MSA-Management science journal
ISSN 2974-3036
Volume: 1, Issue:2, Year: 2022, pp. 1-20

WATER SCARCITY IN THE CONTEXT OF CHINA

Amal Gamil [1]
Faculty of Political Science, Economics, and Business Administration
May university, Cairo, Egypt
Email:dramalsalem96@gmail.com

Mahmoud Abdelrashied[2]
Greenwich University, United Kingdom
Email: Mf8836z@gre.ac.uk

Abstract *Irrigated agriculture is crucial to China's food production, but it is in danger due to the country's growing water shortage. As a result, the main objective of this research is to improve knowledge of the evolving patterns in the balance between water supply and demand, their effects on food output, and governmental policy reactions. The environmental change increased water shortage in various river basins in northern China, which led to a decrease in irrigated land. decreased food production and regions. The study shows that China's water shortage is a regional problem, particularly in the north. Here restricted and unequal access to water resources, a drop in surface water supplies, and depletion are all examples of this deterioration of water quality, depletion of groundwater supplies, and rising water consumption. As a result, the Chinese government has attempted to regulate overall water consumption. extraction, increase water use effectiveness and reduce pollutants in the water. Although these legislative measures are encouraging, their efficiency in addressing China's growing water shortage needs to be investigated.*

***Keywords**: Pollution, Scarcity, Sustainable Development, Water resources, Urbanization, Deterioration, Depletion, Climate Change, Global Warming, Green ecology, Wastewater Treatment Plants (WWTPs), Eco-environmental damage, The Yellow River basin (YRB) of China.*

JEL Codes: *: H12, I14, I31, J11, Q01*

[1] ORCID iD 0000-0002-6134-4785
[2] ORCID iD 0000-0001-9702-3900

Introduction:

Irrigation plays a vital role in China's agricultural production, but the continued viability of irrigation systems has been threatened by rising water shortages. Since the 1950s, the Chinese government has made significant investments in the building of irrigation facilities to distribute water from either surface or underground resources due to the better productivity of irrigated land. Half of the area under cultivation has irrigation systems as of now, and irrigated land produces more than 70% of the nation's grain, 80% of its cotton, and more than 90% of its vegetables. But since the late 1990s, there has been a noticeable increase in the scarcity of water. The lower portions of the Yellow River, China's second-largest river, dried out for 226 days in 1997, having a severe impact on the socioeconomic activity in the rivers downstream. Since then, there has been mounting evidence of an increase in water scarcity, particularly of the lowering of the groundwater level and the deterioration of water quality. Global warming has recently been identified as a significant contributor to China's water shortage.

As a result, experts think China has reached a turning point where crucial decisions must be taken to address its water issue. Chinese officials are also paying attention to the growing water shortage and the strain it puts on maintaining food security. Since 2004, the central government has released the No. 1 document, a paper published every year to address concerns relating to agriculture, rural areas, and farmers by the Chinese government. To secure food security, these publications emphasize how to maintain the state of irrigation systems and increase irrigation efficiency. The Chinese government has also made an effort to switch from procurement to requirement flood control policies to guarantee the security of supply and advance sustainable socioeconomic growth. The World Bank examined the country's overall water shortage status and significant water management issues in the late 2000s and offered some recommendations for improving water infrastructure in China. However, this assessment did not specifically address how water shortage affects food security, and the evidence and data utilized were from before 2007.

However, China's government's handles the present situation will have a considerable impact on whether irrigation can remain to play a vital part in securing China's food safety in the future. Consequently, the following should be considered to help policymakers create successful policies: What is the background and present state of the water crisis in

MSA-Management science journal
ISSN 2974-3036
Volume: 1, Issue:2, Year: 2022, pp. 1-20

China? What are the projected trends in water shortage, as influenced by socioeconomic growth and climatic change?

What progress has been made in terms of the government's reaction to the growing water shortage? These problems will be addressed by this study using in-depth secondary data, distinctive collected from survey data, simulation findings from the China Water Simulation Model, and a literature review.

The remaining sections of the essay are structured as follows. The historical data on China's increasing water shortage per river basin is presented in Section 2. The effects of water shortage and climate change on agricultural productivity in China are examined in Section 3 per river basin. In Section 4, the government's reaction to water shortage is described, including institutional and regulatory measures to limit total water extraction, increase water usage effectiveness, and reduce water pollution. The study is concluded in Section 5 with a discussion of these policy implications.

Research Questions:

1) What are the reasons for water scarcity in China?

2) How does water scarcity affect the Chinese economy?

3) How does climate change affects water scarcity in China?

4) What implications does the Chinese government implement to fight water scarcity?

Research Objectives:

1) Identify the reasons for water scarcity in China.

2) Analyse the Chinese government's implications.

Literature review:

Previous studies have focused on specific aspects of water resource management. For example, the global water pollution crisis has motivated scholars to address the environmental benefits of water resource management and proposed preventive measures to protect the ecological environment concerning water resources (Grizzetti et al., 2016) (Chen et al., 2017). (Birol and Das, 2010) explored methods for increasing investments in wastewater treatment plants (WWTPs) in India to improve their capacities and technology, and to reduce the pollution of the River Ganga. (Joanna et al.,2017) focused on the effects of water resource management within the dairy industry of Poland, concluding that advanced technologies are necessary for water conservation. (Ramírez et al., 2020) assessed sustainable water resource management by the industrial sector of Mexico, finding that economic investments in technology for industrial water treatment and reuse had relatively low rates of return. Extensive development in China has also led to significant industrial water pollution. China's environmental protection strategies have been pushed to the highest priority in history, driving remarkable achievements in water pollution control, the collection and treatment capacity of wastewater in China approached the developed country level, with the treatment rates exceeding 90% both in urban and country areas. (Wenzhong Tang, Yuansheng Pei, Hua Zheng, Yu Zhao, Limin Shu, Hong Zhang, 2022).

Scholars have proposed wastewater control approaches in different industries, such as pulp and paper (Wen et al., 2016).

(Gao et al, 2019) researched sustainable water resource management in the coal-fired power energy bases of Northern China, proposing comprehensive countermeasures to relieve water shortages and ensure water security. In addition, it is generally believed that adjusting local government performance appraisal mechanisms, encouraging enterprises to implement green production technology, and introducing public participation in environmental oversight can effectively supplement environmental protection laws (Miao et al., 2015) (Meng et al., 2021). Water resources are an important input factor for economic activity; as such, some scholars have evaluated the effects of water resource management from the perspective of its economic benefits (Donna et al., 2018). These types of possible win-win outcomes were first studied by Grossman and Krueger (1991), who sought to identify ways to minimize environmental pollution while maximizing economic activity. In the case of water resource management, a fundamental principle is that ‘more can be achieved with less.

Consistent with this principle, water use efficiency is a useful index for evaluating the economic benefits of water resource management (Alsharif et al., 2013). (Bithas, 2012) noted that improving water use efficiency was an objective of the Water Framework Directive to manage water resources in Europe. However, the current European policy mix for urban water use appears to be internally contradictory, reducing water policy effectiveness. China is a large consumer of water resources and a large producer of economic outputs. As such, its water use efficiency has attracted much attention (Long and Pijanowski, 2017) Sun et al, 2018). From an industrial perspective, (Li and Ma, 2015) found that low industrial water use efficiency has become a resource bottleneck to industrial development in China. Given the low recycling rate of polluted industrial water, there is room for improvement in industrial water use efficiency. (Liu et al. 2020) assessed industrial water use efficiency in China by setting water consumption as the main input and establishing industrial value-added output and wastewater discharge as the main outputs. They found that the water use efficiency increased from 0.9874 to 0.9962 from 2012 to 2015 in the industrial sector; in contrast, the water-stressed, water-scarce, and water-abundant regions had failed to achieve an overall effective level of efficiency.

In general, an increased level of water use efficiency would ensure that China’s water resources are used in a reasonable, effective, and sustainable way (Fujii et al., 2012) (Geng et al., 2019). Some scholars have comprehensively considered economic and environmental benefits to evaluate if policies can mitigate the dilemma between water resource management and economic development. For example, (Marsh, 2012) noted that New Zealand faced a choice between environmental improvements and the dairy industry’s profitability and employment. It was found that respondents were willing to pay for water that was safer for swimming, with improvements in clarity and ecological health, but was concerned about job losses.

(Xu et al, 2018) assessed the conflicts existing between energy economic development and water resources protection in the coal and chemical industry of China. Economic efficiency and environmental pollution can be balanced by establishing and maintaining an equilibrium between water resources and waste load allocation strategies (Xu et al., 2018). In general, because of rapid population growth, manufacturing-oriented industrial structures, and insufficient technological innovation (Guerena et al., 2015) (Zeng et al., 2019), developing countries face more challenges in achieving win-win outcomes concerning water resource management. For example, Brazil's water resource management model has been implemented for two decades, and yet, it has not yet delivered the expected policy outcomes (Libanio, 2018). Many countries have adopted policies similar to the United States Clean Water Act and Europe's Water Framework Directive in response to water crises. However, most developing countries are still challenged to achieve win-win outcomes given their initial development stages.

In addition, most studies have focused on industries and river basins rather than cities. The differences in water resource abundance, industrial scale and wastewater regulation intensity of cities may significantly hinder the achievement of win-win outcomes. Finally, previous studies have focused on environmental benefits, but have not addressed the evidence and solutions related to effective water resource management along with economic development. This study addresses these research gaps.

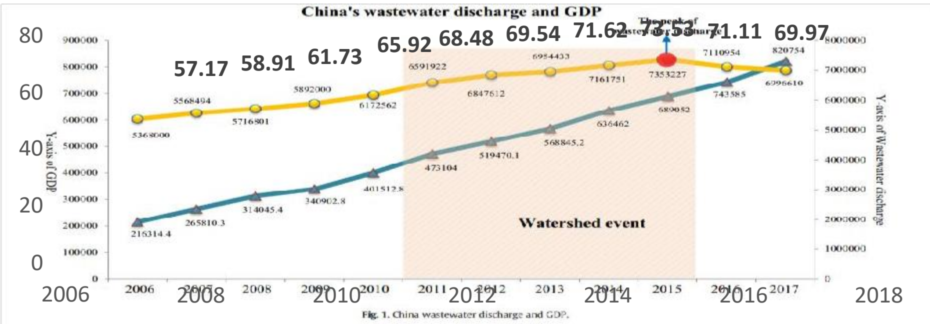
Among the authors who have invested in this direction, we propose Ordás Carido et al. (2011) who developed the Green Solow model and provide a theoretical framework in which pollution reduction is endogenously determined. In particular, the theoretical predictions formulated by the authors suggest that through the scale (defensive) effect, the growth rates in pollution are associated positively (negatively) with GDP growth (emissions levels).(Nicholas Z. Muller & Daniel Raimi, 2020) The theoretical model introduced by Ordás Carido et al. (2011) is opposed to the model of Brock and Taylor (2010), who link CO2 emissions (a global stock pollutant) with economic growth. Their model is designed for local flow pollutants, such as SO2 and NOx emissions.

Mthods & Data

The date source of this paper is the Chinese Government's Yearbooks, as well as the secondary data, as it has previously been examined and analyzed. This data has more availability and is easier to get which helps to tackle the time constraint. The data collected in this paper are both qualitative and quantitative.

With the acceleration of urbanization, cities are now facing great environmental challenges, as the total amount of urban wastewater discharge increases and the condition of water pollution in China becomes more severe. Looking at the development of wastewater discharge during the period from 2007 to 2019, we find a significant increase, as water discharge increased from 55,68 billion tons to 77,74 billion tons, i.e., by 39.6%. Domestic wastewater significantly affects surface water and groundwater quality, there is an annual increase in domestic sewage discharge in urban areas amounting to 76% of total wastewater in 2017 (Yanan Sun, Fangrong Ren, Jiawei Liu, Naixin Shi, Haofei Wang & Xiaotong You, 2021).

Figure (1)Total amount of wastewater discharge in China & GDP from 2006 to 2017.



Source : Statista Research Department , Dec 11, 2020 This statistic shows the total amount of wastewater discharge in China & GDP from 2006 to 2017.

China has the great potential to reduce eco-environment damages. In 2016 and 2017, wastewater eco-environmental damage has decreased compared with that in 2015, and the effect of government policies was remarkable. Since 2016, China's wastewater discharge has gradually declined, but China's economy is still growing at a high speed. We can say that decoupling of China's economic development form eco-environmental damages of wastewater is began to appear the implementation of China's environmental policies and the green upgrading of industrial structure are main driving forces.

Historical indications of China's rising water shortage

China's total freshwater resources are 280 billion m3, only accounting for 6% of the world's water resources with 18.55% of the world's population (Ministry of Environmental Protection, 2016). Therefore, China is one of the countries with the poorest per capita water resources, the largest consumption of water and the most wastewater discharge in the world. As a result of the rapid development of modern industry and the increase of urban population, domestic and industrial water use has increased dramatically (Cai et al., 2019; Liu et al., 2020). Freshwater resources in China are very scarce.
China's water supply-demand imbalance has grown to a present level of 53.6 billion m3, the problem is getting worse, with 28,000 rivers in China having dried up over the past 25 years. (Paul A. avies & R. Andrew Westgat, 2018), which has led to clear losses in productive capacity. Water constraint has reduced China's yearly grain production by more than 27 million tons during the previous 20 years. In our study, water scarcity is defined as the absence of enough groundwater sources to fulfil regional water requirements. Water demand also has an impact on scarcity, in addition to the water supply. The historical data on the growing water shortage both from the demand and supply perspectives are presented in the section that follows.

Limited endowment and uneven spatial distribution of water resources

Water supply problems include limited availability, unequal distribution, and an imbalance among supplies and socioeconomic activity. While China encompasses almost 20% of the world's population, the country contains only 7% of the world's fresh water, leaving it with much less annual fresh water available per capita than most other countries (World Eonomic Forum, 2016).Water is also not regionally distributed equally, with 81% of water resources concentrated in southern China. Northern China supports more than 65% of the country's arable land, 50% of its grain output, and more than 45% of its GDP while having just 19% of the country's water endowment. Additionally, China's strong monsoonal climate results in very variable rainfall, which leads to frequent droughts and floods, especially in the

MSA-Management science journal
ISSN 2974-3036
Volume: 1, Issue:2, Year: 2022, pp. 1-20

north of the country. As a result, the uneven spatial variability of water resources is made even worse by the sequence of precipitation.

The country's uneven resource distribution further exacerbates the scarcity problem: 80% of water is concentrated in South China, but the North is the core of national development. For instance, (Jingping, 2018) integrates three heavily industrialised Northern provinces- Beijing, Tianjin and Hebei- as a single megalopolis to compete with other world-class economic regions such as the New York Tri-State Area. The estimated population of the regions combined is 130 million, whereas the water available for consumption annually per person in the three provinces stands below 184 cubic meters (Hubei is below 100) as illustrated by the China Statistical Yearbook (CSY), far below the 500 cubic meter standard of water scarcity. Water is insufficient in the North and intense development is only putting more pressure on water demand.

The decline of surface water resources

Six significant river basins showed a downward trend in river runoff during the previous 60 years (1961–2011), including four in northern China (Hai, Yellow, Liao, and Songhua) and two in southern China (Yangtze and Pearl). The decline in river discharge that was most pronounced was in Hai (18.2%), followed by Yellow (11.3%). The decreases in the Liao and Songhua basins were 8.3% and 3.4%, respectively. A noteworthy phenomenon is that the Yangtze and Pearl rivers' runoffs decreased by 2.3% and 0.3%, respectively, even though they are located in very water-rich regions of southern China.

This suggests that southern China is also affected by rising water pressure in addition to northern China. Some river basins, like Hai and Yellow, went from being open to being closed due to a drop in river flow, which hurt the biological environment by causing biodiversity loss, atrophy, and seawater intrusion (Wang et al., 2016). More importantly, China's food output has been greatly impacted by the river basin's reduction. In China, these river basins that saw a decline in river discharge over the previous 60 years provided about 75% of the country's irrigated grain output. The Hai and Yellow River basins, which saw the most evident decline in river discharge, contributed close to 40% of the nation's irrigated grain crop production.

In the summer of 2022, China was hit by its most severe heatwave in six decades, exacerbating a drought that has impacted food and factory production, power supplies and transport in a vast area of the country. The Yangtze River Basin, which stretches from coastal Shanghai to Sichuan province in China's southwest and includes Asia's longest river, was considered the worst-affected area, with hundreds of millions of people impacted. Experts say the heatwave could be among the worst recorded in global history (Verna Yu, 2022).According to (Greenpeace, 2018), 82% of China's glaciers have retreated and more than one-fifth of the ice cover has disappeared since the 1950s. Consequently, glacial run-off into the Yangtze alone has been reduced by 13.9% since the 1990s, lessening freshwater availability. Greenpeace anticipates the shortage will become 'dramatically' acute when the glaciers reach their 'peak water- when the rate of water consumption surpasses water supply- which could happen as early as 2030.

Depletion and overdraft of groundwater resources

It was discovered that groundwater irrigation was necessary to grow 83% of the land in six provinces in northern China. In three provinces (Jiangxi, Guangdong, and Yunnan,) in southern China, the percentage of groundwater-irrigated regions reached 58%, well above our expectations. Therefore, it cannot be denied that groundwater has become a significant water supply for irrigation not only in northern China but also in southern China. Unfortunately, relying only on groundwater has had a negative impact on the ecosystem in the form of overdrafts and other issues. Groundwater overdraft has emerged as one of China's most pressing resource issues since the late 1990s.

Around 400 locations in China have groundwater overdrafts that are more than their sustainable capacity. The combined size of these regions represents 11% of China's plain lands. Overdraft zones make up 91% of the plains in the Hai River basin. As a result, several locations' groundwater tables show a downward tendency. For instance, between 1974 and 2000, the shallow groundwater tables in the Hai River basin plummeted at a pace of up to 1 m per year (Qiu, 2010), and the deep groundwater tables dropped at a rate of even more than 2 m per year (Wang et al., 2009). A decline in the groundwater table may be seen in several areas of southern China as well (Zhao et al., 2008). Additionally, excessive groundwater withdrawal has contributed to desertification, saltwater intrusion into freshwater aquifers, and land subsidence (MOE, 2015).

Extension of irrigated land and a rise in water withdrawal from non-agricultural sources

China is the second country in terms of agricultural water withdrawal in the world after India as of 2019 Agricultural water withdrawal in India amounted to 688 billion cubic meters annually and in China 385 billion cubic meters, which represents 23.55% and 13.19% respectively of agricultural water withdrawal in the world (Knoema, World Data Atlas).

The overall amount of water withdrawn in China over the previous 60 years has shown a marked upward trend, virtually tripling. The growth of irrigated regions is the primary factor behind the increase in water withdrawal. One of the key initiatives taken by the Chinese government to increase national food security is the expansion of irrigated land. China's total irrigated land expanded from 16 million hectares to 65 million ha between 1950 and 2014. (NBSC, 2015). So, from 100 billion m3 in 1949 to 387 billion m3 in 2014, but as of 2015, there has been a decrease in agricultural water withdrawals to 385 billion m3.

The overall amount of water withdrawn for the agricultural sector has been trending downward during that period according to an observation of the growth in water withdrawal. The overall water extraction for both the industrial and household sectors has shown a consistent upward trend, even though the growth rate has moderated.

In recent years, the government has given important consideration to ecological water extraction while allocating water resources. Future urbanization, industry growth, and growing environmental protection concerns will make agricultural water withdrawal more competitive with other industries.

Future trend of water scarcity and its impacts on food security in China

Despite some studies' predictions that China's socioeconomic growth will have an impact on water scarcity, our study of the literature revealed that the effects of water scarcity on food security have not been further studied. For instance, MWR forecasts that by 2030, China would utilize 750 billion m3 of water annually, or 90% of the nation's total available water resources (Qiu, 2010). China might have a total water shortage of 400 billion m3 by 2050 (or almost 80% of its present annual capacity of over 500 billion m3 (Tso, 2004). A rising corpus of scholarship has recently concentrated on the effects of climate change on water shortages but has mostly disregarded food security and utilized outmoded climatic projections. For instance, (Zhang and Wang, 2007) and (Zhang et al, 2011) used climatic scenarios to model the effects of climate change on river discharge at the national and river basin levels without focusing on the additional effects on food security.

At the national and river basin levels, (Mu and Khan, 2009), (Xiong et al, 2010), and (Wang et al, 2013) evaluated the effects of climate change on water shortages and food security. However, their climatic scenarios similarly relied on AR4 or a presumption about climate change. We simulate the effects of climate change on water and agricultural production in ten major river basins by 2030 using the China Water Simulation model and the climate scenarios. The primary simulation findings are covered in the section that follows. Climate change and irrigation water scarcity will have significant effects on food production in the region. Considering the CO_2 fertilization effect, agricultural production in the region will be enhanced by climate change and is projected to increase by close to 1.9% compared with production during the historical period. However, irrigation water scarcity can necessitate the reversion of cropland from irrigated to rain-fed management, leading to a decrease in agricultural production. (Yin.Y et al, 2020)

Future trend of water scarcity with and without considering climate change

Simulation findings show that the pressure on water shortages in all river basins has already increased, even without taking the impact of climate change into account. At the national level, the difference between water supply and demand had already gotten to 8% in the base year (2010). The disparity in the northern Yellow, Liao, and Huai River basins was greater than 10% and as high as 26% in the Huai River basin. In all southern river basins, the water supply cannot keep up with the demand. The scarcity of water will get worse by 2030 as a result of continued population development, urbanization, industrialization, and the extension of irrigated regions (reference scenario). If water usage efficiency is not increased, the national water supply and demand mismatch will widen to 39%. Notably, the divide in the majority of river basins (whether in the north or south) would widen considerably.

Impacts of increasing water scarcity on agricultural production

Growing water shortage will cause irrigated areas to shrink and have a detrimental impact on agricultural output. According to simulation results, the availability of water for agricultural output has decreased due to rising water scarcity, and water must now be divided between irrigated and rainfed regions.

As a result, rainfed regions tend to replace irrigated areas in river basins that are experiencing increasingly severe water shortages. The production of agriculture would decline due to the low productivity in the rainfed regions, especially for rice and wheat. For instance, even without the effects of climate change, by 2030, the yield of rice would decline in all river basins by 13% (Yangtze and Huai) to 16% (Southwest). Under RCP8.5, the yield of rice would further decline for river basins where there is a shortage of water, from less than 1% (Yangtze) to more than 10% (Hai and Yellow).

Not only the production of rice but also that of wheat is significantly impacted. Even without taking climate change into account, increased water scarcity brought on by socioeconomic growth would cause a drop in wheat yield of between 16% (in Songhua and Southeast) and 4% (in Liao) by 2030. Climate change would further decrease wheat production by less than 1% (Yangtze) to more than 12% (Yellow). Other crops are less negatively impacted by growing water shortages than rice and wheat. But because rice and wheat are China's two main food security crops, a decline in their production will have a significant impact on the country's food security.

China's food strategy in recent years has focused on ensuring nearly complete self-sufficiency for both rice and wheat. To achieve the goal of food security in the future, China's government must solve the problem of water shortage. Political exigencies will also complicate efforts to lower the agricultural sector’s approximately 60 per cent share of China’s total water resources. One solution would be to allow China to become even more dependent on food imports. However, the policy is heading in the opposite direction as agricultural import dependencies are being increasingly securitised. Consolidation of China’s typically fragmented agricultural holdings would also be politically fraught. (Han et al, 2018)

Government responses to deal with growing water scarcity in China

Water quota management, water withdrawal permission system and water resources fee : The local water resources bureau and river basin management authorities must establish water quotas for different water users at various levels (i.e., river basin, province, city, county, irrigation district, and village) to limit the overall water withdrawal. All water users should also acquire approval from higher-level water management authorities before withdrawing any water, and they should adhere to their allotted quotas for both surface and groundwater. The implementation of these two programs has been delayed and ineffectual, even though the central government has been promoting them since the early 2000s.

The distribution of quotas for diverse users has not yet been finished in many provinces, and it appears to be a laborious process for water management. the majority of farmers in northern China are not required to get permission before using groundwater. The policy of water resources tax has also been in force since 2006 as another policy instrument for limiting overall water usage. Until now, all provinces have charged a water resource cost for both industrial and household water extraction, but only a small number of provinces—such as Gansu—impose an agricultural water resources tax. Hebei has been chosen as the pilot reform province for 2016 as the Chinese government is now aiming to tax the fee amount rather than charge it. The success of these policy tools' application in the future will be crucial to achieving the goals of water control, thus research in this area still needs to be expanded.

Reform of water* pricing *policy

China's government has hastened the reform of its water pricing policy since 2002 as a result of the publication of a new water law. The reform of water pricing has made clear progress in recent years in both the industrial and home sectors, but the development in the agriculture sector remains disappointing (Wang, 2012). The main fear of policymakers is that raising prices will decrease farmers' income, and researchers have also proven the detrimental effects of raising irrigation costs on farmers' income. However, without a reasonable water price, farmers lack the motivation to improve irrigation effectiveness. It is difficult to raise water costs without having an impact on farmers' incomes not just in China but in other nations as well. The good news is that the Hebei pilot reform experience shows that developing an appropriate subsidy program makes it possible to implement an agricultural price reform approach that benefits everyone. A rule on comprehensive agricultural water price reform and providing subsidies to encourage water pricing reform was released by the central government in 2016. (State Council, 2016). Future research will need to focus on whether the change can be successfully implemented across all provinces and how it can achieve the desired goals.

Since 1982 (State Council, 1982), China has been enforcing taxes for the release of pollutants. The government released rules to further strengthen its execution in 2014 to stress the significance of this policy and achieve pollution control goals (National Development and Reform Commission, 2014). Future research will be required to assess how effective this approach is in reducing water pollution. For policymakers in China, it is much more difficult to apply this policy to changing farmers' production behaviours to manage non-point pollution because its main objective is to change the point pollution behaviour of industry and residential water users.

Reforming irrigation management

The World Bank has been pushing China's government to improve irrigation systems since the mid-1990s to improve irrigation effectiveness and foster the sustainable growth of crop output through farmers' involvement in water management. The primary reform strategy is to replace communal water management with Water User Association (WUA).

The overall performance of the reform has not been acceptable, despite the central government's strong attention to it and the release of pertinent legislation promoting it since 2000 (Wang, 2012). Researchers discovered that the majority of reforms are minimal based on a big field survey in northern China since only 20% of reforms create incentives for water conservation, and farmers' involvement in the WUA is also minimal. However, if the right incentives are put in place, the reform can significantly contribute to lowering the use of irrigation and raising water output. Additionally, there aren't many detrimental effects on agricultural output. The financial viability of WUAs, which lack the resources to finance their operation, is another issue with the irrigation reform (Wang, 2012). The efficient implementation of the reform and securing its long-term success remain crucial concerns for Chinese authorities.

On March 2022, The World Bank’s Board of Executive Directors approved a US$380 million loan to help address water scarcity and ecosystem degradation in China’s Yellow River basin. This financing complements over $1.1 billion of China’s resources and will help improve water use efficiency, water pollution control, and ecosystem management in the river basin area. The new program supports important global public goods, such as biodiversity conservation and climate change mitigation, while strengthening the institutional basis for integrated water resource planning and the protection of

MSA-Management science journal
ISSN 2974-3036
Volume: 1, Issue:2, Year: 2022, pp. 1-20

ecosystems. (World Bank, 2022). The program is expected to be 75 percent funded by the government, mostly at the provincial level, to support the achievement of the targeted results. Basin-level activities will be implemented by the Ministry of Water Resources through the Yellow River Conservancy Commission, with overall coordination and guidance provided by the Department of Regional Economy in the National Development and Reform Commission. Provincial-level activities will support ecological protection, water use efficiency, and water pollution control in Henan and Shaanxi, both in the middle reach of the Yellow River, where erosion, ecosystem degradation, and water scarcity are pronounced. (World Bank,2022)

Transporting southern China’s surplus water northwards through megaprojects is increasingly relied upon to address the country’s pronounced water supply and demand imbalance – best illustrated by the fact that China’s north, where agricultural production is concentrated, holds just four per cent of the country’s water. Northern China’s water poverty, combined with myopic government policy, means that the region relies on fast-depleting groundwater for much of its household usage, industrial consumption and irrigated water. (Han et al, 2018)

Conclusion

This paper has studied the problem of water shortage and the evolution of the wastewater discharge caused by economic activity, domestic use and agriculture in China to provide a reference for other countries in the world to overcome the problem of water shortage and wastewater treatment.

We discover that water shortage has become a challenge and difficult problem of global sustainable development, especially in northern China. In addition to the overdraft of groundwater, environmental issues, and a drop in river discharge in six major river basins (four in the north and two in the south), the rising water scarcity is also reflected in the deterioration of both surface and groundwater resources. Although water shortage is more severe in northern China, it has also become a problem in a few southern Chinese districts. Additionally, as irrigation relies heavily on groundwater, authorities may have significant difficulties in the future in dealing with groundwater overdrafts and the quickening degradation of groundwater quality. Importantly, effective action must be taken, to avoid the agricultural industry's yields falling dramatically over time due to growing water shortages caused by socio-economic growth and climate change. Since rice and wheat are both

MSA-Management science journal
ISSN 2974-3036
Volume: 1, Issue:2, Year: 2022, pp. 1-20

important crops for maintaining food security in China, The government's ability to achieve this goal depends heavily on its ability to address the problem of water shortages in the current period.

The Chinese government established various programs for battling the water scarcity problem. Given the fact of water deficit and uneven geographic distribution of water resources, efficient agricultural water utilization is critical against the background of fast urbanization and growing demand arising from industrialization in the coastal area of China. Shortage and waste coexist in Chinese water utilization. Water shortage, eco-environment damage of wastewater, and the inequitable distribution of water resources between different users are common throughout the world. Although a fairly comprehensive policy and institutional framework for environmental management have been developed, China is facing great water-related challenges under the background of rapid urbanization, industrialization, growing agricultural demand, and environmental degradation. As the largest user of water, an increase in agricultural water use efficiency is a necessary condition not only for future agricultural development but also for Chinese social and economic development. Meanwhile, environmental degradation is aggregating the constraint of water shortage on socio-economic development. There are many sources of water pollution, most notably pollution resulting from the practice of industrial activities and domestic use, which have been reduced in some way, pollution arising from excessive urbanization, and the practice of agricultural activities (which use pesticides and fertilizers) constitute a great challenge as the most civilized issues in the 21st century. The downward trend in wastewater discharge is rooted in the green upgrading of China's industrial structure and the stringent environmental policies and measures. China's progress toward wastewater control provided important insights for other developing countries.

Recommendation

China's government should reform the programs addressed for resolving water scarcity issues by taking into consideration external intervention, especially climate change. China's Government should implement different wastewater control policies in different provinces and cities. In industrially developed areas like Beijing, Shanghai, Tianjin, Zhejiang, Jiangsu and Guangdong the total amount of wastewater discharge should be controlled strictly, and the level of wastewater treatment should be strengthened, and should adjust the duration of these programs to concentrate more on the long run period. It needs to urgently improve policies, especially policies that encourage environmentally friendly foreign investment, give more incentives to projects that reduce environmental pollution and lead to green ecological development, accelerate environmentally friendly technological innovation, improve the level of economic structures, and to control excessive urbanization.

Previous studies have suggested the need to limit water use in agriculture by allocating water more efficiently through water rights, regulations and quotas, pricing, trading, and subsidy reform; and improve crop productivity per unit of water. The need to improve water governance through transparent, accountable, efficient, responsive, sustainable, and geographically contextualized institutions; and change diets to reduce demand for water-intensive crops and livestock.

The government should accelerate the construction and promotion of wastewater treatment projects. In the areas of agriculture and animal husbandry, and the infrastructure for centralized wastewater treatment.

In the long run, all provinces and cities in China need to accelerate the transition from extensive to intensive economic growth.

Environmental regulations, which are mainly based on taxes, have an effective role in controlling pollution, however, there are differences in the enforcement of environmental regulations. High-income companies located in high-income areas are likely to impose stricter environmental regulations and more inspections. FDI can be encouraged to make investments in the less developed regions and to bring environmentally friendly advanced technologies. And working on using environmentally friendly materials as much as possible, such as environmentally friendly cars, replacing energy sources that are harmful to the environment, and planting many trees to maintain the atmosphere.

References:

Ali, T., Huang, J., J. Wang and Xie, W., 2016. Global Footprints on Water and Land Resources through China's Food Trade, Global Food Security, http://dx.doi.org/10. 1016/j.gfs.

Cremades, R., Wang, J., Morris, Jd, 2015. The policy supports, economic incentives and the adoption of agricultural water-saving technology in China. Earth Syst. Dyn. 6, 399–410. http://dx.doi.org/10.5194/esd-6-399-2015.

Han, H., Xia, S., & Jiang, Y. (2018). Challenging Issues over Sustainable Water Management in Coastal Area from China. *Journal of Coastal Research*, *83*. https://doi.org/10.2112/SI83-157.1

Huang, Q., Wang, J., Li, Y., 2017. Do water saving technologies Save water? Empirical evidence from North China. J. Environ. Econ. Manag. 82 (2017), 1–16. http:// dx.doi.org/10.1016/j.jeem.2016.10.003.

IPCC, Climate Change 2014: Impacts, Adaptation and Vulnerability, 2014. https://www.ipcc.ch/report/ar5/wg2/

Jiuping Xu, Shuhua Hou, Heping Xie, Chengwei Lv, Liming Yao. Equilibrium approach towards water resource management and pollution control in coal chemical industrial park, Journal of Environmental Management, Volume 219, 2018, Pages 56-73, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2018.04.080.

Kaisheng Long, Bryan C. Pijanowski, Is there a relationship between water scarcity and water use efficiency in China? A national decadal assessment across spatial scales, Land Use Policy, Volume 69, 2017, Pages 502-511, ISSN 0264-8377, https://doi.org/10.1016/j.landusepol.2017.09.055.

Marsh, D., 2012. Water resource management in New Zealand: jobs or algal blooms? Journal of Environmental Management 109, 33-42.

Miao, M., Tang, Y., Wong, C., Zhang, H., 2015. The latent causal chain of industrial water pollution in China. Environmental Pollution 196, 473-477.

MWR (Ministry of Water Resources), 2015. China Water Resources Bulletin, Ministry of Water Resources, Beijing, China(separate bulletin in various years).

Navarro-Ramírez, V., Ramírez-Hernandez, J., Gil-Samaniego, M., Eliana Rodríguez-Burgueño, J., 2020. Methodological frameworks to assess sustainable water resources management in industry: A review. Ecological Indicators 119, 106819.

Nicholas Z. Muller & Daniel Raimi, 2020, Pollution and GDP, Resources Magazin. Pollution and GDP (resources.org)

Paul A. avies & R. Andrew Westgat,2018,Latham & Watkins LLP. China Faces Serious Water Supply Problems | Environment, Land & Resources (globalelr.com)

Qunwei Wang, Zengyao Zhao, Neng Shen, Tiantian Liu, Have Chinese cities achieved the win–win between environmental protection and economic development? From the perspective of environmental efficiency, Ecological Indicators, Volume 51, 2015, Pages 151-158, ISSN 1470-160X, https://doi.org/10.1016/j.ecolind.

Sun,T., Wang, J., Huang, Q., Li, L., 2016. Assessment of Water Rights and Irrigation Pricing Reforms in Heihe River Basin in China, Water, doi: http://dx.doi.org/10. 3390/w8080333

Verna Yu, 2022, China reports 'most severe' heatwave and third driest summer on record, The Guardian, China reports 'most severe' heatwave and third driest summer on record | China | The Guardian

Wenzhong Tang, Yuansheng Pei, Hua Zheng, Yu Zhao, Limin Shu, Hong Zhang, 2022. Twenty years of China's water pollution control: Experiences and challenges, doi: 10.1016/j.chemosphere.2022.133875. Epub 2022 Feb 4. Elsevier.

World Economic Forum, Apr 29, 2016, China has a water crisis - how can it be solved? | World Economic Forum (weforum.org)

Yanan Sun, Fangrong Ren, Jiawei Liu, Naixin Shi, Haofei Wang & Xiaotong You, 2021, Evaluation of Wastewater Pollution and Treatment Efficiencies in China during Urbanization Based on Dynamic Exogenous Variable Data Envelopment Analysis. ORIGINAL RESEARCH article. Front. Environ. Sci., 15 February 2021, Sec. Water and Wastewater Management. https://doi.org/10.3389/fenvs.2021.585718

Yin, Y., Wang, L., Wang, Z., Tang, Q., Piao, S., Chen, D., Xia, J., Conradt, T., Liu, J., Wada, Y., Cai, X., Xie, Z., Duan, Q., Li, X., Zhou, J., & Zhang, J. (2020). Quantifying Water Scarcity in Northern China Within the Context of Climatic and Societal Changes and South-to-North Water Diversion. *Earth's Future*, *8*(8). https://doi.org/10.1029/2020EF001492