Tackling Industrial Water Pollution

LESSONS FROM CHINA

Environment and Development
Policy Brief 2019/1

INTRODUCTION

Though the manufacturing sector has been a key driver of growth across Asia, it is also the source of critical environmental problems, including the surge of water resource use and water pollution. Further, estimates suggest that the industrial sector of the region will see the largest increase (of 65 per cent) in water use by 2030 compared to any other sector in the economy.[1] Combining with projected population growth this can exacerbate water-access problems in Asia.[2] Within this context and given the People's Republic of China's (PRC) prominent position as a global industrial hub, the PRC offers a valuable case study in managing and enforcing environmental controls in the face of rapid industrialisation. This is especially relevant for countries in the region seeking to undergo similar structural change in terms of industrial development but with lower impact on the environment. This policy brief outlines the context of the PRC, the PRC's key policies, case studies from the city of Shaoxing and Shandong Province (the PRC's hub for the textile industry and paper and pulp industry respectively), and some key policy recommendations. This policy brief is a key input for work carried out by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), in collaboration with Tsinghua University,[3] to strengthen the capacity of regional governments to implement policy for improving water and resource use in key industrial sectors.

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

THE CHINA CONTEXT

Today the People's Republic of China hosts one fifth of the global population (and growing) and contributes to almost 50 per cent of Asia's manufacturing output. However, the PRC commands little over 6 per cent of the total global water resources, presenting serious concerns for fresh water supply. While the PRC experiences water scarcity, the industrial revolution has done little to aid the situation. Within the PRC, authorities have gone to great lengths to curb water use, water pollution and introduce environmental safeguards to address the associated hazards of industrialisation (see section 2 and 3 for a discussion of policy experience from China). The PRC carried out some of the most comprehensive environmental and water quality assessments in Asia. The most recent comprehensive water quality survey was carried out between 2006 and 2014 in the North China Plain by the Institute of Hydro-geology & Environmental Geology at the China Academy of Geological Sciences. It was reported that China's water quality had deteriorated so greatly that over 70 per cent of shallow & deep groundwater was severely polluted that it classified as Grade IV+ (unfit for human touch)[4]. This figure is alarming as 70 per cent of China's 1.3 billion population, plus over 60 per cent of China's cities primarily rely on groundwater as drinking water source.[5]

The investigation that followed this survey concluded not only that the PRC relied heavily on scarce water resources, but also highlighted the level of negligence by the industrial sector to implement sufficient environmental safeguards to protect the much-needed water resources. While it was recognized that previous policy measures implemented since 2006 had been effective, it was only to a limited extent, mainly due to the rapid expansion and changes that occurred in industry and agriculture, which led to more complex and intensified pollution issues, not previously anticipated by policy makers. As a result, in April 2014 the Chinese central government declared a war against pollution at the annual National People's Congress and approved an amendment to the Environmental Protection Law enacted in the 1980s. The new amendment was designed to address and strengthen environmental governance by way of enabling the executive branches and enforcement arms to hold polluters more accountable for their actions.

Entering into force in January 2015, the amendment addressed the issue of enforcement by strengthening the coherence between specialised regulations to enable more effective governance of the entire landscape of environmental laws and protections in the PRC. Comparing with the previous provisions, the amendment repositioned and empowered the strategical importance of the environmental protection agenda, forcing greater liability and accountability of polluters. For example, the amended Environmental Protection Law gave the local environmental protection bureau and associated institutions the authority to conduct on-site inspections, and where they found non-compliance or risk for any serious pollution, the executive branch had the power to issue penalties for non-compliance,[6] suspend, shut down, or detain the polluting facilities.[7] To account for corruption and ensure local government enforcement of environmental protection, targets and indicators were incorporated into public performance appraisals for local governors (Article 26). This pushed the PRC authorities to implement stronger measures against environmental pollution, namely targeting the PRC's top water consuming and water polluting industries: the food product, pulp and paper, textile, and chemical manufacturing industries. This led to what is known today as Water Ten, a package of stronger, more integrated and interdisciplinary policy mechanisms (discussed in detail in section 4). As a result, in 2016 alone 22,730 cases in total were reported, with 44 per cent of cases resulting in the seizure of equipment or facilities.[8]

THE POLICY CONTEXT

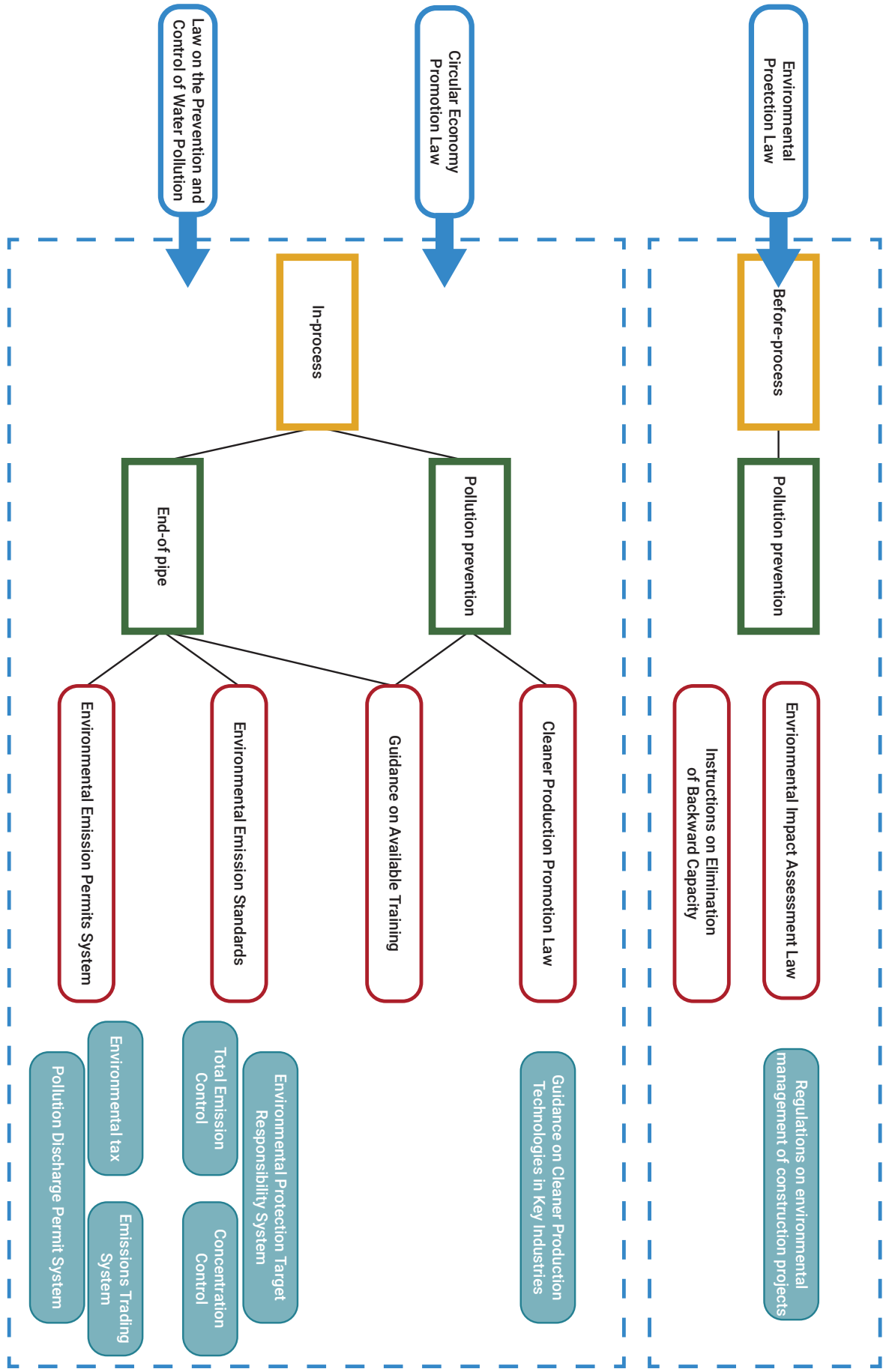
It is important to understand the structure of the PRC government. The PRC operates with a democratic centralist government, state power is exercised through the Communist Party, the Central People's Government (State Council) and their provincial and local representation. Government administration operates in three tiers: the provincial level (provinces, autonomous regions, directly-controlled municipalities and special administrative regions), prefectural level (prefecture-level municipalities, prefectures, autonomous prefectures and leagues), county (districts, county-level municipalities, counties, autonomous counties, banners and autonomous banners) and township level.[9] The centralist nature of the PRC government espouses a force of unity amongst government when governing, this sense of unity has been key to the success of the PRC's ability to coordinate within, amongst and between ministries and officers of government to achieve the inevitably multifaceted goal of environmental protection. Notably the policy package of Water Ten fully embodies this centralist nature, a policy turning point away from a patchy and permissive environmental management system to a more integrated and accountable one focusing on not only end results, but supply chains and the ecological relationships between the environment and industry.

The industrial water management system in the PRC is spread over two phases (see Figure 1). The first phase is "before-process", which means the management before construction and production. The second phase is "in-process", which means the management during production. Before initiating an industrial development, the enterprises must pass an environmental impact assessment to qualify for a permit. In this phase, the government can also consider whether the project is prohibited according to the Instruction on Elimination of Backward Capacity.[10] After receiving a permit, the enterprises must follow the "Three Simultaneity" principle during the building process, implying the facilities for pollution control must be designed, constructed and used at the same time with the main facility. Therefore, in this phase, the ways of management mainly follow the principle of pollution prevention.

In the production process, the Cleaner Production Promotion Law encourages enterprises to adopt cleaner technologies, use environmentally friendly materials, and produce greener products. Required by this law, enterprises in key industries, e.g. textile industry, must perform cleaner production auditing to guide the production process towards cleaner production. Accordingly, the national government releases Guidance on Cleaner Production Technologies in Key Industries almost annually. End-of-pipe treatment involves emission standards and the Environmental Emission Permits System, comprising of an environmental tax, pollution discharge permit and emissions trading system.

The PRC's policy instruments can be divided into three distinct categories: information, market-based and command/control. When put in practice, these policy instruments act on two levels, with affirmative actions and restraining actions. Information instruments refer to policies which include the government's attempts to influence people through communication, transfer of knowledge and advocacy through the distribution of government-led inventory, data collection and guidebook compilation to industries and consumers. Market-based mechanisms include grants, loans, taxes, fines and other user charges. They embody the 'polluter pays' approach, which dictates that those who produce pollution should bear the costs of managing it. Lastly, command/control instruments are used to define, monitor and manage polluting behaviours and practices, which are applied in the form of permits, licenses and rules. The result of regulation mostly depends on the authority and ability of the government to exercise direct command and control over the industry. Further, affirmative actions like financial incentives, for example, are used when the government wishes to encourage specific behaviour. Contrastingly, restraining actions are used to punish behaviours that do not conform with the government's agenda. Section 3 elaborates on some of these policy instruments, along with some lessons learned from these policy experiences.

Figure 1. Overview of policy framework related to industrial water management in the PRC



Source: Tsinghua University Study

LESSONS FROM CHINESE POLICY EXPERIENCES

Before evaluating the PRC policy experience, a notable concept consistent in the PRC's environmental policymaking is the polluter pays principle. The polluter pays principle aims to correct market failure and its resulting social injustice by shifting pollution costs from the public at large to polluting enterprises, while at the same time reducing the amount of pollution produced.[11] The polluter pays principle began life as a principle of economics, but it now carries normative force as a legal principle. This means that to control pollution a national or subnational government must, as a matter of law, implement the principle whenever it is possible and appropriate to do so. In particular, governments must find ways to quantify the pollution from industrial facilities – society's largest polluting entities – and make them pay for its environmental cost.[12] The Chinese policy evolution is steadily progressing from identifying polluters to measuring pollution and enforcing the polluter pays principle. All policy instruments from environmental tax, pollution permits, and water pricing, to industrial parks act in a concerted effort to identify and monitor polluters in an effort to ensure those who pollute, pay. This section discusses some of the selected instruments used by China to limit water pollution and promote sustainable use of water by the industrial sector over the years and lessons learned.

Subsidies for promoting water reuse: The recycling of water has been promoted by the Chinese government through various approaches at both provincial and municipal levels. For industrial users, the price gap between regular water and recycled water makes using recycled water a smart economic alternative. In a city like Beijing, for example, where industrial water prices are exceptionally high at 9.5 RMB/tonne, the cost of the recycled water price is very appealing at just 3.5 RMB/tonne for industrial water users.[13] However, the economics of wastewater treatment and recycling can be prohibitive in some other parts. The cost of treating recycled water continues to be higher than its final selling price in most cities in China, and so considerable government funding is required to support such a policy approach. In fact, without government subsidies water treatment companies in China could not survive financially due to the high costs of treating water for reuse. The average selling price of recycled water for industrial use in China is 1.19 RMB/tonne while the cost of treating recycled water is 2.11 RMB/tonne.[14] Although this policy approach has its advantages in terms of discouraging freshwater consumption, it is at the same time economically unsustainable and not viable without substantive government support.

Pollution discharge permit: The pollution discharge permit system stipulates that a pollutant-discharging entity must lawfully obtain a pollutant discharge permit and discharge pollutants in accordance with the provisions set out in the permit. Enterprises must apply for and obtain a pollutants discharge permit. From 1990 to 2014, China has operated under a permit system that issues permits for the discharging of industrial pollutants into waterways,

Box 1- Case Study Shaoxing:

Encouraging a circular economy

The government encouraged textile enterprises to adopt circular economy practices, especially with regards to water treatment and water reuse. In 2015, the local government invested a 35-million-yuan subsidy to incentivize water reuse. If a factory was equipped with a water reuse system, it was eligible for a subsidy of 260 yuan/tonne of reused water.[26] The subsidy agenda encouraged the practice of water reuse and the implementation of digital automatic monitoring systems of pollutant emissions. These combined efforts resulted in the decrease of the total effluent discharge from 0.9 million tons to 0.54 million tons.[27] Print and dyeing enterprises in the district invested a total of 1.3 billion yuan, and 210 enterprises have built sewage pre-treatment facilities. In addition, 65 enterprises have built water reuse facilities. More than 100 enterprises use membrane treatment technology to recycle wastewater, and the recycling rate is over 40 per cent.

Source: Tsinghua University Study

as well as for the drawing of water for industrial purposes. However, due to lack of legal support the permit system was only weakly enforced. In 2015, the PRC launched the Integrated Reform Plan for Promoting Ecological Progress, which emphasized improving the pollutant emissions permit system. It was stated that a unified and fair business emissions permit system covering all fixed pollution sources will be established quickly nationwide. Subsequently, a permit system aimed at all industries was implemented at provincial and municipal levels.[15] Any firm or organization is required to apply for and receive a license before releasing any pollutant into a designated area. For enterprises, regulation centred on "one-license" has effectively lightened the burden, as there would no longer be repeated declarations. Practice has proved that standardized and refined environmental management will not lead to an increase in the burden of enterprises, but will save resources and reduce energy consumption. For government staff, the process of issuing pollutant emission permits could help them clarify the basic equipment, process flow, and pollutant emission position of each industry. These clear and accessible contents, including the technological characteristics of each enterprise, have been specified in the emission permit, which will greatly improve the efficiency and transparency of management. For environmental management efforts, the permit provides solid legal support. As requirements of enterprises for environmental protection will be concentrated on the discharge permit, they will improve the fine level of environmental management and standardize environmental law enforcement and supervision. For environmental protection tax (see section below), the implementation of the emission permit system provides great convenience. Enterprises would pay taxes according to the implementation report of pollutant discharge permits. The data are clear, the methods are unified, and the collection process of taxation is made concise and efficient. This permit is complimented by other policy tools, such as the setting of quotas to monitor the water consumption of high water-consuming license holders. In addition to these permits, the Chinese government also imposes strict regulatory measures on industry including the shutdown of any factory that violates national industrial policy. As stipulated by Water Ten, any factory that does not comply with relevant national policy, standards or industrial regulation within a certain time frame would be shut down, with targeted industries including paper and pulp, leather, textile dyeing, coking, sulphur and arsenic smelting, oil refineries and pesticide production. This includes the use of any machine or technology listed as 'environmentally non-compliant technology or equipment' by State Council and the Bureau for Environmental Protection. This policy

Box 2- Case Study Shandong Province:

From phased control of pollution to development of a basin comprehensive emission standard

The phased emission control of Shandong province is noteworthy. Shandong divided the eight-year process of tightening emission standard into four stages. Take the emission limit applied on CODCr (Chemical oxygen demand) contained in bleached straw pulp effluent as an example. Before 1 May 2003, the CODCr emission standard was 450 mg/L, the corresponding emission standard was modified in gradual stages, as a result in 1 January 2010 on, the CODCr emission control limit reached a level of 120 mg/L. However, if only environmental benefits were considered without considering the adaptive capacity of enterprises, most of the pulp and paper enterprises would have gone bankrupt, bringing huge economic loss and social instability. The phased approach helped avoid this problem, as the enterprises were given a clear path of legislation and were given plenty of time to take positive steps, including increasing polluting control input, optimizing producing processes, and adjusting raw material structure to achieve compliance. Meanwhile, with phased control on industrial wastewater emission, the industry's entry barrier had been raised. According to statistics, six years after the implementation of the phased standard, the number of straw pulp enterprises had decreased by 80 per cent, while the overall economic output of the industry had increased substantially, and the pulp and paper industry embarked on a healthy development path.[28] At the same, the province gradually moved from implementing the industry-specific emission standards to implementing basin-wide comprehensive emission standards, which all enterprises in the basin should obey. This resulted in substantial reduction in the presence of high polluting industries in the region.[29]

Source: Tsinghua University Study

is implemented at the national level with local government responsible for its enforcement.

The pollution discharge permit system is based on information disclosure and has greatly widened transparency in terms of manufacturing capacity, discharge data, and corporate reporting on environmental information. The permit system has helped achieve more coordinated and aligned inter-department and inter-ministerial cooperation by making data available in a unified form. Further, the permit system has given a unified standard and lays foundation for the environmental tax system. However, the permit system is not without its challenges. Its design is complicated as it deals with a complex mix of sources of pollutions and industrial sectors. The permit system is not flexible enough to integrate the specific requirements for different sub-regions and often the voice of smaller firms is not adequately heard in the design and implementation of the permit systems. The roles and responsibilities and the processes for implementing the permit system need to be further streamlined by the government to lower its administrative cost, whereas companies need to ensure accurate reporting of their emission levels and the operation status of their facilities.

Discharge fee: The purpose of the discharge fee policy is to charge companies across all industries for any pollutants discharged into the environment if contamination exceeds national or local standards. The discharge fee is as an adaptation of the polluter pays principle. According to this policy, the polluter is required to pay a pollutant discharge fee if they are responsible for discharging any of the top three nationally recognized contaminants in their wastewater.[16] However, the discharge fee policy that was implemented at a national level by the State Council in 1984 was subsequently abolished in 2017.

The many problems associated with the discharge fee system were exposed during the decades following implementation. Firstly, the discharge fee was too low to effectively incentivize factories to change their polluting behaviours.[17] The cost of treating wastewater in the chemical and dyeing industries is 6.99 RMB/kg and 3.81 RMB/kg respectively, while the discharge fee is only 0.9 RMB/kg, meaning companies benefit more financially by simply paying the discharge fee rather than treating their wastewater. A secondary problem was that the environmental capacity of a factory or industrial area was not being holistically evaluated before discharge fees were applied and collected.[18] Therefore, even if factories were meeting the discharge standard, their pollution emissions might still have been exceeding the environmental capacity in terms of water pollution. As a result, environmental degradation continued unabated, despite the introduction of the discharge fee. Lastly, poor implementation of the policy at the local level, including issues like corruption, resulted in insufficient fee collection,[19] also because the policy stipulated that the amount of the discharge fee was subject to the affordability of the polluter. That is to say, for discharging the same amount of pollutants, a poor polluter could pay a lesser discharge fee than a more affluent polluter. As a result, the actual amount collected by the authorities varied greatly from the amount anticipated. Ultimately, this critical policy fault meant that the public were covering the costs of the environmental damages caused by profit-seeking enterprises and so those sources responsible for emitting the pollutants were not sufficiently incentivized to change their polluting behaviours.

Environmental tax: The environmental protection tax law replaced the discharge fee system officially in early 2018. The environmental protection tax system was developed based on lessons learned from the discharge fee system. As explained earlier, the environmental tax system is linked to the emission permit system. Enterprises would pay taxes according to the implementation report of pollutant discharge permits. The emission permits give clear data on the pollutant emission levels. The methods are unified, hence the collection process of taxation (unlike pollution levy) is made more efficient and transparent. The law stipulates that the environmental tax pricing range for emitting water pollutants is 1.4 RMB to 14 RMB per unit pollutant with the exact tax rate to be chosen by provincial governments, given the disparity in water resource between provinces. The environmental tax system strengthens the tax net and increases the cost of production for all manufacturers that emit taxable emissions prescribed under the law.[20]

Beijing has the highest environmental tax bracket of all municipalities and provinces, with neighbouring provinces the next highest when compared with other regions. On the other hand, the western provinces, as less developed provinces, have the lowest tax rate of 1.4 RMB per unit pollutant. Interestingly, while some provinces are discouraging

the presence of highly-polluting industries by higher tax rates, less developed regions are attempting to attract investments from those industries through setting lower environmental taxes. A feasible approach would be to adjust the national geographic composition of the industrial sector, but until this happens factories will continue to relocate and operate out of more remote, rural areas where environmental taxes are lowest. Another downside of the environmental tax policy is that its approach to incentivizing positive behaviours is unclear. The law is not specific regarding under what conditions companies should receive tax concessions,[21] hence more clearly defined incentives may help quicken the transition to more environment-friendly production methods.

Tiered water pricing: In China, tiered water pricing is widely used to control water consumption levels, for both domestic and non-domestic use. For non-domestic use additional fees are demanded for any water consumption above a designated limit. For example, in urban areas in Julin Province that face water scarcity or that use groundwater as a key water source, non-domestic users that consume 0 to 10 per cent more than the allocated limit will be charged surplus fees for excess amounts of water used, and above this, further charges apply. Since relevant industries affected by this policy must consider higher water fees in production costs, they are forced to re-examine the amount of water consumed on a regular basis. Thus, tiered water pricing is an effective approach to controlling water consumption and usage behaviours, especially in those provinces lacking abundant water sources.

That being said, the tiered water pricing system also has its challenges.[22] Firstly, a lack of national standards to regulate local policy makes implementation difficult. There is a huge difference between tiered water prices in each area of the country, meaning some provinces collect almost no additional water charges while other municipal governments charge 116 million RMB to non-domestic users for using similar amounts of water. Secondly, the punishment for violation of the policy is not stringent enough to truly discourage industry from polluting behaviours. Authorities lacked the power to do anything beyond inform violating companies to pay the required fee within a certain timeline; they were not permitted to use other methods such as turning off the water supply (this situation has changed with the new environmental protection law). Thirdly, there is a lack of disparity in the fee structures applied to regular industries and more heavily polluting industries. If a different fee structure was applied to more polluting industries, such as the tiered water pricing system, it could be a great tool for guiding companies seeking a transition to more environmentally friendly, resource conserving technologies.

Industrial parks: Industrial parks are characterized as a clustering of industries designed to meet compatible demands of different organizations within one location. It usually includes an administrative authority, making provisions for continuing management, enforcing restrictions on tenants and detailed planning with respect to lot sizes, access, and facilities.[23] Generally, there are selection criteria for industrial parks in China, which include but are not limited to (1) abundant water resources and (2) enough environmental carrying capacity. It is known that water resources are the key to developing industrial parks as such parks are also large consumers of water due to their industrial density. If there are not enough water resources available, the government will not allow development of an industrial park at such conditions. Further, now if new or old developments inside the industrial park do not meet any new environmental standards, the development will be fined or shut down. Although many measures for protecting the environment have been adopted by industries, pollution is still unavoidable. Therefore, a certain environmental carrying capacity within and around the park is necessary so that some pollution can be "carried" by the local environment. Usually, an environmental impact assessment done by the developers is a prerequisite for developing a new industrial park.

The industrial park minimizes the problems of zoning by grouping various types of industrial activities. Costs of infrastructure and utilities are further reduced by concentrating activities in planned areas. Under Water Ten, large industrial plants were encouraged or forced to move into industrial parks/zones to make it easier to manage associated pollution. While moving industrial plans into these zones has proven costly and difficult, it has undoubtedly proven to be a more effective and efficient way of controlling mass pollution.

At a local level, these industrial zones have also resulted in environmental problems such as magnified pollution, water treatment costs due to

pollution, increased safety problems and health care costs, loss of biodiversity and increased challenges to coastal zone management. The impact of industrial parks when coupled with current natural resource scarcity issues inflates environmental risk.[24] However, the grouping of industrial parks has proved to be an effective approach towards controlling water pollution (see case study of Binhai Industrial Park) under the new environmental protection laws, which has encouraged the PRC's move towards eco-industrial parks. Industrial parks foster an environment where industrial symbiosis is both easier to implement and an effective method for promoting circular economy. Different enterprises are able to build connections by sharing infrastructure and using by-products and waste. The establishment of recycling and reusing in a broader scope helps enterprises not only reduce emissions and energy consumption, but also lowers costs. Further, industrial parks offer more space for policy innovation as there is greater and high frequency data available from production units within industrial parks.[25] However, if a mix of industries exist in the industrial park, setting of standards and managing pollution can be challenging.

Box 3- Case Study Shaoxing:

Binhai Industrial Park, Keqiao District

To deeply investigate the wastewater management in the textile industrial agglomeration area analysis has been directed to the Keqiao District in the city of Shaoxing. It is one of the most concentrated printing and dyeing production areas in the world. With the establishment of the Binhai Industrial Park, enterprises in the area have been moved into the park, with some enterprises being merged into one company. The industrial wastewater in the agglomeration area adopts a centralized treatment mode. Compared with the traditional distributed treatment, industrial parks offer scale advantage, reduce the treatment cost, improve the processing efficiency, and at the same time facilitate centralized management and reduce the burden on the enterprise. A centralized water treatment facility enables more effective management of wastewater, which is also convenient for the supervision of government. Further, the centralized treatment system trumps an individual treatment system in robustness, meaning it has capacity to manage and process excess in the case of accidents and irregular activities when enterprises occasionally exceed the standard. However, it is notable that in order to implement an industrial park, a strong industrial base and government support is required, especially to create supporting infrastructure. In order to reduce pollutant emissions, the main measures taken by enterprises include improving pre-treatment, source control (using environmentally friendly production materials), and adjusting product structure (as the characteristics of pollution emission in the textile printing and dyeing industry are closely related to the type of products). An industrial park environment enables government to intervene and help achieve these goals on a larger scale in a more concentrated area. This ensures environmental targets are met, enabling government to set up plans and goals for enterprises in the park.

Source : Tsinghua University Study

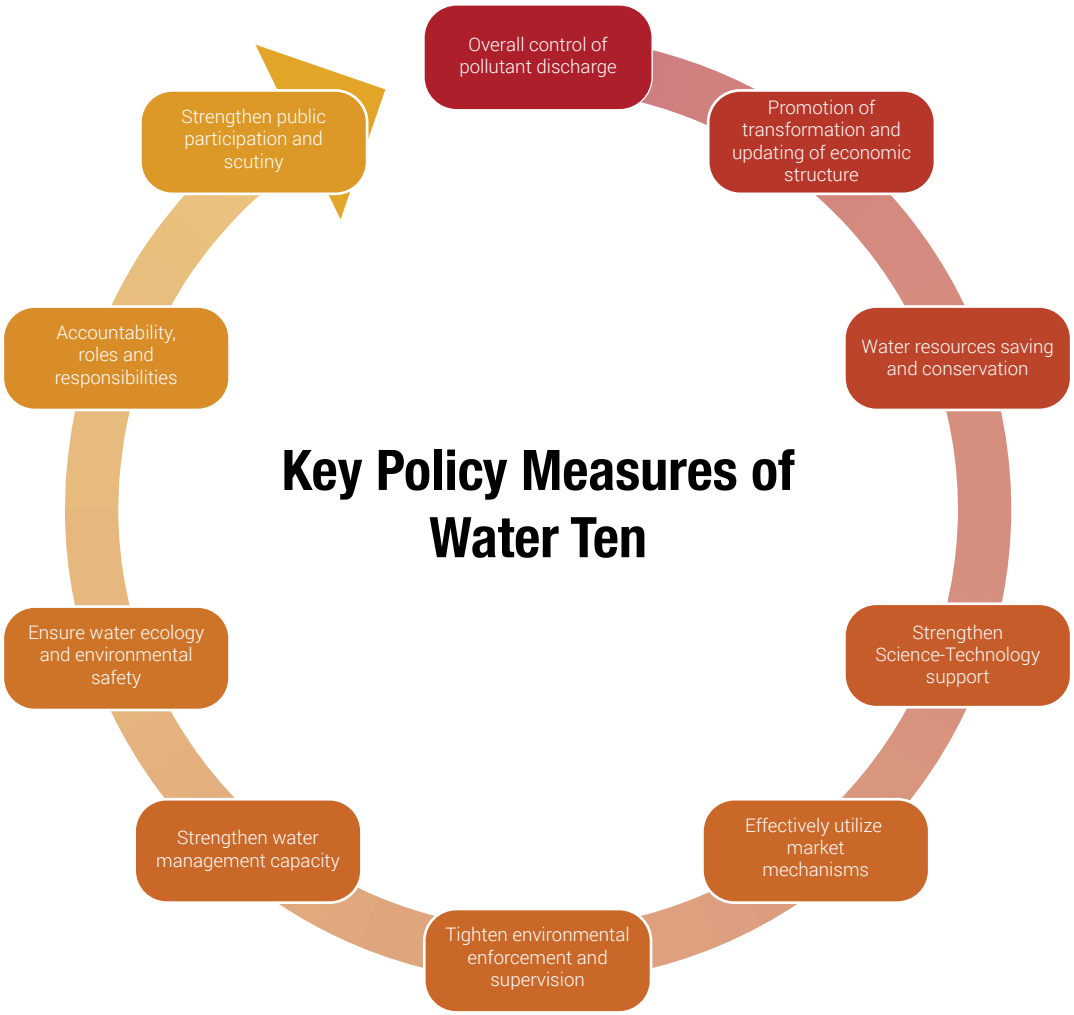
Table 1: Key policy instruments, benefits, challenges and lessons learned			
Policy instrument	*Main features and benefits*	*Challenges and lessons learned*	*Policy mechanism*
Subsidies for promoting water reuse	• Makes water recycling economically viable	• Need large operational budget from Government	Market instrument
Pollution discharge permit	• Improves transparency in terms of manufacturing capacity, discharge data, and corporate reporting on environmental information • Enhance coordination and inter-ministerial cooperation through unified data availability	• Complicated design • Not flexible as single standard used for all firms • Accurate reporting from entities is crucial	Command/ Control
Discharge fee	• Using the polluters pay model, issuing pollution fees directly to emitters to discourage pollution	• Fee set can be too low to effectively incentivize factories to change their polluting behaviours • May not holistically account for the environmental capacity of the industrial area	Market instrument
Environmental tax	• Highly developed regions experience higher taxation rates to compensate for the exponential cost of environmental degradation • Strengthen tax net and more efficient revenue generation	• Less developed regions may attempt to attract investments from those industries through setting lower environmental taxes • Policy not specific regarding under what conditions companies receive tax concessions	Market instrument
Tiered water pricing	• Industries experience higher water fees in production costs and are forced to re-examine the amount of water consumed on a regular basis • Tiered water pricing is an effective approach to controlling water consumption and usage behaviours	• Lack of national standards to regulate local policies on tiered pricing can make implementation difficult • Lack of disparity in the fee structures applied to regular industries and more heavily polluting industries can be problematic and may send wrong signals	Market instrument
Industrial parks	• The problems of zoning can be minimized by grouping various types of industrial activities • Costs of infrastructure and utilities can be reduced by concentrating activities in planned area • More effective and efficient way of controlling mass pollution • Promotes industrial symbiosis by sharing infrastructure and reuse of products/waste as inputs by other industries • More space for policy innovation as there is greater and high frequency data available	• Industrial zones have resulted in environmental problems such as magnified pollution, water treatment costs due to pollution, increased safety problems and health care costs, loss of biodiversity and increased challenges to coastal zone management • If a mix of industries exist in the industrial park, setting of standards and managing pollution can be challenging. • Risk of 'free rider effect'	Command/ Control

WATER TEN, A HOLISTIC POLICY PACKAGE

While the PRC's ability to develop, adapt, review and adjust their environmental policies showed both commitment and power, there was an element of coordination and streamlining absent from the PRC environmental policy agenda. The PRC's environmental policy challenges then became about ensuring government-wide consistency and coherence among policy instruments. This evolution in policy thinking comes from central tenants in environmental policymaking, recognizing that environmental issues cannot be addressed independently from one another, and that environmental impacts are not just a result of end user emissions, but rather the entire supply chain. With this recognition came the initiative to champion Water Ten, a new age policy package that enforced the cooperation of 12 central ministries across the PRC government to act in a coordinated effort to control pollution.

Water Ten encompasses a menu of information, market-based and command/control mechanisms in a concerted fashion to exercise control over industrial water pollution. Water Ten maps out a set of concerted actions to be carried out by 12 ministries under the State Council in the next 10 to 15 years with the ambition (see table 1 of Annex) to overcome the root causes of the severe water risks and stresses accumulated over the past decades, including limited management capacities; lack of technological and financial support; and lax laws and regulations with weak institutions and enforcement.[30] Water Ten commands the entire water pollution policy. The main policy provisions in Water Ten are illustrated in Figure 2 (see annex Table 2 for more details on each of these provisions). Some of the main innovations introduced by Water

Figure 2. Key policy measures of Water Ten



Ten are discussed in Box 4.

As previously mentioned, to implement a polluter pay principle, several steps are imperative to successful implementation, those being monitoring and enforcement. Previously the PRC experienced multiple challenges in this regard, including but not limited to corruption, monitoring technology, legal awareness and reliable data (see table 2). When the Water Ten policy package was introduced, one of its main tenants was to strengthen the implementation of the polluter pays principle, through the tightening of environmental enforcement and supervision and stricter accountability regimes.

The implementation of the Water Ten package has already started showing results in terms of improvement of water quality over the past few years. According to the "2017 Bulletin of the State of the Environment of China",[31] the share of surface water qualifying Grade I-III standards rose from 64.5 per cent in 2015 to 67.9 per cent in 2017, and the share of surface water inferior to Grade V standard dropped from 8.8 per cent to 8.3 per cent during the same period. Despite the modest improvement, there is still a substantive work required in order to reach the ambitious target of over 70 per cent of Grade I-III and less than 5 per cent of inferior Grade V surface water by 2020, as set in China's 13th Five-Year Plan (2016-2020).[32] However, a more thorough assessment of the policy is needed in order to understand the contribution of Water Ten on water pollution reduction in China.

Table 2: Enforcement evaluation of environmental management measures before introduction of Water Ten

Measures	*Enforcement evaluation*	*Major problems*
Environmental impact assessment	Good	Corruption, reliability of conclusions
Pollution levy	Not good	Corruption, no incentive
Emission permit	Average	Reasonableness of emission allocation, illegal emission
Environmental supervision	Not good	Capacity, lack of finance, lack of long-term effectiveness
Environmental monitoring	Not good	Capacity, low technology level, lack of money
Information disclosure	Not good	Accuracy, timeliness, completeness
Public participation	Not good	Not enough legal support, low environmental awareness

Source: Qi and Xin Zhou (2009)[38]

Box 4: Water Ten Innovations

Some of the noteworthy innovative features of Water Ten from the perspective of industrial water pollution control are highlighted here:

Integrated approach

While many of the policy instruments prescribed under Water Ten already existed (see section 3), the remarkable feature was to provide a comprehensive framework that ties together these instruments in a consistent and integrated manner, while attacking the environmental issue from all angles. For example, information instruments included a menu of case studies, booklets and information sources designed to encourage enterprises to take actions to curb water pollution or public water resource contamination. Booklets were provided on water pollution treatment, encouraging enterprises to seek professionally certified environmental service companies.[33] To back this up, expenditure instruments within the Water Ten package

were introduced to include the allocation of funding to support any programs dedicated to improving water treatment technologies, including funding of a major science and technology program focused on water pollution control and treatment. To match these efforts, Water Ten set out a number of regulatory instruments encompassing rules on the use of recycled water by enterprises in specific industries. This type of integrated thinking that cuts across policy platforms is essentially what sets Water Ten apart from the history of the PRC's policymaking. There is a distinct and concerted effort to simultaneously assist, encourage and enforce change, enabling proper and planned industry transformation.

Clear accountability and division of roles and responsibilities

Water Ten clearly specified the role, both leading and supportive, played by the 12 main ministries involved. Apart from the ministries, local governments and governors are clearly held accountable for the water environmental quality in their respective jurisdictions. For example, if inspection and investigation show the project concerned has caused severe water pollution and environmental damages, the appropriate official will be held liable, even in the case that a local governor who used to oversee environment protection is retired (Article 33 of Water Ten).

Provision to tackle emergent pollutants

Water Ten highlights the exponential environmental risks associated with toxic chemicals and pollutants that were not included in the environmental monitoring radar, such as substances of high environmental and health concerns. Water Ten has called for a periodical assessment of environment and health risks of industry facilities and clusters, and for a nationwide thorough assessment of the existing chemicals both in terms of their quantities and environmental and health risks to identify those to be prioritized for risk control measures, including elimination, restriction and substitutions. In December 2017 the Ministry of Environmental Protection, Ministry of Industry and Information Technology, and the National Health and Family Planning Commission issued the first batch of priority control chemicals involving 22 chemical substances posing high environmental and human health risks based on their intrinsic hazards and bio-accumulative nature. Now these 22 chemicals are subject to restrictions and substitution in production, certification for cleaner production and information disclosure, and to be incorporated into the pollution discharge permit system. By doing so not only has the environment management radar been expanded, industries manufacturing, using or discharging these concerned substances are now mobilized to reduce and eliminate these substances. In the future, this would also help in addressing emerging issues like microplastic pollution originating from the industrial sector.

Flexibility for management at different level

Water Ten was able to aggregate and establish an umbrella framework leading to multiple policy goals, from improving water quality to implementing water pollution control incentives. Water Ten outlined 238 specific policy measures that broadly addressed the key general policy measures shown in Figure 2. These broad categories enabled issue-oriented thinking. Water Ten could be paired with any other policy instruments and substantiated by each of the participating ministries to bring the needed action to the specific challenges on the ground. Such policy elasticity gives Water Ten the level of ambition and flexibility to target issues at various scales to fix the systemic challenges.

Promoting viable technology and innovations

Over the years, the PRC has witnessed a variety of local innovations that aim to reduce environmental impact and promote principles of circular economy (see box 4.1 on the Tralin Model). At the same time, the PRC has also championed application of technology for more effective implementation of pollution control (see box 4.1 on Shaoxing). Recognizing the role of technology and innovation, Water Ten has designated the Ministry of Science and Technology to work with other relevant ministries to promote the engagement of the science,

technology and innovation community in research and development of key technologies, and to demonstrate and disseminate accessible technologies.[34] Water Ten aspires to promote such local innovations to limit water pollution and promote sustainable use of water. This also builds on the PRC's experience of promoting equipment revolution in specific industries in collaboration with industrial associations. For example, since 2013 the city of Shaoxing has vigorously implemented equipment and technology upgrading projects in the textile industry. To phase out the outdated equipment, experts from the China Printing and Dyeing Association were invited to check the in-use equipment one by one. The equipment phase-out rate exceeded 30 per cent.[35]

Box 4.1- Case Study Tralin Model:

Role of local innovation in promoting cleaner production and circular economy

Tralin Group is famous for its 'Tralin Model' of cleaner production in paper and pulp industry. Tralin Group is located in Shandong province, with a strong agriculture sector, where before the Tralin Model, most straw were burned directly in the farmland. The technical research team of the Tralin Group, with the support of provincial government, developed an innovative production process that created a new form of industrial and agricultural circular economy model. The technology is able to separate fulvic acid and cellulose from the straw of crops. Fulvic acid could then be used to produce fertilizers of high quality, while cellulose could be used as raw material in papermaking, replacing the role of wood in pulp and paper industry. The Tralin Model's way of manufacturing realizes the efficient and comprehensive utilization of straw, promoting a wider application of fulvic acid in agriculture. More importantly, it prevents waste as crop straw are of much value to be excavated and reduces the pollution that may be caused by burning straw in the open atmosphere. The Tralin Model effectively provides a practical solution to key issues in the fields of agriculture, resource saving and environment protection. The promotion of these practices enabled Tralin Group to perform well in wastewater control practices as well. This model highlights the importance of local technological innovations in promoting cleaner production and circular economy.

Case Study Shaoxing:

Applying technology for effective pollution monitoring

In the city of Shaoxing, 239 sets of automatic control systems were installed in 251 enterprises, which covered printing and dyeing industry and four other major industries. The financial cost was more than 2 million yuan. When the sewage discharge of an enterprise reaches 80, 90 and 100 per cent of the approved emission permit, the lights of the automatic monitoring platform will be blue, yellow and red. It shows the current sewage discharge status of the enterprise, and the system will automatically send a text message to inform the person in charge, the environmental protection administrator, and the person in charge of the environmental protection department urging them to take effective action. Otherwise, the sewage outlet would be closed compulsively. This illustrates the application of new technologies for more effective implementation of pollution control measures.

Source: Tsinghua University Study

Ensure adequate financing

The installation of wastewater treatment facilities, deploying new technologies and monitoring are costly. Therefore, Water Ten makes provision for financing. The Ministry of Finance mobilized RMB 13 billion, approximately US 2 billion, to fund water pollution control and prevention. This funding aimed to mobilize private funding and investment through public-private partnerships to finance the installation of new technologies and water treatment facilities. As a result, the total value of investments in water management and pollution control reached over RMB 430 billion (approximately US$ 70 billion) in 2016. However, these investments come with significant co-benefits. It is estimated that by implementing Water Ten over 3.9

million new jobs will be created as part of the growing environmental service sector (2.3 per cent growth of the service industry share in total GDP) worth some RMB 5.7 trillion to offset the losses from phasing out the outdated polluting sectors.[36]

Promoting structural transformation by applying a theory of change

The PRC has committed to transform itself into a service and consumption-oriented economy, implying industrial upgradation and moving up the value chain.[37] Water Ten ties together the envisaged strategic direction of China's industrial development pathway with ecological targets (see Annex table 1). In doing so, Water Ten applies a 'theory of change' lens, addressing not only end user pollution, but also the transformation of the supply chain and the broader industrial structure. The theory of change approach helps ministries to work in cooperation and introduce policies that address the root causes of environmental issues as well as support the broader industrial and ecological transformation. To align the reforms on water management with the economic structure in China, Water Ten is positioned to "promote the transformation and updating of the economic structure" as it maps out actions to adjust industrial structure, raise the bar high for environmental permission, and push for the re-design of industrial policies in line with the environmental carrying capacity. By the same token, it accelerates the exit of resource-intensive and polluting industries and favours the circular economy.

Enhanced transparency and public engagement

In addition to the associated legislative and policy changes, Water Ten emphasize improvement in transparency, not only within government, but also in the public sphere to overcome corruption and address accountability and enforcement. In line with the new Environmental Protection Law, entities and local government are now required to publicly publish all environmental reports and water quality data. This has enabled greater public participation and monitoring of incidents and entities that would otherwise be impossible for the local environmental bureaus to monitor (see case study of Shaoxing).

Box 4.2- Case Study Shaoxing:

Developing social monitoring for enforcement

The government established a four-level supervision and inspection team spread amongst districts, towns (streets, development zones), villages (communities), and enterprises. Aside from government officials, citizens also participate in this monitoring system, which adds a more publicly and socially engaged monitoring method. Further, when enterprises are discovered with illegal levels of pollutant emissions, they are legally obliged to publish this online and apologize in the mass media, adding extra levels of social accountability. As a result, between 2013 and 2014, more than 12,000 enterprises were inspected, 307 illegal enterprises were administratively punished, and fines totalling 12.8 million yuan were imposed. More than 300 small and micro-pollution enterprises were shut down, 11 suspects were arrested, and two were sentenced to nine years in prison for environmental pollution.[39]

Source: Tsinghua University Study

CONCLUSION

This policy brief explored the experience of China in limiting water pollution and promoting sustainable water usage in the industrial sector. The PRC experimented with various policy instruments over the years, with varying degree of success. The adoption of the Water Ten policy package is an amalgamation of the learnings over the years. It emphasises the role of legislation, an integrated approach towards policy formulation founded on a theory of change and the need for enforcing the polluter pays principle. The experience also revealed that any policy framework at the national level should have flexibility to target issues at various scales to fix the systemic challenges. To strengthen enforcement of environmental policies, the PRC experience also highlights the importance of giving additional powers to executive branches of government powers, promoting transparency of pollution data from both enterprises and governments, and actively engaging the public in pollution monitoring. These policy experiences from the PRC, as highlighted in this policy brief, offer valuable lessons for other developing countries envisaging industrial expansion, offering an opportunity for South-South learning in the era of industrial Asia.

ANNEX

Table 1: Main objectives and indicators of Water Ten (2020-2050)

Year	*Objective*	*Indicator*
2020	Improve water quality nationwide	• Over 70% of water bodies in seven major river basins[40] reach Grade III level or above[41]
	Drastically reduce heavily polluted water bodies	• Black and odorous water bodies in built-up urban areas is reduced to 10%
	Increase drinking water safety, control groundwater over extraction, and curb the deterioration of groundwater pollution	• Over 93% of centralized drinking water sources reach Grade III level • Extremely poor groundwater quality is reduced to 15% across the country
	Stabilize the environmental quality of the offshore waters	• 70% of offshore water reaches Grade I-II[42]
	Improve water environment in seven major river basins	• 15% reduction of inferior Grade V water in Beijing-Tianjin-Hebei area, and elimination in the Yangtze River Delta and Pearl River Delta
2030	Improve water quality across the country and water ecosystem functions preliminarily restored	• Over 75% of water bodies in seven major river basins reach Grade III level or above • Black and odorous water bodies in built-up urban areas are eliminated • 95% of centralized drinking water sources reach Grade III level
2050	The ecology and environmental quality are comprehensively improved, and the ecosystem has achieved a virtuous circle	

Table 2: Water Ten policy measures[43]			
I.	Overall control of pollutant discharge	1	1) Control and prevent industrial pollution (targeting 10 sectors) 2) Clean production and circularity (targeting 10 sectors) 3) Water pollution in industrial clusters
		2	1) Strengthen control over urban domestic pollution 2) Fully reinforce supporting pipe network construction 3) Promote sludge treatment and disposal
		3	1) Boost prevention and control of agricultural and rural pollution 2) Control agricultural non-profit source pollution 3) Adjust planning structure and layout 4) Accelerate rural environment management
		4	1) Strengthen control over ship and port pollution 2) Enhance ability to prevent and control port and terminal pollution
II.	Promotion of transformation and updating of economic structure	5	1) Adjust industrial structure 2) Permission standard for technologies
		6	1) Optimize spatial layout 2) Promote exit of polluting enterprises 3) Proactively protect ecological space
		7	1) Promote seawater utilization 2) Advance cyclic development 3) Promote utilization of reclaimed water
III.	Water resources saving and conservation	8	1) Control total water consumption 2) Strictly control groundwater over-exploitation
		9	1) Increase water use efficiency 2) Industrial water saving 3) Strengthen water saving in cities and towns 4) Agriculture water saving
		10	1) Science-based water resources conservation 2) Strengthen water dispatch and management in rivers, lakes and reservoirs 3) Scientifically measure the ecological flow
IV.	Strengthen the sci-tech support	11	1) Disseminate and demonstrate appropriate technologies
		12	1) Develop prospective technologies
		13	1) Proactively promote the development of the environmental protection industry 2) Accelerate the development of the environment service industry
V.	Effectively utilize market mechanisms	14	1) Streamline the pricing and taxation schemes 2) Improve the charging policies 3) Improve the taxation policies
		15	1) Promote diversified financing 2) Increase public financing
		16	1) Set up incentive mechanism 2) Implement green credit system 3) Implement trans-boundary water environment compensation
VI.	Tighten environmental enforcement and supervision	17	1) Improve regulatory standards 2) Refine relevant standards
		18	1) Strengthen law enforcement 2) Improve environmental supervision and law enforcement mechanism. 3) Crack down on environmental illegal behaviours.
		19	1) Enhance supervision level 2) Refine water monitoring system 3) Increase environmental supervision capacity

VII.	**Strengthen water management capacity**	20	1) Strengthen the outcome-oriented management approach focusing on environmental quality
		21	1) Tighten environmental risk control 2) Appropriate management of water pollution incidents
		22	1) Fully operationalize the pollution discharge permit system 2) Appropriate management of water pollution incidents
		23	1) Fully operationalize the pollution discharge permit system 2) Strengthen the management capacity of the pollution discharge permit system
VIII.	**Ensure water ecology and evironmental safety**	24	1) Ensure safety of the drinking water sources 2) Strengthen the protection of drinking water sources 3) Control and prevent groundwater pollution
		25	1) Strengthen the control and prevention in seven major river basins 2) Strengthen the protection of clean water bodies
		26	1) Enhance environmental protection in offshore areas 2) Promote ecologically friendly aquaculture 3) Strictly control pollutions of endocrine disrupting chemicals
		27	1) Control black and odorous water bodies in cities
		28	1) Protect water and wetlands ecosystems 2) Protect marine ecology
IX.	**Roles and responsibilities**	29	1) Strengthen the responsibility of local governments on water environment protection
		30	1) Strengthen intern-department coordination and joint action
		31	1) Enforce the liability of discharging entities
		32	1) Strictly implement the outcome-oriented appraisal system 2) The appraisal result is regarded as a reference for the allocation of water pollution prevention and control fund 3) In the event of failure to pass the annual appraisal, local governors or officials in charge of environmental protection at the provincial level will be called to a meeting for inspection and supervision, and in the meanwhile the EIA approval will be suspended in the concerned areas; lifelong liability for government officials includes after retirement.
X.	**Strengthen public participation and scrutiny**	33	1) Environmental information disclosure 2) Local governments shall regularly publish water environment quality data; major discharging entities shall disclose information of pollutant discharges
		34	1) Strengthen public scrutiny
		35	1) Public engagement

FOOTNOTES

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ACKNOWLEDGEMENTS

This policy brief is produced by the Environment and Development Policy Section (EDPS) within the Environment and Development Division (EDD) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), in collaboration with Tsinghua University. The publication was drafted under the overall guidance of Stefanos Fotiou (Director, EDD) and supervision of Katinka Weinberger (Chief, EDPS). The research team comprised of ESCAP staff: Solene Le Doze, Arun Jacob, Qian Cheng, Sanming Nam; consultants: Caroline Turner, Mallory Bellairs; and interns: Ying Hong, Heng Qi, Yaolei Pan and Min Che Jo. The Tsinghua University team consisted of Prof. Lei Shi, Wei Cong, and Chupei Lin. The extensive background research, including case studies from China, prepared by Tsinghua University research team is available at https://bit.ly/2GyEWOP.