Innovations in Greenhouse Rainwater Harvesting System in Beijing, China

Beijing is a city faced with a shortage of water. Less than 600 mm of rain falls per year; but this figure is highly variable and actual rainfall has been lower than average in the past eight years. Less than 300 cubic metres of water is available per person per year; this is one eighth of the average volume per person available in the country as a whole and one thirtieth of the world average. Because of the downward trend in rainfall, surface water is gradually drying up and the level of ground water is declining.

The agricultural sector consumes a large volume of water, 90% of which is groundwater. Excessive use of water for agriculture threatens Beijing's ecology and the availability of water for consumption. The lack of a sufficient water supply also influences glasshouse agriculture around Beijing since it is increasingly difficult to get access to groundwater. Thus, saving water in agriculture has become an urgent task and a common goal for the whole society.

In April 2007 the Beijing municipal government started to charge a fee for agricultural water use exceeding a particular quota (depending on the production type, e.g. paddy rice, wheat, aquaculture, vegetable gardening, fruit trees, or livestock). Now if farmers exceed their quota, they have to pay 0.08 Yuan per extra cubic metre of water used for grain crops and 0.16 Yuan per cubic metre used for other crops. Most farmers are able to limit their use to stay within the quota, but with decreasing rainfall, it is becoming more important to save water and find other sources, like rainwater. Farmers' water use for home consumption is not limited by a quota (a separate system has been implemented for this type of water use).

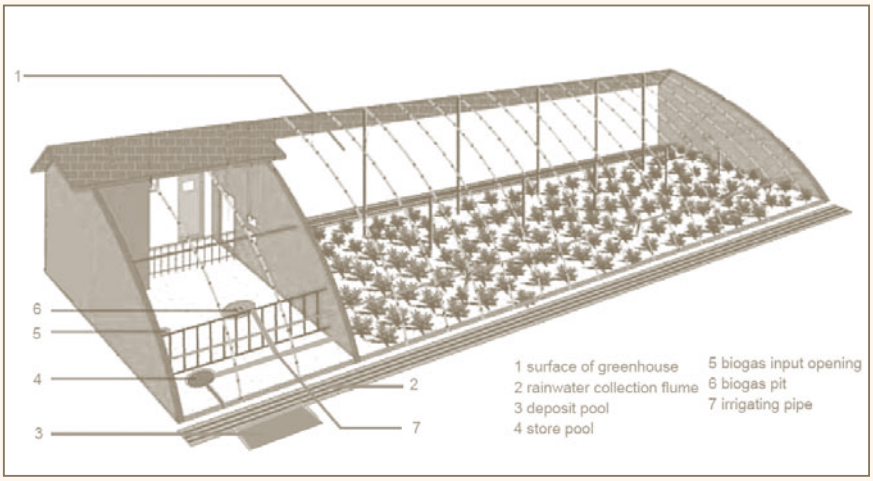
A NEW TECHNOLOGY

The Department of Water Saving, of the Water Authority, has undertaken a series of projects on saving water in agriculture under the motto "tap new sources of supply, reduce consumption and prevent pollution". Rainwater harvesting is one of these projects. The technology of using the surface of greenhouses to collect rainwater was developed in China in 2005 by the Beijing Agricultural Technology Dissemination Station and the Soil & Compost Work Station. Both authorities fall under the Beijing Bureau of Agriculture. The construction of this type of greenhouse is subsidised and farmers are supported by exhibitions, training, farmer to farmer exchanges and websites.

The capturing of rainwater is combined with efficient irrigation techniques (drip irrigation). The farmers are further stimulated to include a reuse component by composting and producing biogas (see figure).

The technology consists of a greenhouse (see figure) with a special roof that collects rainwater. Water is guided through the rainwater collection flume at the bottom of the greenhouse into a deposit pool and pumped into an underground storage pool, where the temperature of the water increases and it is mixed with micro-compost. The water is then again pumped into a basin and through gravity it enters the micro-irrigation system. An average greenhouse of this type is about 85 metres long and 8 metres wide. The plastic roof measures about 900 square metres, while the cultivable area under the roof is about 500 square metres.

This technology has a number of advantages. Firstly, it taps a new source of water – rainwater – thereby reducing the pressure on groundwater. In areas that are suitable for agriculture, but have limited access to water, the technology allows agricultural production and increases livelihood options. The rainwater is of good quality for irrigation and suitable for micro-irrigation. The chemical composition of rainwater is such that it rarely jams micro-irrigation pipes. The technology provides a reliable supply of water (especially important under erratic rainfall), and thus stimulates the production of several harvests of a wider diversity of crops. This increases the benefits for farmers, and subsequently stimulates the



Structure of rainwater harvesting system (one greenhouse)

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local economy. After the structure is built by local builders, it is relatively simple to use and maintain.

HUAIROU

Supported by the city of Beijing and implemented by the Bureau of Agriculture and the Beijing Water Company, two pilot projects have been started in Huairou disctrict (one of the 10 districts in Beijing). It costs 80,000 Yuan (8,000 euros) to build a small tank system, but these projects are being fully subsidised by the Beijing government. This technology is now being used for the production of about 10,000 ha in Huairou, and accounts for 85.3% of all land under irrigation. In 2007, twenty new rainwater greenhouses were built.

Each greenhouse can collect up to about 200 cubic metres of rainwater per year (capturing water from May to October). However, in the past years this amount has never been reached due to erratic rainfall. For one cropping cycle, grapes need 85-100 m3/mu, Chinese cabbage needs around 100 m3/mu, cucumber needs 60-80m3/mu, and tomato needs 80 m3/mu (1 mu is approximately 670 square metres; the standard greenhouse would have 500 square meters or about 0.75 mu).

Capturing 200 cubic meters of rainwater would allow for 2-3 cropping cycles per year. But due to the scarcity of rainfall and land to store the water, in practice most farmers using this technology still need to add groundwater.

IMPROVING THE SYSTEMS

Huairou Fruit and Vegetable Cooperative is one of the government's pilot projects (see UA-Magazine no. 18). The cooperative specialises in the production of grapes and Chinese dates. The cooperative currently encompasses 1108 households and it has built five greenhouses in its contracted farmland. But according to the cooperative's leaders, the potential of this system has not been fully explored. In light of the opportunities offered by the growing market in Beijing and the multiple functions urban agriculture can offer (see earlier papers on this in UA-Magazine), the cooperative plans to extend the single production units into an integrated system by combining the five greenhouses that do not include a rainwater harvesting system. The rainwater from five greenhouses will be collected in a big pond of about 500 cubic metres (20 m long, 10 m wide, 2.5 m high). In the rainy season, the big pond cannot contain all of the collected rainwater, so excess water will then be used for aquifer recharge. The cost of constructing a big pond is estimated to be 200,000 Yuan (20.000 Euro) (which is cheaper than constructing three smaller ponds).

By using a rainwater harvesting system and drop irrigation in Grapes production in a greenhouse, less money needs to be spent on labour, pesticides and electricity for pumping water, thereby reducing costs to about 950 Euro per greenhouse per year. This system is currently being tested.

The structure of a rainwater harvesting system under construction in Huairou

The RUAF-CFF programme supports the organisational development of the cooperative to improve its functioning and the support it provides to its members. This involves the establishment of a multi-functional rainwater harvesting system and development of the agri-tourism component. The SWITCH programme supports this endeavour by conducting research into water flows and water quality.

The proposed system will be composed of:
- five rainwater harvesting greenhouses that will support the activities of individual farmers in the greenhouse, additional farming on land outside the greenhouse, other activities and aquifer recharge;
- reuse of household grey and black water and organic waste for composting and a biogas installation (for light bulbs in greenhouses; compost dissolved in irrigation water);
- a pond system designed as an ecological landscape (with reed, duckweed and fish) and recreational facility;
- tourism/leisure infrastructure (fishing, houses, regional food and products).

The development of this project is based on the following arguments:
- It is easier to build a big pond than five small tanks (in terms of space available and design), although the initial cost may be higher.
- It could be used to promote agri-tourism activities, such as fishing, and lodging.
- A wider impact on the community is sought by developing the multiple functions of agriculture, by involving other farmers in vegetable and fruit production, aquaculture, fishing and other leisure activities.
- Due to the enormous pull of the labour market in Beijing, more and more farmers are getting jobs in urban areas, and as a result, only elders and women are engaged in agriculture. The potentially higher income of urban agriculture may keep labour in the area.
- It will improve the regional food system and development direct linkages between farmers and urban consumers of organic produce;
- It is important to improve the regional food system and develop direct linkages between farmers and urban consumers of organic produce;
- It provides an experience with participative/bottom-up development of cooperatives and famers' organisations.

A number of challenges remain, which are the focus of current research. A first challenge is the technical design of the pond, considering the distance over which water has to be pumped back to the greenhouses and for other uses. Another challenge concerns the amount of land needed for this system. Research will have to look into the supply of water and whether this pond could meet the needs of agricultural production every year. One of the main aims and challenges for the cooperative is to reduce the use of groundwater while at the same time improving the farmers' incomes.
In addition work needs to be done in demonstrating the potential of this pilot project to cooperative members and related institutions. Therefore, not only the technical aspects, but also the whole development process in Huairou, will be recorded for use elsewhere and for showing that the system can improve the quality of water, and provide benefits to various stakeholders. This approach is also still being researched by the cooperative.

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Growing a wider diversity of crops in the greenhouse