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MSWRMS-LAB: A TOOL OF WATER RESOURCES MANAGEMENT IN CHINA

BY ZONGZHI WANG, LIANG CHENG, KELIN LIU & XIA HU

The Chinese government came up with the Most Stringent Water Resources Management System (MSWRMS) in 2011 in order to realize sustainable water resources utilization and support sustainable social and economy development. The core of the system is the 'Three Red Lines' which set control targets on four key management indicators, including total water use, industrial water use per ten thousand Chinese Yuan, irrigation efficiency and the percentage of water functional zones complying with the water quality standards up to 2015, 2020, and 2030, designed to set limits on water use, water use efficiency and water pollution.

MSWRMS is a new approach in Chinese water resources management. Issues including the dynamic change and interannual variability of management indicators with socioeconomic development and water resource, the feedback between indicators, setting dynamic annual management target, changing water use behavior and adjusting industrial structure to fulfil control target must be addressed in the MSWRMS implementation. The Most Stringent Water Resources Management System Lab (for short MSWRMS-Lab) is an effective tool that supports addressing the above issues.

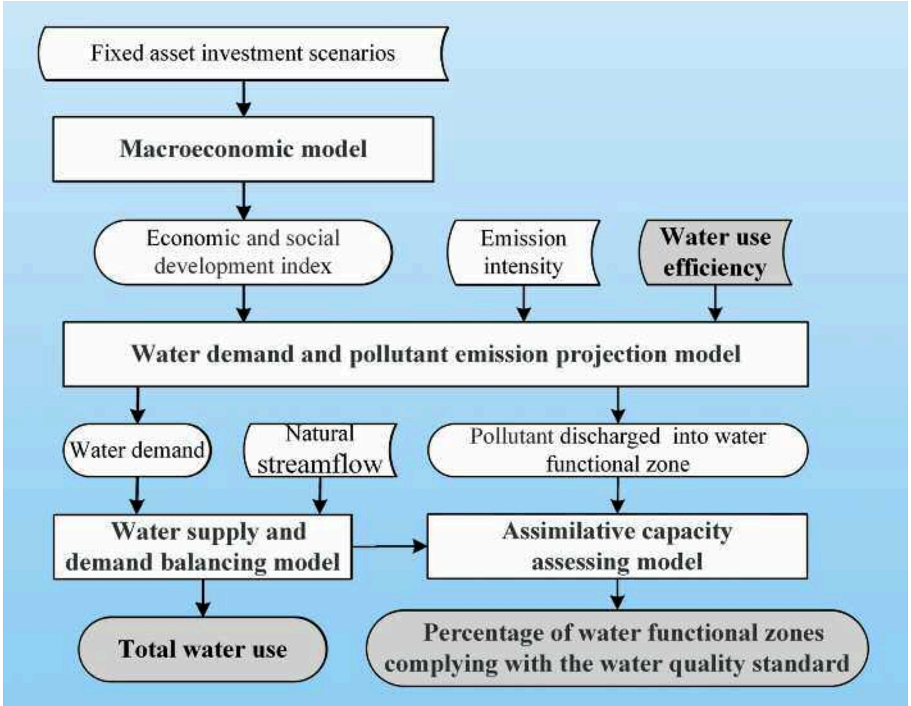

Figure 1. Components of MSWRMS-Lab

Principle and function of MSWRMS-Lab

The MSWRMS-Lab tool consists of four models, including a regional macroeconomic model, a water demand and pollutant emission projection model, a water supply and demand balancing model at basin scale, and a model estimating the percentage of water functional zones complying with the water quality standard, as shown in Figure 1. The macroeconomic model is mainly used to simulate and predict the economic and social development index including industrial added value, urbanization rate, population, income of urban and rural residents under different fixed asset investment scenarios. Water demand for each region and pollutant discharges into each water functional zone is projected by the water demand and pollutant emission projection model using the forecasted economic and social development index. The total water use of each region is determined by balancing water supply and demand and water allocation between different users. The pollutants discharged into a water functional zone include pollutants transmitted from upstream zones which are in excess of its assimilative capacity and pollutants discharged within its own corresponding water demand region. When pollutants are less than the corresponding assimilative capacity, then the water functional zone is complying with the water quality standards. We have built the MSWRMS-Lab in the Shandong province and the Beijiang river basins by using browser/server (B/S) software architecture.

The main interface of the MSWRMS-Lab application in Shandong province is shown in Figure 2. This lab has many functions, such as system simulation, scenario prediction, dynamic regulation and implementation evaluation. The lab supported the development of dynamic annual management targets for Shandong province and the assessment of whether the control targets of the 'Three Red Lines' for each city of the Shandong province were met at the end of 2015 and 2016.

MSWRMS-LabApplication 1: simulating dynamic change of management indicators

Using the model system, we can simulate how management indicators change with socioeconomic development accounting for the inter-

Figure 2. Main interface of MSWRMS-Lab in Shandong province

annual variability of precipitation. The feedback between management indicators can be simulated too. Figure 3 shows how the total water demand and total water use of Shandong province in 2015 varies with three different socioeconomic scenarios and the exceedance frequency of annual precipitation. The Gross Domestic Product (GDP) and the irrigated area of the Business as Usual (BAU) scenario was forecasted based on the trend of the fixed asset investment during 2011～2014, while the fixed asset investment of low or high development scenario was 20% smaller or larger than the BAU scenario. The exceedance frequency of annual precipitation was based on the annual precipitation from 1956 to 2000. The total water demand increases with the frequency the level of socioeconomic development in terms of the GDP and the irrigated area as shown in Figure 3. In wet years, water demand can be guaranteed and total water use increases with the frequency and the level of socioeconomic development up to a point. Beyond that point, i.e. in dry years, satisfaction of the water demand cannot be guaranteed and the total water use decreases with the exceedance frequency. The total water used under different socioeconomic development levels is very small, almost the same.

MSWRMS-Lab application 2: calculating dynamic management targets

The control targets of the 'Three Red Lines' are based on an average number of historical water inflow in terms of annual precipitation or natural streamflow. In the assessment of whether the control targets are met at the end of a year, the dynamic management targets corresponding to the frequency of water inflow of this year are needed. A method to calculate the dynamic targets is established based on the lab. In this method the average number of dynamic targets is equal to the control target. Figure 4 shows the control target of total water use of Shandong province in 2015 and its dynamic management targets under annual precipitation for the period 1956 to 2000. In wet years when the exceedance frequency of the annual precipi-

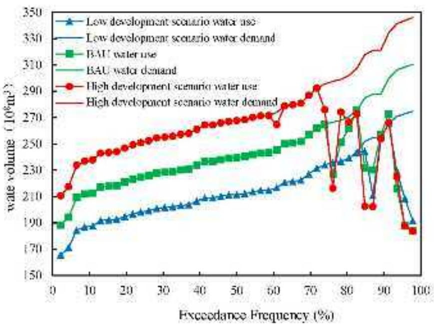

Figure 3. Total water demand and total water use of Shandong province in 2015 under three different socioeconomic scenarios and annual precipitation of 1956 to 2000

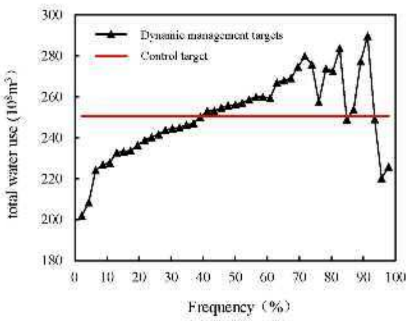

Figure 4. The control target of Shandong province in 2015 and its dynamic management targets

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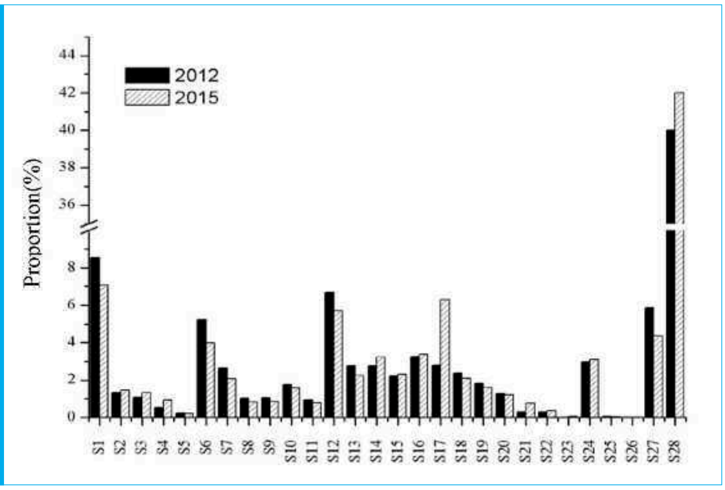
tation is less than 40%, the dynamic management target is less than the control target. When the exceedance frequency is in the range 40%~94%, the dynamic management target is mostly higher than the control target. But when the exceedance frequency is larger than 94%, the dynamic management target is less than the control target.

MSWRMS-Lab application 3: adjustment of industrial structure

The unreasonable development of the industrial economy is one of the important reasons for China's resource and environmental issues. Adjustment of the industrial economy and improvement of water use efficiency are important measures for the implementation of MSWRMS. An optimization model based on the simulation model system was developed to adjust the industrial structure. The economy was divided into 28 economic industries, including primary industry, construction, tertiary industry and 25 other industries in the model. The objective in the model is to maximize GDP. The decision variable is the industry added value of these 28 industries. The control targets of the 'Three Red Lines', industry diversity, employment, consumption and investment are set as constraints. The adjusted industrial structure of Shandong in 2015 is obtained by the model. The initial industrial structure in 2012 is chosen as baseline. The changes in the proportion of GDP contributed by each of the 28 industries in 2012 and 2015 is shown as Figure 5. The model shows that the relative contribution to the GDP of high water consumption industries , such as primary industry, food industry, textile industry, paper industry and oil processing and chemical industry, decreases, while the relative contribution to the GDP of the tertiary industry, general equipment industry and special equipment industry increases. ■

Figure 5. Relative contribution to the GDP of each of 28 industries in 2012 and 2015



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