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# Alternative water sources for agricultural production in Beijing

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**Abstract**
Beijing is the capital of China and faces severe water shortage. This paper will describe the water balance between water resources and water use. How many efforts have been done by the Beijing government to relieve water pressure recent years. Agriculture is the biggest water user in Beijing. To find alternative water sources, such as waste water and rain water , is an important and emergent way to help urban agriculture development.

**Keywords:** rainfall, ground water, water policy, urban agriculture, rain harvesting

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# 1 Introduction

Beijing is the capital of China and locates in the north of China. It has 8 urban districts and 10 suburb districts. Land area is about 16,400 square kilometeres. High temperature and heavy rain occur together in the summer. It changes to cold and dry in winter. And the spring and autumn is very short. In 2005, population was 15.4 million. Average income of citizen is 17 thousand Yuan and average farmer's income is about 8 thousand Yuan.


Map 1: Beijing municipality

# 2 Water resources and use

Beijing is a city faced with a shortage of water. On average Less than 600mm of rain falls per year, but this figure is highly variable and actual rainfall has been lower than average in the past eight years. In addition, the lower rainfall in the upper valley causes reduction of water inflow from outside of Beijing. Because of the downward trend (show in graph) in rainfall, surface water is gradually drying up and the level of ground water is declining ( Beijing Water Authority, 1999-2007).

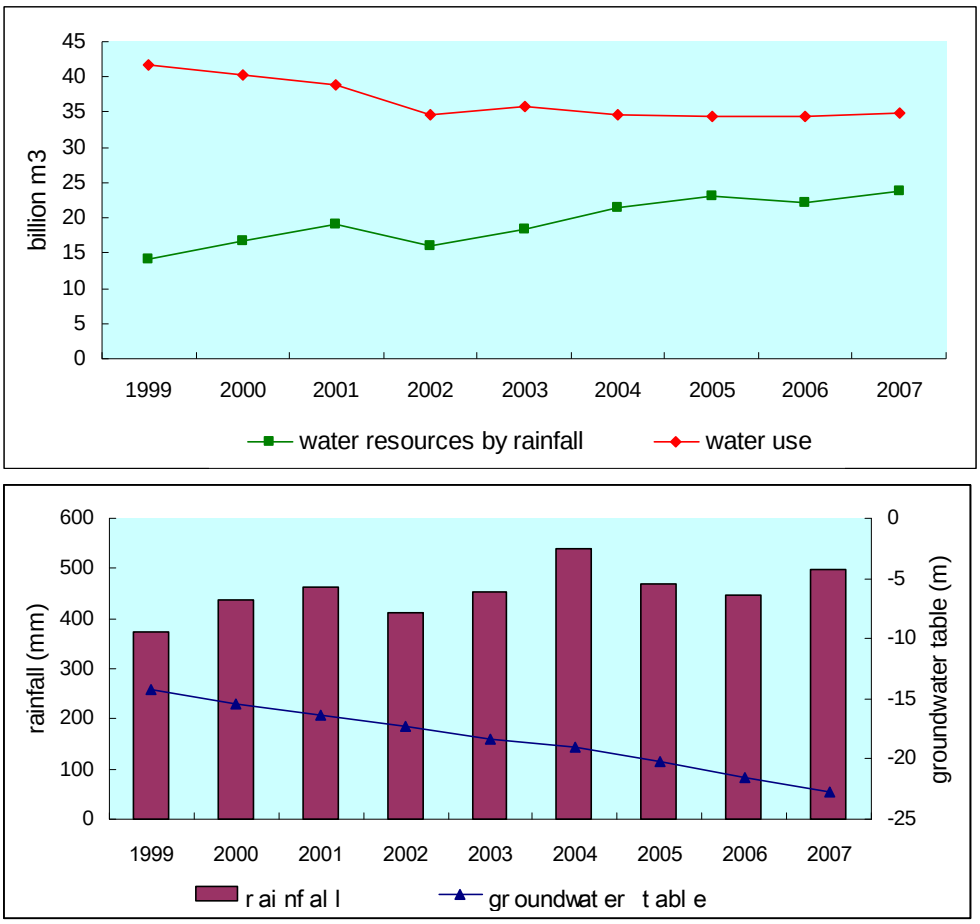



Figure 1: Rainfall, water resources and use, groundwater in Beijing

In 1999, rainfall was 37 cm and about 6.27 billion $m^3$ of water in Beijing but only 1.42 billion $m^3$ (accounting for 40 percent of normal year) could be used due to evaporation or ran out, in which 0.52 billion $m^3$ in surface water. Beijing consumed 4.17 billion cubic waters at the same year which means about 2.7 billion cubic waters came from other water sources, such as water transfer from outside. Part of the deficit (2.75 billion $m^3$) has been transferred from Shanxi and Heibei provinces (as from 2003) into Beijing every year, up to about 0.15 to 0.3 billion $m^3$ each year (Water yearbook of China, 2003-2007). The excess water use of over 2 billion $m^3$, was from groundwater. This situation of water shortage and overusing groundwater continued to happen in the past 8 years.

In 2007, rainfall in total was 50 cm and 8.38 billion $m^3$. And in which 2.38 billion $m^3$ water could be used, including 0.76 billion $m^3$ in surface water and 1.62 billion $m^3$ in groundwater. The water still cannot meet the needs of the year, 3.48 billion $m^3$. The water shortage was about 1.1 billion $m^3$ in 2007. Considering 0.3 billion $m^3$ water transfered from near provinces, about 0.8 billion $m^3$ of groundwater were overused in 2007.

In 2007, Beijing consumed 3.48 billion $m^3$ water, agriculture consumes the largest part of this, using 1.24 billion $m^3$ water for rural living and irrigation (about 300,000 ha. agricultural land), which accounts for 36 percent of total water use. Industry consumed about 0.58 billion $m^3$ in 2007 (less water than 2006, a decreasing trend in recent years), and 1.39 billion $m^3$ water had been used for service

industry and domestic use. The rest 0.27 billion $m^3$ was used for improving environment, such as supplement for rivers and lakes, irrigation of parks and gardens.

The shortage in availability of water is also felt by urban and peri-urban agriculture in the municipality. Although ground water is still the main water source for urban agriculture in Beijing (90% in 2003), in some areas the average water table of groundwater is more than 30 meters, making it impossible for the farmers to use it. In April 2007 the Beijing Municipal Government started to charge a fee for agricultural use exceeding a certain quota. Thus farmers are confronted with rising cost of agricultural production (Beijing municipal development and reform committee, 2007). On the other hand, water use efficiency in agriculture is still comparatively very low.

# 3 Changes and innovations

Changes and Innovations are sought, by both the government and by farmers in improving water efficiency, like water management reform, restructuring the water sector and rising water price, and in developing and using new water sources, like diverting surface water (the south north transfer), and using (treated) wastewater and rainwater harvesting.

The SWITCH programme supports this endeavour by research in urban water planning and a demonstration on multiple use of capturing rainwater with an agro-tourism component and conducting research into water flows, water quality and the cost-benefit of this practice (Zhang Feifei et al., 2007).

# 4 Improving water efficiency

## 4.1 Water management reforms

The Beijing municipal Water Authority was founded in 2004, illustrating the beginning of reforms in the water management system urban and periurban Beijing. The aim of the reform is to reduce the numbers of departments in management system and then improve the water efficiency. For a long time, the management of water resource in Beijing is dispersing. The management of surface water and groundwater, city water and country water, well and tap water, clean water and waste water were separate. The orders came from different departments and were inconsistent, which seriously affected the Beijing water resources optimizing.

Now integrated urban-rural water management is being developed at four levels: municipality, districts and counties, water stations and at user (farmer) level. At the latter level, The Beijing Water Authority has village water managers and stimulates the organisation of farmer's water use associations. These village level associations manage issues as access to water (and developing alternatives, like use waste water and building rainwater harvesting structures), water pricing, irrigation practices, and quota management. By the end of 2006, Beijing had established more than 3,339 of these farmers' water use associations. Every villager (except the village leaders in order to preventing the power to be too concentrated in the hands of few people) has the right to apply for the position as water-manager, and selected villagers will receive capacity building by the Water Authority (Beijing Water Authourity, 2006). In December 2006, 10,800 farmers were appointed as water managers of their village in Beijing (the total number of periurban villages in Beijing is 3,954).

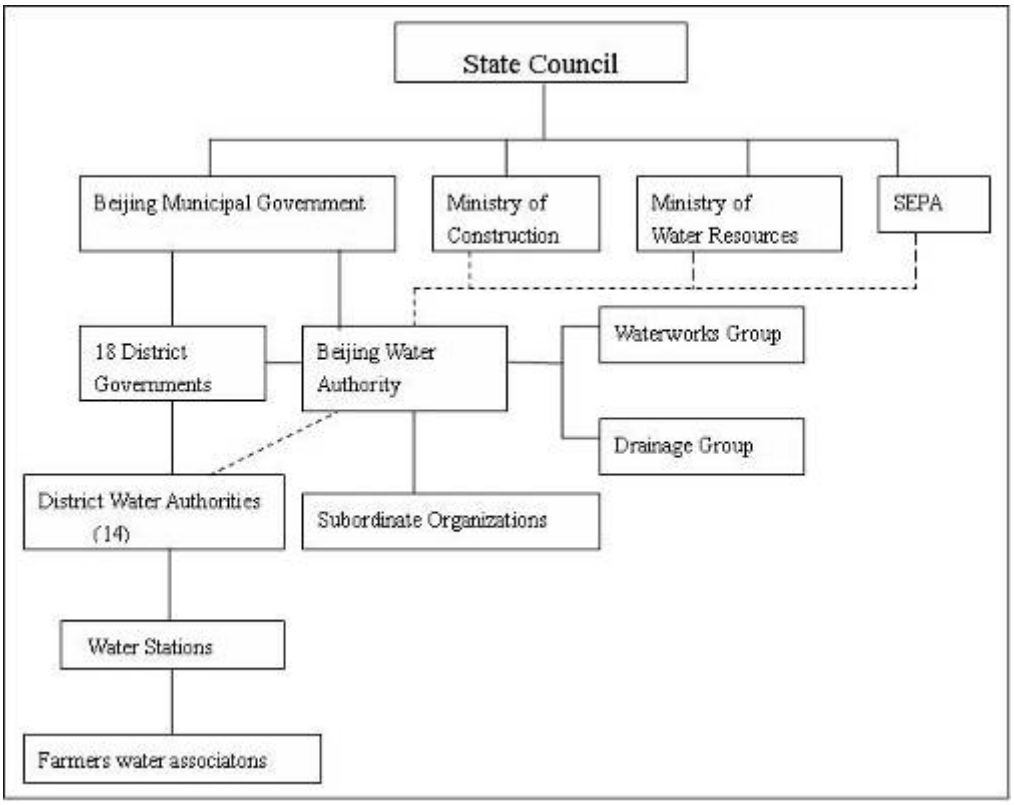



Figure 2: New water management system

### 4.2 Restructuring the water sector

Water use efficiency is much higher in the service industry than in agriculture and industry according to water consumption of unit production value. In a lot of development reports, Beijing government shows that priority will be given to the development of service industry. So the production value proportion of the service industry have been increased dramatically in the recent years and the proportion of the other industries drops quickly at the same time. These cause changes in water consumption. The total water use in Beijing have been decreased in the past years due to the reduction in agriculture and industry. Although the water consumption in the service industry has increased.

During the restructuring action, agricultural development has been affected. The agricultural land had been reduced from 0.52 million ha. in 1999 to 0.32 million ha. in 2006. Also the planting structure switched from high to low water consumption plants (Beijing Statistical Bureau, 2000-2007).

Good news for agriculture is the Beijing government support the farmers to develop water saving technologies, such as drip irrigation system. More than 80 percent of agriculral land had been equipped with water saving system in 2007.

### 4.3 Water price reform

In China water price reforms have been practicing for many years. It's also a big issue in Beijing. The government also many stakeholders believe that water price is very important to reduce water waste and the present water price is relative low to control water consumption. Before 1996, the water price was quite low for industries and for living in Beijing. But the tap water price rose from 1996. For

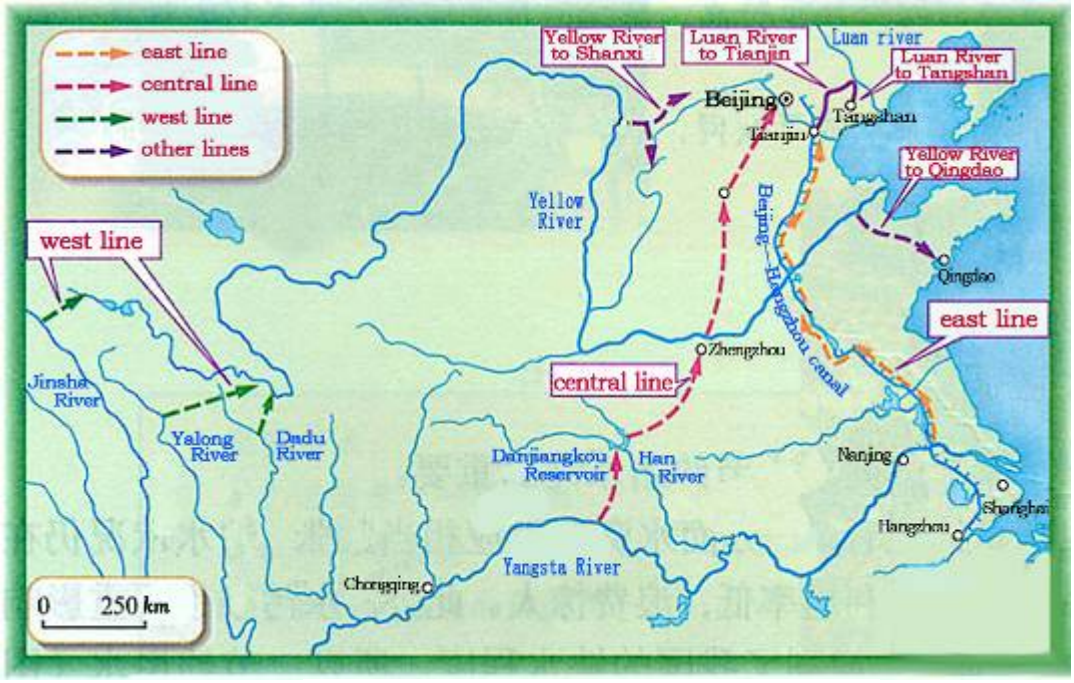
example, the price of water for domestic use (in city) rose from 0.5 Yuan per $m^3$ in 1996 to 3.7 Yuan in 2004. Water price for rural living rose from 0.1 Yuan to 0.6 Yuan per $m^3$ at the same period (Zhang Houming, 2005). But the fact that the water consumption for living had increased during these years caused a discussion about the step water price policy. This policy will charge more money if people use tap water more than a quota. But a water price hearings in 2004 denied using step water price policy due to the technical problems: Beijing is far from a long-distance read system. And some officials also worried that the step water price policy will influence the living of poor citizens.

On the other hand, a waste (treated) water reuse policy was reported in the "Water resources sustainable use plan of Beijing in the early 21st century (2001-2005)" (Beijing Government, 2001). It mentioned that treated water price for industry is about 50 percent of tap water price (5.6 Yuan per cubic meter) and the price for agriculture is about 30 percent of tap water price (0.6 Yuan per cubic meter).

# 5 Using new water sources

## 5.1 The south-north water transfer

In 1952, the first chairman of the PR of China, Comrade Mao Zedong said 'water rich in south, water shortage in north, if possible north should borrow water from south'. After about half century's research and discussion, the south-north water transfer project started finally in 2002 (Committee of South-to-North Water Diversion, 2001). These project include three parts or three routes. The first one is the east route which will transfer water from Jiangsu province to Shandong province and Tianjing municipality. The second one, the central route, will transfer water from Han river (a branch of Yangtse river) to Hubei, Henan, Hebei provinces and Beijing and Tianjing municipalities. The third one, the west route, will transfer water from several branches of Yangtse river to Yellow river.




Map 2: South-north water transfer

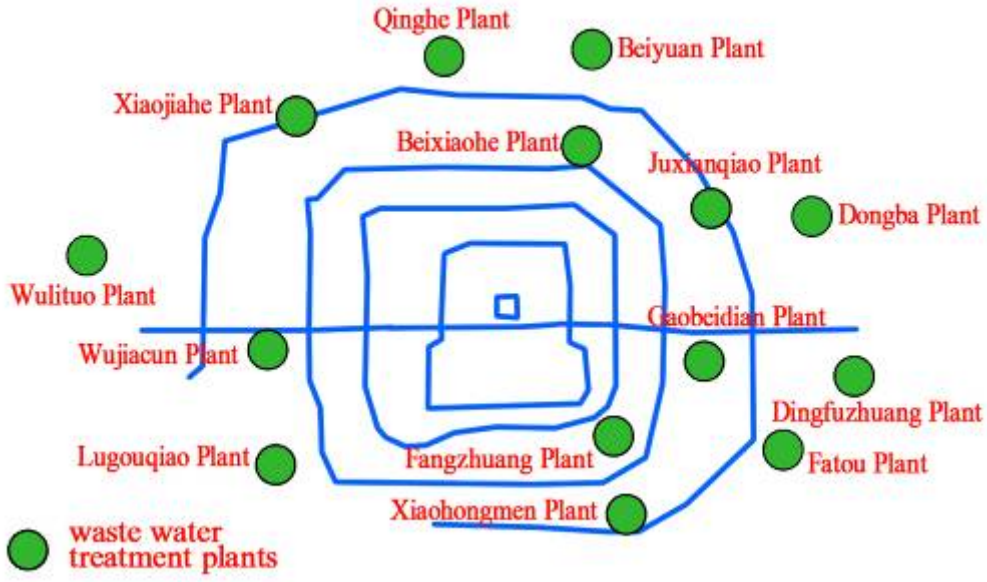
Although the south-north transfer projects are under construction. There are some big challenges. Some people worry that the transferred water is still not enough until changes happened in north area, high pollution and low efficiency. Others argue that climate changes will threaten the big project. What can we do if the dry season happened together in the north and south area? And what's the benefit from the projects if the north area come into a rich rain period.

The central route will be finished in two stages. The first stage is estimated to be finished before 2010. At that time, 0.3 billion $m^3$ transferred water will be supplied to Beijing. The transfer water to Beijing will reach to 1 billion $m^3$ after the second stage. In 2007, Beijing faced water shortage of 1.1 billion $m^3$ while all water resources from rainfall have been used (it means no groundwater recharging ). In this case, 1 billion $m^3$ transferred water is not enough to keep water security in Beijing.

According to some government reports, these waters will not be used in agriculture because of the high water quality and high water price. So it's very important to find some new water sources for agriculture development in the future.

### 5.2 Waste water use

The waste water disposal rate in the city area reached to 90 percent in 2006 and more than 0.7 billion $m^3$ waste water had been treated. At present, Beijing has 14 central waste water treatment plants in the city area. Most of them are managed by the Beijing water Authority. In 2007, 0.48 billion $m^3$ waste (treated) water was provided for industries and for municipal public utilities from central waste water treatment plants at a low cost.




Map 3: waste water treatment plants in city area

The use of waste water has a long history in China. But not until 2000, farmers around Beijing started to use treated water from the central waste water treatment plants, which was initiated by municipal government in an aim to reducing depletion of groundwater. In 2004, only 70 million $m^3$ of treated water was used for urban agriculture in Beijing. This amount increased to 230 million $m^3$ in 2007 and accounted for about 20% in total water for irrigation. In the 11th five-year plan, it is mentioned that there will be 400 million $m^3$ treated water available for more than 0.66 million ha. of croplands in

Beijing in 2010, which is less than one quarter of agricultural land in Beijing Municipality. The quality of this treated wastewater is sufficient for use in almost all kinds of crops and fruit trees.

However, not all the farmers can access treated wastewater because they are located too far from the wastewater treatment plants. Till 2007, only about 26,000 ha. agricultural land (accounting for less than 10% of all agricultural land) of two suburb districts, Tongzhou and Daxing district, used 230 million $m^3$ treated water. And the rest land need to have access to other sources of water, like rainwatr harvesting.

Comparing to the development of the central waste water treatment plants, decentralized waste water treatment establishments developed slowly. These establishments were invested by real estate developers who are unwilling to build it due to the high cost and low benefit. Although the Beijing government released several rules to order the developers to invest it. The fact is a lot of decentralized waste water treatment establishment have been left unused.

### 5.3 Rainwater harvesting

In addition to the use of (treated) wastewater, the use of rainwater is an important (potential) source for the water needs of parks, gardens and agriculture in Beijing Municipality. Rainwater harvesting systems are currently being propagated in residential areas in Beijing and in periurban agriculture.

Capturing rainwater in residential areas of the city has being promoted since 2000. Techniques like porous pavement and roadside gutter collection of stormwater (rainwater from the roof and road) and storage in local deposit pools after which this water is transferred to larger water saving ponds for primary treatment (sedimentation). This water can be used for many purposes, such as irrigation of parks and gardens, acquifer recharge, maintaining water levels at small ponds and lakes in the city, and other uses like car washing (after some simple treatments) (Hou Lizhu, Ding Yueyuan, 2004). Especially the last two years saw an increase in projects in Beijing. For example, the Beijing National Stadium for the Olympics captured rainwater will be used for toilet cleaning, cooling towers, fire fighting, and irrigation of green areas (Scholes and Shutes, 2008). In 2006 more than 300 rainwater collecting projects were built in and the capacity for collecting water can reach to 40 million $m^3$ in Beijing.

Rainwater harvesting using roofs of houses in rural China has been practiced for thousands of years. Capturing rainwater for irrigation of crops, using the roof of greenhouses, is being propagated since June 2005 (Ji Wenhua et al., 2008).

These projects became popular, because they are relatively simple to use and maintain, and because they are subsidised about 70 percent of cost by the Beijing Government. Up until now, twenty demonstrations of these rainwater harvesting systems (on average 30 greenhouses per demonstration, and one greenhouse is about 600 square m) have been installed with the subsidy of Beijing Water Authority and Beijing Agriculture Department (Beijing Agricultural Technology Dissemination Station, 2007). However, the land on which these demonstrations have been built belong to local government. As a single household, average farmers maybe have access to the subsidy after the experiment period.

On average, 200 $m^3$ of rainwater can be collected per greenhouse (85 meters long, 8 meters wide) each year, which can irrigate 2-3 times of the same area with efficient irrigation (drip irrigation). The twenty demonstrations can harvest more than 100,000 $m^3$ each year.

The demonstration project of SWITCH in Beijing, supports this work by analysing water flows and cost/benefit analysis of typical farming systems, and by working with a Huairou Vegetable and Fruit Cooperative, Beijing, in linking other productive activities, like, mushroom production and agro-tourism (more in a second article by the same authors).

So the potential of this technique is high, and given there were some 20,000 ha. of agriculture land under glasshouses in 2005 in Beijing, the current proportion of irrigation by using rainwater harvesting is very low, accounting for less than 1percent. In the case of installing rainwater harvesting system for all glasshouses (under the subsidy of government) and each glasshouse can collect average 200 $m^3$ water per year, more than 60 million $m^3$ rainwater can be harvested as a alternative water source for agriculture one year. In the next article we will go into more details on these demonstrations.

# 6 Future perspective

Water management reform, water price reform, restructuring water sector and the south-north transfer project are important ways to reduce water consumption, to enhance water efficiency, to add new water sources and to relieve water shortage pressure in Beijing.

Integrated reuse of wastewater, rainwater harvesting, and more efficient water use (a.o. by village water managers and farmers' water use cooperatives) are important technological and institutional innovations to urban agriculture in Beijing. Challenges remain, especially in terms of financial sustainability. Farmers in Beijing Municipality are used to have free access to all kinds of water for agricultural purposes. By asking a fee, higher returns will need to be established. But this also opens new opportunities to improve current farming systems.

The SWITCH programme in Beijing, together with the RUAF-CFF programme, seeks to demonstrate a model of urban agriculture which incorporates multiple sources and efficient use of water and delivering higher returns by diversifying production and services. These higher returns not only cater for water fees, but also enable farmers to pay for the relatively high investment for the rainwater harvesting facilities.

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