

A potential water management mode for developing countries in the future----- based on the situation in China

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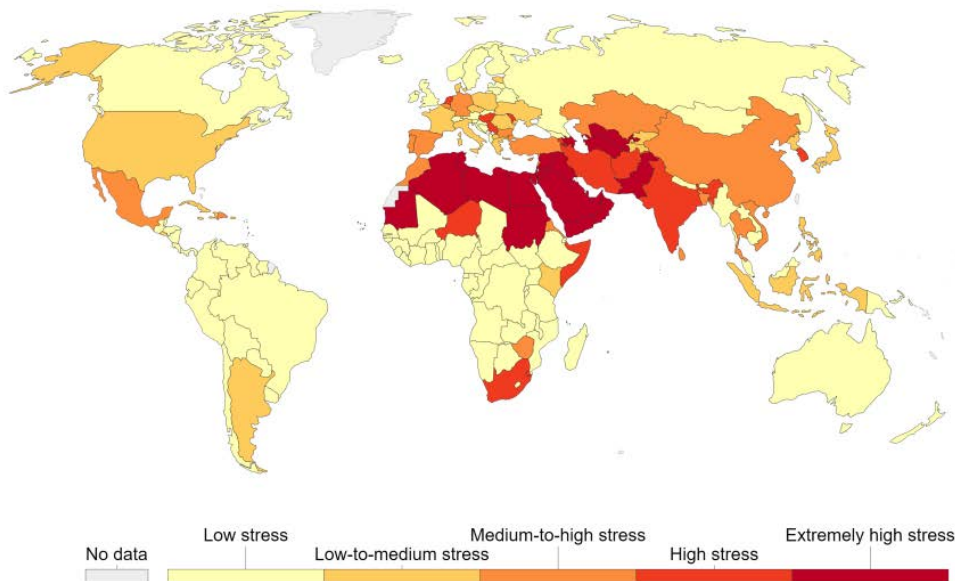
Abstract: The paper demonstrates the water management in China, the USA, Singapore and India and analyses Chinese water management mode's successful experiences and its defects. The paper also demonstrates 3 other countries water managements' policies or solutions so as to provide an effective and flexible reference for countries which have negative conditions of water using and distributing. Through showing the current stressful situation of available water resources all over the world, the paper aims to appeal for the people's attention and awareness of solving the shortage of water resources. After viewing the experience and examples of these countries, it is clear that what have been done is perfect and what still needs improvement in water management. As a result, water management needs an overall and long-term system design to ensure the implement effects. What's more, government needs to incentivize proper scale of private sectors to household water using market and encourage residents to participate in reserving waste water and recycling daily water.

1. Introduction

In the modern era, nearly 70% of the global population (5.3 billion people) has access to safely managed drinking-water service. Yet, more than 785 million people lacks such privilege and does not have access to basic drinking-water service, including 144 million people who are dependent on surface water all over the world. More problematically, there are at least 2 billion people using a drinking water source contaminated with faces and contaminated water can transmit diseases such diarrhea, cholera, dysentery, typhoid, and polio. Contaminated drinking water is estimated to cause 485 000 diarrheal deaths each year [1] (WHO, 2019). The World Resources Institute classified water stress based on following standards: if water withdrawals are less than 10 percent of resources then a country has low water stress; 10-20 percent is low-to-medium stress; 20-40 percent medium-to-high; 40-80 percent high stress; and greater than 80 percent is extremely high stress. [2] (Gassert, F., Reig, P., Luo, T., & Maddocks, A., 2013) According to figures from UN Food and Agriculture Organization, some countries from the Middle East, North Africa and South Asia have extremely high levels of water stress. Besides, most countries across South Asia are experiencing high water stress; medium-to-high across East Asia, the United States and much of Southern and Eastern Europe. Water stress in Northern Europe, Canada, much of Latin America, Sub-Saharan Africa and Oceania is typically low or low-to-medium. (FAO, 2017) The graph below demonstrates the current situation of worldwide freshwater consumption. It was severe that the whole world will be facing a stressful water using situation in the future.

Freshwater withdrawals as a share of internal resources, 2017

Annual freshwater withdrawals refer to total water withdrawals from agriculture, industry and municipal/domestic uses. Withdrawals can exceed 100% of total renewable resources where extraction from nonrenewable aquifers or desalination plants is considerable.



Source: UN Food and Agriculture Organization (FAO)

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Figure 1. Graphs of freshwater withdrawals as a share of internal resources in 2017. Adapted from 'Our World in Data' 2017(<https://ourworldindata.org/water-use-stress>)

In China, total water resources are sufficient but unequally distributed across regions [3] (Liu et al., 2013). The latest survey reported that the annual per capita renewable freshwater availability of China was $2,048m^3$, which is about one third of the world's average (about $6,184m^3$) according to the World Bank [4]. With an increasing population and rapid economic development, many areas of China have been suffering from terrible water stress for recent decades [5] (Liu, Yang, et al., 2017; Wang et al., 2016). Severe water stress may cause a great number of environmental and social issues, such as reduction of crop production and degraded water quality that are harmful to human health [6] (Cheng et al., 2009). Water stress in China has been estimated in previous studies in different geographical and economical views, ranging from water resources view (Zhang et al., 2021; Xiang et al., 2020), large river basin view (Zhang et al., 2021), to normal city view (Ying Zhen, 2017). These views demonstrated the general regional feature of water management and helped understand current water stress in China. However, they often covered short periods, restricted areas or only a particular point, thus ignoring the significance of comprehensive water management system. Moreover, the different time and space views with which the assessment has been performed allow only up to partial comparisons between these studies. Water management and stress in China was also widely studied in global assessments (Huang, 2014; Kong et al., 2021; Yin et al., 2020) which provided general pictures of water situation in China for both historical and future periods. Nevertheless, the domestic water management in China was not explained in detail due to a macroscopic perspective of these studies. Hence, further research in Chinese domestic water management reforms and motivating private sectors' participation are required to better understand the solution of water stress in China and its social impacts.

To address these issues, it is vital to consult advanced experience of countries which succeed in water management and distribution and avoid disadvantages of some developing countries which are suffering poor water management situation, based on some factors detrimental to water supplement in developing countries.(e.g., huge population scales, poor climate conditions and economy situation) Then, concluding an effective mode of water management as a reference for developing countries to increase the efficiency of their water consumption and reform their relevant institution.

2. Method

The study focuses on exploring an innovative and effective water resource management mode for China and similar developing countries. To find a proper solution, the paper looked through corresponding papers of various countries' water policies and management systems. Firstly, author will find out Chinese government's water policies' success and defects to show a possible solution of water management of Chinese style, in order to provide a potential mode from China for other developing countries. Then, in order to conclude experience of developed countries which do well in managing and distributing water resources, author has selected 3 typical countries (the USA, India, Singapore) based on population, economy, territory, political system and climate factors. By comparing the Chinese water management mode and other developed countries' water mode, author will lay out effective and heritable experience and find out what still need to be solved and reformed. Finally, author will deliver some constructive suggestions and point out a possible blank field of governments' water management so as to explore a new aspect of water resource using and management in order to form a flexible mode of water management as a reference for developing countries, which are suffering from shortage of water resources.

3. Main Body

3.1 Water Supplement in China

Chinese government had increased water use efficiency and corresponding water use standards in industrial production and the death rates of unsafe water in China and other developed countries are considerably low nowadays. As for the water resource's regional governance, China had set key target regions for China's regional water related policies and provided more financial support for riparian areas and key water source areas [7] (Zhang, 2021). However, there are still some defects in daily domestic water management and millions of people are still suffering from the shortage of clean drinking water in some regions. Besides, Chinese government also focuses merely on the cleaning water sources both in domestic and industrial water. Therefore, lacking of renewable water and recycling technology cause inefficiency in water consumption in China. The situation of renewable freshwater resources in China is also not optimistic. To keep sustainable levels of clean water resources, rates of water withdrawals must be below rates of freshwater supplement. 'Renewable internal freshwater flows' refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country, so renewable internal flows are an essential index of water security or scarcity. If rates of freshwater withdrawal begin to get over the renewable flows, resources begin to reduce. According to data from UNFAO, per capita renewable resources are declining in China as a result of population increases. Hence, China faces a severe situation of water supplement but there are exactly some successful policies and measures of water management that can provide reference for developing countries suffering shortage of freshwater. Then, I tend to explain some Chinese excellent solutions and what Chinese government has not done and their defects in detail.

3.1.1 Chinese relevant solutions of water resource

As a country having a large number of population and vast territory, China had a great pressure on water management. In addition, China's water resource availability was almost the lowest all over the world. With the development of Chinese economy, the demand of water also continuously increased, especially in the industrial and residential sectors. (Huang, 2014) Fortunately, Chinese government had a series of effective and successful water supplying constructions such as South-to-north Water Diversion Project and Three Gorges Project. These huge water conservancy projects were specially designed for overcoming uneven distribution of water resource in time and place. Meanwhile these projects also released the pressure of domestic and industrial water consumption. Chinese government also paid attention to reforming in agricultural sector. According to Qiuqiong Huang's research, the management of agricultural irrigation water was transferred to water user associations or contractors from the village committee. (Huang, 2014) The results showed that water user associations increased

water-use and water supplement efficiency and corresponding expenses. Besides, the water supplement infrastructures were also improved in Chinese rural areas.

3.1.2 Defects in household or domestic water management

Compared with comprehensive overall water distribution plans, household water management needs more adjustment. For instance, the price of household water purifier is too high, the regulation and standards for water purifiers had not been enforced and lack of concentration on recycling water in daily lives. These all led huge waste of water resource and inefficiency in Chinese domestic water consumption. In addition, Chinese residents' awareness of saving and recycling water was slightly low at present. The government needed to focus more on the propaganda of saving water and strongly support the experiment of innovative and cheap water-saving facilities. Besides, China also had weakness in dealing with wasted water and its recycling. Therefore, China had to strengthen sewage treatment technology.

3.2 Water Management in other countries

According to the figures from UN Food and Agriculture Organization, Internal renewable freshwater resources all over the world vary greatly in different regions. The renewable freshwater resource in South America keeps in the highest level, nearly $12724km^3$, and is far more than other areas' renewable freshwater stock. Compared with the South America, water-deficient areas (e.g., Middle East, Central Asia and Northern Africa) store dramatically scarce renewable water resources which are all lower than $500km^3$ [8]. Moreover, there is a close relationship between water resources and industrial structure. Overall, there is a negative correlation: agriculture's share of total water consumption tends to decrease at more incomes. This links strongly to the industrial structure; at fewer incomes, agriculture forms a higher share of total GDP and a greater share of agricultural employment (World Bank). Therefore, the water management needs assistance from governments' policy making and economy strength. Besides, the worldwide freshwater consumption is at a huge scale in recent years. Global freshwater use — that is, freshwater withdrawals for agriculture, industry and municipal uses — has increased nearly six-fold since 1900. This is shown in the chart.

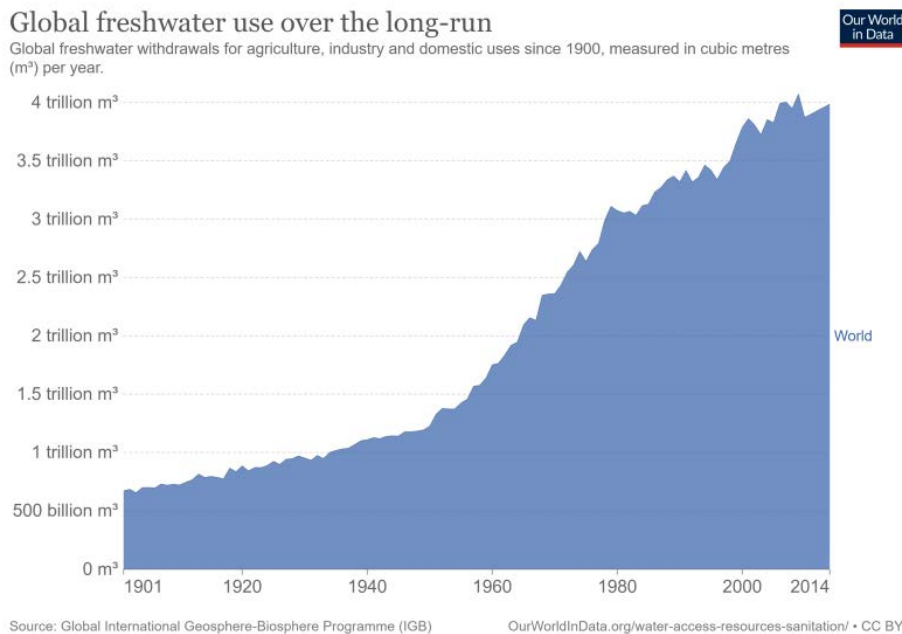


Figure 2. Graph of global freshwater use over the long-run (2018). Adapted from 'Our World in Data' 2017(<https://ourworldindata.org/water-use-stress>)

Rates of global freshwater use increased dramatically from the 1950s onwards, but since 2000 appears to be plateauing, or at least slowing. (IGB) However, the global freshwater use has reached a quite huge level (nearly 4 trillion m³ per year). It can be a great burden for every countries'

governments to ensure their residents' daily consumption and the demand from industrial production and economic development. In addition, as what is mentioned above, renewable internal flows are an important indicator of water security or scarcity. Per capita renewable resources depend on two factors: the total amount of renewable flows, and the scale of the population. If renewable resources decline — as can take place frequently in countries with large annual variability in rainfall, such as monsoon climate — then per capita renewable withdrawals will also reduce. Similarly, if total renewable sources keep constant, per capita levels can fall if a country's population is increasing. (UNFAO) Therefore, this is the reason that author selected 3 representative countries based on population, economy, territory, political system and climate factors. All these factors can play different roles in a country's policy making and the consequences of water management implement. Then author will introduce the water management situation and its effect in these 3 countries.

3.2.1 Water Management in the USA

3.2.1.1 Integrated water management

The USA government gave high flexibilities in water management to every state and also set specialized departments for vital basins such as Tennessee Valley Authority. Besides, the management system was divided into 3 levels of administrative power (federal, state and county). The system permitted that the state governments had enough autonomy to distribute and use water resources and even had rights to make their laws according to the conditions in the state. Every state and county also founded their own water management authorities. Combining with particular basins management departments, the USA founded a mature integrated water resource management system.

3.2.1.2 Need cooperation with other countries in the USA border areas

Although the American government had set an effective and successful water management system, there were still some defects in dealing with cooperation of water management with other countries and foundation of co-governance mode in border areas, which shared a common basin or the same region of groundwater with neighbouring countries. Recent research showed that: 'some border states were seems to be a preference for a border-wide, binational groundwater agreement to incentive the cooperation with neighbors and established a basis of long-term co-governance of groundwater management on the border.' (Rosario Sanchez and Gabriel Eckstein, 2020)

3.2.2 Water Management in Singapore

3.2.2.1 Current water management situation in Singapore

As a small city-state, Singapore had to first face with narrow territory. Therefore, it was significant for Singapore to expand sources of water to guarantee the water supplement including collecting stormwater, purchasing drinking water from neighbor countries, wastewater recycling and so on. Besides, they also focus on demand management. For example, setting ladder water prices clearly defined different levels of people's income and had obvious influence on residents' daily water consuming. What's more, the Singapore spent a large amount of investment on constructing infrastructure of desalination.

3.2.2.2 Potential disadvantages of the Singapore water management mode

Though the Singapore management mode was praised in recent paper that: 'perfectly reach a proper balance between water quantity and quality considerations, water supply and demand distribution, public and private power's participation, efficiency and equity trade-off, strategic national profit and economic efficiency and strengthening domestic abilities and reliance on foreign sources', there definitely were some short-comings when adopted by other developing countries. For instance, the construction of desalination equipment means a large number of investments, so it is not suitable for low income countries. Besides, some countries, like Algeria, Libya and Morocco, which located in dry regions or near desert were not able to collect stormwater. Furthermore, purchasing water from foreign countries increased latent threats from miserable international economic and political relationships.

3.2.3 Water Management in India

3.2.3.1 Severe situation of water supplement in India

As a low-income developing country having a huge number of populations, there was no doubt that the drinking water supplement was under great pressure in India. In 2014, India had the largest freshwater withdrawals at over 760 billion cubic metres per year. This was followed by China at just over 600 billion m³ and the United States at around 480-90 billion m³. (FAO, World Bank) With the continuous population explosion, the main resource of urban daily water---groundwater was nearly used up. What's worse, Indian industry's imbalanced development also led to more and more pollution, which threatened scarce groundwater resource. According to S C Ley's research, 86% of drinking water supplement came from surface water, exactly river(S C Ley, 2012). Besides, the climate in India changed unstably and the precipitation floated markedly. Therefore, it was hard for Indian government to organize a comprehensive solution to collect and put the nature water resource into daily use and industrial production. The experience mentioned above was worth learning by countries with similar situations that India had.

3.2.3.2 Lessons from Indian water management mode

A recent research demonstrated that: 'India's water policy had largely focused on institutions, government interventions and resource development. The significance of technology and innovation in water management had been slightly ignored.'(Venkatesh Dutta、Karunesh Kumar Shukla、Subhash Chander, 2021) In fact, the industrialization lacking of government planning and privatization increasing more dramatically caused inefficient use of water and the imbalanced distribution of water between rural and urban areas, production and the domestic. Therefore, developing countries' governments need a long-term and overall water management policy system. They also have to prevent excessive privatization of different industries in order to ensure the overall policy could be implemented well.

4. Conclusion

The solutions and defects of Chinese water management modes have been extensively discussed in this paper, experience in the USA and Singapore as well as the shortcomings in India by revealing the actual effects of these management modes. Additionally, the paper also highlights the significance of water management system. Author finds out that those countries which lack of an overall and long-term management system are mostly still suffering the chaos of water supplement and shortage of freshwater. It is vital for governments to invest more in some water conservancy projects and necessary propaganda of saving water. Then, the private sector should be allowed to participate in the function of water management to increase the efficiency of water supplement but the scale and the share of private sectors must be limited in case of the private profits threat public interests. The conclusion does not aim at opposing private sector. Author acknowledges the outstanding advantages of private sectors in promoting the construction of huge public construction like water management system. However, the water supplement and distribution is of vital significance to the nation's economy and the people's livelihood. Hence, it is irrational to let private sector to dominate corresponding areas. However, more government purchase means heavier tax burden for both enterprises and residents. The conclusion of the paper aims to highlight that as people's living pressure increases, it is vital to establish effective water management required to be combined with the actual situation and this tests the governance level and abilities of the local government. By applying the advice of the paper, developing countries may ensure basic drinking-water service for residents and relieve the reduction of per capita renewable resources.

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