

The Exploration and Practice of Adaptive Water Management

--A Case Study of Qingdao

Abstract: Qingdao, a coastal city in China, is facing a serious water shortage. Adaptive water management plays an important role in dealing with complicated water resources problems in Qingdao. In this study, the concept, connotation, development course and major characteristics of adaptive water management have been presented. Furthermore, this paper explored the duality of adaptive water management, and took adaptive water management practiced in Qingdao as a case. In this case, the adaptive management countermeasures and effects on water supply security and extreme weather were analyzed from the aspects of legal system construction, management system reformation, management mechanism and technical innovation. Eventually, adaptive water management patterns of coastal shortage cities and adaptive water resource management safeguard measures were proposed.

Keywords: Adaptive water management; Qingdao; Water supply security.

1. Status and problems of water resources in Qingdao

A coastal hilly region, Qingdao has a total area of 10,654 square kilometers. The average annual rainfall is 688.2 mm. The per capita possession of water resources is 313 cubic meters. The possession of land per mu is 306 cubic meters, only 12% and 15% of the national average, much less than the standards of absolute water shortage which is recognized as 500 cubic meters per capita in the world. The need of water resources increased along with the rapid economic and social development and the accelerating process of urbanization. The contradiction between supply and demand becomes more and more prominent. It has become the bottleneck factor restricting the economic and social sustainable development that water resources are facing the multiple pressures of resources water shortage, Water Quality-induced Water Shortage and engineering water shortage.

Besides, the aquatic environmental issues, such as the current water pollution, shrinking rivers, groundwater overexploitation, sea water intrusion have been an important restrictive factors of the economic and social sustainable development. Wetlands and the river's water functional recovery are an increasing concern. It is increasingly urgent to protect the groundwater and reduce the geological and environmental disasters caused by overexploitation.

In recent years, affected by climate changes and human activities, the water resources face even greater uncertainties. Qingdao shows the trend of increased drought, unexpected flood which gives more challenges on water resources management. In the cases of limited total water resources but growing demands for water, it can not fundamentally solve the increasingly serious issue of water shortage which rely on open-source or water diversion. In this regard, the only choice for us is strengthen the Adaptive Water Management in order to seek advantages and avoid disadvantages.

2 .The concept and content of Adaptive Water Management

The adaptive water management is to be proposed for the uncertainty of water resources system.

On the basis of analyzing the uncertainty problems of basin water resources management, to build basin water resources management architecture for providing an effective and feasible method which solve the uncertainty problems of basin water resources management.

The adaptive management need to have the ability of accumulated learn experiences to change management practices. Through continuous adjusting strategies, objectives and programs as to adapt the rapidly changing socio-economic status and environmental changes, to maintain a sustainable social ecosystem. Therefore, the adaptive management is a system process which learning from the result of implementation strategy to continually improve on management policy and practice. That is the process of learning management by management Learning. The adaptive management means a system process what making the implementation effect consistent with the fixed goal by monitoring the effects of project implementation and using the experiences from "learn" to continuously adjust and improve the original management policies and practices. This process should be quantitative and feasible

3.The binary features of Adaptive Water Management

Water resources system is a complex large system including economic, social and ecological environment included into the overall with complicated space-time structure, showing multi-dimension, dynamic, open, nonlinear and other characteristics that lead to lots of uncertain factors of the water management. The uncertainty of water resources system mainly reflect the two aspects of the uncertainty influenced by human activities and the uncertainty influenced by climate change. The goal of adaptive management is how to scientifically evaluate the uncertainty of impact

on water resources by climate change and human activities, and then take corresponding measures for adaptive management being a process of continuous evaluation and adjustment measures.

3.1 The Adaptive Water Management for responding climate change impact

Climate change impact the water resources system that arising from changing the water cycle. Potential climate change including the changes of total rainfall, intensity, shape, duration and changes in snowmelt time, evaporation and transpiration, may lead to spatial and temporal variation of water resources. In china the most obvious example of climate change factors led to the reduction of water flow. According to the latest results of the national water resources evaluation show that the hydrological series from 1980 to 2000 compare with the hydrological series from 1956 to 1979, the four basins of the Yellow River, the Huaihe river, the Haihe river and the Liaohe river which located in the north have 6% average reduction in rainfall, 25% reduction in total water resources and 17% reduction in surface water resources. It is more obvious with the features in Qingdao. Based on the result of the city's water resources investigation and evaluation in 2004, the average annual rainfall is 754.7mm and the average runoff is 2.137 billion cubic meters in the hydrological series from 1956 to 1979, but the average annual rainfall is 609.9mm and the average runoff is only 1.06 billion cubic meters in the hydrological series from 1980 to 2000.

The uncertainty of climate change brought several times of extra draught weather. For example, the whole precipitation in 1981 was only 354.7mm and the rainfall in rainfall season was very few, which led to the zero flow of Dagu river. As a result, the draught farmland reached to 382 thousand, and the volume of water supply in the urban area dropped greatly from 230 thousand to 11 thousand cubic meters. In the rural area, water shortage problems was very serious.

In the beginning of this year, Qingdao city was through continuous drought. For the whole city, there have been 142 days in effective rainfall since sep.21, 2010, instead, 154 days in ineffective rainfall in Huangdao, in Chengyang, in Jimo, and in Jiaonan,. The average accumulative precipitation of the total city was just 10.7mm, which was increase by 89.9% .this, is the least rain mouth in the history. Drought was rather serious ,which was a time in 150 years .The extreme drought bring enormous difficulties for the management of water resources supplying,which must be take fully into consideration, be relevantly adopted adaptive management measures based on estimate the affection of the uncertainty

On the other hand, climate change exacerbated the flood control situation. According to "Qingdao technical report on statistical parameter characteristics of Storm and study on regularity", although in the 90's and past few years the various diachronic maximum rainfall have not too much change, there the possibility is increased by disastrous storm yearly. From the time of occurrence on the various diachronic maximum point rainfall to see, the maximum point rainfall occurred in the past two decades, especially in recent years. For example, on 26th August 2006, the largest 6 hours torrential rain ever recorded in our province appeared in Jimo Wangcun where the rainfall reached 434mm.

Facing the impact of climate changes to water resources system, water resources management need to analyze the different change scenarios (scenario analysis) and to propose adaptive measures from water resources management, constructions and operational levels in order to improve the ability of adapting the climate change and reduce the negative impacts of climate change, as well as ensure the sustainable development of economy and society.

On the other hand, climate change made the flood situation worsened. Under the technical reports of rainstorm statistical arguments features and regular in Qingdao, although the lasted maximum

rainfall have no great changes at the 1990s and in recent years, the possibility of the disaster rainstorm is increasing, from the times of which ever maximum rainfall appeared, the biggest little rainfall occurred in the past 20 years, especially in recent years, as of august 26, 2006, jimo wangcun appeared a rainfall, which is the biggest of the six hours of heavy rain at the records in Shandong province., rainfall at 434mm.

Facing the influence of the climate change in the water system, water resources management need to analyze the different situations of the change (situation analysis), proposing adaptation measures out of water resources management construction and operation levels to improve the ability to adapt to climate change and reduce the negative impact on climate change and guarantee the sustainable development of economic and social.

3.2 Adaptive water resource management to cope with influence of human activities

Human activities' influences on water resource system mainly display in the following respects. The first is influence on atmospheric circulation. Acceleration of industrialization influences heat transfer and water circle of underlying surface, which causes change of rainfall precipitation, evaporation capacity and precipitation space-time distribution. The second is reallocation of surface water capacity. Large quantity of reservoirs, gate dams and diversion projects change underlying surface conditions of producing water and reserving water and make water resource adapt to water demand of human beings in terms of space and time. Till the end of 2006, Qingdao had built 5,088 large, medium and small reservoirs, including two large reservoirs, 21 medium reservoirs, 499 small reservoirs, 4,221 small reservoirs in the hilly area, and 345 river sluices, with storage capacity of 937.55 million cubic meters. Trunk stream of Dagu River has built over ten river sluices in Qingdao for controlling flood and reserving water, which greatly change the natural water production and

confluence conditions of Dagu River basin. The third is that lots of sewage cause water pollution and intensify water shortage. According to Qingdao Water Quality Circular, there are 79 wells for inspecting nitrate nitrogen overweight in underground water, accounting for 55.2% of total appraisal wells, with maximum overweight of 8.4 times (in Jiangjiazhuang, Laixi). In rural water supply, the maximum problem is nitrate nitrogen overweight, with overweight rate up to 31.49%. The fourth is excess exploration of underground water resource causes geological disaster. In Binhai District, Qingdao, seawater invasion causes salinization of underground water. The fifth is continuous increase and uneven distribution of population doesn't match water resource. Economic development and continuous improvement of the quality of life demand increasing quantity of water resource and cause reducing per-capita water resource. In 1990, the per-capita water resource was 376m³, while it is 303m³ now. The sixth is that continuous improvement of urbanization, land cover and use, consumption of water resource, and infrastructure of water resource influence water resource system and its management. The seventh is that the change that the land is used as city and farm land from the original natural vegetation increases surface runoff, which increases the risk of water flood.

Due to complexity of water resource system and limitation of human beings' knowledge, human activities and water resource management will be influenced inevitably by the uncertainty. Therefore, they will inevitably face various risks. It requires that water resource management should fully consider the uncertainty of water resource influenced by human activity and adaptive measures should be put forward in terms of water management, engineering construction and operation. In addition, we should set up scientific and perfect water resource monitoring and appraising system and adjust strategy in the continuous practices to ensure sustainable usage of water resource and

sustainable development of economic society.

4 .Management practice of water adaptability in Qingdao

In recent years, in order to actively cope with water shortage, face with extreme draught and water shortage problem caused by climate change, and ensure the rural and urban water supply security, Qingdao Municipal Government has made active exploration in terms of legal system construction, mechanism construction, technical and measure innovation, gained rich and valuable experience, and formed a set of mode for adaptive water resource management in coastal city.

4.1 Legal system construction

Based on the Water Law, Qingdao Municipal Government issues and implements Several Rules on Implementing Water Law of the People's Republic of China, unveils Measures for the Implementation of Water-drawing Permit System in Qingdao, revises and issues Administrative Measures for Water Charge Collection and Usage in Qingdao (No.185 Document of Qingdao Municipal Government), prepares and prints Regional Division of Water Function in Qingdao, and issues Rule for the Implementation of Water Resource Assessment of Construction Project in Qingdao. In order to the ensure water supply security, the government also issues Administrative Measures for Rural Public Water Supply in Qingdao and Regulations on Urban Water Supply in Qingdao. In order to practice strict water conservation, the government issues Administrative Measures for Urban Water Conservation in Qingdao. These regulations and normative documents, together with Water Law, Law on Prevention and Control of Water Pollutions, Administrative Regulations on Water Drawing License and Water Rate Collection, and Management Measures for Water Resource Assessment, build up the relatively perfect water resource management regulation system in Qingdao.

4.2 Initial water right allocation

After determining initial water right allocation principle and priorities, adopt scientific analysis, democratic consultation, and administrative adjudication to define initial water right and water amount allocation plan for eight cross-Qingdao rivers, macro control index of water resources and micro quota management index, water usage index for each area, industry, and department, provide reliable basis for development, usage and scientific management of water resources. In 2010, the related department has prepared Planning Program for Initial Water Right Allocation and Water Usage Amount Control of Dagu River Basin.

4.3 technical measures

In recent years, Qingdao had adopted a series of adaptive management countermeasures on safeguarding water supply security and dealing with water scarcity problem, including constructing new reservoirs and river sluices, the Popularization And Application of seawater desalination and mid-water reuse technology, developing agricultural water-saving irrigation and industrial water conservation and domestic water saving technology greatly.

Based on the complicated water resource adaptive allocation theory and model, 'the water resources optimum distribution engineering web planning of the urban area' had already been compiled in 2009. the "the planning of the water supply in scale in rural of Qingdao have been compiled. For guarantee the water supply security and improve the water supply efficiency in the rural.

1)Water resource distribution of the urban area

The water supply of urban area started from 1901, and the water supply quantity was about 70 thousand cubic metre every day in the early 1960's. but serious water supply crisis appeared by

continuous and serious draughts. From the beginning of the 1970's, 4 emergency water supply engineering projects were constructed to solve the crisis from 1968 to 1983, furthermore, the project of diverting the yellow river water to Qingdao was completed from 1986 to 1989. By now, there are 10 major water supply sources of the urban area in Qingdao. However, the direction of present backbone network of water resource distribution is too simple and limited to the four regions of urban area, the anti-risk ability and the coordination of it was very weak. So the water supply security of the urban area and the development of society face severe challenge. Therefore, the water resources optimum distribution engineering web planning of the urban area was compiled in 2009. In the planning, the water distribution schemes of all intake areas in different level years were determined by the investigation of the present water supply and using conditions, the water demand prediction and the analysis of the balance of water supply and demand. According to the distribution schemes, the layout water resource distribution energizing network was presented and the flow rate, pipe diameter and length of each water conveyance projects were accounted. In the planning, the role of the pivotal project was especially emphasized and Real-time monitoring system and informatization project were totally programmed to improve anti-risk ability and realize the capacity of joint water supply dispatching. The water dispatching and early warning regime were also determined in the planning.

2) The spreading of water-saving irrigation

1970s later, with the development of science and technology and the recognition of water resources shortage, field irrigation gradually change for water saving, mainly form as follows: Drip irrigation, spray irrigation and slight irrigation. Qingdao government plan and build the projects of high level water-saving irrigation around many aims. By 2009, cultivated land, in Qingdao, covers 6.28 million

mus, with irrigated areas covering 559.43 and the efficient irrigated areas covering 4.1522 million mu. By the "Eleven-five", irrigated areas covers 2.2991 million mu, increasing by 13.7 percent than ten-five, takes up 57.8 percent in the whole efficient irrigated areas. Utilization coefficient of the whole irrigation water and water-saving irrigation is separately to 0.6 and to over 0.8. Joining to the country item, Qingdao government organize and issue 7 medium extending build and mating project of irrigation area, for example Chanzhi 1-9 period in Laixi City. The efficiency and benefit of irrigation water projects, in the farm, has been remarkable improved. Most of the investment of the water saving irrigation in Qingdao comes from the local farmers, and the leave small part come from the government. on the basis of actively developing the research of farmland irrigation experiments, new technology, new equipments are actively spreaded to improve the whole benefit of water saving irrigation.

3) seawater desalination and reclaimed water reuse

In recent years, Qingdao government widely popularize seawater desalination and reclaimed water reuse. By 2009, there had been 8 projects on sewage disposal and recycle, with handling ability of 0.515million cubic meter per day, 6 projects in the urban 4 district and Huangdao district, with handling ability of 0.415 million cubic meter per day, 1 project in Jiaonan and 1 project in Laixi city, with handling ability of 0.06 million cubic meter per day and 0.04 million cubic meter per day. Seawater comprehensive utilization in Qingdao mainly focuses on urban 4 district and Huangdao district, with chemical, electricity water for cooling. In 2006, direct seawater utilization goes up to 1.315million cubic meter per day in urban 4 district and 2.192 million cubic meter per day in Huangdao district, mineralization of utilization seawater a year is 4.80 billion cubic meters in urban 4 district and 8 billion cubic meters in Huangdao district.

5 Adaptive water management modes in coastal cities with water shortage

Total supply of the whole city increased from 66.5 million cubic meters in 1980 to 98.6 million cubic meters in 2009, with an average increase of 1.8 percent a year. With the rapid development of economy and society, nowadays there is a growing tendency in the requirement of water resources. so, the basic goal, in Qingdao city, on water resources management is to remiss the problem of water shortage, to improve the efficiency of water utilization, to protect water ecological environment, to ensure economical and social development by the sustainable utilization of water resources. Given such a goal, Qingdao government adjust the water management strategy by the changing water resource conditions, to adjust the management systems of water resources step by step, and to reform and renew the management of water resources, to improve and adjust the rule systems of it basing upon the law framework of the management of it. Qingdao government also spread the use of water-saving irrigation methods, promote the industrial and water-saving application technology, develop the skill of sea water desalinated and use the unconventional water resources, protect the water ecological environment, improve water resources monitoring network system and supervision mechanism, expand the participation mechanism of the masses and multiple agencies, supply some useful experiences of the model of water resources management for adaptive water management mode about a coastal city with water shortage.

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