

## Supplementary materials

### 1. The index system for evaluating “society, economy and eco-environment” system in the Haihe basin

Considering the main ecological environment problems of the Haihe basin and experts' investigation, the index system was built to evaluate the development quality of “society, economy and eco-environment”.

At present, there are no uniform standards for the evaluation criteria of sustainable development. Based on the existing relevant national standards, conventional international practice and expert consultation, the evaluation criteria of the study area was made and divided into 5 quality level (I-V), expressed as: very high (score 1), high (score 0.75), moderate (score 0.5), poor (score 0.25), very poor (score 0). Specific instructions are as follows:

(a) Per capita GDP: an important index of the social wealth. A widely recognized standard for a well-off society is \$3000 per capita GDP and a \$4000 per capita GDP for middle-income countries. Considering the reality in Haihe basin, in 2007, per capita GDP of China is approximately 16.8 thousand CNY (\$2460), and that of Haihe basin is for 25.2 thousand CNY. Therefore, this paper set the upper limit of a moderately prosperous society, per capita GDP of 27.0 thousand CNY (\$4000) as level I; set the lower limit of a moderately prosperous society, per capita GDP of 20.0 thousand CNY (\$3000) as level II; set per capita GDP of 14.0 thousand CNY (\$2000) as level III; set per capita GDP of 7.0 thousand CNY (\$1000) as level IV, set the per capita GDP of 5.0 thousand CNY (\$800) as level V.

(b) Per capita water use: an important index of the life quality, especially in dry areas. In 2007, China's Per capita water use is 442 m<sup>3</sup>. There are 8 provinces which per capita water use is more than 600 m<sup>3</sup>, and 10 provinces is less than 300 m<sup>3</sup>, the lowest one is only 174 m<sup>3</sup>. Per capita water use in Haihe basin is 284 m<sup>3</sup>, less than the mean annual value of 305 m<sup>3</sup>. We established the following evaluation criteria: 600 m<sup>3</sup> as level I; 400 m<sup>3</sup> as level II, 300 m<sup>3</sup> as level III; 260 m<sup>3</sup> as level IV; 200 m<sup>3</sup> level as V.

(c) Drinking water quality class: an index of the social development level. According to China surface water environmental quality standard (GB3838-2002), water classes of 1, 2, 2.3, 2.7 and 3 were set as critical values in the index system (Table 5).

(d) Water use per unit GDP: an important index of reflecting the economic development quality level. The water use per 10 thousand GDP in China decreased from 2909 m<sup>3</sup> in the early 1980s to 297 m<sup>3</sup> in 2007. And the GDP per unit cubic water of China is only 1/3 of the world average. The water use per 10 thousand GDP in Haihe Basin is 113 m<sup>3</sup> in 2007, and the average of the past 10 years is 256 m<sup>3</sup>. We determine the evaluation criteria for the water use per 10 thousand GDP of the Haihe Basin: set 60 m<sup>3</sup> in water use per unit GDP for grade I (developed country level); 100 m<sup>3</sup> for grade II (the world average level); 150 m<sup>3</sup> for grade III (moderately prosperous society is 125 m<sup>3</sup>); 260 m<sup>3</sup> for grade IV (near the average in the past 10 year); 400 m<sup>3</sup> for V level (equal to the level 10 years ago).

(e) Irrigation water per mu: is an important indicator of reflecting the economic development of water-saving technologies in agriculture. With the promotion of the agricultural water-saving technologies, irrigation area and food production of the Haihe Basin increased, agricultural water use reduced 3.8 billion m<sup>3</sup> in 2007 compared with 1998. Irrigation water per mu also reduced from 288 m<sup>3</sup> in 1998 to 249 m<sup>3</sup> in 2007. We set irrigation water per mu of 200 m<sup>3</sup> for grade I; 240 m<sup>3</sup> for grade II (equivalent to the level of the status quo); 260 m<sup>3</sup> for grade III (equivalent to the level 5 years ago); 280 m<sup>3</sup> for grade IV (equivalent to the level 10 years ago); 300 m<sup>3</sup> for grade V.

(f) Waste water discharge per unit GDP: an important index of the impact of economic development on environment and resource. Waste water discharge per 10 thousand GDP goes down from around 60t ten years ago to 14t in 2007, that is a relatively good level, and the average in the decade is about 33t. The evaluation criteria of Waste water discharge per 10 thousand GDP was set as follows: 10t for Grade I, 15t for Grade II (equivalent to the present level), 30t for Grade III (equivalent to the level of 5 years ago), 60t for Grade IV (equivalent to the level of 10 years ago) and 300t for Grade V.

(g) Modulus of exploited groundwater: an important indicator of reflecting the eco-environmental quality. Groundwater is an important water resource for economic and social development of Haihe Basin, and at present, the exploitation of groundwater is about 2/3 of the total water supply. Plain area of the Haihe Basin began the large-scale exploitation of groundwater from the 1970s, with the economic rapid development, the water table continues to drop. By 1998, the over-exploitation of groundwater has already accumulated about 89.6 billion m<sup>3</sup>.

The groundwater management in Haihe basin now is trying not to exploit the deep groundwater and to avoid the lowering of shallow groundwater. Given the pressure of demand of social and economical development on water, it is a quite difficult for the modulus of exploited groundwater to drop to 1.0; 0.8 is already the most ideal standard. In the decade, the average of the modulus is around 1.3, the peak of which is 1.8 (in 2002 dry year). Based on these analyses, the evaluation criteria of the modulus of exploited groundwater in Haihe basin was set: 0.8 for Grade I, 1.0 for Grade II (meaning no change of the water level), 1.1 for Grade III, 1.2 for Grade IV and 1.3 for Grade V.

(h) Water discharge to sea: a significant index of the eco-environmental quality of a river. The exploitation degrees of Haihe Basin's water resources have been over 98% and many rivers almost dry up. Haihe Basin's water discharge to sea per year has decreased from over 20 billion  $m^3$  to around 1.7 billion  $m^3$  from 1950s to 2007. It has been calculated by experts that the water discharge into the sea per year to keep a normal ecosystem in Haihe basin should be 6 billion  $m^3$ ; 10 billion  $m^3$  is the level of benign condition while lower than 3 billion  $m^3$  will lead to ecosystem degradation. Therefore, the evaluation criteria of water discharge to sea was set below: 10 billion  $m^3$  for Grade I, 6 billion  $m^3$  for Grade II, 3 billion  $m^3$  for Grade III, 2 billion  $m^3$  for Grade IV and 1 billion  $m^3$  for Grade V.

(i) River water quality class: an important index of the water quality. Now there are 64% of the length of the rivers has been polluted (exceeding water quality Grade III); the length of rivers heavily polluted (water quality worse than Grade V) makes up 51% of the whole with the deterioration trend. According to the surface water environment quality standard of China (GB3838-2002), the water quality divided into five classes: Grade I-II for the first level quality; Grade III (equivalent to the quality in 1960s) for the second-level; Grade IV for the third-level (light pollution), Grade V for the fourth level (medium level pollution), and Grade VI (or worse than Grade V) for the fifth level (serious pollution).