A lifeblood transfusion: Gansu's new rainwater catchment systems

by Qiang Zhu and Fuxue Wu

For centuries, the people of Gansu utilized what little rain there was — they also spent days fetching water, and came to rely on government rationing. Could a new catchment design make all the difference?

ZHENGMIN WEI USES a handpump to fill a bucket of clear water from his new underground tank; he can now cook his lunch. Wei told his foreign visitors from a Seventh International Rainwater Catchment Conference tour group: 'Now I no longer worry about water, and I don t need to fetch it from several kilometres away'.

This is a tremendous change for the remote village in the hills where, only five years ago, the people had to rely on the water truck sent in by the local government. Everyone stood in line waiting for two buckets of water, each family's two-day ration. Since 1991, when the rainwater catchment system extension programme was set up, 10 540 of the 10 700 families living in the mountainous area of Yuzhong county, 70km from Lanzhou — capital of Gansu province — have built new rainwater catchment systems.

By combining both new and old traditional systems, they have engineered the end of the water scarcity which afflicted them and their ancestors for hundreds of years. This is no isolated example, but typical of developments in Gansu where more than 140 000 people have already benefited from the ongoing rainwater catchment system implementation programme.

An arid land

Gansu is a landlocked province in the north-west. The average annual precipitation is only 302mm, and its spatial and temporal distribution are very unfavourable. In the middle and eastern part of the province, composed of ta loess plateau and hilly gullies, things are worse than in other parts of the province. Although the mean annual precipitation is 366mm — a little higher than the province average — 70 to 80 per cent is concentrated in the wet season, which runs from July to September, and consists mostly of heavy storms. About 90 to 95 per cent is absorbed by the loess, a silt layer with a thickness of between 100 and 300 metres; much of this then evaporates.

Furthermore, most of the runoff is saline and cannot be consumed or used to irrigate the land. Ninety-five per cent of the cultivated land is rainfed by the limited and unevenly distributed rainfall, and drought occurs frequently The grain yield amounts to only 1.5 t/ha and, on average, people earn less than US$70 a year. During the dry years, the yield, and consequently people's income, drops dramatically.

An estimated 1.5 million people — and their livestock — have to cope with a very serious drinking-water shortage; every year, the trucks cost the government between US$600 000 and 800 000.

Zhengmin Wei built his own rainwater catchment system in 1992. Now water is well within reach.

Fuxue Wu

Water is the key to improving agricultural productivity and the quality of life in Gansu. The only potential water resource in this area is rainwater and, for centuries, people have used their threshing floors, courtyards, sloping roofs, and the roads to catch the water which they store in underground tanks until it is needed in the dry season. Government support has, in the past, equipped most families with two tanks, each with a capacity of between 15 and 20m^3. But as people's roofs are traditionally made of straw and mud, and most of the catchment area is made of natural soil, the rainwater-collection efficiency of these systems is very low. Almost no runoff occurs during small rains and, during storms, the runoff carries dirt and silt into the tanks, causing water-quality problems. The quantity was also a major cause for concern; the amount of water collected by these methods was nowhere near enough for domestic use.

The challenge

Rainfall distribution is a big problem. Records over the last 20 years show that small rains — with intensities of less than 0.03mm/min and leaving less than 10mm/event — account for between 55 and 80 per cent of Gansu's annual precipitation. Calculations based on field experiments show that, in any normal year, the rainwater-collection efficiency of the traditional systems is only 9 per cent, dropping to 7 per cent in extremely dry years (roughly once in every 20 years).

Since 1988, in an attempt to remedy this situation, a research and demonstration programme of rainwater catchment and utilization has been underway. Run by the Gansu Institute for Water Conservancy, the work was funded by provincial government agencies, including the planning committee, the water resources bureau, and the Liangxi development committee.

Various materials, including concrete slabs, plastic film (exposed and buried with sand or soil), cement soil, compacted loess, and lime soil are used to line the surface, and tiles made of cement and clay (both machine- and handmade) provide better roofing. Technicians conducted a

number of runoff tests and, to speed up the experiments, used both natural and simulated rainfall (a spray). A total of 33 plots were set up: 22 relied on natural rain; while 11 were watered by the spray — five were in the field, and six were set up under laboratory conditions. A control with natural soil was set up for reference. In all, 766 tests were conducted — 310 of them with natural rain.

Results

These tests enabled researchers to examine the relationship between rainwater-collection efficiency and the rainfall characteristics on different surfaces lined with various materials.

They found that a concrete slab was the most suitable material for using directly on soil surfaces; while cement tiles proved effective — and cost-efficient — for roofing. Both materials were also found to be equally long-lasting. The research team decided against considering corrugated-iron sheets because of the high costs — they are about eight times more expensive than cement tiles — and because they rust.

The rainwater-collection efficiency of both cement tiles and concrete slabs ranges from 64 to 87 per cent in a normal year; to between 60 and 83 per cent in an extremely dry year.

Designing a system

Once the initial research had been done, a new system could be introduced. Daily water quotas were drawn up: an average of 10 litres per person, and 30 litres for livestock, in any normal year; and 6 and 20 litres respectively in extremely dry years. These figures appear low, but they are realistic: the funds available for developing the rainwater catchment systems are very limited. Besides, people can supplement their supplies from their traditional system. Experts estimate that a Gansu family of five, plus one animal, requires 20m^3 of water for the eight dry months of a normal year, and 15m^3 for the 10 dry months of a drought year, when the lower quota is applied.

Local factors

The Institute has introduced design guidelines for systems that work with local conditions such as the existing condition of the farmer's house. If the original roof is made of clay tiles — machine- or handmade — it will be kept for rain collection, and a concrete slab-lined courtyard will be added to extend the catchment area. Where the roof is made of straw and mud, the surface is made smoother, and cement tiles are added; the courtyard is then lined with concrete.

Gutters are too expensive; instead, a small concrete ditch is built below the roof's eaves to guide the water into the tank. In drier regions — where average rainfall levels are around 250mm — a total catchment area (incorporating the roof and the courtyard) of between 160 and 190m^2 is required. In slightly wetter areas, where precipitation is around 450mm/year, a catchment of only 80 to 105m^2 will suffice.

The system also includes a 15 to 20m^3 underground tank. In the loess area, tanks are traditionally bottle-shaped. To prevent seepage, people pasted a layer of red clay on the loess wall — an effective, but very labour-intensive solution. In the new design, a layer of cement mortar is applied and a hemispherical cover placed on the top of the tank to increase its stability. In areas of sandy soil, a design incorporating a 15cm-thick concrete wall and base is adopted.

Fuxue Wu

A typical Gansu rainwater catchment — a tiled roof and concrete-lined courtyard for rainfall collection, and an underground tank with a capacity of 15 to 20m^3 .

Water quality

To the people of Gansu, water is precious. People hate to waste a drop, so they will not use the first rain to wash off the catchment surface. Furthermore, the rain is too sporadic. The only measure that people take is to sweep the surface when they expect rain.

Between January and September 1992, researchers tested water from 10 rainwater tanks; from local springs and streams; and from the Yellow River. Overall, the quality of the stored rainwater was much better than the water obtained from local water sources; very low 'hardness' and mineral content; and a very low concentration of chloride and other salts. But researchers also identified some problems:

- The water in the new tanks is rather turbid — the suspended sediment is a little higher than recommended Three out of the four samples from traditional tanks, and three out of the six samples from the new tanks, exceeded the national limits;
- in two out of the six new tanks, the pH of the water measured 9.6 (a result of the release of calcium hydroxide from the cement mortar), but it returned to normal after a year; and
- the total coliform counts in the two traditional tanks, and in a new tank were as high as 24 000/l (2.4 times the recommended level).

The high coliform count was the most serious concern as it indicated bacteriological contamination. Fortunately, local people usually drink tea made with boiled water.

Rapid replication

Since 1992, these new rainwater catchment techniques have spread rapidly in Gansu. The government has set up a programme with an annual budget of between 4 and 6 million yuans (US$500 000 to $750 000) to help people to build household catchment systems. Families receive subsidies of between 400 and 500 yuans ($50-62) to buy cement. The farmers are responsible for providing both labour and local materials such as sand and gravel. At the start of the programme, people had little confidence in the new design, and were not convinced that the changes were worth their time and

effort. Some had objections on superstitious grounds.

The first householders to participate were those suffering most severely as a result of the water shortage. Once the effectiveness of the technology had been demonstrated, enthusiasm grew quickly, and the programme grew to encompass many villages. By the end of 1994, 22 800 new tanks, with 2.4 million m^2 of new catchment area, including cement-tiled roofs and concrete-lined courtyards, had been built; and a total of 28 000 families (141 000 people), 43 000 large livestock, and 139 000 pigs and sheep had enough water to drink.

In early 1995, the region faced a serious drought; its worst in 65 years. But, although there was very little rain between September 1994 and the following June, the new systems continued to supply water. Where new systems have not been set up, the water continues to be brought in by truck.

Fuxue Wu

In 1994, Mrs Ding harvested 300kg of vegetables — with a little help from her greenhouse and rainwater catchment system.

People's liberation

Now the people of Gansu accept the new system without reservation. They call it the 'life project', and the 'liberation project' — the community, and the women in particular, no longer have to fetch water from far away. In the past, a family of five spent the equivalent of 70 days every year fetching water. The programme has brought other benefits: the farmers' living conditions are better, the environment is cleaner, and the concrete-paved courtyard can be used for drying grain and other products.

By 2000, up to 130 000 Gansu families should be using new systems — between 33 and 43 per cent of the population — but 200 000 families will still be without adequate water supplies. Following a recent local government review of the drinking-water programme, the governor asked the Water Resources Bureau to speed up programme implementation, and to try to solve the rural water-supply problems in the province within three years. But the lack of funds is a major obstacle.

Irrigation with rainwater

The first goal of the rainwater catchment programme is to solve the drinking-water problem. But it is not the only objective; the lives of the rural poor in Gansu will only be improved fundamentally if rainwater is fully used in agriculture production. There are two ways of optimizing rainwater use in the region: first, more efficient use of rainfall in rain-fed agriculture. This includes terracing slopes, small watershed management, and other agricultural measures. The absorption and retention of rainwater improves, and the productivity of the water will increase. According to the Institute's findings, yields on a terrace can be twice that on a natural slope. But, owing to the uneven distribution of rainfall, the rain cannot meet the crop demand, as drought occurs frequently.

The second approach is to use the rainwater for irrigation. A number of small dams have been built in gullies to form reservoirs to regulate the rainfall. With the retention of silt and sand, a 'step'-type configuration is created along the gully and the yields are much higher than on adjacent slopes. But, as suitable dam sites are not available everywhere, it seems preferable to provide irrigation systems for individual families — this optimizes operational performance, and keeps costs low.

Since 1990, the Gansu Research Institute of Water Conservancy has set up pilot rainwater catchment irrigation schemes. The rainwater is collected from the courtyard, or slope catchments lined with concrete slabs, and stored in underground tanks. Water can be siphoned, using gravity, on to the fields below, to simple pipe irrigation or drip-irrigation systems. Cash crops such as vegetables, Chinese medicinal herbs, flowers, and fruit trees — as well as nurseries — have been planted. In 1993, farmers in the northern, mountainous area of Yuzhong produced their very first crops of peppers, aubergines, tomatoes, and squashes.

By the end of 1994, 20 pilot rainwater irrigation systems were helping farmers to earn between 1500 and 2000 yuans ($185-250) per *mu* (= 667$m^2$). The cost of installing such a system to irrigate one *mu* is between 2000 and 3000 yuans ($250-375); the investment pays for itself within two years.

The Institute is recommending that the government sets up another programme to provide each local family with one *mu* of rainwater-irrigated land. New plastic greenhouses have also allowed people to harvest additional rainwater, collected in a surrounding ditch; the people use this to water their vegetables, and to protect them from frost at higher altitudes. Plastic sheeting is another valuable method: it is stretched over ridges in fields to concentrate rainwater runoff on to crops in the furrows.

Water is the lifeblood of society. For centuries, the people living in the hills of central and eastern Gansu have suffered from the lack of water. Water shortages block economic and social development. The new rainwater catchment system has acted as a lifeblood transfusion for the whole community; the people can work themselves out of poverty, and build new and better lives.

Project 121

Project 121 is Gansu's latest initiative: one field for rainwater catchment (including roofs); two storage tanks; and one plot planted with cashcrops and irrigated by rainwater.

The project hopes to provide drinking-water for at least 1.2 mllion people — 300 000 by the end of 1995. The funding comes from local government agencies and personal donations from workers in local institutions and factories.

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