the importance of providing drinking water quality for small communities, including using Rainwater Catchment as a natural source.

The time has come to seek ways of providing affordable, appropriate solutions to increase the quality of rainwater so as to fulfil drinking water requirements and thereby create growth for Rainwater Harvesting

Until now, only simple mechanical filtering devices have been available. These take out large particles but do not stop micro-organisms, organic and inorganic contaminants, such as heavy metals, getting through.

This prompted a development programme, in partnership with the Technical University of Twente in The Netherlands, to create a compact, integrated drinking water filter suitable for domestic use by small communities in urban, peri-urban and rural areas.

### **3.8 Environmental Considerations With Respect to Rainwater Harvesting**

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#### **Technical description**

Rainwater harvesting for domestic use is an option, which has been adopted in many areas of the Palestinian territories since ancient times. A rainwater harvesting system consists of three basic elements: collection area, conveyance system and storage facilities.

The technology is based on small-scale rainwater catchments systems. As rainwater falls of a roof, the water flows through plastic pipes (4" VPC or plastic pipes) and into a large cistern. The collection area in all cases of domestic use is the roof of a house or building. The effective roof area and the material used in construction the roof influence the efficiency of collection and the water quality. The water ultimately is stored in cisterns, often excavated in the lime stone rock formation or in a storage structure, which may be part of the building.

None of the rainwater harvesting systems uses any devices for filtration or disinfecting, but as a normal practice, the users divert the 'first flush' water so that it does not enter the storage facility. This practice is normally implemented once at the beginning of the rainy season only.

### **3.9 Disinfecting Effects on Collected Rainwater and Cost Analysis**

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#### **Introduction**

When rainwater is collected and pre-treated by sedimentation before entering water storage, the sense perception is nice. However, during rainwater collection, the water quality may deteriorate through the putrefaction of organic material in the water, or through growth of bacteria and other micro-organisms, in resulting to carry infectious diseases, such as higher morbidities of dysentery and diarrhoea among people drinking the cellar water then that drinking the well water as showed in Table 1 and 2. It is, therefore, necessary to disinfect the collected rainwater before use. To provide a simple and cost effective method, we have compared several solutions and analyze their feasibility, based on

10 cisterns and 10 cellars located in Zhejiang Province and Gansu Province, respectively. Their characteristics, indicated in Table 3 and Table 4, include catchment route, material and size of the roof, material, storage volume and storage days of the cistern, rainwater collecting way, people numbers per household drinking water from the cisterns, numbers of flushing toilet, washing machine and shower per household, garden areas per household irrigated by the cisterns, as well as disinfecting method, if any.

## POSTERS

### 3.10 Maintaining Participation an a Longitudinal Study of Gastroenteritis and Tank Rainwater Consumption in Young Children

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#### Introduction

Two important aspects of longitudinal studies are recruitment and maintaining the interest and cooperation of participants. In this paper these are discussed in relation to a longitudinal study of gastroenteritis and water consumption among children aged 4-6 years in South Australia.

### 3.11 Improvement on the Harvested Rainwater Quality in Rural Areas of Southern Nigeria

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#### Introduction

Water is life is an old axiom. The level of availability of potable water could serve as a yardstick for measuring the quality of life especially in developing countries.

Nigeria has a total landmass of 923,768 sq km. About half of the country is underlain by basement rocks, which comprise of metasediments, granite gress, quartzite granite etc. Whereas the other half is underlain by sedimentary rocks comprising of shale, sands, silt, clay limestone, etc.

The country is endowed with an estimated 267,000 million cubic meters of surface water, and about 52 million cubic metres per year of groundwater potential. These vast potential notwithstanding only 30% of the rural populace, 35% of semi urban and 50% of the nations urban dwellers are served with potable water. The outstanding water supply gap is augmented through other means including rainwater harvesting.

Annual precipitation varies from less than 500mm per annum in the arid north to about 3000mm per annum in the humid south. Evaportranspiration is less than annual precipitation in the South but there is more annual precipitation in the arid north. The rainy season spans May to October in the north but April to November in the south.

Rainwater harvesting is a practice as old as the emergence of man on earth. Initially, the quest was more for quantity rather than quality. As development progressed, the quality of the available water became addressed. Catchments system ranged from thatched roofs, earthen pots, cut calabashes, corrugated iron sheets, household cisterns, communal ponds to use of discarded burrows pits and earth dams. The quality of rainwater harvested from these catchments systems vary significantly.

## 4 RAINWATER CATCHMENT IN AGRICULTURE

### PAPERS

#### 4.1 Efficacy of the Small Water Harvesting Structures in a Dryland Region in India: Implications for Crop Productivity

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#### Introduction

Small water harvesting structures were important sources of irrigation before the advent of big dams and canal systems. While these structures serve as a major device for ground water recharge, especially in low rainfall/dryland regions, they are often viewed as having limited economic benefits. The recent revival of interest in small water harvesting structures however, is an outcome of the increasing environmental concerns, particularly due to depleted ground water resources in large parts of the country. While the primary objective of such measures is to improve recharging of ground water, they often provide a source of supplementary irrigation. Hence, if properly introduced, these measures can ensure economic viability which in turn, may induce private investments. What is however missing in these efforts is (a) mechanism of sharing of benefits with those who do not derive any direct economic gains from such structures; and (b) emphasis on water use efficiency such that it improves the ground water table to a sustainable level. One of the possible ways to overcome this distributional problem is to make smaller structures, like farm ponds, on a large number of privately owned farms which in turn may cater to a large number of farmers, especially those who otherwise cannot afford investing in private wells and/or remain outside the reach of small irrigation schemes.

Given this context, the government of Gujarat (a federal state in India) has initiated a Farm Ponds Scheme in 1995-96. The major objectives of the scheme are twofold: (i) to recharge the ground water table; and (ii) to improve crop yield through increased soil moisture and supplementary irrigation. Generally, these ponds are made on farmers fields and in vicinity of the irrigation wells. The ponds are typically of small size i.e. of 12, 14 and 15 square meters. The corresponding costs are about US\$ 180, 270, and 310 respectively. Despite the fact that the scheme is likely to generate 'substantial' private benefits to farmers, the state is subsidising 85 per cent of the cost. A likely corollary of such a high degree of subsidisation might be low incentives for water-use efficiency as well as maintenance. Besides these, given the budgetary constraints, the scheme with a high rate of subsidy for all categories of farmers may have only limited coverage. Very often this might be at the cost of the poor farmers. By 1996-97 about 6868 ponds were made in different districts with special concentration in

the dryland/semi-arid regions in the state. The present analysis is based on a larger study involving a primary survey of 688 farmers in the major districts of Gujarat. The survey consisted of about 10 per cent of the total 6868 ponds, selected from each district, on a pro-rata basis.

## 4.2 The Effectiveness of Rainwater Catchment on Flood Control in Slope Land Area

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### Introduction

Taiwan is a mountainous island. The total area is about 36,026 km<sup>2</sup>. The Central Mountain Range runs north to south, dissecting the island into two halves. Flatland with less than 100 m elevation comprises 26.4% of the total area. The remaining 73.6% is slopeland. Forest cover in higher elevation is about 46.6%. Along the Central Mountain Range, there are about 20 peaks exceeding 3,000 m. Rivers originate from mountain tops flow east and west to the Pacific Ocean and the Taiwan Strait, forming narrow river valleys as a result of torrential river flow. Suitable reservoir sites are limited.

The average annual rainfall is about 2,500 mm. However, rainfall is unevenly distributed both temporally and spatially. The north, central, south and east receive about 62%, 78%, 90%, and 79% of the total rainfall during the month from May to September, respectively. Wet and dry seasons are very pronounced. The available water resources are limited. Due to increases in population, economic development, housing areas, and agricultural land, slopeland ecology has been damaged, resulting in severe soil erosion and runoff, ruined water retention capacity, accelerated water pollution rate, and deteriorating sedimentation and water pollution problems in reservoirs.

Torrential typhoon rains often lead to massive soil movement and landslides; concentrated runoff and large peak flow, causing significant damages downstream in the Hsichih area, Taipei. The main objective of this study is to determine the effectiveness of storm water collection using small infiltration enhancement structures and retention ponds on storm runoff reduction and flood control.

## 4.3 Green Water: Enhancing Food Security in Kenya Through Rainwater Harvesting

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### Introduction

Various strategies have been applied, with the aim of improving food security among small scale farmers in Kenya, especially those from the semi-arid areas. These have ranged from extension packages, trials with different and new crop varieties, fertilizers and pesticides, soil conservation

campaigns, as well as research strategies (Tengberg et al 1998; Kiome and Stocking, 1995; Lewcock, 1997). Despite this, the small-scale farmer in Kenya is much poorer and the need for food relief has been growing compared to 30 years ago. The reasons for the success or failure of the various interventions has been discussed and publicized (Sherington, 1997; Lacy, 1996; Norman et al, 1994; Chambers et al, 1989; Reij et al, 1996). Recent studies have shown the need to shift from top-bottom, capital-intensive approaches, to ones developed with more farmer involvement. Even so, efforts to achieve a more systematic involvement of resource poor farmers through public sector agricultural research organizations have been weak. This is due to a lack of internal motivation on the part of the scientific community, and also lack of external pressure from the farmers (Lacy, 1996). Farmers rarely demand services from the technocrats. To bring about a more effective functioning of the system, several models have emerged that describe the relationship between scientists/technology developers, extension educators, farmers and the informal sector.

#### 4.4 Water Harvesting for Afforestation in Dry Areas

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##### Introduction

In arid and semiarid regions, where rainfall is not sufficient to sustain a good seedling/tree growth, water harvesting for **afforestation** is applied. Water harvesting can significantly increase the rate of tree establishment in drought prone areas by concentrating the rainfall/runoff ('Run-off Irrigation').

These advantages are countered by the problem of unreliability of rainfall, which can be partly overcome by interim storage (cisterns, small reservoirs etc.). Modern hydrological tools (e.g. calculation of rainfall probability) allow a more precise determination of the necessary size of the catchment area (Prinz et al., 1998).

There are two major groups of water harvesting techniques: (1) **Rainwater Harvesting**, which is the collection of runoff and its use for the irrigation of crops, pastures and trees and (2) **Floodwater Harvesting**, also called 'Spate Irrigation', which uses the floodwater of ephemeral streams and rivers.

**Parameters:** The most important parameters to be taken into consideration in selecting a water harvesting technique for afforestation are: (1) rainfall distribution and rainfall intensity, (2) topographical condition, (3) runoff / infiltration characteristics of the location, (4) water storage capacity of soils, cisterns and reservoirs, (5) the type of fruit, nut, or forest tree, (6) available technologies and socio-economic conditions and preferences of the cultivator.

## 4.5 Calculation and Assessment for Developing Rainwater Resource Potential of a Small Watershed in the Loess Plateau of China

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### Introduction

The Loess Plateau, located in northwest China, covers 6.9% of the country's area and holds 1.8% of the total water resources. It uses 3720 m<sup>3</sup> water per ha and 654 m<sup>3</sup> water per person per year, 14% and 24.1% of the country's total respectively. The West China Development Program is concerned about the limited water resources because they limit the development possibilities of its rich resources of coal, petroleum, natural gas, ore and rare metals and contribute to peoples' poor standard of living. A local proverb saying 'everything can be lent but water', demonstrate the Plateau's water problems.

In recent years, as a result of the tremendous achievement of providing drinking water for 1.2 million people and irrigating 300 thousand hectare of crops in China's Gansu Province, the engineering of rainwater utilization has received more attention. The purpose of rainwater utilization is not merely to make people collect and use rainwater. The more important aspect of rainwater utilization is that people begin to have a new understanding and acceptance of the traditional methods of water conservation. People recognized rainwater as a new type of water resource (Liu, 1998). In a certain region, rainwater is probably the only water resource (Ma et al., 1997). Compared to the conventional assessment method which only includes surface water and shallow ground water, we get different amounts according to the viewpoint of rainwater resources when analyzing and calculating water resources.

## 4.6 Converting Rainwater Into Food Efficiently

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### Abstract

The problem was highlighted in the 3 May 1999 issue of the official newsletter of the National Department of Agriculture in which it was reported that "...more than 14 million people in South Africa are vulnerable to food insecurity." This is a serious problem. One of the main factors limiting food production over large areas in South Africa is a shortage of water. It is also true that a large proportion of the rain that does fall is wasted. In other words it is not used productively to produce food. Every drop of rain that is wasted contributes to this problem of food insecurity. The problems is

most serious for those people who depend on small areas of land to provide their food requirements. If we want to reduce food insecurity we therefore need to focus first on the needs of these people.

Rainfall use efficiency, and therefore crop yields, can be increased significantly in semiarid areas on fairly deep clay soils using a water conservation production technique which combines the benefits of water harvesting, no-till, mulching and basin tillage.

#### **4.7 Women's Empowerment Through Hilltop Rainwater Harvesting**

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##### **Backdrop**

The experiment under consideration was undertaken in a drought prone area of Andhra Pradesh in India with a high population of poorer castes and tribes who practice subsistence agriculture. There is a high degree of landless population and the ones with land have very small units ranging from half acre to three acres. Total annual rainfall is less than 500mm. Overall socio-economic indicators of health, literacy, incomes are very low.

##### **Proposed objectives**

To conserve rainwater on hilltop in a closed structure for later use for supporting income yielding plantations on the hill slopes through women's involvement by providing supplemental irrigation using water efficient technologies.

#### **4.8 Water Harvesting, Dryland Farmers and Yields**

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##### **Introduction**

We present a on-farm research project carried out at two sites in semiarid environments, one in Burkina Faso and one in Kenya. Both sites use rainwater harvesting systems to improve water management for crop growth. In this paper we present some yield data and compare to farmers' food security situation in the neighbouring areas of the research sites. The research was carried out by the Department of Systems Ecology Stockholm University in collaboration with IRD and INERA, Burkina Faso, and KARI and RELMA in Kenya. The period of study went from 1998-2001.

## 4.9 Mini-Catchment Technique for Crop Production and Forestation in Semiarid Areas

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### Introduction

The total amount of water resources in the Gansu province is 29.494 billion m<sup>3</sup>. The water resources per capita are only 1171 m<sup>3</sup>, less than 1/7 of that in the world. Due to the effect of topographic and climatic conditions, water resources are unfavorably distributed both in space and time. The annual precipitation is 250-450 mm and in more than 70% of the areas, rain is concentrated in the period from July to September. There is a great difference between the time of crop water demand and rain occurrence. In the past it has not been possible to guarantee water supply for both domestic use and crop irrigation. To solve the serious water shortage, rainwater harvesting projects have been carried out since the 1980's and showed satisfying results. The most successful project is the so-called "121" Project: the provincial government helped the farmers to build one rainwater collection field of 100m<sup>2</sup>, two water cellars and one piece of land for courtyard economy. The drinking water problem of more than 250,000 households and their livestock has thus been solved. After that, a rainwater harvesting and irrigation project has been conducted to provide supplemental irrigation during the critical period of crop growth. However, in many remote mountainous areas, farmers do not have enough funds to build their rainwater collection fields and water tanks. A new technique of mini-catchment has been tested, demonstrated and replicated. Using this technique, one only needs to cover the strip lands between the crop lines with plastic film during sowing. When it rains, the water will concentrate on the cropping areas and increase the moisture surrounding the crops. The method is simple, cheap and affordable for the farmers and effective for increasing the yield.

## 4.10 Potential of Rainwater Harvesting for Raising Agricultural Productivity of Rain-fed Areas

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### Introduction

More than 70 per cent of India's gross cultivated land is under rain-fed agriculture and the agricultural production of these zones is very low compared to irrigated agriculture. Even though more than 1000 mm of rainfall occurs in the rainy season, the erratic distribution of rainfall along with frequent occurrence of dry spells causes severe reduction in yield. Vast areas remain fallow during rabi season due to a lack of irrigation facilities. At times, high frequency of rainfall of longer duration causes floods at lower end of cultivated areas leading to severe soil erosion and prolonged inundation

of crops consequently affecting yield. Considering all these aspects there is a dire necessity of effective rainwater management in rain-fed areas. Rainwater management, crop planning and judicious allocation of stored rainwater are the most effective means for sustainable agriculture in rain-fed areas. In this paper rainwater management by way of harvesting it in an on-farm reservoir (OFR) and optimal use of stored water by its recycling to the cropped fields are discussed. The stored water is used optimally as supplemental irrigation (SI) to crops especially during critical growth stages (CGS).

#### **4.11 Rainwater Harvesting: Impact on Agriculture and Environment in Pakistan**

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##### **Introduction**

Pakistan falls in the arid and semiarid climatic region and about 11 million hectares or 14% are covered by the deserts Thar, Cholistan, Thal, Changi and Kharan. These deserts have acute shortage of water supplies and as a result a harsh life. In deserts, the primary source of water is rainfall and underground water resources are mostly saline. When there is no rainfall, people are faced with droughts and famines. The years without rain also reduce grazing lands, increase livestock mortality and bring additional miseries for human beings.

When water is scarce, the need for water management skills and efficient use rises. In such areas the water for growing vegetables and fruit trees as well as for drinking purposes can only be provided through rainwater harvesting technologies. Due to constant population growth, there is a necessity for an increased food supply, requiring the use of marginal and desert lands for livestock and farm production. The saline groundwater cannot be used for human and animal consumption nor for growing crops and trees. To combat this problem water harvesting techniques have generally been used to get water. This paper has the objective to evaluate the water resources available through rainwater harvesting and its impact on agriculture, the socio-economic conditions of the inhabitants and the area's environment.

## 4.12 The Influence of Rain Intensity and Crop Stages on Runoff Production

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### Abstract

The efficacy of vegetation barriers intended for runoff reduction was evaluated at a research station in central Burkina Faso. On a 2 % slope of a sandy loam seven local species (grasses, woody species and a succulent) were planted as conservation barriers to examine their influence on soil and water conservation. After each erosive storm runoff was measured to determine the catch efficiency. Large differences were found between the barrier types. Grasses proved to be very effective. The through-flow in the barriers with woody species and succulents was rather high. Compared to this barrier effect, the effects of rain intensity and crop development are rather small. Runoff reduction during the growing season is highest on plots without a barrier and on plots with the less effective Agave and Ziziphus barriers. The increase of rain intensity is resulting in the highest reaction on plots with Agave and Ziziphus barriers. On plots with the more effective Andropogon barrier the influence of rain intensity and crop stages is rather small.

## 4.13 Effects of Rainwater Harvesting on Dry Farming

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### Introduction

The middle and eastern part of Gansu, one of China's driest and poorest provinces, is a typical dry farming region. Most of the area is mountainous, crisscrossed by ravines and gullies and covered with deep loess soil. The annual precipitation is only 330 mm with unfavourable distribution within the year. Due to the climatic and geological conditions, the runoff coefficient is as low as 0.05 and there's a lack of groundwater. Frequent droughts made the agriculture production a very low level. Serious water scarcity caused food insecurity and inadequate drinking supply for the people. In the past decades, people have made many efforts within the conventional measures of dry farming, including the cultivation measures such as deep ploughing and harrowing, mulching, breeding of varieties adapted to water stress, etc. The soil and water conservation measures such as terracing, contour planting and constructing fish scale pits are also adopted to retain rainfall-runoff. All these measures have proven to be effective in raising crop yield, however, the effects are limited especially in the dry years. They could not bridge the gap between the time rainfall occurs and the time when crops demand water. Figure 1 shows the water demand versus rainfall in the crop periods for winter wheat.

We can see that crop water deficit is mainly owing to the rainfall distribution rather than the yearly water shortage. The soil porosity is far from enough to store all the excessive water in summer and autumn for the next spring.

#### **4.14 An Economic Analysis of a Rainwater Catchment System on a Farmstead in Sipili, Kenya**

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##### **Abstract**

The appropriateness of a Rainwater Catchment System (RWCS) in a given situation depends on costs and benefits relative to alternative water supply systems. In this paper, the benefits-cost analysis of installing a ground catchment system with a multipurpose open lined subsurface tank of 150 m<sup>3</sup> on a farmstead in Sipili was carried out. The stored water was used for domestic purposes, watering of two grade dairy cows and supplemental irrigation of a cabbage crop grown on small plots (kitchen gardens). The analysis showed that rainwater catchment system technology is an economically feasible venture.

## **POSTERS**

#### **4.15 Recent Rainwater Harvesting Progresses in Iran**

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Following the 8th IRCSA, held in Teheran, Iran in April 1997, various types of rainwater collection methods were studied in the northwest of Iran. These studies were based on some valuable experiences from other countries, which had been discussed during the conference.

The aim of this paper is to describe the most important results of the employed methods, including water spreading, micro-catchment systems for reforestation and water ponding using micro-catchment systems. The result of the studies have shown that in areas with limited rainfall, storing water in soil profile appears to be a key for survival for plant and domestic water supply in terms of rangeland improvement.

One has to keep in mind that even rainwater micro-catchment systems are having limitations in terms of applicability. Particularly in drought prone areas, rainwater harvesting is the only way to guarantee water supply.

However increase in natural plant composition, establishment of plantation, increasing spring discharges as well as underground gallery, so called qanat, are the most important results in the study areas. In order to promote the use of rainwater harvesting methods to supply water for different proposes, extending the use of water harvesting techniques and training programs on a national level are essential and imperative for sound rainfall management in water deficient regions.

The key points in this regard are as follows: (a)Feasibility of techniques to be used, (b)Reasonability of the techniques in economic terms , (c)Acceptability of the techniques by farmers, (d)Simplicity of the techniques in terms of design, layout, implementation and operation.

It has to be emphasized that in the study area all the above criteria were taken into consideration and more than 80 hectares of wasteland were rehabilitated using micro-catchment systems. In addition 25 water points supplying water for more than 500 head sheep were supplied through the construction of a flood water spreading system. The discharge of ten shallow wells and two Qanat systems was also increased.

#### **4.16 Small Scale Water Harvesting Approach for Agricultural Production in Semi-Arid India**

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##### **Abstract**

The project is located in semi-arid region of Anas river catchment in state of Madhya Pradesh, India. Due to rapid increase in agricultural land, the traditional sources of irrigation water are often overused. The ratio of annual potential evaporation to precipitation varies between 1.2 to 3.0, and only a small fraction of rain falling during monsoon season percolates into deeper soil to recharge an aquifer. The small scale water harvesting approach offers significant potential for sustaining agricultural production in semi-arid region of Anas river catchment. Remote sensing, geographical Information system and indigenous knowledge are linked in a participatory survey to identify suitable water harvesting areas.

## 4.17 Innovations in Watershed-based Rainwater Harvesting

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### Summary

- The programme was based on people's know-how and decisions on watershed-based rainwater harvesting, structures and processes. To add to this, exposure trips and training programmes helped communities to grasp the concepts and its workings perfectly.
- Technical inputs by the implementing agency slowly reduced over a period of four years, to the point that certain communities built their own structures, without any technical assistance from the implementing agency.
- From the very beginning, the programme emphasised on landless and other marginalised persons within the community. Benefit-sharing within the community has therefore worked towards equity, actually empowering significant numbers – for instance poor single women, landless families, etc.
- Landless and land-poor families often rely on their livestock to survive. The programme gave special weight to this fact, and a lot of the small surface-water bodies created were for the express purpose of serving the drinking water needs of livestock.

## 4.18 Artificial Rainwater Collection and Utilizing Modes in China's Loess Plateau

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### Abstract

In the Loess Plateau, there has been a long history in rainwater utilization and a rapid development in recent years. Two kinds of high efficient catchment with new materials and their catchment efficiency are given. Forms of water storage and their utilization modes are introduced.

## 4.19 **Forgotten Rain, Rediscovering Rainwater Harvesting in Arizona**

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### **Abstract**

This poster uses tables, pie charts, and photographs to depict Arizona's current water availability and the extreme detrimental environmental conditions created by current groundwater overdrafts. The poster provides historic Native American rainwater harvesting practices and current efforts to reinstate passive and active rainwater harvesting practices. Collected rainwater is offered as an alternate water source to the municipal supplies currently usurped for potable and non-potable uses in an effort to reduce groundwater withdrawal. Arizona's examples of residential, commercial, and research facilities are shown along with municipal pamphlets prepared to educate the general public about low water use opportunities. The back drop of the poster is the stately saguaro cactus, Arizona's and the Sonoran Desert's signature plant.

## 4.20 **Water Conservation Techniques on Small Plots in Semiarid Areas to Increase Sunflower Yields**

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### **Abstract**

Dryland crop production in South Africa is liable to short seasonal or long annual droughts that lead to uncertain yields and frequent crop failures. There is a great need therefore to quantify risk and improve the rainfall use efficiency (PUE) by employing appropriate production techniques. A large area east of Bloemfontein (750 000 ha), sometimes termed the "resettlement area", has been earmarked for developing farmers. The area is marginal for crop production. There are two reasons for this (a) low and erratic rainfall (520 mm to 600 mm per annum) and (b) dominantly clay soils on which the PUE is low due to high runoff (R) and soil evaporation (Es) losses. The production techniques developed by the ARC-Glen team (Hensley, Botha, Anderson, van Staden & du Toit, 2000) that combines the advantages of water harvesting, no-till, basin tillage and mulching in the basins on high drought risk clay soil reduced total runoff to zero and Es considerably. The main water loss is considered to be Es. Soil movement from the runoff strip into the basins however may be a problem in the long-term in the relation to sustainable crop production. The question that needs to be answered can be stated as follows: Can an appropriate water conservation production technique be developed which can decrease Es to a reasonable level, and which is also sustainable?

It is hypothesised that mulch (organic or stone) on the runoff area will depress Es and soil movement and therefore promote higher yields and sustainability.

Significantly higher sunflower yield were obtained with the WHB technique compared to the Con technique, due to a reduction in runoff. WHB-OS and WHB-SO techniques also gave higher yields than the WHB-OB technique because of the reduction in Es. The experiment has shown that the losses,  $R + Es$ , play an important role in crop production. Although more research is needed, results have shown that with the WHB-OS and WHB-SO production techniques, crop production with reasonable high yields are possible on these high drought risk clay soils. The new technique could lead to a reduction of poverty or serious financial problems resulting from crop failures.

#### **4.21 Best Rainwater Harvesting for Plant Production: Iran Experience**

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##### **Introduction**

It is believed that water harvesting can increase plant production in the Mediterranean arid and semi-arid. But, it also is believed that most of the known water harvesting techniques have not been adopted on a significant scale both by experts and farmers (Ghoddousi, 1992). It therefore is recommended that water harvesting package be based on recognizing best water harvesting techniques or practices (Reij et.al.,1990). Considering that water harvesting is employed as an umbrella term describing a whole range of methods of collecting rain where it falls and resultant runoff before it has run away into rivers (Pacey with Cullis, 1986), recognizing best water harvesting methods or techniques seems to be the first step to be taken for promoting farmers to make the best use of available rainfall on the farms and pastures.

In this paper in addition to defining best rainwater harvesting practices, the results of research studies in Iran as well as the related data are presented suggesting that prescriptive best rainwater harvesting practices have resulted in increased plant production, canopy cover, plant palatability classes and in reduced soil erosion and sedimentation.

## 4.22 The Micro Irrigation and Amelioration of Stored Rainwater with Natural Energies

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### Abstract

This paper describes some experiments with micro irrigation systems and the amelioration effects of zeolite filter for better use of stored rainwater with natural energies. Energy is derived from the force of wind or sunlight collected by solar cells. Electric power is used directly from solar cells or ordinary car batteries, and connected to a 40W DC pump or a blower, which circulates water through zeolite filter to prevent water pollution. The transmitted sunlight effect is tested with waterweed (*Egeria Densa Planch, EDP*), where sunshine is hard to collect. The sunlight is collected by fresnel lenses and transmitted to the 100 l test water tank through optical fibers. Micro sprinklers or tubes with holes are effective in small irrigation systems. Aeration provided by water cycling through zeolite filter in the 25m<sup>3</sup> water pool decreases COD from 14mg/l to 9.8mg/l and dissolves little phosphorus in a week. However, the bottom of the small rainwater storage pond with lots of waterweed shows a slight decrease in DO due to the heat and weak sunlight.

## 4.23 Supplemental Irrigation Through Conjunctive Use of Rainwater for Aquaculture and Horticulture

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### Introduction

Aquaculture has emerged as one of the more promising industries in the world with considerable growth potential and expected to contribute around the global fishery harvest by the year 2000AD .The aquaculture industry has multidimensions in perspective growth. Aquaculture is a tool for utilizing the water more economically and optimally for increasing the productivity of both, land and water. The world scenario indicates the total fish production of 100, million tones by the year 2000. Even if India ventures to contribute 5% of the world fish production by that period, the aqua food would remain the scare commodity for the 500 Million population which is ever increasing.

The countries in the Asia -Pacific regions have vast and varied aquaculture resources such as dams, reservoirs, ponds, Lake Tanks, rice fields and lagoons. These are main sources of the water supply for urban development in the urban region. Oftnly the water from these sources is used accordingly to the national priority for domestic , industrial and the agricultural purpose . Hence it is necessary to develop the water use plan by optimizing the available sources. Waste water reuse from aquaculture

industry along with the use of rainwater for urban agriculture become essential to avoid the high cost transfers from irrigation schemes. This poster will deal with barriers to replicate successes in terms of clean technology and wastewater treatment in aquaculture industries in industrialized and developing countries .

#### **4.24 Plastic-lined Canal for Environment Protection: Multi-Use Canal**

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Over 20 percent of the Brazilian territory is an extensive region called Central Brazil, with approximately 2,000,000 km<sup>2</sup> (the “*cerrados*” area). The soils are predominantly porous with intake rates above 50 mm/h. It is necessary to line canals impermeable in order to use them to: a) conduct water for irrigation, animal and domestic consumption, and fishery; b) conduct wastewater from farm animal operations and from urban and industrial treatment facilities. The project was constructed in the Calciolandia farm, Arcos county, State of Minas Gerais, Brazil. The canal has a length of 2.5 km, width of 5 m, depth of 0.8m. Lining is made with common plastic sheets 200 microns thick, 6, 8, 10 or 12 m width, 100 m long, easily available in the market. This type of lining has shown a lot of advantages compared to other special lining sheets since it is cheap and easy to construct. Besides, it requires no more than a wheel-loader machine to do the field work. It is important to mention that the plastic sheets need to be covered by a 20 to 25 cm thick layer of soil in order to fix them in place and to protect against sun radiation and animal traffic. The slopes of the canal should be gentle, not exceeding a 30 percent grade. A good balance between slopes and depth determine the width of the canal. The grade of length must be gentle, a maximum of 1.0 m/km.

#### **4.25 Rainwater Harvesting Is the Way of Highly Efficient Utilization of Water Resources**

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##### **Abstract**

The Inner Mongolia Autonomous Region is a typical area of dry farming, where the water shortage is the key factor obstructing development of agriculture and husbandry and the main cause of people's poverty. The “112” Rainwater Harvesting and Irrigation Project (one family with one water tank for irrigating two Mu (0.067 hm<sup>2</sup>) cultivated land) has been implemented in Zhunge'er and Qingshuihe Counties. The rainwater collection efficiency, types of water tank and the construction method, irrigation scheduling and methods as well as the economic assessment have been studied during project implementation.

## 4.26 Catchment Effect of Contour Hedgerow Plants on Slopeland

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### Introduction

Sloping Agroforestry (contour hedgerows plants) is an available land use with low input and high ecological output. It is widely applied in China and some developing countries. The purpose of this paper is to study catchment effect, runoff loss control of contour hedgerow plants on purple soil slopeland in the Three Gorges Reservoir areas of Yangtze River, South China and on loess slopeland in the Northwest hilly area of Hebei Province, North China.

The experimental plots are located in Hongshiyan Branch of the Nursery for Orange Improved Varieties under the Bureau of Farm and Local Products of Zigui County, the Three Gorges area of Hubei Province in China, with an elevation of 200 m and on a southwest facing slope. The parent rock is Jurassic Penglaizhen Formation with a soil thickness of 50-70 cm. Five experimental plots of 25 degrees steepness were used for water and soil loss observations of different hedgerow plants, including *Hierochloe odorata*, *Coriariaceae*, *Vitex negundo*, and *Neoleucaena glauca*. No.H-9 was a control plot, a slopeland mainly devoted to normal farming practices. In addition to year-round observations of natural rainfall, runoff and siltation in the experimental plots, simulated rainfall experiments were also carried out twice a year to observe rainfall-induced runoff and sediment yield to compensate for inadequacy in natural rainfall observations. Nearly 60 simulated rainfall experiments were completed with down-sprayed rainfall simulator introduced from Canada, and SPRACO cone-shaped sprayer made in U.S.A. The momentum obtained from the simulated experiments was roughly equivalent to 90 percent of isointense natural rainfall (Cai et al., 1992). This study conducts quantitative analyses on 16 selected simulated rainfall experiments to determine the impact of different land use types on soil and water loss.

## 4.27 Catchment Surface Study at Zhangjiakou City, China

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### Abstract

Zhangjiakou City is located in the northwestern part of Hebei Province. Precipitation is low (about 400 mm per year). Since surface and groundwater resources are often unavailable, droughts are a common occurrence. One solution to this water shortage problem is to make use of rainwater harvesting technologies. Since catchments are vital to obtain adequate volumes of rainfall runoff in rainwater harvesting systems, the objective of this study, therefore, is to initiate a pilot study to

determine the best catchment surface for collecting the most runoff water and to demonstrate to local farmers the beneficial effects of rainwater harvesting to increase crop productivity.

Experimental design consists of 12 small field plots (2 x 5 m), with 7 ground surface treatments, namely concrete-cover, asphalt-felt, plastic-film, silicon-spray, compact-soil, waterproof-chemical-mix, and bare. Observation results from the past 2 rainy seasons (1999-2000) indicate that among all treatments, plastic-film, asphalt-felt, and silicon-spray surfaces produce more surface runoff than all other surfaces. Plastic-film is the best, followed by asphalt-felt and silicon-spray surfaces. Comparing the material plus labor cost, concrete-cover surfaces is the most expensive treatment averaging 16.9 yuan (US\$ 0.125) per m<sup>2</sup>, followed by asphalt-felt (5.5 yuan), silicon-spray (5.0 yuan), waterproof-chemical-mix (5.2 yuan), plastic-film (2.5 yuan) and compact-soil (2.0 yuan). Accordingly, plastic-film is the best and most cost-effective material for treating the catchment surfaces. However, routine maintenance and replacement is necessary to achieve maximal and efficient runoff collection.

#### **4.28 Peculiarities of Runoff Generation in Deserts (The Kyzylkum Desert as an example)**

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The source of nutrition for temporary water drains in Central Kyzylkum is rain and sometimes thawed snow. Observation of the formation of drains (G. T. Leshinsky, 1963) shows that water gates, formed by takir and takir sort soils, precipitation in quantity of up to 3-5 mm for the period of one rain does not usually cause drains. They are completely spent on infiltration and for surface detention in microfall comprising so-called initial losses of drain. At very damp soil or at downpours initial losses are several times less. So, precipitation in 5 mm with intensity 0,10 mm/mm already form a drain.

In water gates formed by loamy-sandy soil earth, initial losses of drain in dry water gates reaches 20-26 mm and sometimes even more. It means that the intensity of precipitation, particularly in the autumn and spring, usually does not exceed intensity of infiltration of these soils. In very moist soil or in downpour the initial losses are less. Research of G.T. Leshinsky shows, that the precipitation in 5 mm with intensity 0.10 mm/min already forms drain.

According to the data of Gidrometcenter maximum relative number of cases of drain-forming rain (8.5-14.3%) is observed under precipitation of 5-10 mm, under precipitation exceeding 20 mm, it is insignificant at less 2 %. A number of drain-forming rains with precipitation more than 5 mm – from 3 to 8.

Calculations are based on the method of N. M. Alushinskaya (1959) for possible collection of atmospheric precipitation under their various intensity in the area situated between mountains Kuljuctau and Auminzatau.

It is clear that the volume of surface drain for one rain (sum of precipitation – 10 mm, average intensity of rain – 0.5 mm/min) for the water gates with an area of 2700 m<sup>2</sup> equals 518 m<sup>3</sup> of water from the same area under the intensity of rain 0.1 mm/min and 1296 m<sup>3</sup> of water can be collected. Similar calculations are done for the areas with various lithological structure under the various sums

of precipitation per rain and its intensity and different areas occupied by water gates, in different geomorphological conditions of Central Kyzylkum.

The use of a small part of potential water resources permits to improve drinking and pasture water supplies in various desert regions.

#### **4.29 Rainwater Harvesting For Supplemental Irrigation: Promising Technology for Enhancing Food Security in Semiarid Areas**

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##### **Abstract**

It is evident that irrigation continues to play a major role in poverty alleviation by providing food security, protection against famine and expanded employment opportunities. However, irrigation has only been possible where there are adequate developed water resources. In the absence of this, especially in the vast dry areas of Africa, rainwater harvesting has proved to be a viable alternative. This has been made possible by introduction of water saving irrigation technologies—precision irrigation—supplying just enough water during critical crop growing stages.

The great economy of water use is of particular relevance in water scarce areas and this makes precision irrigation an important component of sustainable rural livelihood systems. Due to unreliable rainfall, rainwater harvesting could only make a difference if the stored water is used prudently. One way of doing this is the use of low-head drip irrigation systems. In this paper, the development of a ‘local kit’ is presented. The kit has been developed to address the shortcomings, among her factors, promoted by a number of agencies in Africa. The shortcomings, among other factors, prompted the search of a simple locally developed drip kit that will address the identified gaps in the promotion of low-head drip technologies in Kenya. Due to the minimum amount of water required, rainwater harvesting is an ideal source of water for the system. Hence a combination of RWH and drip irrigation technologies could go a long way in addressing the problems of water scarcity and food security in dry areas as highlighted in this paper.

## 5 LEGAL AND POLITICAL ASPECTS OF RAINWATER HARVESTING

### PAPERS

#### 5.1 Legal Aspects of Rainwater Harvesting in Sub-Saharan Africa

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##### Introduction

The major objective of water law is to establish a framework for the protection and control of water resources in a country. A water law defines the legal entitlement to water and identifies the rights and obligations tied to water use and thus provides the prescriptive parameters for its development.

Until now, water laws don't deal with domestic roofwater harvesting (drwh) as the direct collection of roof runoff and storage for later use. So far, drwh is working outside the legal framework on project-level. Practitioners rather follow a strategy of creating facts without too much government involvement, instead of working on appropriate legislation.

This practice limits drwh though. While individual village-level drwh projects may succeed in the short term, their long term sustainability may be severely tested in the absence of an appropriate institutional and legal framework at all levels. It is also unlikely that widespread replication of appropriate technologies and community-based implementation strategies will be achievable in the absence of supportive institutions at higher levels, even if a isolated project success may be possible. Moreover, we will show that the organization of the water sector has severe direct and indirect implications for the promotion of drwh and thus can't be ignored.

#### 5.2 Rainwater Catchment Systems in Texas

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##### Introduction

Rainwater catchment systems (RCS) in Texas occur under two broad scenarios: land-based (agricultural), and roof-based (for household use). Under the first category, the practice of constructing ponds to collect runoff from land surfaces on farms and ranches is wide-spread throughout the state. In Texas, rural landowners can construct ponds with capacities of up to 200 acre feet (246,680 m<sup>3</sup>) for storing water for domestic and livestock use, without obtaining a permit. Those farm ponds are also often used for recreational purposes. The second category of RCS involves rainwater from roof surfaces collected through a guttering system that leads to a cistern or other containment system. This paper primarily relates to those kinds of rainwater harvesting systems.

Cisterns were used in Texas to collect and store water as far back as the mid-19th century. There is evidence of such systems being used in Central Texas until the 1930s and in some locations until the 1940s. As groundwater exploration increased, and as municipal water distribution systems were being installed, the practice of harvesting rainwater in cisterns gradually became obsolete. It must be noted however, that the modern system of constructing reservoirs to collect surface runoff for meeting municipal demands is essentially a form of rainwater harvesting, but applied on a much larger scale.

In recent years, rainwater harvesting has been receiving attention again in Texas due to several reasons. A primary factor is the inability of obtaining groundwater of good quality or in sufficient quantity in some parts of the State. The expense of drilling a well (which can cost up to US\$15 per linear foot or \$50 per meter), installing and maintaining a filtration system, water softener, and disinfection or other treatment systems can exceed the cost of a rainwater harvesting system. In unreliable aquifers, expending major capital costs for a well system may not be advisable. Another reason why rainwater harvesting systems are becoming more common in Texas is because people are preferring to live away from cities, in a country (semi-rural) environment, where municipal water distribution systems may not be available. Rainwater harvesting is also environmentally safe and enables the homeowner to become self-reliant, as far as his household water needs are concerned.

### 5.3 Subsidies for Rainwater Use by Local Governments

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#### Introduction

In recent years, the recognition of the importance of rainwater use has been increasing in Japan. Rainwater use in a narrow sense is the direct use of collected and stored rainwater, for example, its use as domestic water on islands that don't have any other water sources and its use to flush toilets, water the garden, etc. in urban areas. Since a rainwater seepage facility can promote penetration of rainwater into underground, it is effective in conservation of groundwater. It stores rainwater temporarily during heavy rains and prevents rainwater from flowing out in a sewer or river in a short time. It contributes also to prevent floods in cities. Therefore the effects of using rainwater seepage facilities can also be considered rainwater use in a wider sense.

In January of 1997, after the large earthquake in Hanshin-Awaji, the city water system was seriously damaged. Although inhabitants were supplied with drinking water by water trucks, they suffered from the lack of domestic water. Rainwater use is expected could be of great help under such circumstances. In addition, even in a case of emergency, when lifelines are damaged by natural disasters, we expect stored rainwater to be used as an alternative to city water.

The number of newly-installed rainwater use facilities has been increasing, mainly in comparatively large-scale public buildings. If their numbers grow, the effects they bring will also grow. Therefore they need to be installed in private offices and housing as well. Thus, subsidies for installing rainwater use facilities have been enacted by local governments to promote their further diffusion.

In this research, investigation was made on the existing situation of subsidy systems by local governments.

## 5.4 Why to Promote Rainwater Catchment Systems in the Brazilian Semiarid Tropics?

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### Actual situation of rainwater catchment in the Brazilian semiarid tropics

The 9<sup>th</sup> International Rainwater Catchment Systems Conference held in Brazil in 1999 gave a fresh impetus to grassroots and governmental organizations to tackle water demand and supply issues more seriously. Today, as a visible result there are cistern building programs underway in many parts of the Brazilian Semiarid Tropics (BSATs). Some 20,000 new cisterns have been built in the past two years.

These initiatives converged in a big project called “One Million Cisterns for Northeastern Brazil”, carried out by non-governmental organizations and mostly financed by the government. The outcome of the program, however, is still uncertain since it depends on many factors, especially the prevailing political situation. Therefore consciousness raising among the people, organizations, technicians and politicians is still necessary. This paper explains why to use rainwater catchment systems in the BSATs. These reasons are important for the political discussion in Brazil and they might be useful for other semiarid regions of the world.

### The need for rainwater catchment systems in the BSATs

Learning from experiences in China, where studies using the GIS - Geographic Information Systems-method to identify potential rainwater catchment areas (Mou, 1999) were used, I will present maps of ranks of rainwater catchment demand for the BSATs, based on the two factors, rainfall and hydro-geology, and a combination of both.

## 5.5 Through Rainwater Harvesting to Sustainable Development

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### Introduction

Rakai district is situated in the South-western region of Uganda. The main cash activity is subsistence agriculture. The area is one of worst affected by the HIV/AIDS pandemic and has one of the highest percentages of orphans per household in the country.

Rakai was among the districts benefiting from the South-West Integrated Project (SWIP) whose objective was to provide safe drinking water to rural communities. However, the potable use of ground water was highly constrained by poor water quality exhibited by high concentration of iron and possibly high levels of trace elements. This meant that the only option for provision of safe water

was rainwater harvesting. Rakai receives about 800 mm of rain annually, which made it conducive to promote domestic rainwater at household level.

As a result the Rakai district administration looked around for partners to assist solving this problem. Many of the families in this district are child/widow headed households with orphans due to the AIDS epidemic in the area. The provision of safe water would play a major role in the reduction of the burden for collecting water especially for the children and women.

SIDA Nairobi was one of the partners that accepted to work with the Rakai administration to promote domestic rainwater harvesting.

SIDA sponsored six Kenyan women experienced in water tank construction in early 1997 as consultants together with a technician to assist Ugandan women groups in Rakai to construct their own water jars and tanks. Two groups benefited from the training: “Katuntu Twekambe Women’s Group” and “Bakyala Kwekulakulanya women’s group.” The women groups had one common problem and a shared vision for clean and safe water. This was all it took to get the women moving!

The groups were taught how to make 2 water tanks: a jar and a ferrocement tank, which costs Uganda shillings 160,000 (US\$ 106) and 240,000 (US\$ 159) respectively. The training lasted two weeks. After the training the two women groups embarked on the construction of tanks. The District Water Officer was very instrumental in the promotion of these groups. He introduced them to various donors and NGOs in the district for support with materials like cement, wire mesh etc. The district pledged to assist the groups on technical issues, mobilization, and promotion. With the technical issues and roles and responsibilities set the groups went to work.

## 5.6 Rainwater Harvesting In South Asia: Education and Finance

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### **Introduction**

Rainwater is a major source of irrigation in many parts of Pakistan, India, Sri Lanka, Nepal, Bangladesh, Bhutan and the Maldives. About 60-70 percent of total cropped area is irrigated by watercourses and canals. Only about 30 percent of the area depends on rainfall. Since none of these countries channels rainwater into an integrated system, most of the rainwater mixes into the drainage effluent and is wasted. In some parts of India, rainwater is stored in water tanks for irrigation of crops, but due to non-availability of sufficient educational facilities and financial constraints, the practice of harvesting rainwater is very low in this region.

Rainwater in the big cities goes to waste and no consideration is given to save this precious source of irrigation and drinking. In most of the areas, the drainage channels are covered but inlets are provided to add up the rainwater into drainable effluents. By maintaining separate small channels/drains to drain out and bring rainwater to a center place for storage and keeping it unmixed with drainable effluent, it can be optimally utilized for justified purposes. This objective can be achieved by educating people of the methods and ways to conserve rainwater and store it for future use.

The financing of such activities is also a point of consideration. In fact, a substantial amount is required to implement the idea of having two separate channels: one for drainable effluents and the other for rainwater conservation. The financing can be made partially through self-sponsorship (about 70 percent of the total cost by the beneficiaries) and international and national/regional donor agencies (the rest 30 percent). Some of the works can be carried out by the beneficiaries by providing services instead of spending money over there.

## **5.7 Water Access and Storage as Tools for Integrated Rural Development – Case Study in the South of Hebron Region**

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### **Introduction**

The West Bank is a semiarid with very limited natural resources. The annual rainfall ranges from 100 mm to 700 mm. The major water source is groundwater. The limited natural resources, the political dispute over the resources and the increased demand on water resources in the area due to the increasing population have increased the severity of water shortage problems in the region. Two areas have been identified as the poorest areas in the West Bank, i.e., Hebron District in the south and Jenin District in the north. As a response to the critical water conditions, DFID is supporting development projects in the area to help Palestinians. Hebron Water Access and Storage (H-WASP) was initiated as a pilot project in the region. The first investigation of the area revealed the selection of three villages (Anab Al-Kabir, Tuwani, and Ghuwein) for the pilot phase of the project.

The overall objectives of H-WASP are to:

- Promote the sustainable management and use of scarce water resources in the West Bank and Gaza
- Act as pilot stage for a broader assistance program in the region to improve access to and storage of potable water in the remote rural areas of the southern Hebron
- Maximise benefits to the poorest sections of the community, particularly by taking a demand driven approach to promote and support the development of sustainable livelihood
- Promote a greater awareness of environmental, health, hygiene and financial sustainability issues related to water, and institutionalise knowledge and expertise in community-based approaches to water and sanitation.

## 5.8 Development of Rainwater Harvesting Projects in Sri Lanka

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### Introduction

Sri Lanka has a average annual rainfall of 2400 mm with a range of 900mm in the dry zone and 5000 mm in the wet zone. The rainfall is bi-monsoonal and varies both seasonally and spatially. In the dry zone more than two thirds of the rain falls during the wet season (NE monsoon) from October to March, of which 70% falls during the period October to December. The large variation in rainfall leads to spatial and seasonal variation in water supply. In the wet zone even though the rainfall pattern is fairly even, the terrain is hilly and rain runoff is high. Concentration of rainfall during a specific period in different zones causes water shortages during months of low rainfall.

Sri Lanka has used rainwater for both domestic and agricultural use for many centuries. Traditionally rainwater is collected for domestic use from tree trunks using banana or coconut leaves or from rooftops into barrels, domestic containers and small brick tanks. In recent years we have seen a revival of rainwater harvesting and much research was conducted to improve the technology. In 1995, the Community Water Supply and Sanitation project initiated by the government of Sri Lanka with World Bank funds introduced rain water harvesting as a water supply option in the two districts Badulla and Matara. Since then, government and non-government organizations throughout the country have promoted this technology.

The Lanka Rain Water Harvesting Forum network organization linking the technologies with the stakeholders has been successful promoting the concept as well as the technology in other parts of the country and to government agencies and non-governmental organizations.

## 5.9 Now Is the Time for Global Marketing!

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### Introduction

Rainwater is steadily becoming recognized as an important source of water. But it still has some way to go before it is accepted as the norm for supplying quality drinking water, and it has yet to gain any significant share of the global market for drinking water.

There are various reasons why this promising opportunity has been neglected. One of the most significant is the lack of any widespread, professionally planned marketing.

Limited attention has been paid to positioning and promoting Rainwater Harvesting. Therefore, the business community has yet to grasp this opportunity and recognize its potential.

There is a need to create the right marketing mix to make the appropriate technology and product available at an affordable price. Local needs must be met, as must the need for distribution of products on a global basis. In addition, the idea of rainwater as a quality, uncontaminated source needs to be promoted.

## POSTERS

### 5.10 Low Cost Rainwater Catchment Systems for the Poor in Arid Regions: Process and Procedure

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#### Introduction

Surveys carried out by the Zimbabwe Rainwater Harvesting Association reveals that they was limited participation in rainwater harvesting activities particularly by the poor members of society. The communities during field studies gave a number of reasons for this limited participation; some of the most common reasons include the fact that;

- Materials for rainwater harvesting were beyond the reach of many households
- Lack of empowerment particularly for the women, men were making major water development investment decision in the home, distance and accessibility to the water source from the home was not considered a priority venture requiring capital investment by men. Most homesteads were predominantly thatched, water harvested from thatched roof was always tainted brown and considered unpalatable, and no technology was known to make that water palatable.
- Lack of awareness among major water sector players on the potential of rainwater harvesting water option, most sector agencies considered large schemes such as big dams, piped water schemes and bore-holes as prestigious technologies and were not prepared to degrade themselves into implementing seemingly inferior technology options. Because of the above limitations rainwater harvesting was now being seen as an option for the well to do members of the society.

Mvuramanzi Trust attempted to come up with manuals for alternative rainwater harvesting options that address the needs of the poor communities. These training manuals were being tried in the field, the rainwater harvesting designs discussed below were also practically implemented in several districts in Zimbabwe and the performance so far is quiet encouraging. The following is the procedures and processes of installing shad cloth cover and gutter on a thatched roof.

## 5.11 Rainwater Harvesting in Zambia – Challenges and Opportunities

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### Introduction

Rainwater harvesting in Zambia is a new concept practised by a handful of farmers in the rural areas. Traditionally, rainwater is harvested either directly in an open bucket or indirectly through shallow wells dug along the riverbanks mainly for domestic purposes. Unlike in the past when only male oriented projects on rainwater were organised, the need to include women who are indeed the main users of domestic water has been identified.

The needs of women and men regarding water differ vastly in a developing country where traditions and culture does not recognise the voice and problems of women. Women like men are fighting to have access to and control of resources such as water, and to be able to make decisions, both at community and household levels.

A successful integrated water resource management should call for a cross sectional approach to the planning, development use and protection of water resources. Training in rainwater management should take into consideration the gender differences and inequalities, if development interventions are to be effective.

## 5.12 Community Development of Water Pans in Nyakach - An ICRAF/ Ministry of Agriculture Initiative

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### Introduction

Kenya with population of 29 million has more than half its people living in the Lake Victoria basin. Though the community has vast natural resource potential, the economic infrastructure, environmental and institutional constraints have prevented substantial success in community livelihood systems.

Enormous erosion flooding and drought characterize the lake basin

These features result into low land productivity in this area. Land degradation is of major concern not only for the health of the lake, but also for the food and livestock security of it's rapidly expanding populace. In addition, limited economic activities whose profitability is worsened by poor infrastructure and weak local institutions diminish the capacity of the affected communities to optimally explore and utilize the available development opportunities.

## 5.13 Rainwater Harvesting Possibilities and Challenges in Kenya

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### Abstract

This paper examines the possibilities and challenges of rainwater harvesting in both rural and urban areas of Kenya. The problems of water shortage in urban areas and the high costs of developing new surface water sources, the scarcity and poor quality of ground water supplies in arid and semiarid lands (ASALs) and the unmanageable operation and maintenance costs of large piped water supplies are alarming. Therefore the willingness of the people, particularly in arid and semiarid areas, to embrace low cost initiatives like rainwater harvesting is but a challenge in itself. The solutions suggested emanate from the grassroots community projects that are organisation members of the Kenya Rainwater Association, the author's experiences in water sector as an engineer and recommendations from household rainwater harvesting workshops.

## 5.14 Public/Official Support and Awareness Creation: Promoting Rainwater Harvesting in Uganda

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### Rainwater Potential

Uganda has an average rainfall of 1200mm per year with a minimum of 500mm in the semi-arid north-eastern region and a maximum of over 2300mm in lake Victoria (figure 1). Roughly, the southern half of the country receives bimodal rainfall with the first rains falling in March – May and the second rains falling in September – November; the Northern half of the country receives unimodal rainfall between April and October/November with a marked decrease in June and July. Generally the country can be divided into five main climatic zones [Rugumayo, 1995] i.e.:

- The lake Victoria Basin and Central Region with annual rainfall ranging from 1100 – 2000mm, the first rains being heavier.
- West and Southwest Region with annual rainfall ranging from 800 – 1600mm annually, the second rains being the heavier. The area is generally semi-arid to moist humid except for the Northwest and the Southwest parts having the heaviest rain.
- Northwest and North-central Region with annual rainfall ranging from 1200 – 1600mm.
- North – East Region is increasingly semi-arid to arid in the eastern part with the annual rainfall varying between 600 – 1500mm, the rains fall in April – October.
- East and Central Region is the transitional zone between bimodal and unimodal rainfall patterns with high rainfall variability between July and November. Rainfall varies from 1100 – 1600mm.

Uganda therefore receives on average substantial and well-distributed rainfall annually and the potential for rainwater harvesting as a source of freshwater supply for domestic and productive use is quite high.

## 5.15 Community Rainwater Harvesting Structures for Dalit Habitats

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### Introduction

Water is an essential resource, covering basic human needs. The world's thirst for water is likely to become one of the most pressing resource issues of the 21<sup>st</sup> century. Global water consumption rose six fold between 1900 and 1995 more than double the rate of the population growth. Surface water supplies are Literally shrinking and ground water reserves are being depleted faster than they can be replenished by precipitation. Water crisis started gaining momentum and is likely to accelerate further in future.

## 5.16 Action Research on Rainwater Harvesting in Bangladesh

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### Introduction

NGO Forum for Drinking Water Supply & Sanitation (NGO Forum) implemented the first year of its "Action Research on Rainwater Harvesting in Bangladesh" in April 2001. This action research exclusively dealt with the rainwater harvesting related issues and was implemented covering only eight villages of two thanas (sub-districts) falling under Rajshahi district in western Bangladesh. Agriculture is the main occupation of 75% villagers, while the rest are either businessmen or service holders. People are generally conservative, and both the sexes maintained defined roles in society. Widely known as the "low-water table area", the project areas are reported to be severely arsenic affected. From the available data, it is found that the average annual rainfall of those areas is around 1400 millimetres, where 75% fall between the months of April and October. Prior to the intervention made by NGO Forum, groundwater was used as the sole source of drinking water in those areas. The villagers did not have any clear concept about the usefulness of rainwater harvesting. Taking all these issues into consideration, the action research was launched with the aim of demonstrating that rainwater harvesting can provide a suitable, safe, socially acceptable and sustainable alternative source of water for drinking and cooking for 8-10 months of the year. The specific objectives of the project are as follows:

- to assess technical requirements for the construction of efficient rainwater harvesting systems;
- to test and improve upon existing models (especially with respect to cost effective tank design)

for various sizes); to consider the role of private sector and the householder in establishing the facility;

- to demonstrate, test and promote rainwater harvesting systems in arsenic affected areas through participatory strategies;
- to introduce and test "do-it-yourself" models for the hardcore poor;
- to monitor and document the construction and performance of the rainwater harvesting systems in terms of user acceptance and user friendliness, water quality, water security and general system management;
- to develop construction manuals and procedures for implementation of rainwater harvesting systems as an option in rural water supply.

## 5.17 Watersheds in the New Millennium: Can Rainwater Harvesting Drought-proof India?

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### Introduction

India's substantial investment in rural development during the past five decades of post-independence era has not produced matching transformation on the ground. With focus of development being largely sector specific, the impact has rarely reached the rural poor. Consequently, sustainable transformation of rural ecosystems with people's participation has remained isolated and scattered.

People's participation, the key to community-centered development, has remained largely stuck in the 'you participate in my programme' mode. As a result, for lack of community ownership the impact of investment in rural development and natural resource generation has not been effective and long lasting.

The recent impetus to already-existing watershed development programmes is a policy response to reverse the prevailing malaise in integrated rural development programmes. The experiences, as of now, are quite varied, ranging from about a dozen very successful projects to a large number of non-effective projects. But wherever enterprising community groups had decided to better their circumstances with some external assistance, they were able to improve their socio-economic conditions considerably in a relatively short time span.

*Sukhomajri* project in Haryana and *Adagaon* project in Maharashtra, to name a few, have clearly demonstrated that eco-restoration is possible in highly degraded lands and that it can regenerate local economies and alleviate poverty in a sustainable and cost-effective manner. Today, these initiatives are particularly important because they have now matured. An advanced level of ecological succession has now reached and their economic impact is clearly visible. However, the numbers of

such successful projects continue to be limited. Nevertheless, the success of some of these projects has given an added impetus to watershed development in the country.

## **5.18 Domestic Rainwater Harvesting in Sri Lanka's Conflict Areas (North and East)**

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### **Summary**

The paper describes the work done recently by the Lanka Rain Water Harvesting Forum in the North and East of Sri Lanka where a civil armed conflict is going on for over 15 years. The experience highlight the special advantages of rain water harvesting, as a potable water supply option for a disturbed civil community. The approach, and the technical options applies can be considered for other areas under similar unfortunate situations. The social aspect of the paper describes how people from conflicting communities found a common platform and a language to discuss rainwater harvesting. The interest of local and international NGO trying hard to improve the human suffering. This include visits to demonstration sites constructed in the conflict areas as mixed groups of all communities. Lastly the paper depicts possible scenarios, including advantages and problems of rainwater harvesting in civil armed conflict areas, where the life of the community can hope for a little more security in water, the most important basic human need.

## **5.19 Ecological Sanitation - Dehydration Toilets**

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### **Introduction**

The two most commonly used sanitation technologies today are pit toilets (drop and store indefinitely) and flush toilets (flush and forget). A flush toilet is basically a machine for mixing human urine, faeces and water. The mixture is then removed from private responsibility by sewers making communities responsible for proper disposal. Conventional waterborne sewage systems have proven to be inappropriate to solve sanitation needs in developing countries. It is too costly and approx. 90% of the sewage is discharged untreated, contaminating ground waters, rivers, lakes and coastal areas.

At the same time soil-fertility is decreasing and nutrients from human urine, rich in nitrogen and phosphates would be needed in agriculture.

There is an enormous challenge to rethink and to raise the status of sanitation and a need for new approaches, techniques and methods.

Ecological sanitation as a closed cycle of nutrients in the eco-system could help to overcome these problems, taking care of the environment by protecting resources underground, upstream and downstream of the settlements.

## **5.20 Technical and Ecological Visions of Rainwater Harvesting Systems**

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### **The Use of Appropriate Technology in RWHS**

The use of appropriate technology in RWHS is vital for its success in sustainable use. Because users can afford to buy, to develop and to maintain their RWHS, they should be informed that there are many ways to get water for their use. However, many modern technological water systems are high in cost, beyond many developing countries' ability to afford them. For example, if the RWHS need higher technology skills in operation and maintenance than the users' ability; then the systems are not appropriate for them. If the systems malfunction, the users would not be able to repair them.