Rainwater harvesting: the key to sustainable rural development in Gansu, China

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The 1-2-1 Rainwater Catchment Project initiated in Gansu Province, China has been running for 10 years now. The remarkable growth – now over 2 million people have benefited – has been charted in earlier editions of *Waterlines*. This article reports on the impact the project has had in this remote and arid region of north-west China and beyond, as well as the challenges still remaining.

The use of rainwater harvesting (RWH) for domestic purposes using an underground water cellar is a traditional technology that has been widely used on the *loess* plateau region of north-west China for centuries. However, the upgrading and expansion of the indigenous clay-lined excavated *shuijiao* water cellars and their earth catchments using cement, concrete and clay roof tiles through the 1-2-1 project, which was started in 1995, has greatly improved the effectiveness of these systems. The name 1-2-1 refers to the fact each household acquires 1 rainwater catchment area, 2 large underground water tanks (30–50 m^3 in volume) and 1 piece of land (670 m^2) for micro-irrigation using some of the stored rainwater.

The project is funded by both government and households. As an example, in 1995, a system suitable for a household of four in an area of annual rainfall of 350 mm cost about RMB1200 (US$150), including the purchased material (mainly cement), local materials (sand and gravel) and labour. The government only provided the cement (costing approximately $50), which was sent from the cement factory to the villages on the order of the government. The remaining part was provided by the farmers, though not in cash. They rented a mini-tractor from their relatives or friends and collected the gravel and sand in the valley. Afterwards they would repay these friends by offering their labour when they built their RWH system. So it can be said that the household input was two-thirds of the system.

The original target of providing one million rural people with RWH systems was achieved in the first 18 months of the project and by 2003 over 2 million people in Gansu had benefited. Some families have installed a small electrical pump in their *shuijiao* in order to have a tap water supply in their home. Overall water supply, which was once a major concern, is no longer a problem.

Drinking water quality

While water availability requirements are now being met, the challenge of improving water quality still exists. Owing to the limited amount and irregularity of the rain, few farmers are willing to discard the initial first 3–5 minutes of rainfall that washes dust off the catchment and helps improve water quality. Another solution proposed is that families have two domestic tanks in the courtyard: one raised surface tank stores roof water for drinking and cooking and a larger, subsurface tank stores surface runoff from the hardened courtyard for other domestic purposes e.g. washing, watering animals etc. Unfortunately, due to a lack of funds, only a few families have taken up this idea.

To help reduce the risks associated with using contaminated water, farmers are advised to boil the water before drinking it. To conserve trees, a simple solar cooker was introduced in rural Gansu in the early 1990s. Small pieces of glass mirrors are stuck on a parabolic-shaped base made of ferro-cement,

A typical water tank for household drinking water supply

Solar heaters for boiling drinking water are now very popular

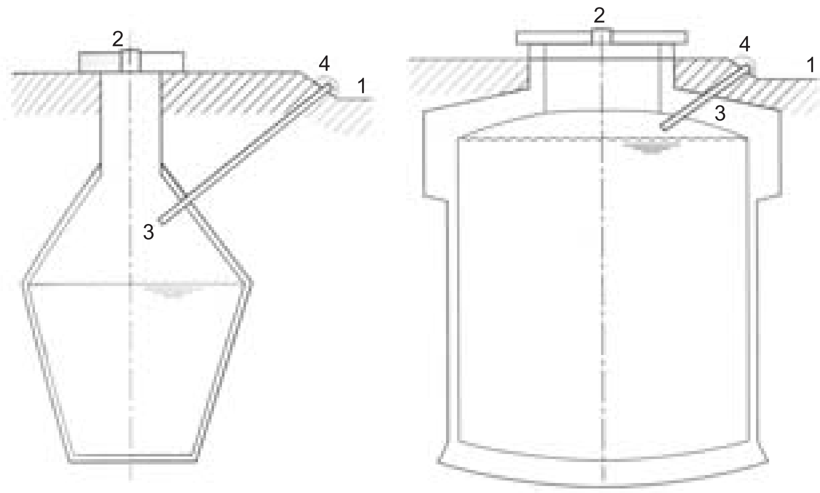
which can be rotated and oriented to the sun. A container with 3 litres of water can be boiled within 20–30 minutes. The cost is only about US$20. Nowadays in the area the solar heater is very popular: almost every household owns one. High demand stimulated the formation of five private workshops in this area, producing about 50 000 solar heaters per year.

Rainwater harvesting for supplementary irrigation

Since 1996 when the rainwater harvesting irrigation project was launched, agricultural production has increased promisingly. Over 2.2 million *shuijiao* sub-surface water tanks each with a capacity of 30–50 m^3 have been built, enabling irrigation of about 339 000 ha.

Research results have shown that crop yields can be increased by between 20 and 88 per cent, and around 40 per cent on average, compared to unirrigated crops. This supplementary irrigation practice using stored rainwater represents a new approach that we have termed 'low-rate' irrigation. To make it as efficient as possible, irrigation consists of only two to three small and targeted applications at critical points in plant growth when serious water shortage would damage the crop beyond the point of recovery, even if water were supplied later.

Many field tests have been conducted to find out the best irrigation timing for different crops. Highly efficient but affordable irrigation methods have been developed locally, which involve applying water direct only to the root zone to minimize evaporation losses. Research results showed that with RWH irrigation, not only is the water supply efficiency (WSE = yield increase / irrigated water amount) higher than for conventional irrigation by 45–220 per cent, but also



1. Sedimentation chamber; 2. Cover. 3; Inflow pipe; 4. Coarse inlet filter

Figure 1. Sub-surface rainwater tank designs from Gansu (reproduced from Rainwater Catchment Systems for Domestic Supply, Gould and Nissen-Petersen 1999, IT Publications).

the water use efficiency (WUE= yield / water consumption, where consumption equals the amount of effective natural rain plus rainwater irrigation component reaching the crop) increases by 10–60 per cent. This finding demonstrates that even using only relatively small amounts of supplementary irrigation it is possible to improve the effectiveness of natural rain and boost crop yields significantly. In fact, the rainwater irrigation component accounts for less than 20 per cent of the total water consumed by the crop with more than 80 per cent being provided by direct rainfall.

To reduce costs, wherever possible RWH systems use impermeable surfaces as catchments, such as paved highways, threshing floors, etc, and tanks are built as close to the crops as possible. Channels are constructed to convey water collected from the highway to the many tanks located next to the fields.

Another way of concentrating rainwater to enhance crop production is to cover each small ridge in the field with plastic film and thus concentrate runoff into the furrows where the crop is planted. This method helps double or triple the effective rainfall received by the crop and reduce soil evaporation loss. Using this method crop yields can be increased by 20–40 per cent. Special machines have been developed which will lay this sheeting while drilling seeds and applying fertilizer and water to assist germination. The only problem is the large amount of plastic sheeting left littering the fields after harvest.

The application of RWH techniques for production purposes also poses some challenges. The small farmers in Gansu are no different from those in other regions around the world and are typically very conservative. While farmers readily accept the RWH system for drinking and domestic supply they

Harvested water irrigates crops through these drip lines

The paved highway is used for a runoff catchment

are not so ready to consider using it for irrigation, since they have relied on rainfall alone for generations. In the past, supplementary irrigation has only been undertaken during droughts to ensure crop survival but is not used regularly for improving productivity. In some villages, the rainwater irrigation tanks remain untouched throughout the growing season as no irrigation is being practised.

More awareness is needed, but it is a hard job to teach the farmers about the benefits of RWH irrigation, especially as many lack funds for the initial capital outlay for irrigation equipment.

Rainwater harvesting for income generation

Despite the caution and slow adoption rates by some farmers, others are using rainwater for irrigation and are adapting crop-planting patterns according to the market need. One of the results of RWH projects is that many thousands of greenhouses harvesting their own irrigation water have appeared in the mountain area at altitudes of 1500–2200 m above sea level. These simple plastic film-covered greenhouses, have been developed using a local design based on a mud brick wall and steel or bamboo frame. They are typically about 300 m^2 in area and cost around $1200. They are generally used to produce cash crops to sell in the local market. With the net income from two harvests of tomato or pepper typically amounting to $1000, the return period on this investment is often only little more than one year. The plastic roof of the greenhouse provides an excellent catchment surface, harvesting around 100 m^3 in areas with an annual rainfall of 400 mm. The rainwater is stored in a 30–50 m^3 sub-surface tank, is typically applied by hand or using a small pump and drip irrigation system, and can normally meet the water demand of 1–2 harvests of vegetable crops each year.

Another example of RWH use is for orchard development in Pengwa village in Qin'an County, Gansu. Here, the County Water Resources Bureau supported the villagers to build a concrete-lined catchment on a hilltop with area of 4800 m^2 and 40 tanks each with a capacity of 50 m^3. The stored water can irrigate 8 ha of orchards with yield increases of 48 t, valued at $12 000. Each cubic metre of rainwater generates $6. The investment of the RWH system is about $27 000, which can be paid back within 2.2 years.

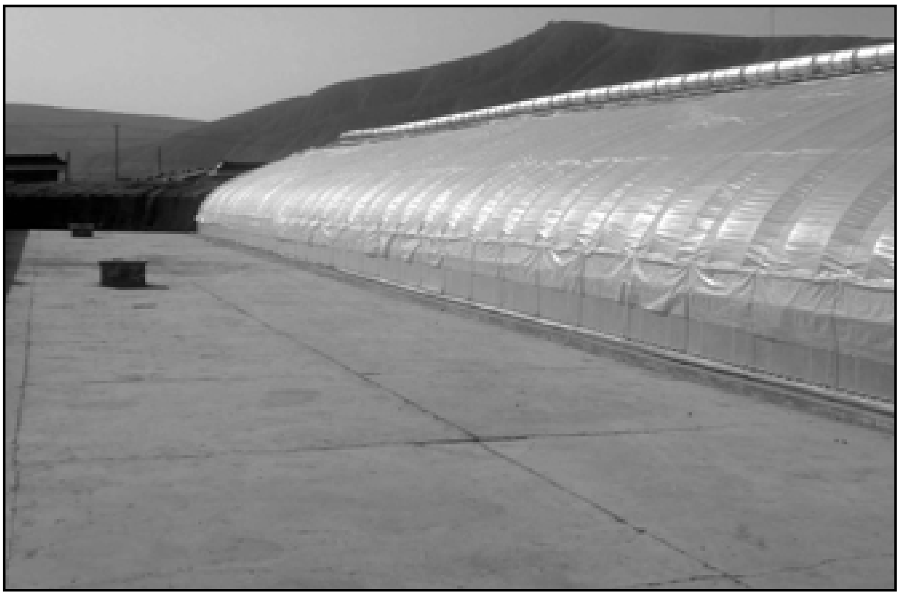
Box 1. Lanzhou International Training Course on Rainwater Harvesting and Utilization

Since 2003, the Gansu Research Institute for Water Conservancy (GRIWAC) has conducted an International Training Course on Rainwater Harvesting and Utilization in Lanzhou with government support and the assistance of the International Rainwater Catchment System Association (IRCSA). The target group consists of water professionals working in the RWH field in developing countries. The course lasts for 45 days (18 lectures, 12 field excursions, 5 participant presentations). The lecturers are experts from China and around the world and participants also visit rainwater harvesting projects and some water resources schemes in Gansu as well as taking part in some on-site construction practice.

Since 2003, three successful courses have been held for almost 100 participants from Africa, Asia, Latin America and the Pacific. The great impact of rainwater utilization on the lives of ordinary people in Gansu has left a deep impression on course participants, many of whom have expressed a desire to apply the knowledge learned from the course in their own countries. As a result of contacts made through the course a technical assistance project between GRIWAC and the Gigawa State of Nigeria is underway. Experts from GRIWAC have also been invited to Saudi Arabia to draw up a proposal for developing rainwater harvesting for domestic and agricultural purposes there.

Replication of the approach used in Gansu has not always been straightforward. The realities in rural Africa are quite different. Apart from the absence of the favourable *loess* (silt) soils, the costs of materials such as cement are much higher and skilled labour for construction is less abundant and more expensive. Further research and development to find techniques and implementation methodologies more suited to local conditions in Africa is still needed.

The course is open for participants from all developing countries. Persons who are interested can apply through the Chinese Embassy in their countries. A few places are available to candidates applying directly to GRIWAC. The contact persons are: Mr Li Yuanhong, Director of GRIWAC (gsws@public.lz.gs.cn), and Mr Ma Chengxiang, Chief of the RWH Division of GRIWAC (irrigs@public.lz.gs.cn).



This simple greenhouse collects its own water for irrigation

In many villages, wheat planting has been substituted with corn, which has a much higher yield but needs more water. It is only feasible with a RWH system for supplementary irrigation in some dry areas. Luo Zhenjun's family was one of the poorest among villagers in Luoma Community, Huining County before the RWH project. In the past, his family of four harvested only 800–1000 kg of wheat in a normal year. When implementing the RWH project in 2001 he built six water cellars with a total storage capacity of 120m^3. He then planted 0.4 ha of maize using plastic-sheeting to concentrate runoff, which yielded 2400 kg. Using supplementary irrigation, his small orchard doubled its production. He was also able to keep nine more sheep than before the project. His yearly food production increased from 900–3675 kg, and his annual net income increased from $190 to $700 three years after the project.

National and international technical dissemination

The Gansu experience has now been widely shared throughout China where over 30 million people in 15 provinces, mainly in remote and mountainous areas, are now benefiting from RWH techniques for both domestic water supply and crop production improvement.

Since the 'National Code of Practice for Rainwater Collection, Storage and Utilization' issued in 2001 by the Ministry of Water Resources (MWR), four national training courses with over 600 participants have been held all over China.

Since 2003, the Ministry of Commerce has supported the Gansu Research Institute for Water Conservancy (GRIWAC) in conducting annual international training courses for water professionals from developing countries (see Box 1).

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About the author

Qiang Zhu was the former Director and Chief Engineer of the Gansu Research Institute for Water conservancy (GRIWAC) China and Li Yuanhong is the Director and Research Professor of the GRIWAC and the General Secretary of the China Rainwater Utilization Special Committee.

conference call

Rainwater as an additional water supply

Depleting groundwater tables, pollution of surface water and increased demand on conventional ground and surface water resources, has resulted in the international water sector placing increased attention on rainwater catchment systems. To meet the Millennium Development Goals by 2015, the XII International Rainwater Catchment Systems Conference in Delhi, India (15–18 November 2005), focused on the optimization of rainwater as an additional water resource.

The conference was organized on behalf of IRCSA by AFPRO (Action for Food Production) and co-supported by the IRCSA, UNICEF, WHO and WSSCC. It was attended by 600 Indian and international participants. A total of 63 papers on technical topics included rainwater structures for different geo-hydro-thermo regions, water laws, socio-economic impact of rainwater and water quality. These were followed by discussions on both rural and urban rainwater applications within the Framework for Mainstreaming Rainwater Harvesting. A special session was organized by UNICEF India on the role of children in rainwater management. This included a particularly interesting 'rainwater song' performed by the children within the plenary session.

During day three, field visits were organized where different types of low-cost treatment, pumping devices and collection were shown to the participants in various urban and rural field sites near New Delhi.

Areas of interest arising from the conference included the importance of both use and reuse of rainwater in water-scarce environments. During the 'Definitions of rainwater harvesting' session, the conventional definition was felt to be slightly restrictive and could be expanded to include rainwater *and* the reuse/recycling of water, which may be more appropriately termed integrated rainwater management. This was further complemented by good examples of field practice from Madhya Pradesh in Central India on the application of rainwater for mitigating contaminated (fluoride-affected) groundwater by dilution and recycling water. There was also some discussion of the relative merits of rainwater harvesting to replenish aquifers versus RWH to fill tanks.

Additionally, the participants recognized the important role that women and children can play in the promotion of rainwater harvesting. Communication of the potential risks of rainwater to the civil society for potable and non-potable purposes in given scenarios was also emphasized with specific reference to emerging risk assessment and management (Water Safety Plans) outlined in the third edition of the WHO *Guidelines for Drinking Water Quality,* 2004.

In summary, the conference addressed the key issues of rainwater catchment systems and emphasized the importance of rainwater as an additional water resource that should be carefully used and reused. With only 45 per cent of papers and 25 per cent of delegates coming from outside the country, the conference was a little too 'India-centric' and I recommend that the organizers of the next IRCSA conference (Sydney, 2007) give more attention to international, as well as host nation, viewpoints.

Rainwater harvesting is as much for urban as for rural areas. Speaking at the closing ceremony, Delhi Chief Minister Shiela Dixit said the people of Delhi need to adopt rainwater harvesting to augment water resources in a big way. Very soon the surrounding states that provide the bulk of the water supply for New Delhi may be increasingly unwilling to pass on this water. 'The real need of the hour therefore is to conserve and preserve the water available to us', she said.

Sam Godfrey is a Water and Environmental Sanitation Officer with UNICEF India.

Children perform a rainwater song