There is no surface or ground water on the plateau. People had to carry water from the deep gully. Photo: Author.

Drought-proofing villages in Gansu Province

Zhu Qiang and Li Yuanhong

The semi-arid Gansu Province is one of the poorest and driest areas in China. Droughts and dry spells are extremely common in this mountainous area, where people depend primarily on rainfed subsistence agriculture. Since the late 1980s, a project for supplying water for domestic use and irrigation has been developed in the area. A simple and affordable rainwater harvesting system combined with an integrated approach to improving agricultural production has effectively improved the lives of Gansu farmers.

Background

In the mountainous Gansu Province over 90 percent of the population live in the rural areas. In this area of primarily subsistence agriculture, most farmers have traditionally relied on the unfavourably distributed rain. Two-thirds of the rain falls between July and September each year, often in the form of heavy thunderstorms. Only about 20 percent of the rain falls in the spring, when crops need water most. It is only possible to grow one crop per year.

The main crops grown in Gansu are wheat and maize. In the middle Gansu, spring wheat is the main crop, but recently maize grown with plastic mulching has been widely adopted owing to its higher yield and adaptability to the natural rainfall. This is sown in late April and harvested in late September. Plastic mulch is essential for growing maize in this area as it raises the soil temperature, which allows the crop to mature. In the eastern Gansu, winter wheat and maize are the two main crops. In the mountainous areas, cows and horses are used as draught animals for sowing, ploughing, and tillage. Harvesting is done mainly by hand.

Water resources in the area are scarce. Most of the river runoff is salty and cannot be used for drinking or irrigation. Groundwater is also very limited and of poor quality. Owing to the mountainous topography and geological condition, it is difficult and expensive to divert water from other watersheds. Drought occurs frequently. Studies in Gansu show that heavy drought, reducing yields by more than 30 percent, has occurred in 11 out of the last 40 years.

Under these adverse conditions, yields are as low as 1000 kg/ha in a normal year. In dry years, yields do not even cover the cost of seed. Without irrigation, it is impossible to grow most cash crops. As a result, the annual family income from a little less than one hectare of land is between US$500-US$750. The poor productivity of land has forced farmers to reclaim as much ground as possible even on steep slopes. This has caused more soil erosion and land degradation and this in turn has had a negative effect on agricultural productivity. The environment has deteriorated rapidly. Inadequate drinking water supply, food insecurity, low income, serious soil erosion and a deteriorated environment have become common features in the area.

Taking action

Experiences in the past decades have shown that water is a key factor in the struggle to change basic conditions in the area. Rainwater harvesting (RWH) is the most effective way for the local people to get water. People in the area have a long tradition of harvesting rainwater for domestic water use, but the water collected was far from sufficient to meet the domestic demand for water, let alone the water needs of agricultural crops.

Since 1988, the Gansu Research Institute for Water Conservancy (GRIWAC) has undertaken a project for Research, Demonstration and Extension of RWH, aiming at improving the efficiency of rainwater utilisation and working out RWH technologies suitable to local conditions. The Project was very successful in supplying water both for household and crop use. By the end of 1994, about 40 000 rural households had built their own RWH systems.

When it is raining, the ditches can lead water collected from the road and hill slope to the two rows of tanks. The tank water is used to irrigate crops and trees on the lands below. At the right below, land is sheeted with plastic films to prevent erosion and raise soil temperature. Photo: Author.

In 1995, a once-in-sixty-year drought occurred. Millions of people suffered from thirst and almost all the summer wheat died. Because of the successful experiences of the GRIWAC RWH project, the local government decided to initiate a "**1-2-1**" rainwater harvesting project, aiming to solve the drinking water problem for one million people in the area. In this project, government and donors supported each household with cement equivalent to US$50 to enable them to build **one** collection field, **two** underground tanks and to irrigate **one** piece of land with rainwater to develop the courtyard economy enabling them, for example, to plant vegetables or fruit trees in the courtyard, raise animals and poultry and process agricultural raw materials. By the end of 1996, there were 1.2 million beneficiaries of this project.

The apple orchard yields around 40 percent more on average with supplemental irrigation. In dry years, the increase is even higher. Photo: Author.

In 1996, a follow-up RWH Irrigation Project was initiated, starting with pilot projects at 12 sites with different natural and social conditions. The project was later extended to a much larger area. By the end of 2001, using the methods recommended by GRIWAC, there were 2.2 million newly built storage tanks which made possible the supplemental irrigation of 236,000 ha of land. At the same time, the beneficiaries of the domestic water project had increased to nearly two million people.

Benefits

The 15-year experiences of RWH in Gansu have proved that RWH not only can provide safe and cheap water for domestic use, but can also increase production by providing supplemental irrigation to crops. Crop yields have increased by around 40 percent in a normal year and by much more in a dry year.

With water in their tanks, farmers can diversify their cropping systems. Before the project, the only foods available at the family table were potato, onion and cabbage. Now, many crops that are sensitive to water stress can be grown, like cucumber, tomato, eggplant, pepper, tobacco, and herbs. Simple greenhouses have also been developed to grow vegetables and flowers. Water collected from the roofs of greenhouses can meet 40 percent of the water needed to have three harvests of vegetables. The remaining 60 percent of water needs to come from other catchments. The simplified green-house built with bamboo and steel rods and covered with plastic films costs about US$1000, while the annual net profit can be up to US$350-US$500. At this rate, investment can be recovered in 2 to 3 years.

When land productivity improved, farmers started to participate more in the Land Conversion Programme initiated by the State Government. This programme encourages farmers to plant less fertile land with trees and grassland species to improve the ecosystem. Irrigation with rainwater is a precondition for the establishment of new vegetation.

The RWH system

The RWH system consists of a rainwater collection field, tanks for water storage and water supply and irrigation facilities. Less permeable surfaces of existing structures are used for rainwater collection. In the RWH system for domestic water use, tiled roofs and concrete lined courtyards are used to produce cleaner water. Paved highways, country roads, threshing yards and sport grounds are used for collecting rainwater for irrigation purposes. Sometimes, hilltops or slopes are lined with concrete slabs to increase runoff.

Traditional underground tanks, known locally as *Shuijiao* and *Shuiyao,* are the most common types of water storage. The total investment for each *Shuijiao* is about US$120, of which US$50 is subsidised by the government. The remaining investment is supplied by farmers in the form of labour, local materials and some cash.

The tanks usually have a bottle shape with a diameter of about 3-4 m and a depth of 5-6 m. Irrigation tanks usually have a capacity of 30-50 m^3. A concrete, dome-shaped top with a thickness of 10-12 cm helps to sustain the soil weight and the load on the surface. A hole in the centre acts as both a water outlet and a manhole. The bottom of the tank is made of 10 cm thick concrete.

The underground tank has the advantages of preventing evaporation loss and maintaining a low temperature, which helps to maintain water quality. Each tank is used for the supplementary irrigation of one Chinese *mu* (approximately 670 m^2). One such structure generates two water applications of approximately 20mm each, enough to mitigate one dry spell during the growing season.

Water for domestic use is usually supplied by hand pump. The limited amount of rainwater available for irrigation is applied sparingly to crops, using the principle of limited irrigation. This means that water is applied in limited amounts during a few critical periods of crop growth. For this purpose, a lot of experiments have been conducted to determine the best time to provide the different crops in the area with supplemental irrigation. The most commonly used methods are very simple,

A ditch diverts water collected on a paved highway to a tank, which provides supplemental irrigation to the crops. The crop in the photo is maize. Photo: Author.

affordable and effective. For example, irrigation when the seeds are being planted or supplying water through the holes in the plastic sheeting. If farmers can get support or a loan, they also use drip irrigation and mini-sprinkling for high value crops.

Drought-proofing villages

Luoma Village is located in the northern part of Huining County, one of the 592 key impoverished counties in China. The annual rainfall is only 250 mm. There are 65 households in the village, which has a population of 323. Before the RWH project, the annual food production per capita was less than 300 kg, and annual income per capita was less than US$50. Local people had no water supply for domestic use.

This village was chosen as one of the pilot RWH projects in Gansu Province. From 1996 to 1998, the village built 330 *Shuijiao*s, 130 for the domestic use, 65 for the courtyard economy and the remaining 195 for field irrigation. During the recurring droughts between 1999 and 2000, the RWH system not only ensured water for domestic use and animal husbandry, but also provided enough water for the supplemental irrigation of 22 hectares of land.

Drip irrigation of fruit trees. Photo: Author.

Now that they have water, farmers have changed their cropping system by planting maize instead of summer wheat. Maize can produce much higher yields than wheat in this area owing to a longer growing period and a higher adaptability to natural rainfall patterns. However, it requires more water and heat in order to mature properly. Annual yields have now increased from 975 kg/ha of wheat to 3950 kg/ha of maize. Annual food production has increased by 144 percent and income per capita has increased by 187 percent. Even in years of severe drought, households have enough to meet their food needs.

Simple greenhouses have become very popular. Photo: Author.

Villager Luo Zhenjun's family was one of the poorest in the community before the project. His family of four harvested only 800-1000 kg of wheat in a normal year. During the RWH project implementation, he built six Shuijiaos with total storage capacity of 120 m^3. Using water from the RWH system, he now plants 0.4 ha of plastic-sheeted maize each year, yielding 6000 kg/ha/yr. Using supplemental irrigation, his small orchard doubled its production.

With more tank water available, he now keeps two pigs and 17 sheep, nine more sheep than before the project. His total food production has increased from 900 kg to 3675 kg per year, and his annual net income has increased from US$190 to US$700.

Experiences

The great success of the RWH project in Gansu is considered to be the result of the wide participation of the farmers and the firm support of the government. The main experiences of the project in Gansu can be summarised as follows:

- Household ownership of RWH system is the key factor to the high degree of motivation shown by farmers. Unlike the key water projects owned by the State or big enterprises, which farmers regard as "welfare", most of the RWH systems belong to the households themselves.
- Both the farmers and government can afford the inputs for the RWH system. The high profits gained from the RWH system means that investments can be recovered quite quickly.
- RWH is a tradition of the local people, but it has been updated with appropriate modern technology. This meant that farmers were more ready to accept it.
- With a little assistance from villager technicians, farmers can build their own RWH system. This decentralised approach of the RWH project suits the natural and social conditions of this mountainous and impoverished area.
- Proper preparation, organisation and management of project implementation are also important success factors. Demonstrations were very important in showing the benefit of the projects to both farmers and decision makers. From the very beginning, GRIWAC helped thousands of "scientific households" to build RWH systems that provided good examples for both the general public and the politicians. Research on the technical and economic feasibility of the RWH project was carried out over a 3-year period before the project increased in size. Technical guidance and training courses at different levels were also essential elements in the implementation of the project.

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