Concluding Remarks

Over the past few decades rainwater harvesting has truly come of age and is now widely recognized around the world as a technology that has great potential in tackling the challenges of overcoming water scarcity and providing food security for all in the twenty-first century.

In the 1980s, the spectacular success of the Thai jar program in NE Thailand where several million 2000 L ferrocement water jars were built in less than a decade demonstrated that roof catchment systems could meet domestic household water demand in areas with moderate rainfall. This program was influential and inspirational in encouraging the adoption of RWH for domestic water supply across the developing world.

In the 1990s, the RWH program in Gansu China demonstrated that using a combination of clay tile roofs and cemented courtyard catchments and large excavated 'Shujiao' water cellars rainwater supplies could support household domestic water demand even in semi-arid areas with relatively low and seasonal rainfall.

Since around 2000, the Gansu program has further demonstrated that RWH can also support productive agriculture in a semi-arid region by adopting it in tandem with LORI methods, micro-irrigation systems, and careful water management. In combination with appropriate technologies, such as low cost greenhouses using plastic film, significant increases in crop yields and household incomes can be achieved using quite small quantities of irrigation water.

While the success of the RWH program provides a model with the potential to be replicated in other regions around the world with similar conditions, care needs to be taken to ensure that both the technology and the approach to implementation are adapted and tailored to meet local environmental, economic, and cultural conditions.

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Future Challenges and Opportunities

Despite the progress made in rural China a number of key challenges to the continued spread of RWH remain. As a result of the rapid modernization which is now reaching even remote rural locations there are growing calls by government to increase both the quality and quantity of rural domestic water supplies. The Ministry of Water Resources' (MWR) latest policy is aimed at promoting more centralized plants involving treatment and reticulated supplies. However, unless users are charged a much higher price for water, which currently they are unwilling or unable to do, it will prove very difficult to sustain the operation and maintenance costs of centralized water plants in rural areas, especially in those remote, mountainous areas. This focus on centralized, treated, and reticulated supplies will inevitably draw resources and community support away from decentralized RWH systems. Ironically, recent research and demonstration projects around the world are showing that by using first flush and household level treatment of rainwater, high quality potable water supplies can be guaranteed.

Another challenge relates to the use of rainwater for irrigation, some of the tanks built for this purpose are not being used very effectively and in some cases not at all, this is usually because farmers either lack the knowledge or funds to implement drip irrigation systems. This indicates a need for some targeted training of farmers and funding or support mechanisms for improving access to irrigation systems.

Despite these challenges the untapped potential to fully utilize RWH across China to increase agricultural production and rural incomes is very high. A few farmers have become relatively affluent purely through maximizing the opportunities of the RWH and low cost greenhouses and have realized incomes of as much as up to 50 Yuan per cubic meter of water utilized. Some individual families have shown that RWH can be used to fund profitable small-scale horticulture which can support a comfortable rural life and such luxuries as washing machines and hot showers. Such improvements to daily life can help to realize the goal of setting up an overall well-off society in the country.

Around half of China's agriculture is rainfed, and low productivity is common especially in the drier regions. Potentially, if RWH-based irrigation systems could be used to increase agricultural productivity by just 20 % in these areas, this would provide a great boost to the rural economy and help meet the food requirements of China's growing population over the next 50 years. This is certainly feasible since research and demonstrations have shown RWH typically lead to yield increases averaging 40 %. A further opportunity relates to further ecological restoration. Improvements in productivity through supplementary irrigation have already helped many farmers in embracing the state-supported land conversion programs, encouraging them to shift from low-yield crop production on steep hill slopes to planting trees and grass, thus promoting environmental conservation and reducing soil erosion.

The experience from Gansu has clearly demonstrated that RWH provides a decentralized solution for water management that is particularly suitable for populations scattered in mountainous areas. Since the technology is simple and builds on traditional, tried and tested techniques, it is widely accepted by the farmers. Because the implementation is predominantly done by the householders with limited government support, the water users feel ownership of the systems that legally belong to them. Householders therefore have been highly motivated to participate in every stage of project implementation, from planning, design, and construction to operation and maintenance. Unlike large-scale water development schemes that often create significant impacts on ecological systems and can be socially divisive, household-level rainwater harvesting projects are both environmentally friendly and attract significant community support.

Over the past 20 years RWH systems have helped to lift millions of rural people out of poverty. The utilization of rainwater has now become part of an integrated approach for sustainable development in the mountainous areas of Gansu and neighboring semi-arid regions. According to an investigation in 2007, the number of rainwater tanks (and small rainwater storage reservoirs and ponds) constructed in 15 provinces across China amounted to over 10 million units, with a total storage capacity of 4.6 billion m^3. These rainwater systems have provided domestic water supply to 22 million people and supplementary irrigation for 2.8 million ha of rain-fed farmland.

RWH has thus become an important component of water resource development in China. While the approaches to RWH outlined in Part 1 above are tailored specifically to the soil and rainfall conditions of Gansu Province with some adaption, similar techniques could be applied to many arid and semi-arid regions in Africa, South Asia, and Latin America facing similar challenges.

The development of RWH and LORI technologies shows that the world can meet the food and water security needs of a future global population of between 9 and 10 billion people in about 50 years from now. Crucially, using these technologies it will also be possible to meet these future needs in a sustainable way that will not compromise the use of water to provide the numerous environmental services on which we all depend.

Annex

Useful Websites

ASAL Consultants Ltd—Nairobi, asal@wananchi.com Website: www.waterforaridland.com have produced an excellent series of small, well-illustrated handbooks that will be of great value to water technicians, engineers, planners, and builders implementing a range of appropriate water supply options in rural Africa by E. Nissen-Petersen and others. In 2006/2007, these include: *Water for Rural Communities*, 52p; *Water Supply by Rural Builders,* 60p; *Water Surveys and Designs,* 58p; *Water from Rock Outcrops*, 55p; *Water from dry river beds*, 60p; *Water from Roads*, 57p; *Water from Small Dams* 58p; *Water from Roofs* 78p, CDs, PowerPoints, and Videos on these topics are also available for purchase. The handbooks can be accessed at the website and can be downloaded for free at http://www.waterforaridland.com/Books/Water%20from%20roads.pdf

Asian Institute of Technology (AIT) International Ferrocement Information Center (IFIC)—E-mail: geoferro@ait.ac.th Website: http://www.ait.ac.th/clair/centers/ific

Centre for Science and the Environment (CSE)—http://oneworld.org/cse/html/cmp/cmp43.htm—Rainwater harvesting page—a very active Indian Group, Website: www.rainwaterharvesting.org 41 Tughlakabad Institutional Area, New Delhi 110062, India E-mail: cse@cseindia.org

Development Technology Unit, School of Engineering, University of Warwick—Coventry CV4 7AL, UK. E-mail: dtu@eng.warwick.ac.uk. Website www.eng.warwick.ac.uk/DTU/rainwaterharvesting/index.htm—a number of case studies from around the world, with good descriptions. Roofwater Harvesting: A Handbook for Practictioners, Thomas T. and Martinson D 2007 IRC

FAKT—Consult for Management, Training, and Technologies Email: fakt@fakt-consult.de Website: www.fakt-consult.de, FAKT have developed a web-based Toolkit on Rainwater Harvesting: http://rainwater-toolkit.net and have various

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resources including a video “Mvua ni Maji—Rain is Water” (language versions in English, French, German, and Swahili) about Ugandan women who visited Kenya to learn about rainwater harvesting in 1996

Global Applied Research Network (GARNET)—info.lut.ac.uk/departments/cv/wedc/garnet/tncrain.html Site of the Global Applied Research Network (GARNET) Rainwater Harvesting Page.

GRIWAC (China)—Rainwater Harvesting in the Loess Plateau of Gansu, China—a paper presented at the 9th **IRCSA** Conference in Brazil, Email: gssk@163.com

International Rainwater Catchment Systems Association (IRCSA)—Archive of conference papers: www.eng.warwick.ac.uk/ircsa/

IRC (The International Water and Sanitation Centre)—This site has some great freely downloadable resources on Rainwater Harvesting and Water and Sanitation in general—including the excellent book ***Roofwater Harvesting*** by Thomas and Martinson 2007. PO Box 93190, 2509 AD The Hague, Netherlands Email: www.ircwash.org

The **International Rainwater Harvesting Alliance** (IRHA)—was created in Geneva in November 2002 following recommendations formulated during the World Summit for Sustainable Development in Johannesburg two months earlier. The mandate called for federation and unification of the disparate rainwater harvesting (RWH) movement around the world—http://www.irha-h2o.org/

Lanka Rainwater Harvesting Forum (LRWF)—c/o Practical Action South Asia, 5 Lionel Eridisinghe Mawatha, Colombo 5, Sri Lanka E-mail: rwhf@itdg.lanka.net Website: http://www.rainwaterharvesting.com/

People for promoting Rainwater Utilisation—1-8-1 Higashi-Mukojima, Sumida City, Tokyo, Japan E-mail: murase-m@tc4.so-net.ne.jp

Practical Action—www.practicalaction.org an excellent source of information on WATSAN appropriate technologies and innovations and publishers of Waterlines.

Rain Centre (India)—http://www.rainwaterharvesting.org/raincentre.htm: Raincenters are a network of permanent exhibitions that seek to spread water literacy among urban Indians. They define the role played by every Indian citizen in harvesting rainwater and using it to combat the menace of water scarcity. The raincenters provide people the know-how to harvest rain.

RAIN Foundation—www.rainfoundation.org The Netherlands-based RAIN foundation has been working since 2003 to spread, develop, and implement rainwater harvesting systems around the world and currently supports partner projects in Africa, Asia, and Europe.

Rainwater Harvesting (Australia)—This is a commercial site offering a range of products all designed to collect, store, and distribute higher volumes of cleaner water for all homes, specializing in water catchment, storage, insect/pest control, and leaf

and debris removal systems used in both rainwater harvesting and home protection. http://rainharvesting.com.au/knowledge-center/rainwater-harvesting-intro/

Rainwater Tank Performance Calculator—This is a free online tool to assist users in designing roof catchment systems providing guidance on the performance of rainwater tanks of specified volumes from a given catchment area. To use this tool, 10 years of mean monthly rainfall data input is needed from the user. www.warwick.ac.uk/fac/sci/eng/research/civil/crg/dtu-old/rwh/model

Rainwater Wiki—www.rain4food.net/wiki/#akvopedia:Rainwater Harvesting: A knowledge library on Tools, Technologies and Innovation Pilots, all specifically about rainwater harvesting. It has been developed by the Rainwater for Food Security program, in collaboration with Akvo Foundation.

Roofwater harvesting discussion forum—www.jiscmail.ac.uk/lists/rwh.html

SA WATER (**South Australian Water Corp**.)—www.sacentral.sa.gov.au/agencies/saw

SEARNET—The mission of SearNet is to network among its member associations within the region for the promotion of rainwater harvesting and utilization. There are a total of 18 countries covered in the joint venture between CSE and GWP-Associated program in Eastern and Southern Africa, India, Pakistan, Sri Lanka, Nepal, Bangladesh, and Bhutan. www.Searnet.net

SimTanka—Software for sizing reliable rainwater harvesting systems with covered storage tanks—SimTanka, is freely available. http://sourceforge.net/projects/simtanka/

SODIS—The SODIS Reference Center based at Eawag/Sandec is engaged in providing information, technical support, and advice to local institutions in developing countries for the worldwide promotion and dissemination of the Solar Water Disinfection Process www.sodis.ch

SOPAC South Pacific Applied Geoscience Commission—excellent source of information on domestic rainwater harvesting on small and remote islands www.sopac.org

The Pelican Tank Rainwater Collection System—a packaged RWH collection system developed in Australia for developing countries www.trade.altconcepts.net

UNEP publications—www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8e/index.html. Sourcebook of Alternative Technologies for Freshwater Augmentation in Some Countries in Asia—another in this series of **UNEP** publications www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8d/index.html#1—'Sourcebook of Alternative Technologies for Freshwater Augmentation in Small Island Developing States' that includes some useful information on RWH

World Bank—Save the Rain—This tool allows you to identify your own home on Google Earth and estimate how much rain you could potentially collect from your roof each year—http://save-the-rain.com/SR2/

World Meteorological Organisation (WMO)—www.wmo.ch

WELL—www.lboro.ac.uk/well/resources/technical-briefs/36-ferrocement-water-tanks.pdf A technical brief on how to make a ferrocement water tank

Note: *The above websites which were current at the time of publication are a good starting point for searching for information online but new website sites and online resources are appearing all the time—so undertaking your own search using Google or other reputable search engine would be worthwhile.*