Prediction of Efficient Water Use in Crop Farming of Hebei Province

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Abstract In order to alleviate the grim situation of groundwater overexploitation in Hebei Province, using the expert interview method and law of large numbers, we predict the water consumption and amount of water saving concerning 7 different crops in 3 schemes ("low", "medium", "high") under economical irrigation in different ecological areas during the period 2011 -2015, and the period 2016 -2020 in Hebei Province. (i) During the period 2011 -2015, in "low" scheme, the water consumption will be about 12.9 billion m^3, and the amount of water saving is about 1.4 billion m^3; in "medium" scheme, the water consumption will be about 12.2 billion m^3, and the amount of water saving will be about 2.1 billion m^3; in "high" scheme, the water consumption will be about 11.5 billion m^3, and the amount of water saving will be 2.8 billion m^3. (ii) During the period 2016 -2020, in "low" scheme, the water consumption will be about 12.3 billion m^3, and the amount of water saving will be about 0.7 billion m^3; in "medium" scheme, the water consumption will be about 11.2 billion m^3, and the amount of water saving will be about 1 billion m^3; in "high" scheme, the water consumption will be about 10.2 billion m^3, and the amount of water saving will be 1.2 billion m^3. We can find that each "medium" scheme is ideal, having the greatest feasibility, which can provide a theoretical basis for solving some problems in Hebei Province in the next 5 to 10 years, such as serious water resources shortage and overexploitation.

Key words Efficient water use, Water use efficiency, Water-saving potential, Prediction research, Hebei Province

Water is the material basis that living creatures in the nature rely on for survival, and also the indispensable natural resources for human production and life[1]. China is a country with serious drought and water shortage, and one of 13 countries with the scantiest water resources per capita in the world[2]. According to the classification of the United Nations' international population plan research project, the regions with the per capita water resources less than 500 m^3 are the regions with water crisis[3]. The per capita water resource in Hebei Province is 311 m^3, accounting for one seventh of the national average, thus it is the area with the extreme water shortage[4].

At the same time, China is one of the world's major agricultural countries, and the water needed by agriculture accounts for 73.4% of the total water[5]; in some developed countries, the proportion of water for agriculture is mostly below 50%[6]. Hebei Province is truly a major agricultural province, and crop farming consumes considerable water in Hebei Province, accounting for more than 70% of the total water consumption in Hebei Province[7]. How to solve the contradiction between great consumption of crop farming production and shortage of water resources in Hebei Province, make each drop of water produce more grain, is always the focus of attention[8]. Using the expert interview method and law of large numbers, we predict the water consumption and amount of water saving concerning 7 different crops in 3 schemes in Hebei Province, in order to alleviate the grim situation of groundwater overexploitation in Hebei Province, solve great consumption of water in food production, and provide a reference for stable production and high yield of crop farming.

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1 Overview of the study area

Hebei Province is located at 36°05′ -42°37′N, 113°11′ -119°45′E. Most of central and southern Hebei lies within the North China Plain. The western part of Hebei rises into the Taihang Mountains (Taihang Shan), while the Yan Mountains (Yan Shan) run through northern Hebei, beyond which lie the grasslands of Inner Mongolia. Hebei has a continental monsoon climate, with cold, dry winters, and hot, humid summers. Temperatures average -16 to -3 ℃ (3 to 27 °F) in January and 20 to 27 ℃ (68 to 81 °F) in July; the annual precipitation ranges from 400 to 800 millimeters (16 to 31 in), concentrated heavily in summer. The overall climate conditions in the province are good, suitable for the growth of a variety of crops[9]. We mainly research the crops with water use efficiency and water-saving potential in Hebei Province, including winter wheat, summer maize, spring corn, vegetables, fruit trees, cotton, and cereals. These crops are distributed in 6 ecological areas in Hebei Province: high-yielding piedmont plain area, low-yielding low plain area, Taihang Mountains hilly area, Bashang plateau area, Yanshan hilly area and coastal plain area[10].

Wheat and corn are the major food crops in Hebei Province, the total growing area of which accounts for 85% of the growing area of food crops in Hebei Province, and the total output of which accounts for 92% of total grain output in Hebei Province[11]. They are mainly distributed in high-yielding piedmont plain area, low-yielding low plain area, and the Taihang Mountains hilly area in Hebei Province. There are also cotton,

fruit and vegetables with certain planting size in these 3 types of areas. In Bashang plateau area and Yanshan hilly area, the soil is barren, with low fertility and poor water retention capacity, so vegetables and cereals are mainly planted there. In coastal plain area, the soil salinization is serious, therefore, the salt-resistant cotton is mainly planted in this area; winter wheat and summer maize are also planted with small size. From the above analysis, we see that Hebei Province is a truly major agricultural province, and crop farming consumes considerable water in Hebei Province. The water consumption of crop farming in Hebei Province accounts for more than 70% of total water consumption in Hebei Province, but Hebei Province is a province with a shortage of water provinces. The total amount of water resources in the province is 20.47 billion m^3, but the per capita water resource in Hebei Province is 311 m^3.

Therefore, farming irrigation is mainly dependent on the exploitation of groundwater. Due to successive years of overexploitation of the groundwater, the ground water table generally declines, the deepest and widest "funnel group" arising from groundwater overexploitation in the North China, which will not only cause the geo-ecological crisis, but also pose a huge threat to the continuous development of agriculture in Hebei Province[12]. Hebei Province should not only ease the grim situation of groundwater overexploitation through efficient water use in crop farming, but also make crop farming production stable and increase yield. It is necessary to open up a new path to efficient water use in crop farming and yield increase.

The crop farming areas in Hebei Province are divided into 6 ecological areas: Bashang plateau area, Yanshan hilly area, the Taihang Mountains hilly area, high-yielding piedmont plain area, low-yielding low plain area and coastal plain area. The classification of 6 ecological areas in Hebei Province is shown in Fig. 1.

2 Research of the water consumption and water-saving potential in crop farming during the period 2011 –2020 in Hebei Province

The prediction of water use in crop farming mainly refers to Part 1 of *DB*13 *Hebei Local Standards of Water Quota*[12]: in agricultural water use, the benchmark irrigation quota of different crops in different regions takes into account the local standard of water quota, and the economical irrigation quota of different crops in different regions in the period 2011 –2015 and 2016 –2020 is set for the water-saving technology development in the designated year 2015 and 2020.

The irrigation quota in the current year takes the actual irrigation quota of different crops in different regions in 2008 (irrigation quota in the current year > economical irrigation quota). The amount of water saving is equal to the difference of water consumption of crops in the current year and water consumption in the state of economical irrigation, that is, the amount of water saving of crops in the next 5 to 10 years = the water consumption of crops in the current year – the water consumption of crops in the next 5 to 10 years = irrigation area of crops × irrigation quota of crops in 2008 – irrigation area of crops × economical irrigation quota of crops in the next 5 to 10 years. We assume that the crop farming structure and the growing area during the period 2011 –2015 and the period 2016 –2020 in Hebei Province are approximately the same as the crop farming structure and the growing area in the current year (with 2008 as the base year), to predict the situation of water use and water conservation in crop farming in the next 5 to 10 years.

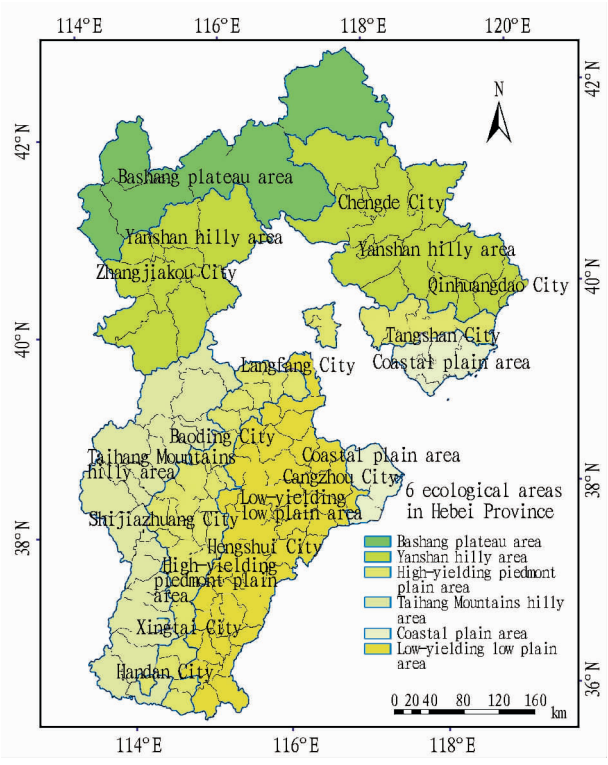

Fig. 1 6 ecological areas in Hebei Province

2.1 Data and method The data are based on the water used for agriculture and its proportion in the survey report Water Resources and Irrigation Quota in Hebei Province conducted by Hebei Provincial Department of Water Resources in 2004[7]; the water consumption of crops in different ecological areas, water balance in different ecological areas, the growing area of different crops in different regions, the conversion proportion of irrigation area in the current year, the irrigation area of different crops in different regions in crop farming during the period 2011 –2020, the irrigation quota in the current year, and the economical irrigation quota in the next 5 to 10 years, in *Technology Roadmap of Efficient Water Use in Crop Farming in Hebei Province*[13]; the interview with experts outside the province and expert consultants. We conduct calculation and analysis by Excel, and get the most ideal water-consumption and water-saving scheme on crop farming in Hebei Province during the period 2011 –2015, and the period 2016 –2020. Table 1 is the growing area of different crops in different regions in current year[13].

The growing area of crop farming includes two parts: the area of irrigated land and the area of dry land, so we should calculate the irrigation area using the growing area of different crops in crop farming to multiply the proportion of irrigated land

and dry land, and then calculate the water-saving potential on the basis of irrigation area.

The irrigation area of different crops in different regions is obtained through the relevant experts' conversion. The specific conversion proportion is shown in Table 2[13]; the irrigation area of different crops in different regions that is converted is shown in Table 3[13]; the irrigation quota of different crops in different regions in the current year is shown in Table 4[13]; the economical irrigation quota of different crops in different regions during the period 2011 –2015 is shown in Table 5[13]; the economical irrigation quota of different crops in different regions during the period 2016 –2020 is shown in Table 6[13].

Table 1 The growing area of different crops in different regions in current year 10^4 hm^2

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals
Bashang plateau area						7.4	17.8
Yanshan hilly area	1.9		36.4		14.2	11.9	17.2
Taihang Mountains hilly area	31.3	36.8	5.5		4.6	7.9	12.1
High-yielding piedmont plain area	95.5	113.3		8.1	18.9	48.4	
Low-yielding low plain area	100. 0	117.7		55.4	17.9	25.7	12.2
Coastal plain area	12.6	16.3		38.1	2.9	8.8	
Total	241.3	242.3	41.9	67.3	58.5	110.1	59.2

Table 2 Conversion proportion of irrigation area of different crops in different regions

Growing area	Irrigation proportion						
	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Coarse cereals	
Bashang plateau area						0.03	1.00
Yanshan hilly area	1.00		0.49		0.70	0.46	1.10
Taihang Mountains hilly area	1.00	0.76	0.22		0.68	0.49	1.20
High-yielding piedmont plain area	1.00	0.93		0.90	0.65		1.30
Low-yielding low plain area	0.97	0.88		0.65	0.65	0.41	1.30
Coastal plain area	0.90	0.76		0.10	0.69		1.20

Table 3 Irrigation area of different crops in different regions during the period 2011 –2020 in crop farming 10^4 hm^2

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals
Bashang plateau area						7.4	0.5
Yanshan hilly area	1.9		21.9		9.9	11.9	7.9
Taihang Mountains hilly area	31.3	20.1	3.1		3.1	7.9	5.9
High-yielding piedmont plain area	95.5	88.3		7.3	12.3	48.4	
Low-yielding low plain area	97.1	87.0		36.0	11.6	25.7	5.0
Coastal plain area	11.3	45.4		0.4	2.1	8.8	
Total	237.0	200.0	25.0	43.7	38.9	110.1	19.3

Table 4 Irrigation quota table of different crops in different regions m^3/hm^2

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals
Bashang plateau area						4140	2295
Yanshan hilly area	2730		1050		2790	3765	1215
Taihang Mountains hilly area	2715	1620	975		2790	3870	225
High-yielding piedmont plain area	2730	1860		1425	2790	3180	
Low-yielding low plain area	1755	1185		1365	2790	3180	375
Coastal plain area	1860	1185		1260	2790	3870	

Table 5 Economical irrigation quota table of different crops in different regions during the period 2011 –2015 m^3/hm^2

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals
Bashang plateau area						3405	1800
Yanshan hilly area	2190	0	1005		2250	3090	555
Taihang Mountains hilly area	2175	1125	975		2250	3030	
High-yielding piedmont plain area	2190	1305		1185	2250	2610	
Low-yielding low plain area	1635	930		1155	2250	2610	
Coastal plain area	1605	930		1035	2250	3030	

Table 6 Economical irrigation quota table of different crops in different regions during the period 2016 –2020 m^3/hm^2

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals
Bashang plateau area						3030	1560
Yanshan hilly area	1920		990		1980	2760	225
Taihang Mountains hilly area	1920	870	975		1980	2610	
High-yielding piedmont plain area	1920	1020		1050	1980	2340	
Low-yielding low plain area	1575	795		1050	1980	2340	
Coastal plain area	1485	795		915	1980	2610	

2.2 Prediction method As for the prediction of irrigation water consumption of each crop in different regions during the period 2011 –2015, there are three schemes ("low", "medium", "high"), representing the situation under the water-saving technology coverage of 50%, 75% and 100%, respectively).

We set the water consumption and water-saving potential in "low" scheme, "medium" scheme and "high" scheme on crop farming during the period 2011 –2015, and use the following letters to represent the relevant indicators, respectively:

A – Water consumption in "low" scheme.

A_1 –50% water-saving technology coverage area of different crops in different regions.

A_2 –50% irrigation area of different crops in different regions.

a – Amount of water saving in "low" scheme.

B – Water consumption in "medium" scheme.

B_1 –75% water-saving technology coverage area of different crops in different regions.

B_2 –25% irrigation area of different crops in different regions.

b – Amount of water saving in "medium" scheme.

C – Water consumption in "high" scheme.

C_1 –100% water-saving technology coverage area of different crops in different regions.

c – Amount of water saving in "high" scheme.

E-economical irrigation quota of different crops in different regions during the period 2011 –2015.

F – Irrigation quota of different crops in different regions in the current year.

G – Total irrigation water consumption in the current year.

So, $A = A_1 \times E + A_2 \times F$

$a = G - A$

$B = B_1 \times E + B_2 \times F$

$b = G - B$

$C = C_1 \times E$

$c = G - C.$

Similarly, we calculate the irrigation water consumption and amount of water saving in the three schemes ("low", "medium", "high") during the period 2016 –2020.

3 Results and analysis

3.1 The water consumption and amount of water saving in "low" scheme, "medium" scheme and "high" scheme during the period 2011 –2015

(i) Water consumption and amount of water saving in "low" scheme. Water consumption in "low" scheme is the irrigation water consumption of crops when the water-saving technology application coverage reaches 50% in 2015.

The irrigation water consumption of wheat, corn, cotton, vegetables, cereals and fruit trees is 5 billion m^3, 2.892 billion m^3, 0.552 billion m^3, 3.414 billion m^3, 0.097 billion m^3, and 0.982 billion m^3. In this scheme, the total water consumption of crop farming in Hebei Province will be about 12.9 billion m^3 in 2015, and 1.4 billion m^3 of water can be saved. The amount of water saving of each crop is shown in Table 7.

Table 7 The amount of water saving of different crops in different regions during the period 2011 –2015 in "low" scheme 10^8 m^3

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals	Total
Bashang plateau area						0.27	0.01	0.28
Yanshan hilly area	0.05		0.04		0.27	0.40	0.26	1.02
Taihang Mountains hilly area	0.83	0.50			0.08	0.34	0.07	1.82
High-yielding piedmont plain area	2.58	2.46		0.09	0.33	1.37		6.83
Low-yielding low plain area	0.60	1.14		0.38	0.31	0.73	0.09	3.25
Coastal plain area	0.14	0.06			0.06	0.37		0.63
Total	4.2	4.16	0.04	0.47	1.05	3.48	0.43	14

(ii) Water consumption and amount of water saving in "medium" scheme. Water consumption in "medium" scheme is the irrigation water consumption of crops when the water-saving technology application coverage reaches 75% in 2015.

The irrigation water consumption of wheat, corn, cotton, vegetables, cereals and fruit trees is 4.79 billion m^3, 2.682 billion m^3, 0.528 billion m^3, 3.24 billion m^3, 0.027 billion m^3, and 0.929 billion m^3. In this scheme, the total water consumption of crop farming in Hebei Province will be about 12.2 billion m^3 in 2015, and 2.1 billion m^3 of water can be saved. The amount of water saving of each crop is shown in Table 8.

(iii) Water consumption and amount of water saving in "high" scheme. Water consumption in "high" scheme is the irrigation water consumption of crops when the water-saving technology application coverage reaches 100% in 2015.

The irrigation water consumption of wheat, corn, cotton,

vegetables, cereals and fruit trees is 4.579 billion m^3, 2.471 billion m^3, 0.504 billion m^3, 3.066 billion m^3, 0.053 billion m^3, and 0.876 billion m^3. In this scheme, the total water consumption of crop farming in Hebei Province will be about 11.5 billion m^3 in 2015, and 2.8 billion m^3 of water can be saved. The amount of water saving of each crop is shown in Table 9.

Table 8 The amount of water saving of different crops in different regions during the period 2011 –2015 in "medium" scheme 10^8 m^3

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals	Total
Bashang plateau area						0.41	0.02	0.43
Yanshan hilly area	0.08		0.07		0.40	0.60	0.39	1.54
Taihang Mountains hilly area	1.25	0.76			0.13	0.50	0.10	2.74
High-yielding piedmont plain area	3.87	3.69		0.13	0.50	2.06		10.26
Low-yielding low plain area	0.89	1.71		0.58	0.47	1.09	0.14	4.89
Coastal plain area	0.22	0.09		0.01	0.08	0.56		0.95
Total	6.31	6.25	0.07	0.72	1.58	5.22	0.65	21

Table 9 The amount of water saving of different crops in different regions during the period 2011 –2015 in "high" scheme 10^8 m^3

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals	Total
Bashang plateau area						0.54	0.03	0.57
Yanshan hilly area	0.10		0.09		0.54	0.80	0.52	2.05
Taihang Mountains hilly area	1.67	1.01			0.17	0.67	0.13	3.65
High-yielding piedmont plain area	5.16	4.92		0.18	0.66	2.75		13.68
Low-yielding low plain area	1.19	2.28		0.77	0.63	1.46	0.19	6.52
Coastal plain area	0.29	0.12		0.01	0.11	0.74		1.27
Total	8.42	8.33	0.09	0.95	2.10	6.97	0.87	28

3.2 The water consumption and amount of water saving in "low" scheme, "medium" scheme, and "high" scheme during the period 2011 –2020 (i) Water consumption and amount of water saving in "low" scheme. Water consumption in "low" scheme is the irrigation water consumption of crops when the water-saving technology application coverage reaches 50% in 2020.

The irrigation water consumption of wheat, corn, cotton, vegetables, cereals and fruit trees is 4.79 billion m^3, 2.682 billion m^3, 0.528 billion m^3, 3.24 billion m^3, 0.083 billion m^3, and 0.929 billion m^3. In this scheme, the total water consumption of crop farming in Hebei Province will be about 12.3 billion m^3 in 2020, and 2.1 billion m^3 of water can be saved, therefore, 0.7 billion m^3 of water can be saved during the period 2016 –2020. The amount of water saving of different crops in different regions during the period 2011 –2020 is shown in Table 10.

Table 10 The amount of water saving of different crops in different regions during the period 2011 –2020 in "low" scheme 10^8 m^3

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals	Total
Bashang plateau area						0.41	0.02	0.43
Yanshan hilly area	0.08		0.07		0.40	0.60	0.39	1.54
Taihang Mountains hilly area	1.25	0.76			0.13	0.50	0.07	2.70
High-yielding piedmont plain area	3.87	3.69		0.13	0.50	2.06		10.26
Low-yielding low plain area	0.89	1.71		0.58	0.47	1.09	0.09	4.84
Coastal plain area	0.22	0.09		0.01	0.08	0.56		0.95
Total	6.31	6.25	0.07	0.72	1.58	5.22	0.57	21

(ii) Water consumption and amount of water saving in "medium" scheme. Water consumption in "medium" scheme is the irrigation water consumption of crops when the water-saving technology application coverage reaches 75% in 2020.

The irrigation water consumption of wheat, corn, cotton, vegetables, cereals and fruit trees is 4.474 billion m^3, 2.366 billion m^3, 0.492 billion m^3, 2.978 billion m^3, 0.054 billion m^3, and 0.85 billion m^3. In this scheme, the total water consumption of crop farming in Hebei Province will be about 11.2 billion m^3 in 2020, and 3.1 billion m^3 of water can be saved, therefore, 1 billion m^3 of water can be saved during the period 2016 –2020. The amount of water saving of different crops in different regions during the period 2011 –2020 is shown in Table 11.

(iii) Water consumption and amount of water saving in "high" scheme. Water consumption in "high" scheme is the irrigation water consumption of crops when the water-saving technology application coverage reaches 100% in 2020.

The irrigation water consumption of wheat, corn, cotton, vegetables, cereals and fruit trees is 4.159 billion m^3, 2.05 billion m^3, 0.456 billion m^3, 2.717 billion m^3, 0.026 billion m^3, and 0.771 billion m^3. In this scheme, the total water consumption of crop farming in Hebei Province will be about 10.2 billion m^3 in 2020, and 4 billion m^3 of water can be saved. The amount of water saving of different crops in different regions during the period 2011 –2020 is shown in Table 12.

Table 11 The amount of water saving of different crops in different regions during the period 2011 –2020 in "medium" scheme 10^8 m^3

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals	Total
Bashang plateau area						0.61	0.03	0.64
Yanshan hilly area	0.11		0.10		0.60	0.90	0.59	2.31
Taihang Mountains hilly area	1.88	1.13			0.19	0.76	0.10	4.06
High-yielding piedmont plain area	5.81	5.54		0.20	0.75	3.09		15.39
Low-yielding low plain area	1.34	2.57		0.86	0.70	1.64	0.14	7.26
Coastal plain area	0.32	0.13		0.01	0.12	0.84		1.43
Total	9.47	9.37	0.1	1.07	2.37	7.84	0.86	31

Table 12 The amount of water saving of different crops in different regions during the period 2011 –2020 in "high" scheme 10^8 m^3

Growing area	Wheat	Summer maize	Spring maize	Cotton	Fresh fruit	Vegetables	Coarse cereals	Total
Bashang plateau area						0.82		0.82
Yanshan hilly area	0.15		0.13		0.80	1.20		2.29
Taihang Mountains hilly area	2.50	1.51			0.25	1.01		5.28
High-yielding piedmont plain area	7.75	7.38		0.27	0.99	4.12		20.52
Low-yielding low plain area	1.79	3.42		1.15	0.94	2.19		9.49
Coastal plain area	0.43	0.18		0.01	0.17	1.12		1.91
Total	12.62	12.50	0.13	1.43	3.16	10.45		40

4 Conclusions and discussions

Through the above calculation, we can find that: (i) During the period 2011 –2015, in "low" scheme, the water consumption will be about 12.9 billion m^3, and the amount of water saving is about 1.4 billion m^3; in "medium" scheme, the water consumption will be about 12.2 billion m^3, and the amount of water saving will be about 2.1 billion m^3; in "high" scheme, the water consumption will be about 11.5 billion m^3, and the amount of water saving will be 2.8 billion m^3. (ii) During the period 2016 –2020, in "low" scheme, the water consumption will be about 12.3 billion m^3, and the amount of water saving will be about 0.7 billion m^3; in "medium" scheme, the water consumption will be about 11.2 billion m^3, and the amount of water saving will be about 1 billion m^3; in "high" scheme, the water consumption will be about 10.2 billion m^3, and the amount of water saving will be 1.2 billion m^3. According to the comprehensive consideration of the total demand of future social and economic development in Hebei Province for water resources, Hebei's self – produced water, water sources transferred from other provinces, and other factors, we find that the "medium" scheme during the period 2011 – 2015 (water consumption: 12.2 billion m^3; amount of water saving: 2.1 billion m^3), and the "medium" scheme during the period 2016 – 2020 (water consumption: 11.2 billion m^3; amount of water saving: 1 billion m^3), are the most feasible scheme, by which we can save 3 billion m^3 of water in agriculture and achieve water supply and demand balance in Hebei Province by 2020. The crops in the crop farming water-saving study in Hebei Province do not include rice, so in the water consumption and amount of water saving in the most ideal 2015 and 2020 water-saving schemes, the rice's water consumption and amount of water saving are not calculated. Because the current water consumption of rice is large, and water-saving potential is small, but according to the actual situation of severe water shortage and great irrigation water consumption of rice in Hebei Province, the paddy fields are gradually transformed into the dry land, and the growing area of rice will continue to be reduced. It is predicted that the growing area of rice will decrease by 30% and water consumption in the transformation of the paddy fields into the dry land will decrease by 25% in 2015. At this point, 220 million m^2 of water will be saved. In 2020, the growing area of rice will decrease by 60% and water consumption will decrease by 50%. At this point, 430 million m^2 of water will be saved[13]. We know that the rice's amount of water saving is large, which should be included into the calculation of amount of water saving in 2015 and 2020. Therefore, the water consumption in the most ideal 2015 scheme should be 11.98 billion m^3, and amount of water saving 2.32 billion m^3; the water consumption in the most ideal 2020 scheme should be 10.77 billion m^3, and amount of water saving 3.53 billion m^3.

Assuming that the crop farming in Hebei Province will decrease irrigation water consumption by 2 billion m^3, and grain output will achieve the government's expected target of 35 billion kg in 2015, it is necessary to rely on improving the wheat and corn's water use efficiency. The wheat's water use efficiency should be increased to 1.42 kg/m^3, and the corn's water use efficiency should be increased to 1.52 kg/m^3. Similarly, assuming that the crop farming will decrease irrigation water consumption by 3 billion m^3 in Hebei Province in 2020, the grain output needs to be higher than 35 billion kg. The wheat's water use efficiency should be increased to 1.64 kg/m^3, and the corn's water use efficiency should be increased to 1.93 kg/m^3.

However, at present, the water use efficiency of wheat and corn in China is only 1.2 to 1.3 kg/ m^2. In comparison with the expected goal, the current international average wheat and corn's water use efficiency (1.09 kg/m^3 and 1.80 kg/m^3), and the current highest international wheat and corn's water use efficiency (1.7 kg/m^3 and 2.7 kg/m^3)[13], there are some problems in irrigation water consumption of crop farming in Hebei

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Province, such as low efficiency of moisture production, low use rate of irrigation water and serious waste of water. Therefore, based on the regional characteristics of Hebei Province (such as water resource shortage and serious overexploitation of groundwater), we seriously implement the Hebei Provincial Party Committee and Provincial Government's strategic plan on the transformation of economic development pattern; on the basis of giving full play to the role of the scientific and technological innovation in promoting technical progress in traditional industries and cultivating strategic emerging industries, carefully study issues concerning efficient water use in agriculture first started by Hebei Provincial Department of Science and Technology in March 2010.

We try to predict the efficient water use in crop farming, in order to alleviate the grim situation of groundwater overexploitation in Hebei Province, and promote the sustainable use of water resources in Hebei Province, achieving the goal of efficient water use in crop farming, stable production and high yield during the future period 2011 -2020 in Hebei Province.

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