Status and Prospect of Water in Beijing

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Overview of water in Beijing

Overview of socio-economic status in Beijing

Beijing is the capital of the People’s Republic of China and the nation’s political and cultural center. As one of the Eight Great Ancient Capital of China, Beijing homes seven UNESCO World Heritage Sites, including the Forbidden City, Great Wall and Ming Tombs. The city's history dates back over three millennia, and it has been the political center of the country for much of the past eight centuries.

Situated at the northern tip of North China Plain, Beijing is embraced by Mount Yanshan and adjacent to Tianjin and Hebei Province. The Beijing Municipality administers an area of 16,410 km², out of which 10,072 km² in the west, north and northeast is covered by mountains, and the remaining 6,338 km² in the southeast is a flat plain.

In 2014, the GDP of Beijing registered RMB 2133.08 billion yuan with the GDP per capita of RMB 99,995 yuan (about US$ 16,278).

Overview of demographic characteristics

Permanent population in Beijing was 4.20 million in 1949, 10.86 million in 1990, and arrived at 13.636 million in 2000. In 2011, the population in Beijing has broken through, firstly in history, 20 million, for reaching to 20.93 million in 2012. Net increase in population between 2000 and 2012 was 7.057 million, which means averagely 588 thousands per year.

Figure 1: Evolution of population in Beijing since 1999. The unit is 10 thousands.
According to Beijing development plan, the population in Beijing will be retained below 23 million up to 2020.

The city configuration of Beijing today is a result of successive development of the old Beijing city during 3000 years. The initial city form has been established during Emperor Yuan Shi Zu (Yuan Dynasty established by the Mongols). Anterior to the Yuan Dynasty, the site of Beijing was located in the south-western part of today’s Beijing, near to the Guang An Men. The Yuan Dynasty has abandoned the old Beijing site and constructed a new town area to the north-east of old Beijing, which has become the famous Yuan Da Du (literately means Yuan’s Great Capital). The construction of Yuan Da Du took 18 years, and followed strictly the guidelines defined by the construction manual “Zhouli Kaogongji (周礼考工记)”. The core parts of Beijing today is a heritage from the Yuan Da Du. It is since that time that Beijing has begun to be officially registered as a national capital. The morphology of the Yuan Da Du, or Old Beijing Town. The old Beijing is fortified by 4 square loops of city walls and moats, among which 3 of them have the same center except for the south outer city (had never been completed). From the center of the city outwards is, the Forbidden city, imperial city, inner city and outer city. All cities were surrounded by moats.

![Image](image_url)

*Figure 2: Map of Beijing (Yuan Da Du) and its northern-west suburban during the Yuan Dynasty*

**Overview of water resources in Beijing**

There are five major rivers within the Beijing Municipality, including the Juhe, Chaobai, Beiyun, Yongding, and Juma from east from west, which respectively fall into five river watersheds, namely Jiyun, Chaobai, Beiyun, Yongding and Daqing. All these rivers flow into
Haihe River and originate in Hebei, Shanxi and Inner Mongolia, except for the Beiyun River which originates from Beijing.

![Figure 3: Beijing main rivers catchments](http://www.chs.ubc.ca/china/maps/riverbasinmap2.jpg)

As located in temperate zone and influenced by continental monsoons, Beijing has a semi-arid and semi-humid climate. The precipitation, which mainly occurs in summer, averages about 585 mm annually. The annual precipitation totals 9.83 billion m$^3$, which can give rise to the runoff of 1.77 billion m$^3$, groundwater of 2.56 billion m$^3$ and total available water resources of 3.74 billion m$^3$. If these water resources are divided by the permanent residents of 21.516 million in late 2014, the per capita water resource is less than 200 m$^3$, listed as one of the regions most short of water in the world.

Subject to the local hydrological cycle, geological location, topography and other physical conditions, the water resources in Beijing can be characterized by the following features:

Precipitation is not evenly distributed in terms of both time and space. The annual variations of precipitation are significant over time, and in a given year most precipitation occurs in the three-months flooding season, accounting for 75% of the total.

Water resources are difficult to manage and conserve as the water sources mostly are located in northern suburbs and outside Beijing.

The total water resources are seriously insufficient, mostly because of the availability, but sometimes because of water quality and lack of facilities.
Water supply

The water sources in Beijing come from the surface water (stored in Miyun Reservoir, etc. see Figure 3), ground water and diverted water through such projects like the middle line of South-North Water Transfer Project (SNWT).

South-North Water Transfer Project (SNWT)

The Middle Line of SNWT is a super large infrastructure project with an aim to mitigate the severe water stress in northern China and optimize the water resource allocation. The water of its 1,267-kilometer-long central route is diverted from Danjiangkou Reservoir sitting at Hanjiang River, a tributary of Yangzi River, and flows through Hubei, Henan, Hebei and finally into Beijing.

The Middle Line of SNWT central route extends as long as 80 km within Beijing with a designed flow of 50 m³/s and annual supply of 1 billion m³. The construction of Beijing segment was completed in April 2008 and the water in Hebei was transferred to Beijing from September of the same year. Up to 2014, a total of 1.5-billion-m³ water had been diverted from Hebei.

As the entire Middle Line of SNWT was formally commissioned in December 2014, Beijing residents were supplied with water from Hanjiang River. Excessive water from SNWT will be stored at the Miyun Reservoir and groundwater source reserves through diversion facilities in the coming years.

Figure 4: South-North Water Transfer Project (Middle route)
The water supply in Beijing is achieved mainly through public utility, self-reliant wells and rural collective waterworks. The public utility is operating 68 waterworks with daily capacities of 5 million m$^3$, supplying water for downtown and newly-built urban areas. There are about 50,000 self-built water supply facilities (self-reliant wells), extracting about 1.4 billion m$^3$ of groundwater a year. A program was initiated from 2014 to replace those self-reliant wells with the water transferred from the Yangtze River.

**Drainage and Wastewater treatment**

Up to 2014, Beijing had 50 medium and large-sized waste water treatment plants (their daily capacity is 10,000 tons at least) with the total capacity of 4.25 million tons/day, which totaled 1.39 billion m$^3$ of sewage treated water in 2014. That means 86.1% of sewage water was treated, and the figure for downtown was 97%. In 2014, 860 million m$^3$ of reclaimed water was used.
Figure 6: wastewater treatment plants location

<table>
<thead>
<tr>
<th>Name of the WWTP</th>
<th>Capacity m$^3$/d</th>
<th>Concentration of COD mg/L</th>
<th>Removal of COD Ton/year</th>
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Water quality of canals: The quality of water in as long as 44% of canals meets Grade II, 5% grade III, 4% grade IV, 6% grade V, and 41% lower than grade V.

The water quality at reservoirs: Other than the Guanting Reservoir whose water quality meets grade IV, the water quality of all other medium and large-sized reservoirs ranges from grade II to grade III.

Water quality at lakes: The total lake area of 719.6 hm² is under surveillance. 50% of lake area ranges from grade II to grade III in water quality, and 48% stays between IV and V, and 2% below grade V.

Urban flood risks

In old days, flood risks were distributed along two directions of Beijing, namely, Yongding River in the west and Chaobei River in the east. After 1949 when a number of reservoirs like Guanting and Miyun were constructed, large basin-wide flood risks have been almost removed.

However, urban inundations become a major concern due to a rapid urban expansion and insufficient drainage capacities and other facilities in urban areas.

Water supervision and governance

Integrated administrative systems

Beijing Water Authority (BWA) was founded on 15 May 2004, and accordingly water authorities at the district or county level and 93 watershed-based water stations were established for the purpose of a three-tiered integrated water administrative system.

With this integration, all water-related affairs have been supervised in an integrated manner, including water resource protection, flood prevention, water supply, water conservation, drainage, sewage treatment and reclaimed water use are administered by one authority under integrated laws, regulations and policies and coordinated plans and with coordinated actions.

Water conservancy project management

There are 10 water conservancy divisions to maintain, manage and schedule water resources projects and facilities, including the Miyun Reservoir, Guanting Reservoir, Yongding River, Beiyun River, Chaobei River and lakes.

Water supply and drainage

Beijing Waterworks Group (BWG)

BWG was established in 1999 and its predecessor, Imperial Waterworks Co. Ltd, was founded in April 1908. BWG is to supply water to downtown and some districts and counties. It operates 12 urban waterworks, 1 regulation and storage waterworks and 11 suburban waterworks with daily capacity of 4.15 million m³. It can provide services to 3.71 million users with the total length of 12,000 km pipelines and service coverage of over 1,000 km².

Beijing Drainage Group (BDG)

Founded in February 2002, BDG focuses on collecting, treating and reclaiming the rainwater and sewage in urban Beijing and sludge treatment. By the end of 2014, BDG maintains a 5,692-km-long pipeline network for rainwater and sewage collection. It has built and been operating 8 wastewater treatment plants with a total capacity of 2.67 million m³/day, among which a capacity of
785,000m³/day is for reclaimed water supply, and a 783 km-long pipeline network for reclaimed water distribution.

**Laws and regulations**

The Standing Committee of the National People’s Congress has promulgated four water-related laws, including the Law on Water, Law on Prevention and Control of Water Pollution, Law on Water and Soil Conservation, Law on Flood Prevention, while the State Council and Beijing Municipality has also enacted some administrative regulations on water resources protection, water taking license, water saving society promotion, etc.

**Public participation**

Beijing has multiple social organizations engaged in the water sector, including the Hydraulic Engineering Society, Water Supply Association, Drainage Association, non-governmental environmental organizations, and rural water user associations.

Every year, a number of large-scale campaigns are launched at communities, universities, enterprises and other places on such occasions as World Water Day and China Water Week to raise public awareness on water conservation. The Beijing Municipal Government has launched programs to subsidize households using water-saving appliances.
Part B

Climate Change

The general climatic trends in the Beijing region during the last 20 years is drier and warmer. It has experienced a series of drought years since 1999. To face the lack of water resources, a lot of measures have been taken by Beijing’s government, in order to quantitatively put into practice the “three red line” principle and the strictest national regulation of water resource management. These measures include: constrain or eliminate high-water-consumption industries, extend technologies and products of water preservation, adjust water fee, enforce inter-region cooperation, search for water resources outside the region backed on the “South-North water transfer” project including water transfer from adjacent province, promote rain water reuse by developing BMPs, enforce aquifer protection and treatment for domestic wastewater, industrial wastewater, agricultural pollution control, optimize aquifer monitoring network.

The social, economic and environmental aspects of water issues and their impacts

Water scarcity has become the first and foremost bottleneck for the socio-economic development.

Beijing is one of most water-scarce mega-cities in the world with very low per capita water resource. The areas adjacent to Beijing also suffer from the severe water shortage. As water use outstrips available local water resources, the gap between water demand and supply has been growing over time.

Beijing has experienced a persistent drought since 1999, during which the annual precipitation was 498 mm on average, just 85% of the multi-year average, and the annual available water resources was 2.4 billion m$^3$, only 64% of the multi-year average. Due to droughts, along with the urbanization and economic development in upstream areas, the water inflows to the Miyun Reservoir and Guanting Reservoir, two major surface water sources in Beijing, witnessed a severe decline. The Guanting Reservoir and the Miyun Reservoir and other sources are facing water deficit. The shortfall of water supply has to be compensated through groundwater overdraft, resulting in a declining groundwater table in the plain area.

The domestic and industrial sectors consume much water for the environmental purpose, which has seriously compromised the loading of urban water environment. The dire water scarcity has become a major factor constraining the social and economic growth in Beijing.

The water resources scarcity remains serious even the Middle Line of SNWT was completed in late 2014. Beijing is still severely short of water even the Middle Line of SNWT can transport 1-billion-m$^3$ water a year and the population growth stays flat.

Issue of water environment has not yet addressed fundamentally

Most of the city’s rivers are replenished mainly by reclaimed water from wastewater treatment plants rather than fresh clean water. Due to limited treatment capacities, a very small portion of untreated
sewage is discharged directly into rivers, and a considerable part of river canals is polluted to varying degrees.

The security of water supply in both rural and urban areas is of a great concern.

The security of water supply in Beijing is threatened by many factors, including insufficient surface water and pollution risks of groundwater.

The surface water-based waterworks are badly short of water sources as a result of a substantial reduction of water supply from the Miyun Reservoir. The security of the city's water supply is also affected by the overexploitation of groundwater for a long period, which has resulted in declined water availability and deteriorating water quality due to higher water hardness.

The water conservation and water use efficiency should be further improved

Agriculture is a major water user and consumes too much fresh water, so it has a great potential for reclaimed water use. As the reclaimed water distribution network remains limited, drinking water has to be used for some urban greening activities. The water loss and leakage rate is found high in the old water supply distribution network as it is more difficult to maintain and upgrade.

Urban flood and inundation prevention face multiple challenges

As the flooding risks from open rivers have been nearly eliminated, Beijing focuses mainly on the risks of urban inundations, landslides and basin-wide floods in mountain areas.

The urban areas and upwind slopes are more prone to floods as the local heavy precipitation occurs more frequently there. The urban inundations include river overflowing, a wide range of water logging, traffic gridlock, flooding of underground facilities, and associated secondary disasters like power and water outage. The landslides in mountains include flash floods, mudslides, and large-scale subsidence.

Attention should also be given to basin-wide floods that caused devastating losses in old days although they have not been occurred for years.

Countermeasures and their implementation

The water scarcity of Beijing is a long-standing issue. One of the city's high priorities is to address the water shortage, environmental water pollution, deteriorating ecology, and ultimately water security in the process of socio-economic development of Beijing. In recent years, Beijing has taken a series of actions, including Action Plan on Sewage Water Treatment and Reclaimed Water Use, Action Plan on the rehabilitation of Small- and Medium-scale Rivers, and Implementation of State Council Action Plan on Water Pollution Prevention and Treatment.

Water conservation and protection

Protective measures, including ecological restoration and management, have been taken along the upstream of reservoirs and water source reserves. Through the adjustment of agricultural structure, the use of chemical fertilizers and pesticides are better controlled, sightseeing agriculture and leisure agriculture are further developed, and therefore non-point source pollution is reduced. Additional small water conservancy infrastructures are constructed to improve production conditions. The rural sewage and waste treatment facilities fit for local circumstances are set up at villages, tourist
attractions, and other human settlements to improve the living environment. Rivers are dredged and landscape ecology is restored with an aim to help shrubs and aquatic plants purify water and maintain the ecological equilibrium in the river and around lakes and reservoirs. As of 2014, 285 small watersheds have been dredged and their ecologies been restored, and an area of 6,708 km² have been treated to prevent from soil erosion. An area of 3200km² has delineated as drinking water source reserves, where stringent protection and management measure are put in place.

**Sewage treatment and reclaimed water use**

Beijing launched an initiative to upgrade the wastewater treatment plants in the city’s center in 2008. It has completed the update of Wujiacun and other 8 WWTPs. The quality of the reclaimed water with deep treatment processes has been improving.

In the new Standard on Water Pollutants Discharge from Urban Wastewater Treatment Plants (DB/890-2012) that Beijing introduced on 1 July 2012 provides that major parameters for discharged water from any newly-built or retrofitted WWTP shall live up to grade IV of surface water, which lays a solid foundation for a wide-range use of reclaimed water.

The Action Plan on Sewage Water Treatment and Reclaimed Water Use incepted from 2013 has furthered the construction or retrofitting of WWTPs and facilities for the reclaimed water use.

The use of reclaimed water has extended from river and lake landscape, and gardening irrigation to industrial production, agricultural irrigation, car washing, toilet flushing and other areas. In 2014 alone, 860-million-m³ reclaimed water was used.

**Multiple measures to ensure the security of water supply.**

In order to ensure the security of water supply, Beijing has built several contingency water source projects and water replenishment projects for reservoirs. The completed SNWT phase 1 project can transport 1-billion-m³ water to Beijing. A number of supporting facilities have been constructed for the efficient use and storage of the water diverted from SNWT, including a looped water conveyance tunnel, water storage and regulation reservoirs, waterworks and projects diverting the water to the Miyun Reservoir. Many studies have been conducted to understand the risks of microbiological safety and pollution due to the water transfer, and precautious measures have been taken.

**Water tariff is raised to increase the efficiency of water use**

Following the Plan on the Sustainable Use of Water Resources for the Capital in Early 21st Century, Beijing is pursuing a quota-based and schedule-based progressive water tariff, and has conducted a comprehensive reform to adjust fees for water resources and sewage treatment as well as the prices for drinking water and water supplied through water conservancy projects. From 1 May 2014, a tiered water price scheme has been adopted for residential use, under 180m³/year, 5 yuan/m³; 181-260 m³/year, 7 yuan/m³; over 260 m³/year, 9 yuan/m³. The water price for the earmarked sectors has been substantially increased, that is 160 yuan/m³ for carwash industry, bathing industry, pure water manufacturing, golf course irrigation, etc.

The use of reclaimed water has been always promoted and encouraged. From 2003 to April 2014, the price of reclaimed water is kept flat at 1 yuan/m³ and no water resource fee is charged thereof, while the drinking water price for residents in the same period is 4 yuan/m³ and that price for non-residents is 5 yuan/m³. Due to the 3-4 yuan/m³ price difference, the use of reclaimed water has been stimulated.

Beijing raised the water prices in May 2014. The price of reclaimed water is raised from 1 yuan/m³ to 3.5 yuan/m³ at most, while the drinking water price for residents in the same period is increased to 5 yuan/m³ and that price for non-residents is raised to 8.15 yuan/m³. Although the price of reclaimed
water has been raised to some extent, the price difference between reclaimed water and drinking water for non-residents widens to 4.64 yuan/m³, which provide a further incentive for the expanded use of reclaimed water.

The pricing scheme in Beijing reflects the inherent needs to apply market-based instruments for optimal allocation of the scarce water resource and the needs to save water and improve water use efficiency.

**Strong efforts on water conservation**

Since early 1980s, Beijing has made massive efforts to save water, which have yielded prominent results in industries, agriculture and urban life. In particular, in recent years, a number of initiatives, including industrial restructuring, all-round water metering management, water resource monthly reporting system, water-saving appliance application and water price rises, have played a positive role in suppressing excessive water demands and water-saving actions among all sectors.

The use of water-saving appliances has been promoted in public buildings and households. The penetration of such appliances in households across the city is 95%. The water consumption per 10,000 yuan of GDP in Beijing has reduced by 8% annually over the past decade, and it has dropped to 17.6 tons per 10,000 yuan in 2014 from 49.5 tons in 2005.

The agricultural sector has yielded fruitful results in water conservation. The water-saving irrigation rate stands at 87.8%, and effective irrigation water use coefficient reaches 0.74. Water-saving metering in the agricultural sector will be further promoted in the future.

The most stringent water resource management has been put in place. The management of water use plan is strengthened and progressive water tariff is strictly adopted where the amount of consumed water exceeds the planned. The water impact assessment and review scheme is introduced. In order to ensure the obligatory and guiding role of water resources in construction projects, the water resource assessment, review and approval of water and soil conservation plan and flood impact assessment for construction projects are integrated into “water impact assessment and review” as a precondition to the approval of construction projects.

**The combination of flood prevention with flood control for a flood-resilient city**

The institution and mechanism for flood prevention have been further improved. 7 sub command centers for flood prevention are established to improve the urban gridded flood prevention management and suburban watershed-based flood prevention management, which have achieved the full coverage of commanding system and significantly improved decision-making process, forecasting and early warning, and social mobilization.

Beijing will issue a Beijing Emergency Response Plan on Flooding before the flooding season every year. The Plan puts the life and safety first as its purpose. It pursues the principles of preventing flood by laws, government leadership, jurisdictional administration, professionalism and social mobilization. The accountability system is adopted according to the Plan. All flood prevention command centers are on duty 24-hour a day during the flooding season in order to ensure the smooth communications. Precautious measures will be taken for the places at high risks, including low-lying areas and areas prone to flash floods and landslides to avoid the loss of life and property. Emergency rescue task forces have strengthened their skill training and field drills. Rescue and relief supplies scheduling and mobilization have been better orchestrated. According to “Zero Report System”, flooding reports should be sent to the Municipal Flood Prevention Office, which covers the basic elements and
associated analysis, including information on precipitation, runoff, operations, hazards, disasters and countermeasures.

Publicity and outreach programs on flood prevention and risk reduction have been conducted via media with an aim to deliver the relevant knowledge at schools, workplaces, communities and families, and ultimately increase the public awareness of disaster prevention and risk-avoiding and self-help capacities.

In order to mitigate the pressure of urban floods and inundations, Beijing has taken measures to effectively harvest and management of rainwater.