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## Conference Paper

# Research on Water Resource Problems of Capital Economic Circle Based on Circular Economy

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# Research on Water Resource Problems of Capital Economic Circle Based on Circular Economy

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**Abstract**—Capital Economic Circle that is located in north of China belongs to water resources shortage regions. The per capita water of it is only 1/7 of the per capita water of the whole country, and 1/30 of the per capita water of the whole world. Thus water resources problems become one of the key factors that restrict regional development. According to the analysis of water resources situation in Capital Economic Circle, in this paper we find out some main problems existing in regional water resources utilization. These water problems contain a series of water resource problems, such as water environment, water ecology, and water disaster. Finally, based on the theory of circular economy, the proposals on developing recycling economy of water resources are put forward.

**Keywords**- Capital Economic Circle; Water resources; Circular economy

## I. INTRODUCTION

Circular economy is the most effective economic growth mode for utilizing resources and protecting environment, which organizes economic activities according to the 3R-principle (Reduce, Reuse, and Recycle). The basic characteristics and development ideas of circular economy are low-consumed, low-castoff, and high-efficiency [1]. Circular economy requires economic development to follow ecological laws, develop environment-friendly resource utilization for

merging into natural ecosystem harmoniously, and bring in a new ecological economy development model which can actualize the ecotype conversion of the social economic activities.

The meaning of water resource cycling economy mainly contains two aspects: One is saving water to purify, recover and recycle water for reaching water no-discharge. The other is deferring to the law of water circular in nature, to adjust the space-time water distribution by means of economy, lawmaking, and engineering technology [2].

There is a quick increase in population and economy in Capital Economic Circle, which resulted in a series of problems, such as water resources, water environment, water ecology, water disaster, and other water problems that restrict regional development. Accomplishing water circular mode of Capital Economic Circle is the solution for water resource problems.

## II. THE SITUATION OF WATER RESOURCE IN CAPITAL ECONOMIC CIRCLE

### A. The characteristics and values of regional water resource

There are three characteristics in Water resources: natural, economic and social. The natural

characteristic includes mobility, circulation, limitation, relevance, heterogeneity, and polymorphism; water as the indispensable resource in human life and production the economic characteristic contains resource scarcity, monopoly, commodity, external, and multi-functional etc.; the social characteristic includes irreplaceable, double interest, diversity use, broad impact and public nature in society.

The values of water resources can be divided into resource value, ecological value, landscape value and environmental value. The natural circulation of water resources is the cycle of atmospheric water, surface water, ground water; socio-economic value of water cycle contains water supply, demand, drainage, sewage and backwater recycle process.

#### B. Water resource in Capital Economic Circle

The Capital Economic Circle lacks of water resources seriously, its per capita possession of water resources is only 317m<sup>3</sup>, equivalent to only 1/7 of the per capita water of the whole country; its per mu share water 306 m<sup>3</sup>, only equivalent to 1/5 of the country average[3]. Also, an analysis from the internal economic circle area shows that the per capita water in Chengde and Qin huangdao amounts to more than 600 m<sup>3</sup>, thus it shows that Chengde and Qin huangdao have relatively abundant water resource; the per capita water in Tianjin, Cangzhou, Langfang, and Shi jiazhuang is around 200m<sup>3</sup>; the per capita water in other cities is around 300m<sup>3</sup>.

TABLE I. AVERAGE AMOUNT OF WATER RESOURCE IN CAPITAL ECONOMIC CIRCLE UNITS: BILLION M<sup>3</sup>

Administrative Region	Precipitation (mm)	Surface Water Resource	Underground Water Resource	Total Amount of Water Resource	Average Amount of Water Resource (m <sup>3</sup> )
Beijing	585	17.7	25.6	37.3	321
Tianjin	575	10.7	5.7	15.7	168
Shi Jiazhuang	538	9.9	14.8	21.2	231
Chengde	533	34.1	14.1	35.1	972
Zhang Jiakou	420	11.6	11.9	18	420
Qin Huangdao	736	12.6	7.5	16.5	609
Tangshan	647	14.0	13.5	24.2	341
Langfang	555	2.6	5.0	8.0	205
Baoding	566	15.9	21.2	30.3	278
Cangzhou	558	5.9	6.5	13.5	199
Total	571	135	125.8	219.9	317

Source: Beijing Statistical Information Net, China Water Net, Hebei Bureau of Statistics in [4].

From 1997-2006, Capital Economic Circle had experienced 10 straight dry years. Analysis from the annual runoff water, this region was in special low-flow years in the year 1997, 1999, 2001, 2002, 2005, 2006; in 1998, water level of the northern region was equal, and the southern region was in special low-flow year; in 2000 and 2004, the northern region was in special low-flow year, and the southern region's water level was equal; in 2003, the whole region was in normal low-flow year. In the long term, water resource is still confronted with large challenges.

#### C. Water Supply and Supply Structure Analysis in Capital Economic Circle

In 2006, the structure of the water supply in Capital Economic Circle was that surface water accounts for 22% of the total water supply; ground water accounts for 72%; other water supply only accounts for 6%. Only a few cities use sewage treatment whose development level is not high.

Administrative Region	Local Surface Water	Ground Water			Saline Water	Yellow(Laon)/River/Stream	Waste water Reuse	Rainwater Utilization	Sea Water Desalination	Total
		Shallow Water	Deep Confined Water	Subtotal						
Beijing	6.4	21.5	2.8	24.3	0.0	0.0	3.5	0.1	0.0	34.3
Tianjin	10.3	2.6	4.1	6.8	0.0	5.8	0.1	0.0	0.0	23.0
Shi Jiazhuang	5.2	23.8	4.0	27.8	0.0	0.0	1.3	0.0	0.0	34.3
Chengde	4.52	6.52	0.0	6.52	0.0	0.1	0.0	0.0	0.0	11.09
Zhang Jiahou <sup>2</sup>	3.39	8.05	0.0	8.05	0	0.0	0.0	0.0	0.0	11.5
Qing Huangdao	3.20	5.6	0.2	5.8	0.0	0.0	0.0	0.0	0.0	9.0
Tang Shan	5.79	15.34	4.25	19.99	0.1	0.0	0.2	0.0	0.0	25.63
Langfang	1.08	5.40	4.55	9.95	0.0	0.0	0.0	0.0	0.0	11.05
Badong	3.0	26.9	1.7	28.6	0.4	0.0	0.2	0.0	0.0	32.2
Can Zhou <sup>2</sup>	2.2	3.5	7.3	10.8	0.6	0.0	0.0	0.0	0.0	13.6

Figure 2. Water Supply in Capital Economic Circle in 2006 Units: Billion m<sup>3</sup>

Source: Collected from China Water Network (2008) in [5].

The trend of water supply in Beijing is increasing, and Beijing's water supply structure keeps changing. In the "Tenth Five-year period", the total supply of water resources was 17.84 billion m<sup>3</sup>, in "Eleventh Five-Year" period was 21 billion m<sup>3</sup>, and in "Twelve Five-year" period it is estimated to be 26.02 billion m<sup>3</sup>, the average annual supply is 3.57, 42, 52 billion m<sup>3</sup>. Furthermore, as in [6], water structure in Beijing is also changing that the supply of surface water and groundwater is reducing, and the supply of external water and renewable water is increasing.

Period	Total Water Supply	Annual Water Supply	Min and Max Reservoir	Surface Water	Total ground water	Ground Water	Reclaimed Water Utilization	Water from South
Tenth Five-year Period	178.4	35.7	34	6.8	128.6	25.7	2.6	1.6
Eleventh Five-year Period	210.0	42	20	4	110	22	6	3
Twelve Five-year Period	260.2	52	—	—	—	—	6	10

Figure 3. Water Resource Supply and Structure Condition in Beijing Units: Billion m<sup>3</sup>

Source: Collected from China Water Network (2008).

#### D. Water Consumption and Consumption Structure Analysis

The total water consumption for various industries in Capital Economic Circle was 205.57 billion m<sup>3</sup> in 2006. Urban water consumption including residential, public, industrial, environmental was 56.78 billion m<sup>3</sup>, accounting for

28% of the total water consumption; in rural areas water consumption including life, irrigation, fisheries was 148.79 billion m<sup>3</sup>, accounting for 72%, as shown in Figure 3.

Administrative Region	Urban				Country				Total Amount of Water Consumption
	Residents	Industry	Environment	Subtotal	Living	Farmland Irrigation	Forest Grazing and Fishing	Subtotal	
Beijing	12.43	6.20	1.62	20.25	1.27	9.59	3.39	14.05	34.30
Tianjin	2.03	5.73	0.49	8.25	1.09	13.08	0.54	14.71	22.96
Shi Jiazhuang	1.88	4.13	0.46	6.47	2.22	22.88	2.73	27.83	34.30
Chengde	0.53	0.99	0.00	1.52	0.56	8.22	0.79	9.57	11.09
Zhang Jiahou	0.46	2.21	0	2.67	0.77	7.31	0.71	8.79	11.46
Qing Huangdao	0.65	0.94	0.02	1.61	0.55	6.03	0.82	7.40	9.01
Tang Shan	1.22	5.33	0.02	6.57	1.32	15.78	1.96	19.06	25.63
Langfang	0.73	1.42	0.09	2.24	0.76	6.93	1.12	8.81	11.05
Badong	1.26	3.86	0.09	5.21	2.08	23.99	0.90	26.97	32.18
Canzhou	0.69	1.27	0.03	1.99	1.11	9.47	1.02	11.60	13.59
Total	21.88	32.08	2.82	56.78	11.73	123.08	13.98	148.79	205.57

Figure 4. Water Consumption in Capital Economic Circle in 2006 Units: Billion m<sup>3</sup>

Sources: Collected from China Water Bureau's statistic data in Beijing, Tianjin and Hebei.

In urban water consumption structure, industrial water consumption ranked the first, followed by living, public and environmental water consumption; in rural areas, agricultural irrigation water consumption was the first, followed by forest, grazing and fishing water, and living water. In short, the living water consumption kept increasing, and the environment water consumption was relatively low.

#### E. Water Resource Consumption Efficiency and Trend Analysis of Capital Economic Circle

The per capita water consumption in Capital Economic Circle in 2006 was 282 m<sup>3</sup>, equivalent to 64% of the national average; water consumption per 10,000 Yuan is 156m<sup>3</sup>, equivalent to 57% of the national average.

Administrative Region	Water Consumption Per Capital	Per Capital Water Consumption per 10,000 GDP	Irrigation Quota			Industry Water Consumption Reusing rate
			Irrigation Square (10,000mu)	Irrigation Amount (Billion m <sup>3</sup> )	Quota (m <sup>3</sup> /mu)	
Beijing	219.90	43.38	230.05	9.39	375.52	0.92
Tianjin	213.38	52.93	524.37	13.08	249.44	0.86
Shi Jiaduang	353.61	169.25	743.44	22.88	307.76	0.85
Chengde	329.08	259.11	208.11	8.22	394.98	0.75
Zhang Jiakou	274.16	236.69	373.53	7.31	195.70	0.85
Qing Huangdao	310.69	163.21	186.55	6.03	323.24	0.85
Tang Shan	349.66	108.60	748.60	15.78	210.79	0.81
Langfang	276.25	151.40	425.68	6.93	162.80	0.76
Baoding	297.96	268.18	982.67	23.99	244.13	0.81
Cangzhou	197.24	106.03	841.56	9.47	112.53	0.86
Total or Average	282.21	155.90	5284.56	123.08	257.69	0.83
National Average	442.00	272.00	—	—	449.00	0.81
Development Countries Average	—	248.00	—	—	—	0.85

Figure 5. Water Consumption Efficiency in Capital Economic Circle in 2006

Sources: Collected from Yearbook's statistic data in Beijing, Tianjin and Hebei(2004).

### F. Industry and Living Water Consumption Trend in Capital Economic Circle

Tianjin's residents living water has been saved effectively with a good stability overall trend. The living water use of Beijing residents showed a rapid increase trend, but it of Hebei is on the contrary. This phenomenon reflected the implementation effects of the relevant policies in Tianjin, particularly with the earlier implementation of recycle economy in water resources.

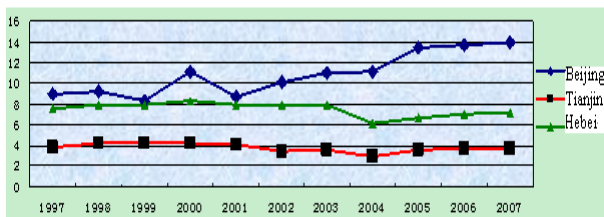


Figure 6. Residents Public Water Consumption Trend in Capital Economic Circle Units: Billion m<sup>3</sup>

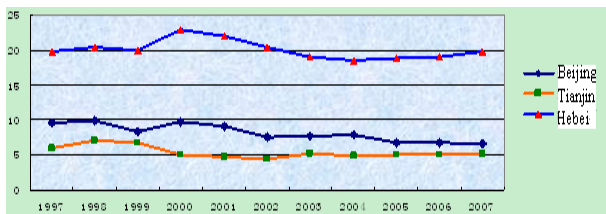


Figure 7. Industry Water Consumption Trend in Capital Economic Circle Units: Billion m<sup>3</sup>

The industrial water consumption showed a steady decline trend. The industrial water consumption in Tianjin was significantly lower than it in Beijing, and it in Hebei was large. In accordance with the principles of determining the need for institution, Tianjin government focused on system implementation to improve the efficiency of water use, also used scientific and technological progress to develop and utilize non-conventional water resources, such as sea water. Tianjin Government controlled groundwater exploitation strictly, implemented market access system for water-saving appliances, deepened the reform of water prices and promoted water-saving irrigation techniques in agriculture. In consequence, in 2006, industrial water recycling rate in Tianjin reached 86%, and non-resident plan water consumption rate was 95%. The water-saving appliances penetration rate was 55%. Compared with urban water supply in the year 2000, it decreases of 20%. The water-saving irrigation area reached 296 mu, which was equivalent to 57% of irrigated area. The water-saving experience in Tianjin is worth promoting.

## III. ANALYSIS OF WATER RESOURCES PROBLEMS IN CAPITAL ECONOMIC CIRCLE

### A. Water Resource Problems

The water resources problem contains shortage of total water resources, steady decline of per capita water and decline in the water resources support. Also, the water condition in Capital Economic Circle is changing from the general shortage of

water resources to the integrated structural water shortage that is formed by insufficient water supply, water waste and pollution.

Beijing and its surrounding areas suffer from drought persistently. From 1999 to 2005, the average precipitation was 450 mm, equivalent to only 77% of multi-year average precipitation. The main surface water resource of Beijing, Miyun and Guanting Reservoir, their average water was 258 million m<sup>3</sup> and 90 million m<sup>3</sup>. The reservoir water storage capacity declined from 1540 million m<sup>3</sup> and 420 million m<sup>3</sup> in 2001 to 1036 million m<sup>3</sup> and 163 million m<sup>3</sup> at the end of 2005. Annual per capita water resource in Tianjin was 160m<sup>3</sup>; plus the immigration and diverted water from Luan River, the per capita share of water resources was 370m<sup>3</sup>. That level is much lower than 1000m<sup>3</sup> which is the water alarm level of per capita consumption in the world, thus Tianjin was in severe water shortage. Furthermore, the per capita water in Tianjin was only equivalent to 1/14 of the national average per capita water resources which is 2338m<sup>3</sup>, less than the national average of the monthly average water level. The shortage of water resources has become a bottleneck restricting the development in Tianjin. There was also a serious water resource shortage area in Hebei province. The average volume of water resources was 20.3 billion m<sup>3</sup>, and the per capita possession of water resources was 311 m<sup>3</sup>, equivalent to 1/7 of the national average, less than 1/3 of internationally recognized per capita water standard--1000 m<sup>3</sup> [7]. In recent years, the water

consumption in Hebei has been increasing year by year. The annual water consumption has been up to 22 billion m<sup>3</sup>, but the available amount is only 17 billion m<sup>3</sup>. There is a conspicuous contradiction existing in supply and demand. According to the relevant statistics, daily water shortage in Hebei has reached 150 ~ 170 million m<sup>3</sup> [8]. At the same time, as a result of the lower level of the water resources reuse and the weak concept of water-saving and waste, the overpopulation and resource shortage problems are worse and worse.

#### *B. Water Environment Problems*

The water environment problems in Capital Economic Circle are mainly lack of effective control and management of water pollution and water pollution is greater than water self-cleaning ability. As in [9], in 2006, urban living and industrial sewage withdrawal water amount was 3270 million m<sup>3</sup>, and that in Beijing, Tianjin and Hebei was 1290, 520 and 1460 million m<sup>3</sup> separately. In 2006, the total water sewage treatment capacity of ten cities was only 7.18 million t/d. By running 330 days a year, the annual disposal of sewage was 2.37 billion m<sup>3</sup>, only equivalent to 72% of urban waste water emissions. And due to the management and financial problems, many sewage treatment plans cannot be operated normally.

The river pollution is still in a serious condition. In the water quality assessment of the 9277 km long river in Capital Economic Circle in 2006, the quality of only 3692 km long river water of surface water was in line with the environmental

quality I ~ III category standards; about 5585km long river has been polluted; contaminated river length accounted for 60% .

The majority of 25 large reservoirs have good water quality, except Beijing Guanting reservoir which ranked below Class III in water quality standards. The water quality in Baiyangdian district was general bad. 75% of the water quality was inferior to V or in V-type, and 25% was classed for the IV. In 2004, light pollution area was accounted for 24.6% of the groundwater pollution in Capital Economic Zone; and heavily polluted area was 27.5%.

### *C. Water Ecological Problems*

Capital Economic Circle has suffered from the deterioration of water environment. Also its water pollution exceeded the carrying capacity of the surrounding environment. The water ecological problems in Capital Economic Circle mainly have three aspects as follows: dried up river, shrinkage of wetlands and excessive exploitation of groundwater.

Firstly, river dried up and water that running into sea declined. In Luanhe, Douhe and other rivers, about half of the river dried up, and the volume of the water in Ziya River into the sea was only 1 billion m<sup>3</sup> in 2004 ( dry year) which declined more than 95% compared with the 23.5 billion m<sup>3</sup> in 1950s. The river that dried up made aquatic animals and plants lose the survival condition.

Secondly, wetland shrunk, and its affection recessed. In Baiyangdian, Qingdianwa and other 9

major lake wetlands in plain, their covering area shrunk from 2570km<sup>2</sup> in 1950s to 469km<sup>2</sup> in 2000, with a decrease of 82%. The shrinkage of wetlands reduced its function as “kidney of the earth” which can regulate climate and flood, purify water body, provide wildlife habitat and serve as biological gene bank.

Thirdly, groundwater excessively exploited. Groundwater is the main source in Tangshan, Shijiazhuang and other cities. Their behaviors of increasing the groundwater exploitation make the groundwater level decrease 1~2m yearly. The proportion of groundwater exploitation is increasing continuously, from 67% in 2000 of the total increasing to 78% in 2004. The aquifer of partial areas have exhausted because of the groundwater excessive exploitation.

### *D. Water Disaster Problems*

The crisis of water resources brings in a series of problems, such as ecosystem deterioration, biodiversity destruction. The annual natural disaster related with water accounts for over 80%, such as flood, debris flow, drought, typhoon. According to the geographical location, urban water disasters can be divided to 5 basic types: Observatory Type; Along River Type; Along Lake Type; Coastal Type; Depression Type [10].

As the main urban regions, the areas in Capital Economic Circle have water hazards with a performance of hardened urban road, street rain deposition. Not timely rainwater infiltration will

lead to water logging disasters at first, thus affecting the normal work and life. In recent years, Beijing city has suffered from continuous drought, which results in the deterioration of urban air quality and the encroachment by sandstorm. The main water disasters in urban areas are the traffic disruption and the damaged roadbed caused by storm. The debris flows frequently occur in the regions around Beijing. In addition, Beijing is short of water resources and precipitation, and has a serious urban heat island effect. The performance of urban water disaster in Tianjin is the coastal type, mainly water logging disasters. The performance of disasters in Hebei urban areas are mainly depression type.

#### IV. CAUSES OF WATER RESOURCE PROBLEMS IN CAPITAL ECONOMIC CIRCLE

There are several reasons that result in water resources problems in Capital Economic Circle:

1) *The growth speed of the utilization of water resources is beyond the natural carrying capacity because of fast population and economic growth in Capital Economic Circle. Thus the sustainable ability of water resources declines. The water pressure composite index in Beijing, Tianjin and Hebei was 0.488, 0.466, 0.502, and ranked No. 3, No. 4, No. 2 of all the provinces in China, while the national average index was 0.220 [11]. We can see that the index in Beijing, Tianjin and Hebei is much higher than the national average.*

2) *Larger water waste and lower water resources utilization efficiency are also outstanding problems. Household water waste is very serious in*

*Beijing ; annual water leakage is more than 100 million cubic meters ; leak rate is as high as 17% which is far higher than advanced countries( 8% to 10% ). In addition, the sewage treatment, the reuse and the utilization of seawater and rainwater are at relatively low level.*

3) *The cultural value awareness of water lagged behind. For a long time, people think that China has a vast territory and abundant resources which are inexhaustible. So we don't have the awareness to take care of natural resources and protect aquatic ecosystems.*

4) *The systems which restraint waste behavior and encourage saving behavior can not be formed incetively, since the price of water resources is low. The penalties on polluters are not enough to stop their behaviors. Furthermore, the agricultural water use is nearly free of charge.*

5) *The construction of market transactions system building and defining of water rights lagged, which is not conducive to water resources effective utilization.*

6) *The system construction lacks unified planning system, governance, and operation mechanism: water management is fragmented; urban-rural water management is spliced; surface and groundwater management is divided. The investment, construction, operation and service behaviors in water management are lack of innovation, which is not conducive to the implementation of the circulatory system.*



## V. CIRCULAR ECONOMIC MODE OF WATER RESOURCES IN CAPITAL ECONOMIC CIRCLE

### A. Principles of regional water resources cycle model

1) *Observe and comply with natural water cycle law.*

2) *Follow the market value law as a economic commodity; and require the modern water management system and the market economy mechanism as a strategic resource.*

3) *Adhere to the urban and rural water resources management; and get the unity of surface and groundwater.*

4) *Strengthen the concept of innovation in system and mechanism in water resources management reform and the water recycling economy implementation.*

### B. Mode of regional water resources cycle

According to the natural, economic and social characteristics of water resources, water resources cycle mode in Capital Economic Circle has to follow the concept of circular economy, and accomplish the recycle of water supply, drainage, sewage and backwater reuse. The structure of regional water resources systems is shown in Fig.7, including the regional circulation, internal and external enterprises, the communities of the circulatory system, the socio-economic, the ecological environment and water circulation system.

As public goods, water resources have strong externalities. Thus the failure of market mechanism often occurred. The government intervention has

significant meaning. The water market system needs the intervention from the government, especially in the water circulatory system implementation.

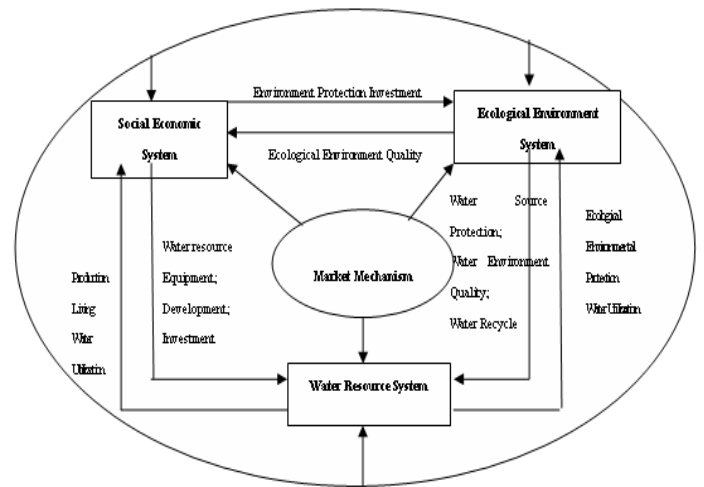


Figure 8. The structure of regional water resources systems

### C. The regional cooperation and management system of water resources cycle

It needs a unity planning and coordination between the rivers and reservoirs, the upstream and downstream, the surface water and ground water development in Capital Economic Circle. Also, water resources need to develop a standard for water-saving. Hence, it needs a regional agency responsible for managing and planning water, establishing community management law systems for water resources, building the regulations and determining the price in water markets.

### D. Regional water resources circulatory system

There are three aspects in constituting a cycle system of regional water resources: industrial water-saving recycling system, agricultural circulatory system, and the residents and public facilities circulatory management system. For instance, industrial water-saving system including the design of the cleaning industry, the

eco-industrial Park, and the urban biology industry chain; agricultural circulatory system including the promotion of high value-added water-saving production in agricultural bio-industrial chain, and water-saving technologies; residents and public facilities water-saving system including the devices and technologies promotion, and the implementation of ladder-type price water. Furthermore, we should control water services in the tertiary industry. All the sectors should be strengthened and linked to constitute the regional water resources circulatory system.

*E. Accomplish international cooperation to introduce water-saving experience and technology*

The developed countries abroad have advanced water-saving experience, mature technology, equipment and design concept. We can introduce these advanced experiences and technologies to regional improvement through international cooperation.

*F. Developing renewable water resources industry and encouraging innovation in water-saving technology*

The renewable water resources are abundant in Capital Economic Circle. As an emerging industry, renewable water resources industries development can save water resources, create new value, ensure supply and demand, reduce pollution and construct ecological environment. We should offer specific supports to industrial and fiscal policy in renewable industry. For instance, we can attract and encourage

the investment from the enterprises or the individuals by variety of forms.

## VI. CONCLUSION

Circular economy applied in regional water resources is not only a new economic development model, but also a new cultural value. The first thing in the management innovation of regional water resources is the concept innovation. The second is the establishment of regional governing agency which unifies planning, builds the regional regulations and the regional water-related policies, and establishes the market trading platform. The third is the development of the renewable water resources industry and technologies. The last is constructing the regional water management group, which realizes the integrated model of the investment, construction, operations and services the management of water supply, water drainage, sewage, and backwater.

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