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Water Resource Supply Security Strategy Analysis

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1 Strategic Analysis for Water Resource Security

The Strategic Analysis for Water Resource Supply Security outlined in this report has been developed to provide a structured approach to deliver the challenging requirements of the China 2011 No.1 Document on "Accelerating Water Conservancy Reform and Development" (No.1 Document). The report draws together water resource planning experience from both China and from the EU to set out a strategic approach to how these challenges can be met.

For many centuries management of water has been a recurring priority for successive Chinese administrations. This has been achieved through policy and administrative instruments such as water drawing permits and water allocations, combined with the construction of infrastructure at all scales from the river basin down to local schemes. The No.1 Document introduces a possible break with this tradition by specifying the introduction of differential water prices.

1.1 Key messages

For water resource supply security, **a change to a proactive risk management approach to water resource planning should be adopted**, rather than the more reactive approach that currently is followed. In addition, drought management responses should be based on robust and up-to-date knowledge of the status of available water resources, so that any reductions in water allocations for the duration of the drought are proportionate and recognise the relative priorities of each sector.

The general trend in international strategic water resource planning has been to move towards more risk management approaches, recognising fluctuations in hydrological conditions, rather than a more reactive approach dealing with the issues when they occur. The concept of drought risk management is based on the knowledge that drought will recur, that its characteristics will vary in time and space from droughts previously experienced, that preparation for managing droughts is based on robust and up-to-date knowledge of the status of available water resources and future demands (both in the short and long-term), and that administrative mechanisms are available to implement the necessary actions.

The principles behind the proposed strategy are:

- To move from a reactive to a pro-active approach to water management in those years with drier than average conditions. This will reduce exposure and hence vulnerability to drier than average conditions

- To develop an effective knowledge base of robust hydrological, groundwater and meteorological data, combined with analytical tools to support strategic planning and when necessary drought management responses

- To provide clear targets of water use efficiency against which the performance of the major water users can be monitored and challenged

- A competent authority will be identified to initiate the necessary administrative and regulatory changes, to monitor performance against water drawing right conditions and targets, and to take disciplinary action where necessary and warranted.

- Moving from the current position of separate technical studies into a coherent and integrated water resources planning strategy that can be delivered in practice requires a mixture of further technical analysis building on existing work combined with institutional and other administrative changes. At present there are different agencies at national, river basin, and provincial level with responsibilities and interests in the water resources sector. Each has a very different sphere of responsibility and capability to influence decision making. MWR, for example, has the leading role in water planning, particularly for surface waters, whereas the management of groundwater also falls under the Ministry of Land and Resources.

- The following chapters set out possible approaches to water resource planning that could be followed in China to help delivery of the water supply security objectives of the No.1 Document in a timely and effective manner. These approaches are drawn from European experience in delivering the requirements of the WFD. Priorities for action are identified, together with possible pilot projects to test and ground truth the proposed approaches drawn from European experience, so that these can be adapted to be appropriate for conditions in China.

1.2 EU Water Framework Directive (WFD)

The Water Framework Directive (WFD) brings together earlier, piecemeal water legislation from across the European Member State. It provides the framework that allows for integrated and co-ordinated management of all waters through:

- management of water on a river basin basis, requiring commensurate management of land as it affects water and water dependent habitats

- a combined approach for the control of pollution, setting emissions limit values and water quality objectives

- the development of ecological objectives

- a risk based approach to protection and restoration of aquatic environments

- an adequate contribution of the different water users, particularly households, industry and agriculture, to the recovery of the costs of water services

- encouraging active involvement of all interested parties in water management.

Each of the EU Member States has approached implementation of the WFD from a different starting point, both in terms of pre-existing regulatory and administrative arrangements, the structure and ownership of water utilities, and the scientific and technical background of the organisations with interests in hydrology, groundwater and water management. The individual approaches taken have been informed by the Common Implementation Strategy, which through a series of pilot studies and other investigations over time has developed a series of agreed scientifically based methodologies for analysis and interpretation. These methodologies continue to evolve over time, drawing on the experience of the first round of River Basin Management Planning.

It is envisaged that a similar programme of research and development, tested in a number of pilot studies is required to ensure a co-ordinated and cost-effective approach to implementation of the No.1 Document.

1.3 Situation in China

There is an extensive body of technical and planning work related to water resources available both in China through MWR, DRC and the academic sector, and also internationally through the European Union, World Bank, Asian Development Bank, DfID, and other funding agencies. This work provides a solid foundation for the new approach to planning for water resource security that is required to meet the objectives of the No.1 Document. In terms of water resource security, these objectives are enshrined in the first two of the Three Red Lines strategy to water resources protection outlined by MWR:

- The first red line sets **water quantity** objectives in rivers, lakes and groundwater. It requires the "total quantity control of water abstraction"

- The second red line sets objectives for **water use efficiency**. This will accelerate the development of national standards regarding water use quotas for high water consumption industries and the service industry. It is only through the aggressive promotion of water efficiency that increases in demand can be kept to the levels set in the No.1 Document, namely less than 630 billion m^3 in 2015 and 670 billion m^3 by 2020 (Article 4).

- The third red line sets maximum permissible **pollution load** for Water Functional Zones, which are catchments, reaches of rivers or lakes that must meet specific water quality standards.

The recurring theme from the range of reports on China's water resources, of which the ADB report "Drying Up – What to do about droughts in the People's Republic of China" (April 2012) is the most recent example, is the change in emphasis from supply-side options to address an increasing imbalance between available supplies and forecast demands towards demand-side options requiring much more effective use of water to be achieved through a range of administrative, financial and technical water management tools.

The research undertaken for the SKE have also highlighted the opportunity for more transparent assessment of the water resources available not only under average, but also under more extreme conditions. The research has also identified the need to assess and quantify uncertainty in calculations of water resource availability to better understand the risk to supply security. This would facilitate a

more robust approach to water allocations, and decisions about cut-backs in allocations at times of drought. Such water resource assessments are also needed for setting discharge standards and environmental flow objectives, so the strategic approach to water resource security set out in this paper needs to be viewed in the context of the approach set out in the report on Water Ecological Security (RBMP Technical Reports 077 and 078).

2 Technical Approach

The key elements that are required before a risk-based approach to water resource security during drought can be successfully implemented are:

- Evaluation of current water resource availability (both surface water and groundwater), and its variability in both space and time
- Evaluation of current water demands, including water use efficiency and wastage
- Forecasts of future demands and sensitivity to different water use efficiency assumptions
- Real-time monitoring of water resources
- Water allocations that take account of the relative priorities of each sector

2.1 Assessment of water resource availability

The fundamental requirement for any water resource plan is a robust assessment of the water resources that are available once environmental requirements have been met for abstraction and/or diversion to sustain economic and social well-being.

Whilst assessments for a whole river basin can provide useful macro-level statistics, such averages can hide smaller areas, which in China can be far upstream, that are characterized by very high water insecurity. Choosing the appropriate spatial unit for analysis, interpretation and dissemination of the outputs is an urgent initial priority. Under the WFD River Basin Districts are the main units for management of River Basins. It may be that the Water Function Zones (WFZ) is the appropriate unit for China.

Assessments of water resource availability using historically observed data are required for both surface water and groundwater sources under:

- Annual, wet season and dry season under average conditions
- Annual, wet season and dry season under dry season conditions with a return period of say 1 in 10 years.

The potential impact of climate change on these assessments also needs to be assessed by scenario analysis.

2.1.1 Surface water

Current hydrological analysis used to determine water resource availability in China use standard hydrological techniques to assess the water available at different probabilities. In contrast, it appears that current water allocations are based on average conditions and therefore will tend to be too high for every second year, when hydrological conditions are drier than the “normal” year. In such circumstances, that may not be classified as drought years, some form of rationing and/or cutting back on water allocations may be required to prevent unsustainable levels of abstraction.

The hydrological analysis also appears to be based on a relatively short period of observed flow data – for example the average statistics quoted in Table 1-3 of the 2011 China Water Statistical Yearbook are calculated for the period 1956 to 1979. Note that the 2002 National Integrated Water Resources Plan used data for the period from 1956 to 2000, however, the statistics in the yearbook do not appear to have been updated accordingly.

Future work on surface water availability to underpin delivery of the two first red lines of the No.1 Document should therefore comprise:

- Delineation of zones to be used for water resources assessment and planning, whether by river basin, tributary and lake catchments or Water Functional Zones
- Providing water resource availability assessments for a number of different design conditions, for example based on the 1 in 10 year annual average, wet season and dry season flows, and use these, rather than the average conditions, for water allocation analyses
- Water resource availability assessments for different spatial areas within each river basin
- Assessment of the vulnerability of these assessments to climate change
- Incorporation of results into a water resource GIS into which other water and environmental parameters and indexes can be incorporated.

2.1.2 Groundwater

Many reports highlight that China’s groundwater resources, especially in Northern China, are becoming severely depleted as shown by a decline in groundwater levels and poorer water quality. It appears that groundwater abstraction often exceeds recharge rates, and in some areas it is non-renewable fossil groundwater that is being abstracted.

Various academic papers (see RBMP Technical Report 075 for more details) suggest that China’s groundwater resources are the subject of continuing technical and academic research, but the interpretation of the results and their integration into strategic water resource planning is not apparent.

Groundwater reacts slowly to inter-annual changes in rainfall and recharge and is therefore a valuable strategic resource available to balance demands in years of water shortage or even drought, but it follows that these periods must be followed by periods with low abstraction to enable recovery of the groundwater levels.

Future work on groundwater to underpin delivery of the first two red lines of the No.1 Document should therefore comprise:

- Confirmation of the spatial extent and boundaries of the main aquifer units, both those being actively recharged and those with no current recharge
- Estimates of annual average recharge to the main aquifer units, under a range of rainfall conditions, for example average, 1 in 10 year, etc
- Estimates of annual average recharge under different future climates
- Identify areas of shallow aquifers with surface outcrop with actual or potential use as flood detention basins that could serve the dual purpose of flood control and groundwater recharge basins
- Areas with physical characteristics amenable for groundwater recharge schemes
- Development of GIS application to hold time varying and spatial data on groundwater levels, groundwater quality, and overall abstraction.

2.2 Water requirements

Demand forecasts are required by different organisations for a range of policy, strategic and operational purposes. The end use of the forecast will determine the spatial scale of the analysis, the number of different categories of demand (for example domestic, industrial, service etc.) and the time horizon over which the forecast is calculated.

For the development of the Water Resources Security Strategy estimates of current and future water demands, including the returns to the water environment for non-consumptive uses, are needed for the following main categories of use:

- Public water supply; both urban and rural
- Environmental flows to be maintained downstream of points of abstraction
- Irrigated agriculture, both large-scale (predominately through diversions of surface water) and for small-scale local schemes often supplied from groundwater
- Direct abstractions for industry, not supplied from public water supplies
- Hydropower
- Navigation.

The type of high-level demand forecast model appropriate for strategic water resource planning needs to be able to take account of different assumptions about growth, unit water consumption (for example per capita consumption and consumption per unit of industrial output), cropped areas and water efficiency targets. Estimates of the actual consumptive use, and hence of the volumes returned to the water environment through wastewater treatment plants and/or direct discharge are also required.

The models also need to be based on agreed spatial scales (for example Water Function Zones) which can then be aggregated to give forecasts at Provincial and River Basin scale. Further details of the required functionality of such a model are given in RBMP Technical Report 075.

The requirements for environmental flows are discussed in the reports on ecological security (RBMP Technical Reports 077 and 078) and the requirements for navigation and hydropower fall outside the scope of this element of the project.

2.3 Planning water resource allocations

The approach to planning water resource allocations is one of the main aspects of water resource planning, where there are significant differences between current practices in the EU and in China.

The approach in Europe has evolved in the different Member States over many years and is now enshrined in the WFD. The WFD requires that abstractions should only be permitted at the level that does not cause the water body to fail the objectives set for the water body. A database of river flow at the selected assessment points (typically the downstream point of each River Basin District) is created and the natural flows estimated, that is the flows unaffected by upstream abstractions and/or discharges. Such a database typically comprises historic data and also data considered to take account of future uncertainties such as the impact of climate change.

The environmental flow requirements at each assessment point are then calculated in a separate exercise. In order to protect the water environment during drier than average years, estimates of the flow required to maintain targeted environmental objectives are required. The volume of water available for abstraction is then the difference between the total water resources available and the environmental flow. This is then compared against the total licensed volume of the existing abstraction licences (in China called “water-drawing permits”) and the volumes abstracted in recent years. If the aggregate permitted abstractions exceed the water available for abstraction, then this indicates that measures are required to reduce the total permitted quantity.

The current approach in China is to assign water allocations on the basis of conditions of average water resources availability. This means that almost every second year, there is insufficient water available to meet all the allocations in full, so some degree of rationing will be required.

To increase water supply security for all water users, the water allocations should be made on the basis of the water resources available with a return period of 1 in 10 years, with priority users such as households being secured at higher return periods, for instance 1 in 50 years.

2.4 Economic analysis

In the past, water resource planning has tended to rely on the construction of new infrastructure to meet increasing demands. Building supply-side infrastructure to meet unconstrained demands is no longer considered to be sustainable. In recognition of this move towards demand-side measures, the No 1 Document sets out certain high-level targets for water use efficiency. The costs and benefits of achieving these targets will be different for the different commercial and industrial sectors, and also in different regions.

This will require setting priorities for water use, with environmental requirements and urban water supply given the highest priority, followed by the industrial and agricultural sectors, with water use within each sector ranked according to the economic value of water in its competing uses.

In order to set appropriate priorities, a different approach to economic analysis, water pricing and allocations is required to provide a robust basis for planning as well as for operational responses to drought conditions as and when they do occur. The approach comprises:

- An increased use of appropriate economic assessment tools to improve the decisions to be taken, since these complement existing decision support tools
- A more coherent approach to water pricing that considers cost recovery of all water services, incentives to save water, environmental and water scarcity externality costs, and the price elasticities of water demand at the sectoral and regional scales
- The revenues from pricing as a significant source for financing of water infrastructure.

Economics is a cross-cutting theme with links across the Three Red Lines of the No.1 Document, so the appropriate use of economic assessments to evaluate and compare alternative strategic options is important for all three. For water resource security, demand management is crucial and the use of water pricing should be considered as one of the elements of water demand management.

2.5 Uncertainties and risks

Drought and floods are natural occurrences. The magnitude of both types of these extreme events can to some extent be mitigated by risk management, which includes elements of forecasting and pro-active responses to events as they develop. Whilst pro-active flood management is now the norm in China, water resource management in years with less than average rainfall and particularly in drought conditions is much more reactive. This type of response to events is no longer tenable especially given the recent shift in balance between rural and urban populations in China.

This means that the impacts of drought no longer have a disproportional impact on rural areas which are more reliant on local water resources and rain-fed agriculture. The increasing scarcity of water resources is leading to increased competition for supplies. At present, water allocations appear to be based on average conditions, which means that the total water allocation will be greater than the available supplies in year with below average rainfall or other adverse climatic conditions.

So there is increasing pressure for the development and implementation of robust and transparent water allocation processes that are based not only on “normal” hydrological conditions but also a hierarchy from slightly drier than average conditions to extreme drought. Such variability will be enhanced by the impacts of climate change

3 Priority for Action

The No.1 Document and the EU Water Framework Directive have much in common though are characterised by important differences in the administrative and legal context of China, the EU as a whole and each of its Member States. One important common element is that the changes required to deliver the objectives of the No.1 Document on the one hand and the WFD on the other will take time to implement consistently across all river basins.

Experience suggests that a stepwise approach can be very effective to allow the technical methodologies to be properly developed, tested and where necessary refined in pilot project, before they are rolled-out on a countrywide basis. For some specific projects, it may be that an approach already has been tested by one of the River Basin Commissions, in which case the pilot study would focus on adaptation of this approach. For other pilot projects appropriate approaches will need to be developed from scratch, drawing on existing Chinese and EU experience and best practice.

3.1 Urgent Initial Improvement during the 12th FYP (2012-2015)

The focus of this phase will be to integrate the water resource, demand forecast and water allocation activities currently being undertaken by different Government Departments, Provincial Authorities, and other agencies. This will require:

- Updated assessments of water resource availability using consistent approaches across all China, covering both surface and groundwater systems
- Assessing the risk to long-term water resource availability under different climate change futures
- Construction of high-level demand forecasts for the key sectors with clearly defined assumptions on water use efficiencies
- Development and pilot testing of economic assessment tools
- Assessment of the absolute costs and benefits of achieving water use efficiencies
- Development of water charging schemes and incentives for water drawing permits
- New water allocations based on the water resources available in the 1 in 10 dry year
- Integrate water resource security strategy with other strategic aims

- Design of a decision support tool to inform water allocations, drought responses and disaster responses
- Design of pilot projects to be implemented during Phase 2 to develop and test the operational response to drought.

In addition to these quantitative elements of water planning, the risk to drinking water supplies needs to be addressed through the country-wide adoption of Water Safety Plans.

3.2 Medium term improvement during the 13th FYP (2016-2020)

In the medium term (2016-2020) the following actions could be taken:

- Implement the water allocation and drought management decision support system in pilot catchments
- Implement new charging scheme for water drawing permits across China
- Monitor effectiveness of intervention options
- Update intervention options as required in the light of experience from the Pilot Studies.

3.3 Fulfilment of the No.1 Document objectives during the 14th and 15th FYP 2021- 2030

In the long-term the following should be considered:

- Review the strategy for Water Resource Security in the context of the other technical strategies, refine where necessary and develop new programme for monitoring and regulation
- Update and refine where necessary underlying water resource assessments
- Test observed water body status against targets to identify quantity and/or quality measures to achieve compliance
- Review and update where necessary water use efficiency targets.