TECHNICAL FOCUS PAPER

China's water resources management challenge:

The 'three red lines'

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Global Water Partnership

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Our mission is to advance governance and management of water resources for sustainable and equitable development.

Global Water Partnership (GWP) is an international network, created in 1996 to foster an integrated approach to water resources management (IWRM). IWRM is a process which promotes the coordinated development and management of water, land, and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

The Network is open to all organisations that recognise the principles of an integrated approach to water resources management endorsed by the Network. It includes states, government institutions (national, regional, and local), intergovernmental organisations, international and national non-governmental organisations, academic and research institutions, private sector companies, and service providers in the public sector.

GWP's Technical Committee is a group of internationally recognised professionals and scientists skilled in the different aspects of water management. This committee provides technical support and advice to the Partnership as a whole. The Technical Committee has been charged with developing an analytical framework of the water sector and proposing actions that will promote sustainable water resources management.

A **Technical Focus Paper** is a publication of the GWP Technical Committee aimed at harnessing and sharing knowledge and experiences generated by knowledge partners and Regional and Country Water Partnerships.

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Contents

Acronyms

BWA	Beijing Water Authority
CNY	Chinese Yuan Renminbi
COD	Chemical oxygen demand
GDP	Gross domestic product
IUWM	Integrated urban water management
MRP	Middle route project of SNWD
MWR	Ministry of Water Resources
SNWD	South-to-north water-diversion project
WRC	Water Resources Commission
WUA	Water users' association

Foreword

This Technical Focus Paper is the third in a series of papers that provide a critical review of progress made in planning and putting integrated water resources management into practice. The paper synthesises the challenges, successes, setbacks, and the direction for further integration. It provides valuable insights from which others can learn lessons and apply them to their particular and often unique circumstances.

This paper focuses on water resources management in China – an immense country which throughout history has always had water at the heart of its political and economic life. Today, water is still seen as a major constraint on the nation's economic and social development given a growing population, urbanisation, and industrialisation at a time when there are serious water shortages and an increasing frequency and severity of droughts.

This paper describes the water challenges facing China and the steps being taken to put water at the centre of sustainable social and economic development. It sets out ambitious plans for a stringent, integrated approach to water resources management. It establishes 'three red lines' that set limits on future water demand and detail expectations for water use efficiency and water quality within which water resources must be planned and managed. This is a long-term plan and progress is described as the plan is put into practice in an urban setting in Beijing.

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Executive summary

Throughout China's history water has always been an essential part of political and economic life and important to the country's prosperity and stability. Even in ancient times water was mentioned in legends, such as 'King Yu combating flood'.

Today, China is facing a great challenge as water resources begin to constrain the nation's economic and social development. Since the early 1980s when China implemented reform and an open policy to the outside world, the country has seen significant achievements in developing and allocating water, conservation, protection, and water resources management, which greatly contribute to social and economic development and people's well-being. But sustainable economic development is still a major challenge as China faces a growing population, industrialisation, and urbanisation at a time when there are serious water shortages in some parts of the country, and there is growing pollution, and declining aquatic ecosystems.

In 2011, to address these serious and complex water resources challenges, the Central Government set about major reforms to implement stringent water resources management and set up 'three red lines' to control total water use, improve water use efficiency, and control water pollution.

In 2012, the State Council issued *The guidelines on implementing the stringent water resources management system* which mapped out the working arrangements. These guidelines identified the main objectives and put forward the measures to be taken, the tasks to be completed, and the accountability procedures to be put in place to ensure rational development, water use and protection, and sustainable economic and social development.

This demonstrates China's changes in approach from:

- Water supply management to water-demand management
- Planning economic development as a priority to environmental protection
- Cleaning up polluted water to prevention
- Planning disorder to rational order
- Over-exploiting water resources to improving efficient use
- A 'silo' based water administration to an integrated approach with clear accountability.

The paper describes the key water challenges facing China, the steps being taken to introduce this new stringent water resources management system, and the experiences so far in introducing this in an urban setting in Beijing.

1 China's water resources challenge

Throughout China's history water has always been an essential part of political and economic life and important to the country's prosperity and stability. Even in ancient times water was mentioned in legends, such as 'King Yu combating flood'. In Sima Qian's *River canal book of historical records*, he notes that, "Water can be good or bad to people." In more recent times, government leaders on many occasions also have stressed the importance of water stating that, "Water is the lifeblood of agriculture." And that, "Water resources are essential natural and economic resources of strategic importance, and a control element for ecology and environment and the basis for sustainable development of our economy and society." In 2010, the Central Government emphasised that, "Water is the source of life, the key element for production and the basis for ecology." These, and many other remarks from China's leaders, demonstrate the importance of water to China's future security and prosperity.

But regarding future sustainable economic and social development, water is still one of the constraining factors. Since the 1980s, when China implemented reform and an open policy to the outside world, the country has made significant progress in developing and allocating water resources, and in conservation, and protection. This has contributed greatly to social and economic development and people's well-being. But continued sustainable economic development is a major challenge. China is faced with a rapidly growing population, industrialisation, and urbanisation at a time when there are serious water shortages in some parts of the country. Water pollution is increasing and many aquatic ecosystems are in decline. The threat of climate change only increases this burden.

The paper describes the key water challenges facing China, the steps being taken to introduce a new stringent water resources management system, and the experiences so far in introducing this in an urban setting in Beijing.

This new approach demonstrates China's changes in approach from water supply management to water-demand management; from planning economic development as a priority to environmental protection; from cleaning up polluted water to prevention; from planning disorder to rational order; from over-exploiting water resources to improving efficient use; and from a 'silo' based water administration to an integrated approach with clear accountability.

1.1 China's water resources

China is rich in water resources and ranks sixth in the world in terms of volume. But the available water is only 2,100 m^3 per capita, less than one quarter of the world average, and water use efficiency and benefits are relatively low. The gross domestic product (GDP) output per cubic metre of water is only one third of the world average. Water resources are unevenly spread across the country making it difficult to locally balance supply and demand.

China's climate is diverse and dominated by the monsoonal system that brings wet summers and dry winters. The climate varies from cold temperate to tropical and rainfall patterns and amounts vary considerably across the country. Arid conditions persist in the north-west while the eastern region receives an average annual rainfall of between 500 mm and 1,500 mm. The 350 mm isohyet runs diagonally across the country from north-east to south-west. This marks the divide between predominantly rainfed farming in the south and east and irrigated farming in the north and west. Irrigation consumes some 65 percent of all water withdrawals. The

challenge facing planners is that water resources are not well matched with land resources and population. The Yangtze River, for example, provides 80 percent of the nation's water resources, but serves only 36 percent of the nation's land resources. North China has 60 percent of the national cropped area and 40 percent of the population, but only 20 percent of the nation's water resources.

Figure 1. Water resources regions in China

1.2 Water demand is exceeding supply

Recent water resource assessments show that average annual rainfall in four river basins – the Yellow River, Huai River, Hai River, and Liao River – has fallen by 6 percent and surface water flows are down by 17 percent. Indeed, the average annual flows in the Hai River are down by 40 percent. On average, annual water shortages across the country exceed 50 billion m^3 (Figure 2). Some two thirds of China's cities suffer water shortages to varying degrees. Some 15 million ha (230 million mu[1]) of farmland are damaged annually by drought. In the drier north of China, water abstraction now exceeds available water resources, groundwater levels are falling, and there are continuing reports of ecological and environmental damage. Water resources now present the most important obstacle to realising China's strategic objective of building a wealthy society through a process of sustainable development.

In 2008, China's water use reached 591 billion m^3 (Figure 3). The rate of growth in water use has slowed from 1.46 percent in the 1990s, to 0.6 percent in 2010. But there are concerns that water demand will continue to increase as the population peaks around 2030 and China continues to develop its fast-growing economy and moves towards further industrialisation and urbanisation.

[1] 1 ha = 15 mu

Figure 2. Current water shortages in China

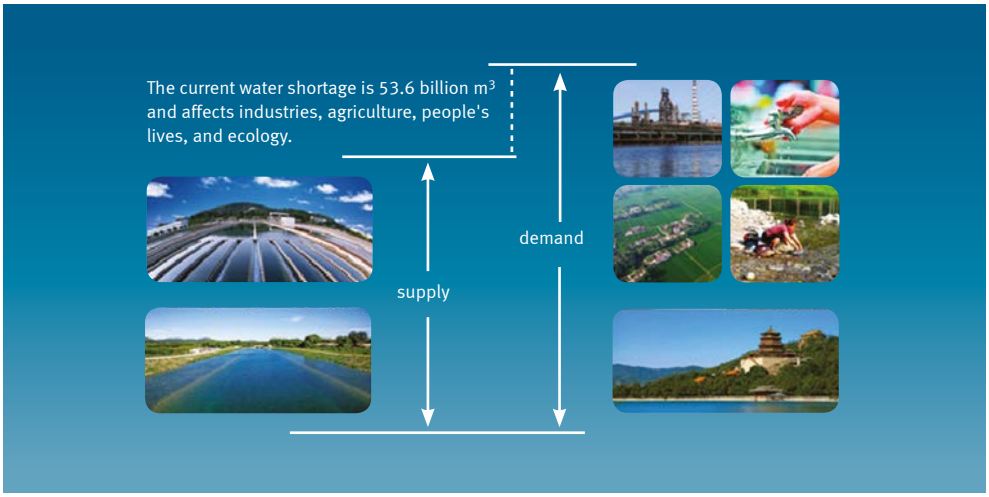
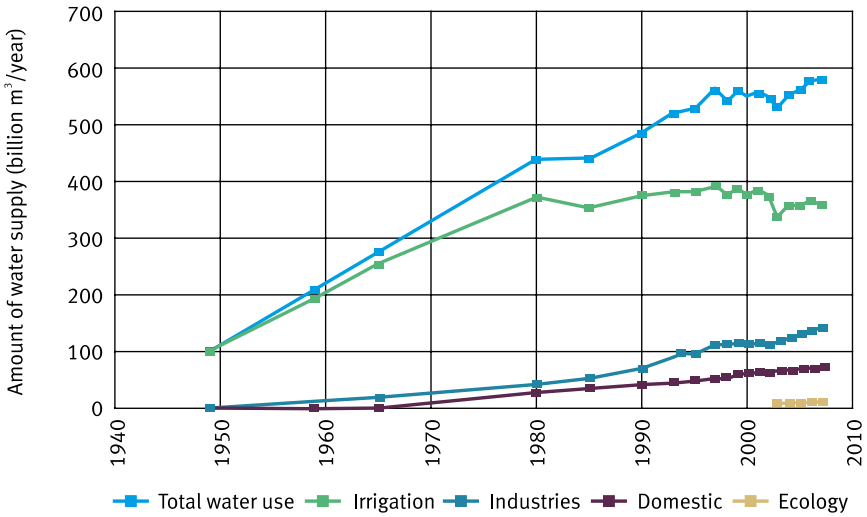


Figure 3. Increasing water use in China



1.3 More water needed for growth

China needs more water for continued economic growth. More products mean more water, but these must now be produced with fewer resources. In the past, water has not been used wisely in production and in people's daily lives. In China, water use efficiency and the benefits from water are low compared to those in developed countries. The value of industrial output from each cubic meter of water consumed is only one third of the world average and the GDP output from each cubic meter of water consumed is only one fifth of the world average. Water stress is intensified as untreated wastewater is discharged into water bodies causing pollution.

China's recent rapid economic development has been at a cost to the environment and has over-exploited resources. In some areas little attention was given to local water resources when planning economic and social developments. For example, in the water-scarce areas of north China high water use industries took a large proportion of the available water resources. Heavy industrial pollution occurred as a result of a lack of water-saving technologies and poor operation and management. Both domestic and industrial water treatment remains at a low level because of a lack of policy support, poor infrastructure for water treatment, and poor and ineffective water management.

1.4 More water needed for people

Water is an integral part of people's lives, health, and well-being and China needs to provide safe drinking water for both urban and rural populations. Yet in 2009, 203 million people in rural communities and nearly 100 million urban dwellers were unable to access safe drinking water because of water shortages or poor water quality. Water resources management must give priority to water supplies that directly affect people's lives and ensure their lawful rights to and interests in receiving reliable clean water.

1.5 Problems of efficiency and pollution control

Low water use efficiency is a common problem. Industry uses 108 m^3 to add US$1,600 (CNY10,000) in added value. Average irrigation efficiency across the country is only 48 percent. Leakage from pipe networks in many cities is above 20 percent, and industrial water reuse is only about 60 percent. This is far behind the level of developed countries and so there is considerable potential for increasing water use efficiency and reducing wastage.

The amount of wastewater discharged is increasing – in 2008 it reached almost 76 billion m^3. Poor effluent treatment capacity has led to severe pollution in rivers and lakes. Only 43 percent of water function zones[2] met national water quality standards. Over 19 percent of total river water was deemed inferior and unusable (Figure 4). Water pollution further aggravates water shortages and threatens drinking water safety and public health. At present, controlling water pollution is the most urgent and challenging task.

1.6 Ineffective water management

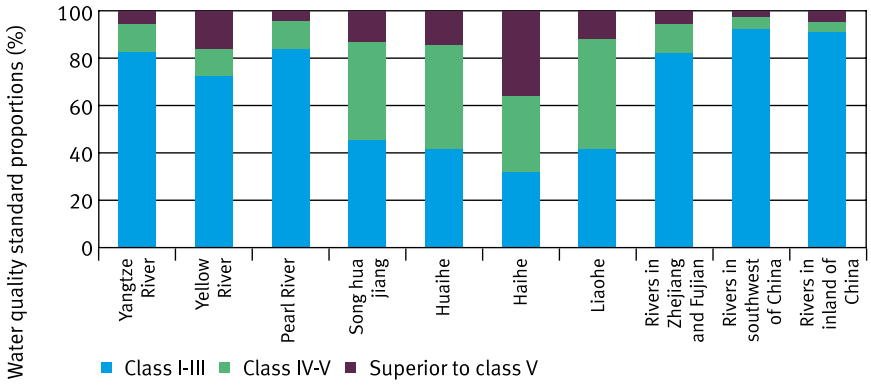
The reasons for ineffective water resources management are many. They include both the limitations set by natural hydrology and a lack of attention given to water conservation and protection. The latter stems from a lack of awareness in the past of the significant role that water resources management plays in economic and social development.

Poor water monitoring

China lacks an effective, modern, system for monitoring water resources, water use, and water quality. Nearly all provinces or municipalities have yet to complete their monitoring and assessment. Baseline monitoring for groundwater is established in some regions, but less than

[2] A water function zone is an appropriate natural water area within a river basin for managing water resources. Its main purpose is environmental quality management and water pollution control. This takes full account of the natural attributes of the water resource and its various uses in order to produce an appropriate and sustainable balance of economic, social, and environmental benefits.

Figure 4. Water quality in ten major water systems in 2011



half of China's cities have metering equipment to monitor abstractions from rivers. There is no water abstraction metering in rural areas where written cards are used to manage water use.

Few indicators are used to measure water quality and measuring is infrequent. Polluted water discharges are generally not monitored. Most provinces do not have data-based information systems for water management.

Poor water administration

China has an established legal framework for water management in line with its emerging market economy. This framework includes systems for water licensing, paying water resources fees, evaluating water resources, water function zoning, and monitoring polluted water discharges into rivers. However, a lack of effective water administration has meant that these systems are not well implemented. The result is that less than 30 percent of water resources fees are collected. Much water is abstracted illegally and abstractors are not penalised. Polluted water is also illegally discharged into water courses.

Lack of long-term funding for water management

Water resources management lacks long-term investment and this has led to low water use efficiency. The channel for fundraising for water management needs to be explored further. It is important to raise awareness of the importance of water management rather than focusing on water infrastructure, which is the conventional investment approach in China.

1.7 The need for reform

Over the past 20 years, China has completed legislation for water management reform, especially the revision and promotion of the Water Law in 2002 which covered every aspect of economic and social development. However, this has still to be effectively implemented.

1.8 Need for an integrated approach

China recognises the need for an integrated approach to water management, but is still seeking effective ways of achieving this in both urban-rural and regional development. Systems for allocating water are relatively weak in key social and economic development plans. In the rural sector, irrigated farming accounts for almost half the total cultivated area and 64 percent of all water withdrawals. It is vital for sustaining agricultural development, food security, and livelihoods in rural communities. This requirement is expected to grow in the future, but there are concerns that irrigation infrastructure is not sufficient to cope with the demands of a growing population and severe drought conditions. These occur regularly, not just in the drier regions, but also across the country. In the towns and cities, high priority is given to water requirements which speed up industrial and urban growth. Together these increasing and potentially conflicting water demands from the urban and rural sectors impose a heavy burden on water resources management and the need for integration to resolve conflicting demands when allocating water.

A number of regional development strategies and a series of master plans address the issue of integration. These include the Great Western Development, Rise of Central China, Eastern China Taking the Lead in Development, and Revitalisation of the Old Industrial Base of North-East China. Construction projects and infrastructure also improve water resources development, use, conservation, and protection.

Strengthening water resources management is seen as one of the most effective ways of achieving the right balance between water demand and water supply. Only by optimising water resource allocations and water conservation and protection, both locally and across the regions, can sustainable development strategies be effectively implemented.

1.9 A new approach to allocating water

Over the past 30 years China has implemented reforms towards a market economy. The success of this can be seen in the significant transformation that has taken place in the way that resources are now allocated. China has moved from a process that focused on planning resources allocation to a market-based approach, which now dominates how resources are used.

However, compared to the other sectors or industries, water resources management reform and water allocation lags behind and the market mechanism was not regarded as the main driver when allocating water. Water was seen as a public good rather than an economic good. This perception is now beginning to change and it is recognised that new steps are needed to reform water allocation mechanisms and property rights systems to fit more closely with the developing and maturing market economy. Water rights need to be defined and clarified and a system set up to manage them.

1.10 A strategy for managing water resources

To meet the water resources management challenge, in 2009, the government established a water resources management strategy that recognised the importance of water to China's future sustainable development and prosperity. It brought together past experiences and lessons learned and referred to good practices adopted in other sectors, such as the land administration department.

The strategy recognised that water resources must be at the heart of sustainable economic and social development. It must serve the whole country and be managed using scientific, evidence-based decision-making. It must improve people's well-being, emphasise water allocation, conservation, and protection, and take full account of measures to control both water quantity and quality. It included many issues such as:

- Water licensing
- Paying water resources fees
- Controlling pollution discharges into water bodies
- Appraising and approving plans for constructing water projects
- Using innovation and reform as driving forces
- Building capacity as a basis for implementing stringent water resources management systems.

By 2020, China expects to have a modern water resources management system that is compatible with the nation's goal of building an affluent and healthy society. The strategy has six main objectives:

Establish stringent water resources management

This includes monitoring and evaluation rules, regulations, technical norms, and standards for water resources management; water allocation and governance systems which focus on total quantity control; abstraction management and licensing; and water resources protection including water function zoning.

Establish and safeguard safe drinking water and industrial water use

By 2020 a safeguarding system will be in place to ensure high-quality drinking water is available for all urban and rural communities, together with a secured water supply to meet national demand for sustainable economic and social development.

Establish an effective water allocation and use system

By 2020 effective water allocation and use systems will be in place to limit water consumption to 670 billion $m^{3.}$ Industries will reduce their water use per US$1,600 (CNY10,000) of industrial added value. Irrigation efficiency will be above 55 percent and 2,670,000 ha of effectively irrigated areas will be increased during the twelfth five-year plan period (2011–2015) (see 'Three red lines').

Establish water resources protection

Water quality for major cities will be improved and over 80 percent of water function zones will comply with national water quality standards. Over-exploitation of groundwater will be controlled to ensure that aquifers recover. Ecological water demand for rivers will be secured and those rivers that have been severely damaged will be allowed to recover. Aquatic ecological degradation will be brought under control.

Establish capacity building and science and technology support

The institutions for water resources management will be improved to include water resources planning; wide application of information systems and modern technology; effective water

resources monitoring, metering, and data management; water regulation and emergency treatment; and statistical analysis and information dissemination.

Establish a secure system for water governance and management

River basin management will be coordinated and combined with government administration. Water management will integrate flood and waterlogging control, water supply and drainage, polluted water treatment and recycling. A coordination mechanism will be established among the various government departments and will include wider public participation in decision-making.

2 'Three red lines'

To support stringent and effective water resources management 'three red lines' will set limits on water use, water use efficiency, and water pollution up to 2015, 2020, and 2030 (Table 1). These set the boundaries which take account of available water resources and reflect the scale of economic and social development, and the level of social management.

Table 1. Future water planning targets

Targets	2015	2020	2030
Total water consumption must not exceed	635 billion m^3	670 billion m^3	700 billion m^3
Industries will reduce their water use per US$1,600 (CNY10,000) of industrial added value	30% below 2010 figures	65 m^3	40 m^3
Irrigation efficiency must exceed	53%	55%	60%
The number of water function zones complying with the water quality standard will be more than	60%	80%	95%
All sources of drinking water will meet set standards for both rural and urban areas		Yes	Yes
All water function zones will comply with water quality standards			Yes

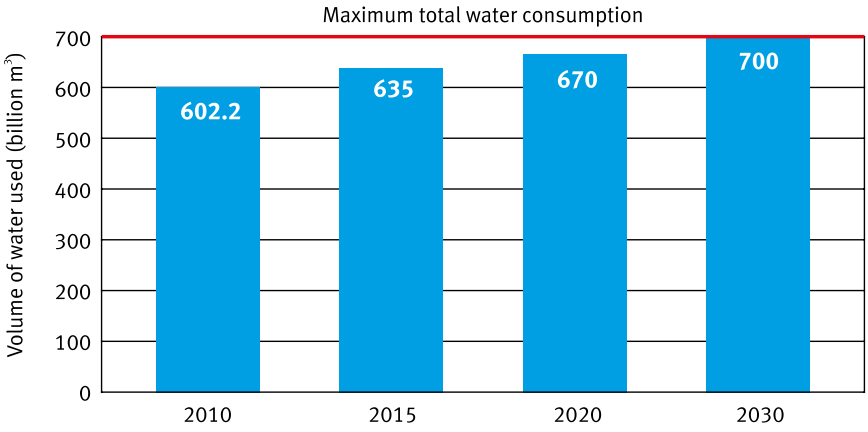
Five measures will be put in place to ensure the targets are achieved:

- Leadership will be strengthened to monitor performance, specify targets, and set up working systems
- Legislative systems will be refined to regulate water conservation
- Supervision and management among key water users will be strengthened
- Key pilot and demonstration projects will be implemented; these will include recycling industrial water, introducing and rehabilitating water-saving technologies, and publicising water-saving devices in cities
- The public will be educated so that water-saving becomes a cultural norm.

2.1 A 'red line' for total water use

This 'red line' reflects the total water available – both surface and groundwater – for all users in each river basin, province (autonomous region or municipality), city, and county (Figure 5). It sets the bearing capacity of water resources within which people can ensure sustainable economic and social development through rational and efficient water use. Thus, formulating this 'red line' is important for achieving harmony between economic and social development and available water resources. The red line will be defined at different administrative levels – river basin, province, city, and country.

Figure 5. Future control targets for total water use



In 2015 the total water demand across the country may reach 635 billion m^3 according to the China Water Resources Bulletin. This sets the water use limit for the whole nation. Plans for surface water and groundwater resources development and master plans will be developed and implemented to meet this demand. In 2020 the demand is expected to increase to 670 billion m^3 and in 2030 it may reach 700 billion m^3. Similarly, plans and projects will be implemented to meet these targets. Groundwater is expected to contribute 100 billion m^3.

The total permitted abstraction from river basins will be determined in accordance with the available water resources and the master plan and water allocation plan. A series of quotas will be used to control abstraction from specific rivers, lakes, and groundwater aquifers. These quotas provide a basis for approving and issuing water licences and will be used as administrative tools to limit water use. The quotas defined for river basins will be used in turn to determine the quotas at provincial, city and county levels.

Water allocation schemes in the master water resources plan will be used to control total water use. They will set upper limits for regional water use and allocation plans for rivers, and provide the legal basis for determining the total permitted abstraction.

Limiting water use within the scope of the total water use indicators will need close attention from water managers, who must approve annual indicators for water use control by building water inventories and placing restrictions on any planned increases.

New applications for water abstraction will be approved on an annual basis according to the local water use agreement; the water resources assessment based on water availability, including planned water development projects; and the water resources fees. Approval will also depend on an evaluation of water use efficiency, the extent of pollution control, the potential for water-saving, and water rights transfer. New applications for irrigation will only be granted for projects listed in the *National plan of 50 billion tonne of food grain*. New applications for increasing industrial water use will be limited to small increases and applicants will be encouraged to offset this increase by trading water rights. Increases in domestic water use will only be allowed if the demand is modest and cannot be avoided. All water-saving measures will be needed to limit the increase. New water abstractions will not be approved if they exceed the control index (the red line) for total water use.

Each water administration region will make an annual water abstraction plan in accordance with the control indicators plus a contingency for unplanned water use. Licences will be reduced if water is wasted and water-saving measures are not used. Strict controls will be placed on water licensing and water abstraction will be supervised and monitored using metering equipment.

Water resources assessments will all be subject to inspection and approval and must comply with the rules and regulations set and administered by the water administration department. If projects start without approval then orders will be issued to stop the work.

Planning will include both routine water demands for domestic, industrial, and ecological requirements, and also for emergency requirements.

Performance evaluation will be built into the management systems to ensure the control indicators are on the right track and being implemented by local government at all levels. Penalties and rewards will be used to encourage compliance and improvements.

2.2 A 'red line' for water use efficiency

The main target for water conservation is to increase water use efficiency. This will be measured in terms of water used by an area or enterprise, and also the level of eco-social development.

Two water use indicators set the 'red line' for efficiency (Table 1 and Figure 6). One indicator is the water used per US$1,600 (CNY10,000) industrial added value. This is applied to seven high water-consuming industries – thermal power generation, oil refining, steel and iron, textiles, paper making, chemistry, and food.

Industry target exceeded in Tianjin

Although targets were set for each province during the twelfth five-year plan period (2011–2015), in Tianjin Municipality the indictor has already exceeded this target and has reached that set by international standards of water practice. Starting from the thirteenth five-year plan period (2016–2020), different targets will be set for the different regions based on their potential for water saving.

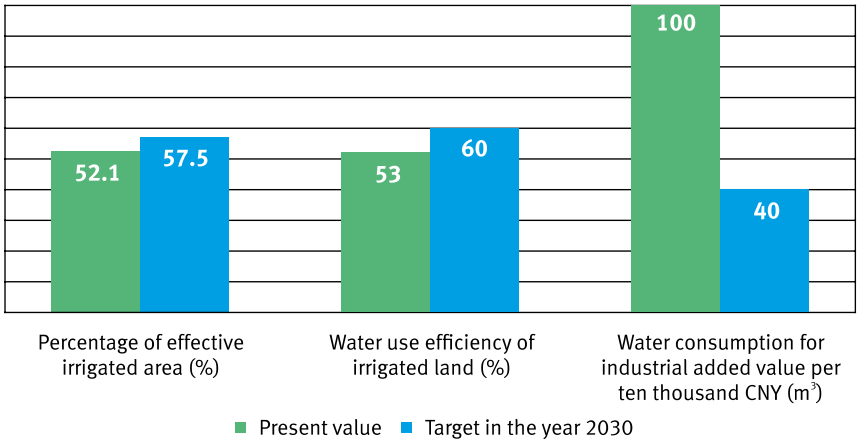
The second indicator is for irrigation efficiency (Table 1). In provinces which have not yet reached 52 percent, an increase of at least 3 percent is expected by 2015.

All water users are expected to take responsibility for applying the control indicators in their regions. Thus performance evaluation is a combination of national and self-evaluation. Local

chief officers in the provinces are responsible for monitoring and evaluating water use and for submitting their data to the national evaluation system. These returns are prepared annually and submitted to the Ministry of Water Resources (MWR). The MWR also will set up evaluation teams to conduct routine inspections to assess and audit what is happening in each province.

The system rewards those provinces that out-perform their targets and gives them priority for annual water abstractions and project investment approval. Those provinces that do not meet their targets are penalised by limiting new water abstraction construction projects and they will be asked about the measures they will take to get back on target.

Figure 6. Indicators of water use efficiency for 2030



2.3 A 'red line' for controlling pollution

The key index for pollution control is the proportion of the total number of water function zones of each river basin and province that reach the water quality standard (Table 1). In addition, a number of evaluation indicators are used to monitor the implementation of pollution control.

The State Council's *Regulations on implementation of a stringent water resources management system* set the targets for pollution control. By 2015 it is expected that 60 percent of the water will reach standard water quality. Technical indicators will be specified to help meet this target.

Water quality will be measured within the water function zones of major rivers and lakes as designated by and reported to the State Council for approval in:

- Major rivers and their main tributaries with catchments larger than 1,000 km^2, and water function zones along key rivers with large and medium reservoirs
- Lakes and reservoirs of national importance, including those with significant ecological conservation issues
- Protected water bodies of national significance, including centralised drinking water sources, national or provincial nature reserves, and sources of cross-basin water diversion
- Water bodies of major rivers or lake boundaries, including those within provincial boundaries, key estuaries, and transboundary rivers.

But the current monitoring capability cannot cover all these areas and so river basin organisations and water administration departments will consult and determine the water function zones to be included into the scope of the evaluation.

Two indicators, chemical oxygen demand (COD) (permanganate index) and ammonia nitrogen, were included for evaluation purposes in the eleventh five-year plan (1996–2010). For lakes, a nutrient salt parameter was added. More parameters may be added when monitoring capacity improves.

In 2008 an assessment of water function zones across the country showed that only 43 percent of measured water resources met the set standards. But there was significant variation from province to province and also within provinces. Over the following five years, this increased to 60 percent of measured water resources.

Additional performance indicators are being introduced to include drinking water safety and water ecology. These include:

- Annual bearing capacity of main pollutants (COD and ammonia nitrogen for rivers, and COD, ammonia nitrogen, total nitrogen and total phosphorus for lakes and reservoirs) and total amount of allowed pollutant discharge into major rivers and lakes of national significance including total point-source pollution.
- Indicators to assess drinking water sources of national significance. By 2015, it is expected that over 95 percent of the key drinking water sources listed in the national list will have been assessed. The indicators will assess:
  - the rate at which water resources are being safeguarded
  - the proportion of drinking water sources reaching the required standard
  - the safety of drinking water supply projects
  - vegetation cover in reserves of drinking water sources
  - monitoring capability
  - emergency response systems
  - performance of drinking water management institutions.
- Ecological water indicators for regulating major rivers and lakes of national significance. These indicators will:
  - evaluate compliance between observed runoff at control nodes on major rivers and planned ecological flows (ecological base flow and discharges for eco-environmental needs)
  - evaluate compliance of low water levels in major lakes with planned ecological water levels
  - evaluate the general health of major rivers and lakes.

Assessments will be conducted annually and reports sent to the MWR for regular systematic evaluation. MWR will conduct irregular audits and on-site inspections to validate the data they receive.

The provincial governments are responsible for limiting total pollutant discharges and the results will be used to evaluate the performance of local government leaders.

2.4 Main tasks

Effective policies, laws, and regulation are needed and must be implemented in order to develop an effective stringent water resources management system. This will require strong

supervision to enforce laws and 'red lines' which set boundaries and define optimum water allocation, water conservation, and protection.

The main tasks outlined in the water strategy include, control over total water use, improving water use efficiency, and controlling polluting discharges into rivers and lakes.

2.4.1 Controlling total water use

Controlling total water use requires careful planning and development, and strong regulation of abstractions from both surface and groundwater resources.

Planning and developing water resources

Water resources planning and development must take account of the main water using activities in a region and these must be integrated within the river basin so that available resources can be effectively exploited. All new developments that require additional water must demonstrate that they fit within the boundaries set by water resources managers, otherwise they cannot proceed. City master plans and major construction projects must take full account of local water resources including flood control.

Controlling abstraction

Controlling water abstraction will cover three administrative levels – province, city, and county. Each province, autonomous region, and municipality will be expected to establish an annual water use plan that takes account of both water resources availability and the rules and regulations governing abstraction. This will involve establishing a water rights system and introducing a water market including water rights trading.

Abstraction will be strictly controlled in basins that are already over-exploited, particularly when new developments are proposed and are liable to increase the demand for water. Projects that do not comply with national industrial policies or those not on the list of guidelines for supporting the national industrial structure will not be allowed to proceed.

Introducing water charges

All water withdrawals are subject to charges and these are expected to increase. The system for collecting fees will be strengthened and expanded so that all individuals and organisations will be expected to pay for the water they use. The fees will be used to conserve and protect water resources. Misappropriating water resources fees will be investigated and prosecuted according to the law.

Controlling groundwater abstraction

Groundwater resources will be strictly controlled and protected from pollution. Concerns about over-abstraction mean that new wells and boreholes for agriculture and industry will not be permitted in aquifers that are deemed to be fully exploited. Deep groundwater aquifers will be held as strategic reserves and for emergencies. Planning priority groundwater use will focus on vulnerable areas, such as the eastern route and middle route of the south-to-north water-diversion project (SNWD), land subsidence areas, and seawater intrusion areas.

Taking an integrated approach

River basin authorities and water administration departments will be expected to take an integrated approach to managing water regulation by formulating water resource regulation plans, including emergencies, in accordance with the law. Regional water resources regulation will need to integrate river basin regulation to include regional requirements for power generation, water supply, and navigation.

2.4.2 Improving water use efficiency

Various steps will need to be taken to improve water use efficiency.

Reinforcing efficient water use and management

Government, at all levels, will fulfil its responsibilities to build a water-saving society and encourage people to save water in all aspects of their economic and social activities. Water pricing can support this process as well as regulation, which limits use, particularly in water-scarce areas. In high water-consuming industries, priority will be given to water conservation. Water use for agriculture also needs strong controls.

Strengthening a quota management for water use

National standards for water use quotas are needed for all high water-consuming industries in line with the targets defined by the 'red line'. Water-saving measures will be introduced for all new construction projects and those which are expanded or rehabilitated.

Developing a conservation and water-saving culture

In order to improve irrigation efficiency, policies will promote a water-saving irrigation industry and improve technical service and financial allocation to subsidise pipes, sprinklers, and micro irrigation systems. Pilot projects for water saving in construction industries will be initiated with a focus on technical rehabilitation.

Compulsory standards will be introduced to provide authentication marks that identify water-efficient products. Products which do not meet the standards will be banned from sale.

2.4.3 Controlling pollution

Monitoring and managing water function zones

Monitoring and managing water function zones will be instigated to limit total pollutant discharges. Action is needed to:

- Control industrial water pollution
- Reduce all major pollutants
- Increase water sewage treatment in cities
- Improve the water environment of major river basins
- Prevent eutrophication of rivers and lakes.

The river basin authorities will strengthen water quality monitoring to rivers and lakes in provincial boundaries.

Protecting drinking water sources

Major drinking water sources will be developed and protected to ensure safe use. Polluting discharges will not be allowed in these protected areas. If discharge outlets already exist then closure notices will be issued. Diffuse pollution will be dealt with by erosion control measures and forest water conservation projects.

Protecting and restoring ecosystems

National plans are needed to protect and restore aquatic ecosystems, conserve major ecological protected zones, water source areas, rivers, and wetlands. An indicator system will be developed to evaluate and support this work and to create a mechanism for ecological compensation.

2.5 Guiding principles

The following principles will guide the tasks and the targets.

Public interest will be the main focus for water resources management. Putting people at the centre is at the core of the Scientific Development Concept[3]. Safeguarding the fundamental interests of the people is the essence of sustainable water resources management and the ultimate aim of water governance.

Harmony between people and nature is essential. Experiences, in China and elsewhere, show that conserving resources and protecting the ecological environment for 'green' mountains and 'blue' rivers can produce new competitive advantages.

Water resources management must integrate water allocation, conservation, and protection. Under the pressure of increasing water shortages and a worsening water environment, water resources management must ensure rational resource allocation and conservation, strengthen demand management, and build a water-saving and pollution-controlling society.

Water resources planning must be part of the comprehensive planning for sustainable economic growth and development. Achieving a balance between domestic, industrial, and ecological water demands in both urban and rural areas will be essential.

Water resources management is a national issue, but solutions lie in local actions that fit with local conditions. In areas where water use is reaching control limits, local action will be needed to bring this under control.

Given the increasing complexity of managing limited water resources with conflicting demands, the focus must be on reform and innovation in order to develop a water management model with Chinese characteristics. This includes setting up new management structures, consolidating scientific and technical support, updating management tools, and reforming institutions.

[3] Scientific Development Concept was a concept put forward by the Central Government in 2003 to ensure that economic and social development is based on good science.

3 What has been achieved so far?

3.1 Political and policy support

Political will, commitment, and policy support from the governments at different levels is essential for achieving effective water resources management. Both central and provincial governments have provided this support by developing a number of key policy documents.

Accelerating reform and development for the water sector: In early 2011, on-farm water infrastructure was still constraining agricultural development and food security. The Chinese government released this document as a policy directive, to emphasise the strategic importance of water resources development and to speed up water resources management reforms. It stated that "Water is the source of life, the essence of production, and the foundation of good ecology." It added, "Water development and management are the primary elements of modernised agricultural development, the basic foundation for economic and social development and the assuring system for bio-environmental improvement. It is of a strong public, fundamental, and strategic nature. Accelerating reform and development for the water sector is not only a matter of developing agriculture and rural areas, but also a matter of overall economic and social development; it is not only relevant to flood control, water security and food security, but also relevant to economic, ecological, and national security."

This document clearly stated that stringent water resources management will be based on the 'three red lines'. At the same time, it proposed a series of tough measures to ensure that resource use would also be within the 'red lines' and it placed full responsibility for managing and protecting water resources with the chief officers in local governments at county or higher level. It included strict rules, such as licences for water abstractions should be suspended if the total demand for water exceeds the control limits[4].

Guidelines on implementing the stringent water resources management system: In January 2012, the State Council issued this document which outlines the overall and specific arrangements for its implementation as well as providing guidelines, basic principles, goals and tasks, and managerial and securing measures, i.e. three 'red lines' and 'four systems'. The 'three red lines' are defined with specific measures, overall arrangement for tasks, management accountability, and performance evaluation. The 'four systems' include:

- A system for total water consumption control, which defines a 'red line' for water resources exploitation and use and control indicators for total water abstraction. This includes planning and identifying water resources that limit total water abstraction from river basins and regions, implementing water licensing systems, paying water resources fees, protecting groundwater, and strengthening the integrated allocation of water resources.
- A system for water efficiency control, which defines a 'red line' for increases in efficiency and promotes and builds a water-saving society and embeds water efficiency into the entire process of economic and social development.
- A system for controlling pollutant discharges which defines a 'red line' for pollutant-carrying limits of water function zones. It includes measures to improve the monitoring and supervision of water function zones, protection for drinking water sources, and protection and restoration of aquatic ecosystems.

[4] http://www.mwr.gov.cn/slzx/slyw/201101/t20110129_254162.html

- A responsibility and performance evaluation system for water management, which incorporates water development and use, conservation, and protection into the indicator list of comprehensive assessments for local economic and social development and for the chief officers of local governments[5].

Regulation on assessment for implementing a stringent water resources management system: In January 2013, the State Council issued this document to promote and effectively implement a system that would ensure the realisation of the main objectives of water resources development, use, conservation, and protection.

Each province, autonomous region, and municipality will be responsible for implementing the directive under the direction of the MWR. This would include mechanisms for evaluating the control of total water use, water use efficiency, pollution control in water function zones, and forming a responsible and effective system of accountability. An evaluation will be conducted every five years in parallel with the nation's five-year plan. The methods used and the reports will be published after approval by the State Council.

Work plan for the assessment of the stringent water resources management system: In February 2014, this document was jointly issued by ten Central Government departments – MWR, National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Land and Resources, Ministry of Environment Protection, Ministry of Housing and Urban-Rural Development, Ministry of Agriculture, National Audit Office, and Bureau of Statistics. The plan clearly sets out the evaluation organisation, procedure, contents, scoring, and results. It indicated that performance evaluation and accountability for the stringent water resources management system was now launched and being put into full practice.

Also, the ten departments formed a working group to take charge of organising and implementing the evaluation process for the 31 provinces, autonomous regions, and municipalities. The office of the working group is located in the MWR, which undertakes the routine work.

The plan sets out the targets and the evaluation process to meet the four main indicators of total water use, water use per US$1,600 (CNY10,000) industrial added value, irrigation efficiency, and the rate at which water quality is being brought up to standard.

The MWR, in consultation with other ministries in the working group, issues working notices on the annual evaluation and makes specific requirements to evaluate the work of the previous year. The provincial level government defines the annual targets and establishes working plans, organises self-evaluation and completes self-evaluation reports. The office of the working group then completes the annual and final evaluation report based on the results of the self-evaluation, and makes random inspections and checks.

The evaluations are placed in one of four categories – excellent, good, qualified, and unqualified.

Announcement of the evaluation results for implementing stringent water resources management: In September 2014 the MWR, on behalf of the ten organisations, set up a 'working group' to evaluate how well the new stringent water resources management systems

[5] http://www.mwr.gov.cn/zwzc/zcfg/jd/201204/t20120416_318845.html

were being implemented in 30 provinces, autonomous regions (except Xinjiang), and municipalities directly under the Central Government.

The results of this evaluation showed that all provinces reached satisfactory status while Jiangsu and Shandong provinces, Tianjin, and Shanghai were graded as excellent. The control targets were met. The total annual water use was 559.6 billion m^3. Water use per US$1,600 (CNY10,000) industrial added value was reduced by 24.4 percent compared to that in 2010. Irrigation efficiency rose to 52.4 percent, and the proportion of up to standard water function zones of major rivers and lakes was 63 percent. Publicising these data helps to raise awareness of the importance of water resources across the country.

Although this was a significant achievement, problems still exist in some parts of China. These include the need to take full account of water resources in economic development; deal with problems of aquatic environmental degradation; extend water conservation, protection, and management; reform water pricing; and improve metering and monitoring facilities[6].

3.2 Capacity building

Implementing stringent water resources management is a long-term strategic decision. It is not something that can be achieved quickly and it will require continuous efforts from various government agencies at all levels, especially the water administration departments. It will require increased capacity not just in terms of people and their professional and technical skill, but also the capacity of institutions to enable people to function effectively.

Improving water-related laws and regulations

Improving and implementing legislation and establishing legal systems are part of institutional capacity building. Over the years, China has gradually established a system of water-related laws and regulations that provide the legal foundation for stringent water management. In 1988, the Water Law of the People's Republic of China was published. This was the first legal document on water management to be enacted. It was revised in 2002. This document included all aspects of water management, allocation, conservation, and protection. A series of rules and regulations were developed from this document. These included *Rules for the regulation of the Yellow River water resources* and *Management regulation of water abstraction licences and water resources fee collection*, issued by the State Council. They also included ministerial regulations such as *Management methods for construction projects for water resources* and *Management methods for pollution discharge outlets to rivers*. Local ordinances on water resources management were also issued and implemented.

Special attention is now being given to supporting regulations for water conservation and water resources protection so that enforcement of the rules and regulations stipulated in the Water Law can become more effective and operational.

Legislation is also being developed to better control water abstracted from ponds and reservoirs owned by collectives. This is to ensure that farmers' rights and interests are protected when water rights are transferred to others or the purpose and use of water is changed. The success of legislation lies in enforcement. For this reason the principle of "the law must be observed and strictly enforced, and law-breakers must be prosecuted" will be applied in all matters concerning water resources.

[6] http://www.mwr.gov.cn/zwzc/tzgg/tzgs/201409/t20140929_575404.html

Reforming and integrating institutions

The amended Water Law of 2002 clearly stipulated that the main function of water resources management is to combine river basin management with administrative regional management so that together they can provide an integrated approach to water resources management.

Integration is seen as essential for managing both urban and rural affairs, water source construction, flood control, water abstraction, water supply, water use, water conservation, drainage, and sewage treatment and reuse. It is a means of providing strong leadership in water governance and management.

In September 2002, the State Council issued *Guidelines for the implementation of institutional reform in the water project management system* in order to promote institutional reform. The process began with pilot projects in a number of cities before extending this to the whole country. In 2015, some 1,740 (70 percent) of the total administrative regions at and above county level (provinces, cities or counties), established new water affairs authorities. Their role is to integrate all water-related management activities in both urban and rural areas into one organisation. Their function is to harmonise and integrate water resources management by integrating river basins with administrative regions, urban and rural areas, and water development and use with conservation and protection. This will be achieved by reinforcing the managerial and supervisory functions of water administration departments and integrating urban and rural water management.

While integration is important, so too is the proper division of responsibilities and duties between river basin organisations and provincial water resources departments. A system has now been gradually created that defines the responsibilities between the government and enterprises and between public services and government agencies. It clarifies the duties and functions, but is operated in a coordinated manner. This provides a solid foundation for implementing robust water resources management.

Building an effective water management system

Water resources management is seen as a social process as well as a technical and institutional one. It includes public utilities for water development and services and individual water users. In order to implement the new system the government and water administration departments are shifting their focus on water development towards conservation and protection. They are adjusting the economic growth pattern and industrial structures through strict governance, and providing guidance for social behaviour towards water use where there are many complex and serious problems that need tackling. The system must be able to solve current problems and withstand the rapid development of water undertakings by using reasonable water pricing mechanisms and including democratic and public participation.

The government plans to create a pricing system that fully reflects water scarcity, complies with the rules of a market economy, has an overall consideration of both social bearing capacity and justice, and benefits water conservation and the sustainable use of water resources. The collection of water resources fees will be adjusted in order to reach a balance between the water tariff and the ability to pay. Reform of agricultural water tariffs are also planned by blocking high consumption and providing open competition among high-consumption industries. A water rights system will be created to promote rational water allocation and effectively protect water resources.

Public participation will form part of the process of policy-making and project development and management. This will ensure that government and water developers and users fulfil their own duties and prevent administrative departments and developers from pursuing their own short-term economic interests.

Since the 1990s, China has encouraged public participation in irrigation management in local irrigation districts, and has gained valuable experience from this. Since 2005, farmers' water user associations (WUAs) have gradually become established. WUAs are authorised to make applications to construct various small water works for irrigation and drainage. Once these structures are completed, WUAs own the properties and are responsible for maintenance and repair.

Long-term, stable investment mechanism

Water resources fee collection has become one of the main financial sources for future water development. But some problems are emerging in collecting these fees that require strong supervision and management and, in turn, this will limit the finance available for development.

One problem is the limited information available on water use because of the lack of metering and monitoring equipment, which in turn constrains the process of good water management. Few water users have metering facilities, which makes it difficult for government to monitor use and charge fees for water use. The shortage of funds has meant that it has not been possible to take advantage of modern information technology for data collection, analysis, and fee collection.

For long-term stable water investment, funding needs to change from a single source of financing to one where several sources contribute. These would include water fee collection and private sector investment with guarantees from the government budget. Only by doing this can water management become the priority of government and the main concern of both the general public and water resources managers.

It is the government's responsibility to educate and train competent staff and provide sufficient funds to secure working expenses. Effective water resources management relies on staff working in water administration departments who fulfil their duties to integrate water resources management. To be effective managers and administrators, further improvements are needed to build capable and competent staff.

Scientific and technical support

Currently, science and technical support for water resources are focused on the impacts of global climate change on eco-social development, sustainable water resources development, and aquatic ecosystem protection. Research and development is focused on optimising water allocation, advanced water-saving technologies, water resources protection, ecosystem restoration, and exploiting unconventional water sources. Technical norms and standards continue to be refined for water resources protection, groundwater management, and to encourage wise water use.

In future more attention will be paid to high-technology applications for water resources forecasting, prediction, and early warning for problems such as droughts and floods.

3.3 Accountability and evaluation

China has established a target-oriented responsibility system as part of the strategy for water resources management. Setting responsibilities and evaluating performance is one of the innovative approaches taken to enable government to regulate the behaviour of working staff and make sure that government agencies fulfil their responsibilities. The government's chief officers at and above the county level assume overall responsibility for managing and protecting water resources. The State Council checks and inspects each province, autonomous region, and municipality using appropriate indicators. The MWR is the organisation responsible for organising and implementing this process of accountability and submits the results to the department in charge of high-ranking officials.

One of the main reasons for past failures in water resources management was that the system was unable to trace those responsible for the actions taken. The new accountability system now ensures that statutory responsibilities are fulfilled. Embodied in this system is the principle that "power comes with responsibility and the execution of power must be supervised." This system is now enshrined in law and in the regulations. The Constitution of the People's Republic of China asserts that water resources are owned by the State and the ownership of water resources are exercised by the State Council on behalf of the whole people. The Water Law clearly stipulates the functions and duties of local government agencies, water administration departments, and river basin authorities. The Water Law empowers the various levels of government to act as the representatives of public interests in their respective regions and to take responsibility for managing water, the water administration department, and river basin organisations. All communities and individuals are regarded as stakeholders and the Water Law specifies the obligation of all organisations and individuals to conserve water resources and protect water infrastructure. However, in reality there are areas where law enforcement is still weak.

The established responsibility system includes:

- The government, which has overall responsibility for water resources management and represents the public interest in their respective regions. The chief officers of the government assume overall responsibility for water development and conservation in their administrative regions.
- The water administration departments, which ensure high water use efficiency and promote integrated water development and conservation.
- Other relevant administrative departments, which exercise duties in line with their assigned responsibilities.

There are appropriate departments responsible for environmental protection and pollution control, controlling industrial pollution violations, introducing modern water-saving practices, providing guidance to farmers on water conservation and cropping, organising performance evaluations, and enforcing the law.

Enterprises and individuals who have legal rights to use water also have responsibilities for saving and protecting water resources.

3.4 Monitoring water resources

In 2011, No.1 Document from the Central Government states that, "The capability to monitor water quantity and quality should be strengthened so as to provide technical support for monitoring and supervision." In 2012, No.3 Document from the State Council also makes requirements for "perfecting the water monitoring system; building water quantity and quality monitoring capabilities in key control sections, water function zones, and groundwater aquifers; constructing metering and monitoring facilities for water abstraction, drainage, and outlets discharging pollutants into rivers and lakes; and accelerating construction of the national water resources management system and gradually establishing a platform of water resources monitoring at central, river basin, and local levels."

At present, there is no monitoring equipment at some key control sections at provincial boundaries of rivers and lakes, groundwater monitoring networks are not complete, and metering devices are not installed for irrigation water use. Thus it is difficult to get accurate information on water abstraction and use, and it is not possible to fully meet the requirement of being "able to operate, inspect, and easily evaluate with reward and punishment".

In order to improve this situation, in 2012, the MWR and Ministry of Finance initiated a national programme to build a more robust water resources monitoring system. According to the plan, the first three-year phase started in 2012 to establish three monitoring systems for key water users in order to build a platform for national water resources monitoring and management that comprises one central platform, seven river basin platforms, and 32 provincial platforms. The main tasks included:

- Strengthening water quantity and quality monitoring and inspection at major cross-sections and giving priority to the monitoring of cross-sections at provincial boundaries, city and county boundaries, water sources and groundwater monitoring networks
- Installing metering equipment for water use and conducting real-time monitoring for nationally significant water users and laying a solid foundation for achieving target improvements in water use efficiency
- Designing a water management information system that standardises data and statistics and disseminates information.

3.5 Pilot projects

In 2010, pilot projects were set up to gain experience in adopting the reforms. Pilots were selected in four provinces – Jiangsu, Shandong, Hebei, and Zhejiang; three municipalities at provincial level – Shanghai, Tianjin, and Beijing; and three at river basin, city, and country level – Han River Basin, Zhangjiagang City, and Yongkang City. In each pilot area actions were taken in line with local conditions.

In Shandong Province, the framework for water resources management under the guidance of *Management methods of Shandong Province for the control of total water use* was established. Water abstraction is now under strict management. Water resources assessment is now applied to all new construction projects within the pipe network. Water resources fees are collected by means of differential pricing that allows higher charges for water use above quotas. The control targets for water quality in the water function zones of 17 cities are defined on a yearly basis. The indicators of water management were included in the province's overall evaluation system. Implementing stringent water resources management is now one of the main components of internally evaluating water-related organisations.

In Hebei Province an incentive system for water conservation – 'increasing water tariff with subsidies' – was widely applied to encourage water saving in agriculture. The implementation plan and technical solutions being completed, a chief officer responsible for the system was appointed. Indicators for water resources management were incorporated into the comprehensive assessment system of the municipal government. An accountability system was set up and applied to evaluate groundwater exploitation and water resources fees collection. Responsibility for approving pollutant discharge outlets was transferred to lower levels of management.

In Shanghai Municipality, surface water is managed at both municipal and district levels and groundwater is managed at the municipal level. Water resources assessment was formally introduced into the procedures for administrative approval of plans. Guidelines on the *Evaluation report on water-saving facilities for a construction project in Shanghai (trial)* were disseminated. Approvals of newly-constructed/expanded/rehabilitated projects now depend on including water-saving facilities. Regulations on *Drinking water source protection in Shanghai Municipality* were issued. The construction of a pipe network for sewage treatment plants was accelerated and river courses improved. More than 85 percent of the sewage is now treated. An information platform was set up at the municipal level that integrates data for meteorological, ocean, maritime affairs, hydrological, water resources, water supply, and drainage – the first in China.

In Tianjin Municipality, following a water resources assessment, 10 industrial areas were established with a preference given to those using recycled water and desalination as part of the management plan. A 'three-level water-saving management network' was established involving both government and businesses. This included appointing a chief officer responsible for managing water resources and the aquatic eco-environment and setting up a licensing system for groundwater abstraction which is now widely adopted. (See also Box 1).

In the Han River Basin, a pilot project coordinating group was established in the Yangtze Water Resources Commission. The *Implementation plan for pilot programmes for strong water resources management in Han River Basin* was completed with specific working arrangements and an annual work plan. Indicators of total water use were established for each province, including the main control sections in accordance with the annual target. Zhuxi County was selected as the pilot for implementing stringent water resources management in the basin.

In Zhangjiagang City, *Detailed regulations on water resources management* was issued. Groundwater abstraction is now controlled both by total quantity and water level. Licences were introduced to limit groundwater abstraction using heat pumps. The approach of 'making payment first and then using water' is now widely adopted. Enterprises using more than 1 million m^3 of water annually now use water-efficient technologies. The targets for water quality improvements are listed in the evaluation criteria in advanced districts or townships in rural areas.

In Yongkang City, the tasks and indicators for improving water resources management are now embedded in the relevant departments to enable annual performance evaluation. The project of building 'waterside in the middle of Zhejiang Province' plans to connect rivers with ponds and reservoirs. Water is managed by professional staff in the village. Sewage systems were built in cities, townships, and villages. The Centre for Drinking Water Testing was formed. The city provides information on water quality at river cross-sections in townships and districts and along the street by publishing bulletins on a regular basis. A section chief was appointed to be responsible for managing major rivers.

Box 1. Implementing stringent water resources management in Tianjin Municipality

Tianjin municipality was suffering from water shortages with only 1.57 billion m^3 available annually. Per capita annual water available is only 123 m^3, one seventeenth of the national average. Annual groundwater abstraction was 0.6 billion m^3 and 35 percent of the deeper aquifers were over-exploited. Water consumption per US$1,600 (CNY10,000) industrial added value was 9 m^3 and irrigation efficiency has reached 65 percent. But there is room for improvement. Water pollution is serious and only 21 percent of the water function zones of major rivers and lakes comply with the national standard. Ecological water needs cannot be fully secured. Water problems have become the main constraint for sustainable eco-social development in the city and it is imperative to implement stringent water resources management.

Being one of the first set of pilot programmes, Tianjin promoted a *Work plan and evaluation methods for implementing stringent water resources management* under the guidelines of the MWR. Following approval of the plan, a solid foundation was built by establishing a framework for implementing stringent water resources management.

The pilot plan had six parts, including guiding thoughts and basic principles, objectives, tasks, implementation progress, securing measures, evaluation, and checking and acceptance. Targets were defined using the principle of 'focusing on people, persisting with the scientific approach, harmony between people and water and reform and innovation'. In 2015, depending on the water from water-diversion projects, such as the SNWD, total water use will be limited to 2.75 billion m^3. Water use per US$1,600 (CNY10,000) industrial added value will be reduced by 25 percent compared to that in 2010. Irrigation efficiency will increase to 66.4 percent. The proportion of up to standard water function zones of major rivers and lakes will be increased to 27 percent and water quality in water function zones in the protected area will reach 100 percent.

The following measures were introduced to meet the targets:

- Strict control over total water use, including building the total water use index system, water resources assessment, licensing system and paying water resources fees, and the stringent groundwater protection and management
- Increase in water use efficiency, including water-saving management mechanisms, planned water use, creating an environment for water conservation, water saving by industries, and strict monitoring of key water users
- Control of pollution in water function zones and pollutants discharged into rivers, including five tasks – monitoring water function zones, monitoring pollutant discharge outlets, urban sewage and wastewater treatment and supervision, protection of drinking water sources, and ecological restoration of major rivers and lakes
- Build capability for water resources monitoring, including further construction of water management systems, enhancing abilities for monitoring water abstraction and use, monitoring main water function zones and pollutant discharge outlets, increasing capacity to survey and monitor gauging, metering facilities, and statistics
- Establish an evaluation system and appoint a chief officer responsible for water management, implement inspection and evaluation system and annual evaluation.

According to the pilot plan, all preparation work was completed by the end of 2012. All tasks were completed in 2013–2014, including an annual evaluation and interim appraisal system. All the evaluation work will be completed by the first half of 2015 ready for checking and acceptance by the MWR.

3.6 Integrated urban water management in Beijing

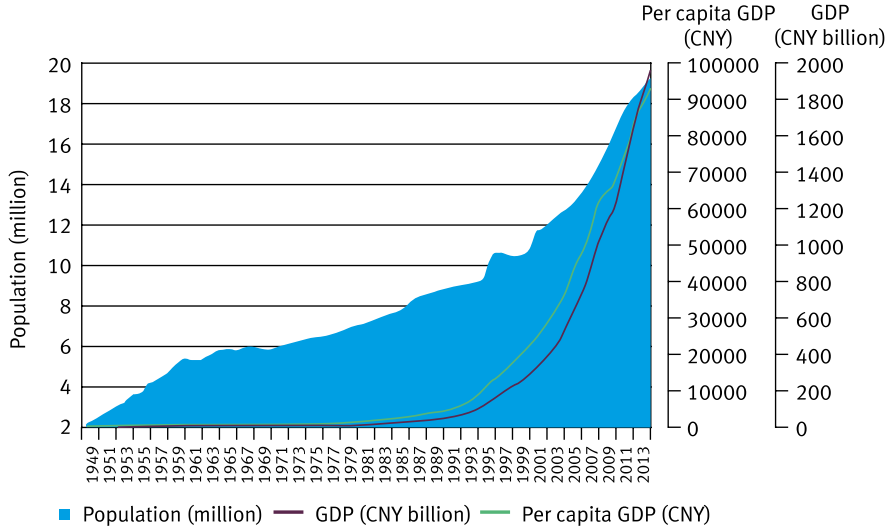
Beijing provides an interesting case study which demonstrates China's experience in changing water resources management policies and practices towards integrated urban water management (IUWM) (Bahri, 2012). Beijing is a typical water-scarce megacity in a rapidly developing country. The growth in urban population has led to a water crisis in both quantity

and quality and the imperative was to apply the principles of integrated water resources management specifically to urban areas.

Water resources and socio-economic development

Beijing lies in the Hai River Basin, a region with serious water shortages. The basin covers 3.3 percent of China's land area while annual water resources are only 1.3 percent of the national total (WRPB, 2014). Per capita water resources available over the past 10 years were less than one tenth of the national average. Increasing prosperity and development (Figure 7) has led to serious conflicts in matching water supply and demand. The urban population has risen from 1.79 million in 1949 to 18.25 million in 2013. Agriculture as a proportion of GDP has declined from 23 percent to less than 1 percent over the same period. Industrial contribution to GDP also decreased from a peak of 71 percent in 1978 to 22 percent in 2013.

Figure 7. Beijing population, GDP, and per capita GDP (1949–2013)



Source: BMBS, 2014.

Beijing's water resources have also seen significant changes (Figure 8). Periodic changes in wet and dry years show that total water availability is gradually decreasing. Despite rapid growth, the annual total water demand for the city has actually declined from 4.0 billion m^3 in the 1980s and 1990s to 3.5 billion m^3 in the 2000s. But over the past 30 years water demand has always exceeded the available water resources, which has led to groundwater aquifers being over-exploited.

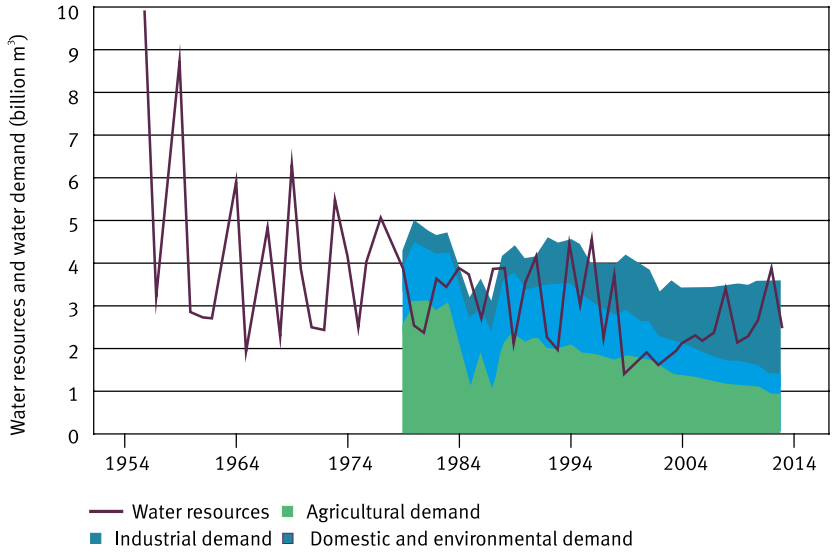
Transition towards IUWM

Beijing began tackling water supply and urban flooding issues after the Commission of Development and Reform was formed in 1949. Major urban streams and channels were dredged and the Guanting Reservoir was constructed beginning in 1951. In 1953, the first draft development plan pledged to make Beijing the political, economic, and cultural centre of China

as well as a powerful industrial base and a science and technology centre. The shortage of water was acknowledged and solutions were proposed which favoured industrial development (Dong, 2006). The *Preliminary master plan for Beijing's urban development*, formulated in 1957, emphasised Beijing's strategy to develop industries and ambitious plans were proposed to augment the water supply. Between 1958 and 1965 various water projects were implemented.

These included the Ming Tombs Reservoir, Huairou Reservoir, Miyun Reservoir, and the Jingmi Diversion Canal connecting the Miyun Reservoir with the city. During this period, treated sewage effluent was advocated for irrigation and two wastewater treatment plants – Jiuxianqiao and Gaobeidian – with primary treatment processes were built. However, their treatment capacity was soon overwhelmed by fast urban development, and this situation remained unchanged until the 1980s. At this time water resources management focused mainly on providing water for the fast-growing population and economy. It was not until a severe drought hit the area in 1965 that measures on water conservation and water pricing were adopted.

Figure 8. Water resources (1956–2013) and water use in Beijing (1979–2013)



Sources: Gao and Fu, 1992 and Wu and Zhang, 2005 (for water resources). BWCHR, 2000 (for water use).

Since the 1960s, inflows into the Guanting Reservoir, one of the major surface water sources of Beijing, has significantly declined. To compensate for this, groundwater was exploited to supplement the water supply. In the 1970s, this caused dramatic falls in groundwater levels, land subsidence, and water quality problems. Surface water pollution increased – including water in the Guanting Reservoir – and this added to the problems of water scarcity. In response to another severe drought in 1972, the *Report of several issues in the master plan for Beijing's urban development* affirmed these challenges and proposed a portfolio of measures, including population control. A water supply task force was set up for Beijing, Tianjin, and Hebei provinces. The task force included top leaders from the three provincial governments and relevant ministries of the Central Government, such as the State Development Planning Commission, the State Construction Commission, and MWR and Electric Power. The task force adopted the principles of integrating water resources development and water conservation for resolving water supply problems.

In the 1980s there was a radical shift in urban development policy when Central Government issued a directive on the guiding principles for restructuring and relocating urban industries, population control, and introducing integrated water resources development, conservation, and protection. In 1983, the *Master plan for Beijing's urban development* set out a detailed plan for achieving this.

The plans were implemented during the sixth and seventh five-year plans (1981–1985 and 1986–1990). In 1987, reusing treated wastewater became mandatory for new hotel and public utility projects. In 1991, a water conservation strategy was implemented to build Beijing into a water-efficient city using the *Guidelines for the ten-year layout and the eighth five-year plan (1991–1995) for Beijing's national economy and social development. The Master plan for the city of Beijing (1991–2010)* stressed the need to integrate surface water and groundwater management. This included using storm water and reservoir discharges to recharge groundwater and giving consideration to the middle route of the SNWD as an option to close the gap between water demand and water supply in the long term. The plan also proposed integrating engineering and non-engineering measures to manage urban flooding, including reducing impervious areas, and using green spaces and depressions to store storm water. This was the beginning of IWUM practice in the city and it brought together a diverse range of water sources.

The *Guidelines for the tenth five-year plan (2001–2005) for Beijing's national economy and social development*, issued in 2001, recalled Beijing's goal to develop a water-efficient city, and adopted the principle of tailoring urban development to water availability. The guidelines also included proposals for using artificial rainfall and storm water retention. The latest *Master plan for the city of Beijing (2004–2020)* published in 2005 followed all those existing principles and measures for water resources management. In 2006, the *Guidelines for the eleventh five-year plan (2006-2010) for Beijing's national economy and social development* pledged to implement the strictest water resources management with a combination of instruments, including strong administration, laws, economy, technology, engineering, and education. Seawater desalination was also put on the agenda as a strategic technology reserve and research on its cost, safety, environmental impact, and distribution systems was included in the eleventh five-year plan. Seawater desalination and deep groundwater use were both listed as strategic technology reserves in Beijing's twelfth five-year plan period (2011–2015) published in 2011. Underground reservoirs and a reserve system for water resources security were also proposed.

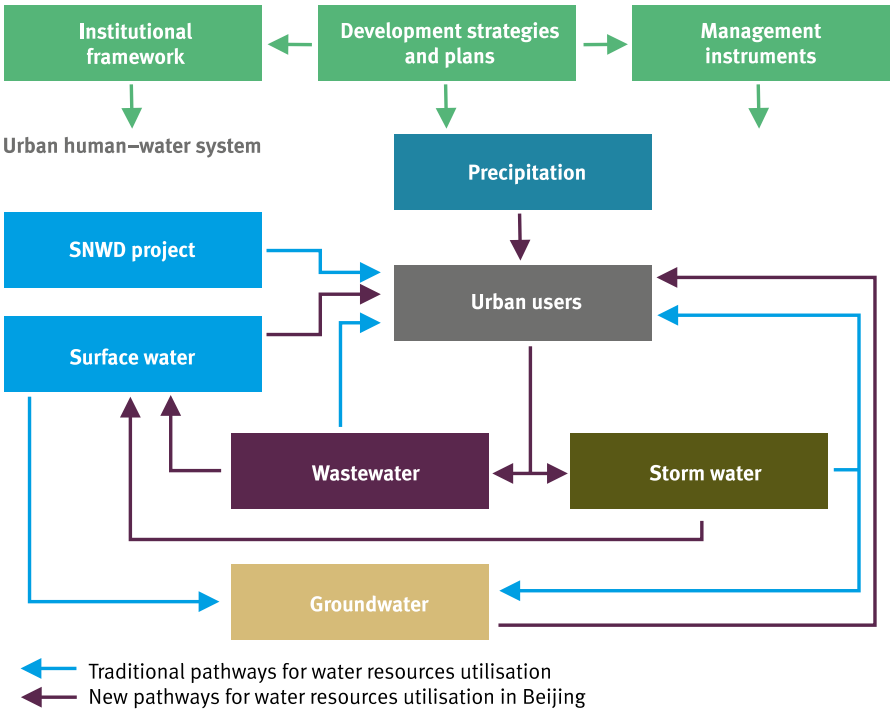
Beijing's IUWM Scheme

Beijing has now established the necessary enabling environment, institutional framework, and management instruments to manage urban water resources systems in a sustainable and integrated manner (Figure 9).

The political significance of Beijing's water issues were always discussed and tackled at the national level and this mechanism facilitated cooperation among local governments in this region and ministries of the Central Government. In 1981 leaders from Beijing, Tianjin, Hebei, Henan, and Shandong Provinces, and state ministries, decided that Guanting Reservoir and Miyun Reservoir would stop supplying water to Tianjin and Hebei and serve only Beijing. At that same meeting Beijing and Tianjin were required to integrate surface and groundwater management and urban flood defences.

In 2001, a high-level coordination task force for sustainable water use into the early 21st century was established, led by the MWR and joined by the local governments of Beijing, Hebei, and Shanxi Provinces, and five state ministries.

Figure 9. Beijing's scheme of integrated urban water management



In addition to this national level cooperation and coordination, institutions were reformed to enable efficient and effective water resources management. Beijing's Water Resources Commission (WRC) was established in 1982 and re-established in 2000 in response to the continuing droughts since the late 1990s. Its mission was to examine and make decisions on key policies for water resources development, use, protection, and conservation, and to coordinate water management in districts and counties, sectors and industries. In 2004 the Beijing Water Authority (BWA) was established and has now replaced the WRC, which was decommissioned in 2009. The BWA was established in response to the *Plan for the sustainable utilisation of water resources in Beijing in the early 21st century (2001–2005)* issued in 2001. BWA is now responsible for all water resources planning and management, the survey of water and wastewater industries, water conservation, management and protection of urban rivers, reservoirs, lakes, and dikes.

Limiting urban water use

In the 1980s, China began regulating population growth and industrial development in Beijing. In 1992 this was enshrined in the local law, the *Urban planning regulation of Beijing*. Although controlling population growth was challenging, both this and regulating industrial growth has contributed to the decline in water use (Figure 8). Jia et al. (2004) demonstrated that industrial restructuring was more effective in reducing water use than introducing new technologies. In order to guide industrial investment, the Beijing Municipal Commission of Development and Reform (BMCDR) issued catalogues – one which listed water-saving equipment and another which highlighted high water-demand processes that were restricted or prohibited in Beijing from 2004.

Since the 1980s water conservation has been rigorously promoted among all sectors. In 1981 the *Interim regulation on groundwater resources management in Beijing*, was issued which required all new projects to include water conservation facilities. In 2014, water-saving devices, promoted by government regulation, reached 100 percent coverage among public institutions and 95 percent among households.

Economic instruments have long been adopted to encourage water conservation. Water fees were introduced in the 1960s, but they remained unchanged until 1983. Nowadays, the price of water tends to be adjusted more frequently, given the increasing water scarcity, serious pollution, and rising operational costs. For instance, Beijing's water price was adjusted five times in the 1990s and six times in the 2000s.

Together, all these measures have helped Beijing's total water demand to remain well below its 1980 level even though the population has more than doubled.

Exploiting new sources

Since the 1970s, developing new water sources has always been an important focus for Beijing, but equally important is protecting existing sources. In 1972 the *Interim regulation on the management of water projects in Beijing* prohibited the discharge of untreated hazardous wastewater, which did not comply with the required quality, into surface water bodies. In 1981 the *Interim regulation on groundwater resources management in Beijing* restricted new wells in over-exploited areas and encouraged artificial groundwater recharge. Recently, local laws, such as the *Regulation on water pollution control in Beijing* and the *Regulation on the protection and management of surface water bodies*, were produced to further protect water resources. In 2014 a regional penalty mechanism was introduced to protect the water environment. This means that monetary penalties apply for districts and counties when they fail to meet wastewater treatment objectives and water quality objectives at transboundary monitoring sections.

In 2002, the government launched the SNWD to mitigate water scarcity across north China. The middle route project (MRP) for the SNWD, started in 2003 with water transfers from Danjiangkou Reservoir on the Han River, a tributary of the Yangtze River, to Beijing and Tianjin. This will supply 1.2 billion m^3 of water to Beijing annually. Although the MRP only began operating in December 2014 the Beijing-Shijiazhuang reach has already diverted more than 1.6 billion m^3 of water from Hebei Province to Beijing. This is expected to curb groundwater depletion across the city.

Re-using wastewater

Wastewater treatment started in the 1950s with just primary treatment. In the 1990s, secondary and more advanced wastewater treatment developed rapidly and by 2013 over 84 percent of wastewater was treated. According to the *Twelfth five-year plan for Beijing's water resources protection and utilisation*, 90 percent of wastewater is expected to be treated. In the six central districts it should reach 98 percent by 2015. Increasingly stringent industrial discharge standards, such as *the Discharge standard of water pollutants for municipal wastewater treatment plants* (DB 11/890–2012), and wastewater treatment plants have come on-stream.

In 1987, wastewater reuse was first required in new hotels covering more than 20,000 m^2 and in new public buildings of more than 30,000 m^2. Since 2001, large-scale, centralised wastewater reuse, based on upgrading treatment processes in existing plants, has developed rapidly since the publication of the *Guidelines of the master plan for wastewater reuse in the wastewater*

treatment plants in the central areas of Beijing. In 2008, for the first time, reclaimed wastewater (17 percent) contributed more to Beijing's total water demand than surface water (13 percent). In 2013, reclaimed wastewater increased to 803 million m^3 (22 percent) of total annual water use.

In 2003 the price of reclaimed wastewater was fixed at CNY1/m^3 and has remained unchanged. This provides an obvious price advantage compared to the standard residential water price of CNY5/m^3 (Zhou et al., 2009). In 2014, the BMCDR changed the pricing policy for reclaimed wastewater by setting a price ceiling of CNY3.5/m^3.

Making use of storm water

There is a long tradition in the city of diverting storm water flows away from urban developments and into low-lying areas outside the city to avoid flood damage. But such ideas are now being reviewed. In areas of acute water scarcity, flood water is increasingly seen as a potential water resource to be captured and exploited. The challenge is how to do this without causing damage. In 1991 the *Regulation on water resources management in Beijing* proposed using storm water to recharge groundwater. In the past decade many demonstration storm water retention projects were implemented and a series of regulations and technical guidelines developed. In 2000, the *Provisions on water conservation in Beijing* required public utilities to build storm water collection and use facilities and encourage households and other buildings to do so. In 2003 the *Interim regulation of promoting rainstorm water resources utilisation in project construction areas* required storm water use facilities to be designed, built, and operated simultaneously as an integral part of any new urban development. The principle was that there should be no increase in runoff into the environment as a result of the project.

Beijing also issued two local standards – the Specification for construction and acceptance for water permeable brick pavements (DB 11/T 686–2009) in 2009 and the Code for the design of storm water management and harvesting engineering (DB 11/T 685–2013) in 2013. In 2012, new regulations included the Notice of strengthening the planning and management of rainwater utilisation projects, and the Technical essentials of rainstorm water control and utilisation in new construction projects (trial). In 2013 the Notice of further promoting urban rainwater control and utilisation was issued. Up to 2010, 1,355 rainwater use projects were completed resulting in an additional 50 million m^3 of water being made available annually (Zhang et al., 2011).

3.7 Guidance for future developments

In 2014, the MWR issued *Guidelines for accelerating development and reform in the water sector* in order to facilitate decision-making on water development and reform.

These guidelines set out the pathway to further develop the various levels of responsibility and accountability for water management. The 'three red lines' with control indicators and monitoring systems need to be fully implemented at provincial, city, and county levels.

To date the leverage role of a water pricing system in water resources allocation and conservation has yet to play a full part in transforming the pattern of economic development while taking account of the need for effective aquatic ecosystem protection. The guidelines set out the pathway to improve the water rights system and pricing mechanisms, which include the decisive role that both the market and government play in water management.

The water rights system needs to include a register of water use rights that shows clear ownership and obligations, which are then effectively monitored and managed. A water licensing system needs to be established which provides certificated water licences to users and confirms water use rights.

Water rights trading also needs to be established, with pilot projects to encourage the transfer of water rights between regions and water users. Water markets need to be established for trading at national, river basin, and regional levels.

4 Conclusions

This paper has described China's approach to developing a new, stringent water resources management system that puts water as the first priority in the drive for sustainable economic and social development. It is a system which is 'fit for purpose' and provides the right balance between the bearing capacity of the water resources, aquatic ecosystems and environmental safety, and the water needs for economic and social development. It is an innovative approach which is enabling China to adapt to the growing concerns over future water availability and is in contrast to past water management practices.

Stringent water resources management focuses on:

- Both water supply and water demand management, as solutions must bring these two into balance. It places emphasis on increasing water use efficiency and protection, and constrains irrational water demand.
- Changes in planning that shift the priority from commercial development needs to considerations of water development, conservation, and protection. When plans are made the principles are 'conservation first, then water diversion; control pollution first, then water conveyance; and environmental protection first, then water use'.
- A change from tackling pollution problems after they occur to one of preventing them occurring in the first place. Effective monitoring will be needed to prevent pollution and aquatic ecosystem damage.
- Changing development from irrational water allocation to reasonable and orderly water exploitation and management. This means dealing with the relationship between development and conservation in the interests of all stakeholders.
- Changing patterns of water use from extensive use to efficient use. The impetus is to establish a water-saving society which values water conservation and rational exploitation.
- Changing managerial tools to those that encourage an integrated approach to water resources management which coordinates economic, social, and environmental water needs in a sustainable manner.

This new approach will put more emphasis on:

- Sustainable development
- A coordinated systems approach to water management
- Specific targets with clearly defined 'red lines' on total water use, efficiency, and pollution control
- Management tools to help achieve key targets
- Accountability and clear responsibilities for water users and for those who manage water resources at all levels in government.

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