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The Population Carrying Capacity of Water Resources in Yulin City

Lijuan DANG[1,2], **Yong XU**[1*], **Zhiqiang WANG**[1]

1. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China; 2. University of Chinese Academy of Sciences, Beijing 100049, China

Abstract Assessing the water resource carrying capacity is beneficial for measuring the scale of industry and population agglomeration, and also avoiding the contradiction between increasing people and decreasing available water resource, due to the expansion of industry and city size. Based on the prediction model of optimum population development size, by using hydrological data, also with the demographic data from 1956 to 2010, this article analyzes and predicts the urban moderate scale under the limit of the water resource in the future of Yulin City by GIS. The main conclusions are as follows. There is growing tendency of water resources overloading. According to the result of model simulation, by 2015, the overload rate of population size will be 1.04. By 2020, the overload rate of population size will grow up to 1.08. The oversized population mainly comes from cities and towns. The overload rate for cities and towns in 2015 and 2020 is 1.89 and 1.73, respectively. With the expansion of cities and industries, suburban areas could have a great potential for carrying population, because lots of suburban people may move to cities and towns according to prediction. In view of the above-mentioned facts, the population size should be controlled in a reasonable range.

Key words Carrying capacity of water resources, Population size, Prediction, Yulin City

1 Introduction

The abundance of water resources is related to urban sustainable development, and the water shortage often becomes an important factor limiting urban development. Yulin City is located in China's ecologically fragile zone with serious soil erosion, and per capita water resources are only 38.6% of the national average[1-2]. It is an area with severe water shortage and its ecological environment carrying capacity is weak. With the rapid development of economy and society in Yulin City, there is an increasing demand for water, and the supply of water resources has become a rigid constraint on the scale of urban development. In addition, with the development of coal resources, the mined area in northern regions is growing[3], having a great impact on groundwater. In some areas, the groundwater level declines and the river water inflow decreases[4-5]. The carrying capacity of water resources is an important focus of carrying capacity study and also an important indicator of regional sustainable development[6]. The improvement of carrying capacity of water resources means the enhancement of regional sustainable development capacity. In fact, the analysis of carrying capacity of water resources is also a comprehensive study of relations between regional population and economy, resources, environment[7]. Therefore, carrying out the study of carrying capacity of water resources is of important significance to sustainable development in the region. Currently, the study of population carrying capacity has shifted from the impact of land resources and other single environmental factors to the combined effects of complex factors[8-9]. In recent years, the shortage of water resources directly limits the development and use of land resources as well as the ecological environment, thus affecting the industrial and agricultural development and population size, and restricting the development of the city. In addition, the survey, evaluation, development planning and other studies on water resources have paid increasing attention to the improvement of microscopic techniques such as water-saving technique[10]. However, there is a shortage of studies on urban population size control, population distribution and internal urban restructuring from a macro point of view. Consequently, to further explore how to solve the contradiction between water resources and regional population development requirements, the present study regards the carrying capacity of water resources as the main indicator to quantify and predict the carrying population size and judge the urban carrying situation. In this paper, some policy recommendations are put forth in order to improve the population carrying capacity and achieve regional sustainable development.

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* Corresponding author. Email: xuy@igsnrr.ac.cn

2 Overview of the study area

Yulin is a prefecture-level city in the Shanbei region of Shaanxi province, People's Republic of China, bordering Inner Mongolia to the north, Shanxi to the east, and Ningxia to the west. It has an administrative area of 43578 km^2, accounting for 21.2% of the province's total land area. To the north and northwest of the city lies the Ordos Desert, though the countryside is very green due to the many small shrubs which have been planted to slow the process of desertification. The city is based in a valley which extends north-south, which rises to a very large vantage point to the north east, where a spectacular view of the west and northwest is seen.

Yulin has a continental, monsoon-influenced semi-arid climate, with very cold, rather long winters, and hot and somewhat humid summers. Monthly averages range from −9.4 °C to 23.4 °C in July, and the annual mean is 8.29 °C. Spring is especially prone to sandstorms blowing in from the northwest. There is only 366 millimeters of precipitation annually, 73% of which occurs from June to September. It is the region with the least precipitation in Shaanxi Province. Due to the aridity, diurnal temperature variation is large for most of the year, averaging 13.8 °C annually. With monthly percent possible sunshine ranging from 60% in three months to 65% in four months, the city receives 2780 hours of bright sunshine annually. There are seven types of vegetation in Yulin City (grassland vegetation, deciduous broad-leaved shrub, deciduous forest, desert vegetation, meadow, halophitic vegetation, marsh and aquatic vegetation). The average total water resources of the city for many years amount to 3.201 billion m^3. There is 2.29 billion m^3 of surface water, and 2.478 billion m^3 of groundwater. The total amount of available water is 1.275 billion m^3, and the per capita amount of surface water resources is 550 m^3, only 25% of the national average. The water resources are not evenly distributed. The total amount of water resources in the northern regions with rich coal, gas and oil resources, such as Yuyang, Fugu, Hengshan, Jingbian and Dingbian, is 2.27 billion m^3, accounting for 70.9% of the city's total water resources. The relatively abundant water resources have created favorable conditions for the energy development and construction of the northern regions. In contrast, the southern hilly areas have broken terrain and the groundwater is deep buried, posing great difficulties in development and utilization. The water shortages, coupled with high population density and low per capita water resources, have severely restricted the socio-economic development of southern regions.

3 Research methods and models

3.1 Indicator selection The population carrying capacity of water resources is the maximum population size that the water resources can sustain indefinitely under water constraints. The carrying capacity of water resources is influenced by many factors, including water resource endowments, level of economic development, population and ecological and environmental conditions[11]. The indicator selection should not only reflect the influence of water quantity and quality, utilization, exploitation and dynamic changes concerning " water system-socio-economic system-ecosystem" on carrying capacity of water resources, but also reflect the influence of development scale, structure and level of socio-economic system carried on the carrying capacity. In the actual calculation, there are different ways to select evaluation indicators for the carrying capacity of water resources. The first way is based on the definition to directly select some population and socio-economic development indicators as a basis for measuring the size of carrying capacity of water resources, and the second way is to consider the available water supply, water demand, and bearable population size so as to establish the evaluation indicator system for the carrying capacity of water resources. The indicator selection is directly related to the calculation results of carrying capacity of water resources, and different indicator selection may lead to different results.

3.2 Evaluation model establishment Under the theoretical framework of sustainable development, based on the moderate urban scale computational model developed by Zhao Jianshi[12], Shi Peiji[13] and other scholars, we use Model (1), (2) to calculate and analyze the moderate scale of urban population under the constraint of water resources. There are few indicators for this model. These indicators are easy to obtain, and they fully reflect the water shortage, sewage and other water issues in the urban development. The model can well handle the relationship between population size and water resources in the process of urban development.

$$p_r(t) = \left(\frac{w_n}{q_p(t)}\frac{w_e}{q_p(t)}\frac{w_c}{s_p(t)}\right) = \min(c_1, c_2) \quad (1)$$

$$W_s = \frac{w_s}{\beta}, \beta = \frac{Q}{q} = \frac{C_q - C_0}{C_Q - C_0}, S_p(t) = \frac{w_{ce}(t)}{p(t)} \quad (2)$$

$$z = \frac{p(t)}{p_r(t)} \quad (3)$$

where $p_r(t)$ is the moderate size urban population; $p(t)$ is the actual number of urban population; is the total amount of available water resources (m^3); w_e is the water supply for urban residents (m^3); w_s is the surface runoff (m^3/s); w_c is the self-purification capacity of the river (m^3); Q is the total runoff (m^3); q is the sewage flow (m^3); $w_{ce}(t)$ is the total sewage discharge (m^3); $s_p(t)$ is the per capita sewage discharge (m^3/s); $q_p(t)$ is the standard of urban domestic water (m^3/person); β is the dilution ratio; C_q is the COD content (mg/L); C_Q is the water quality concentration (mg/L); C_0 is the upstream runoff water concentration (mg/L); c_1 is the water carrying capacity (person); c_2 is the water quality carrying capacity (person); z is the degree of water overload (when $z > 1$, the region or watershed is overloaded, and the greater the value, the more serious the degree of overloading; when $z < 1$, the region or watershed has great carrying potential, and the smaller the value, the greater the carrying potential of water resources, and the greater the amount of people that can be accommodated).

In the application of the above method model, the key factors to be considered include regional amount of water resources, amount of available water resources, different levels of per capita domestic water demand, and water consumption.

4 Analysis of population carrying capacity of water resources in the key development zones of Yulin City

4.1 Analysis of various indicators for the carrying capacity of water resources

4.1.1 Analysis of water supply and water supply structure in Yulin City. The water supply mainly includes surface water supply, groundwater supply and other sources of water supply. In various sources of water supply, the surface water supply has the largest proportion (62%), and the water supply of water diversion project accounts for 38%; the water supply of rainwater harvesting project and sewage treatment is relatively insufficient, accounting for only 0.2%; the utilization rate of brackish water has reached 1.3% in Yulin City. During 1980 to 2010, the total water supply in the study area greatly increased, but the proportion of surface water supply declined. In 2010, the city's water supply of various water conservancy projects reached 692 million m^3, accounting for 30.19% of the city's total water resources; the surface water supply reached 442 million m^3, accounting for 59.47 % of total volume of water; the groundwater supply reached 248 million m^3, accounting for 40.38 % of total water supply; other sources of water supply reached about 2 million m^3.

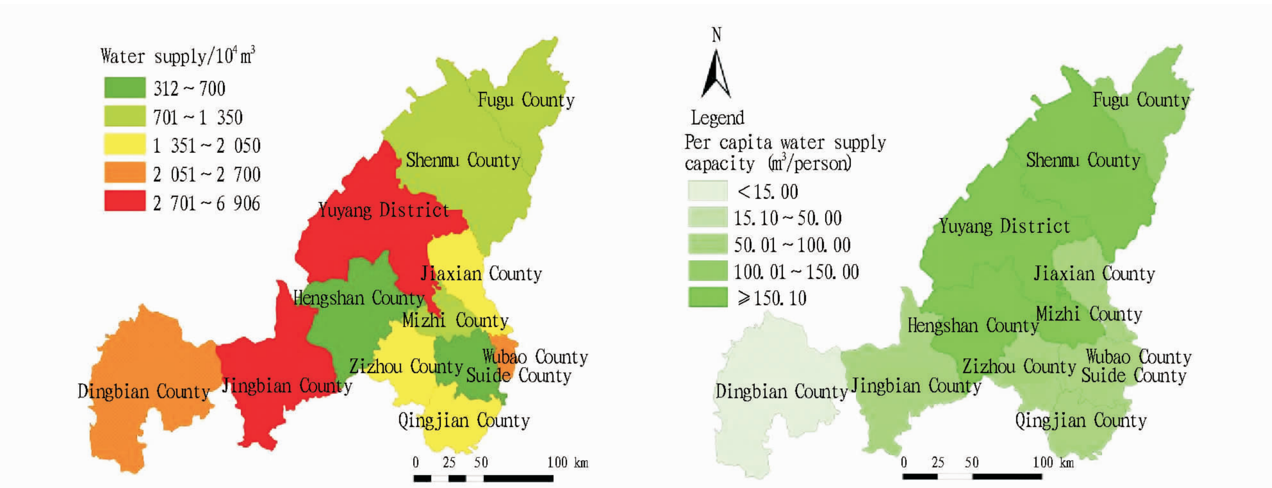

Fig. 1 The spatial distribution of per capita water supply capacity in Yulin City in 2010

Affected by the geographical location, the water conservancy projects are not evenly distributed, thereby causing the uneven regional water supply capacity. From the spatial distribution of per capita water supply capacity, the per capita water supply capacity shows a decreasing trend from north to south, and from east to west. In the counties (districts), Yuyang District has the largest per capita water supply capacity, reaching 861.01 m^3/person, followed by Hengshan County and Shenmu County with the per capita water supply capacity reaching more than 400 m^3/person, and Mizhi County and Fugu County with the per capita water supply capacity reaching more than 100 m^3/person. As for other counties, the per capita water supply capacity is less than 100 m^3/person. Based on the regional water situation, water supply facilities, runoff conditions, industrial water demand, combined with regional water diversion project, we derive the amount of regional available water resources under different conditions of precipitation in different years (Table 1). According to Yulin's requirements of building national energy and chemical industry base, the coal mining and coal chemical industry will be boosted in the future, so the water demand will increase significantly. Additionally, this region is semi-arid region with poor water resource development conditions, so the lack of water resources is bound to be difficult to meet the needs for building national energy and chemical industry base.

Table 1 Predictive results of amount of available water in Yulin City Unit: 108 m^3

Year	Surface water			Groundwater	Wastewater reuse	Others	Total		
	50%	75%	95%				50%	75%	95%
2005	4.71	3.92	3.32	2.80	0.00	0.01	7.52	6.73	6.13
2010	6.81	6.11	5.63	3.73	0.19	0.10	10.82	10.12	9.64
2015	8.43	8.20	7.31	4.04	0.41	0.18	13.06	12.83	11.94
2020	9.27	8.52	7.42	5.27	0.69	0.32	15.54	14.80	13.73

4.1.2 Analysis of water consumption and water use structure in Yulin City. Water consumption is divided into socio-economic water consumption and ecological water consumption. The socio-economic water consumption is divided according to the three sectors of life, industry and agriculture. The major water users in Yulin City consume the irrigation water, accounting for 64.71% of total water consumption, followed by the industrial water consumption, accounting for 18.73% of total water consumption. The forestry, animal husbandry and fishery water consumption accounts for 6.37% of total water consumption; the domestic water consumption, and urban public water consumption account for 8.51% and 1.17% of total water consumption, respectively; the ecological water consumption accounts for only 0.50%. During 1980 to 2010, the per capita water consumption in Yulin City dropped from 213 m^3/year to 176 m^3/year; the water consumption per unit of GDP, industrial water consumption and irrigation water consumption declined significantly, while urban and rural domestic water consumption increased slightly each year.

(i) Domestic water consumption. Domestic water includes urban domestic water and rural domestic water. Urban domestic water includes the water for urban public facilities and floating population, relying on surface water supply; rural domestic water includes the drinking water for livestock, relying on groundwater supply. During 1980 to 2010, with the continuous improvement of people's living standards, the supporting living facilities were improved, and the domestic water quota showed an upward trend. Per capita urban domestic water consumption increased to 69L/d, and the rural domestic water consumption increased to 39L/d, an increase of 50% and 48%, respectively. As can be seen from Fig. 2, the urban per capita water consumption in 2010 showed a decreasing trend. In fact, due to the explosive growth of urbanization in this year, a large number of rural residents were converted to urban residents, and the per capita urban water consumption decreased despite the increase in urban water consumption. The domestic water consumption has a small share in total water consumption, but it places increased demands on the water quality.

(ii) Production water consumption. (a) Agricultural water consumption. Agricultural water consumption includes irrigation water consumption and forestry, animal husbandry and fishery water consumption. From 1980 to 2010, the city's agricultural water consumption showed a slow upward trend, with an average annual growth rate of 0.3%; the real farmland irrigation area increased by 22500 ha, and the irrigation water consumption increased by 1.37 million m^3; the forestry, animal husbandry and fishery area showed a growing trend, and the water consumption increased by 31.6 million m^3. With the improvement of agricultural irrigation techniques and adjustment of agricultural structure, the irrigation water consumption per mu fell by 103.44 m^3. The annual agricultural water consumption is shown in Table 2.

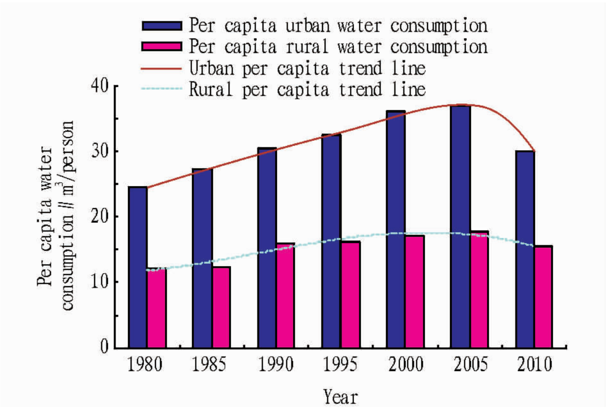

Fig. 2 Changes in the urban and rural per capita water consumption

Table 2 The agricultural water consumption in Yulin City from 1980 to 2010 (Unit: 10^4 mu; 10^4 m^3; m^3)

Year	Effective irrigation area	Real farmland irrigation area	Forestry, animal husbandry and fishery area	Agricultural water consumption			Irrigation water consumption per mu
				Irrigation	Forestry, animal husbandry and fishery	Total	
1980	125.58	104.47	2.52	44650	1252	45902	427.4
1985	103.32	93.32	3.92	38976	1988	40964	417.7
1990	122.65	95.27	5.16	36567	2458	39026	383.8
1995	162.3	144.76	6.42	49915	1857	51772	344.8
2000	161.73	150	6.29	50349	1682	52031	335.7
2005	174.88	146.66	14.66	47420	2359	49779	323.33
2010	180.5	138.25	9.21	44787	4412	49199	323.96

(b) Industrial water consumption. Industrial water consumption includes water consumption for thermal power generation and general industrial water consumption. From 1980 to 2010, the industrial water consumption in Yulin City showed an overall upward trend, with an average annual growth rate of 9.78%, and the city's industrial water consumption increased by 10.89 times in 30 years. Shenmu County had the highest growth rate of industrial water consumption, with the average annual growth of 13%; the city's total production water consumption accounted for 91.44% of total water consumption. With the improvement of process and adjustment of industrial structure, the water consumption per 104 yuan of output value decreased significantly. Affected by industrial restructuring, business conditions, water management, water conservation level and other factors, the annual regional growth rate is not balanced. The annual water consumption of main industrial sectors is shown in Table 3.

(iii) Ecological water consumption. From 1980 to 2010, with the continuous progress of urbanization, the urban greening and landscape construction was constantly strengthened, and the ecological water consumption showed an increasing trend, from 0.81 million m^3 in 1980 to 3.44 million m^3 in 2010. Shenmu County had the highest growth rate, and other counties also attached great importance to the ecological water demand while developing the economy.

Table 3 The industrial water consumption in Yulin City from 1980 to 2010

Year	Industrial water consumption // 10^4 m^3			Water consumption per 10^4 yuan of output value // m^3
	Subtotal	Thermal power	General industry	
1980	93	684	777	468
1985	169	854	1023	411
1990	174	2726	2900	389
1995	827	3092	3919	170
2000	671	4393	5064	118
2005	945	5448	6393	52
2010	1394	7069	8463	67

4.1.3 Prediction of water supply and demand using per capita water consumption method. According to *Statistical Yearbook of Yulin City*, from the beginning of reform and opening up in 1980 to the present, the population in Yulin City underwent dramatic changes. From 1980 to 2010, the population of Yulin City experienced a net increase of 1.3141 million, the average annual natural growth rate of permanent population was 7.5‰, and the average annual growth rate was 1.53%. Since 2000, the urban population has grown at rate of 3.2% annually, and the agricultural population has begun to decrease gradually since 2003. Due to the construction of energy and chemical industry base, the economy of Shenmu County and Yuyang District is enjoying a boom, attracting population from other places, so the population in these areas shows an instable and rapid trend of growth.

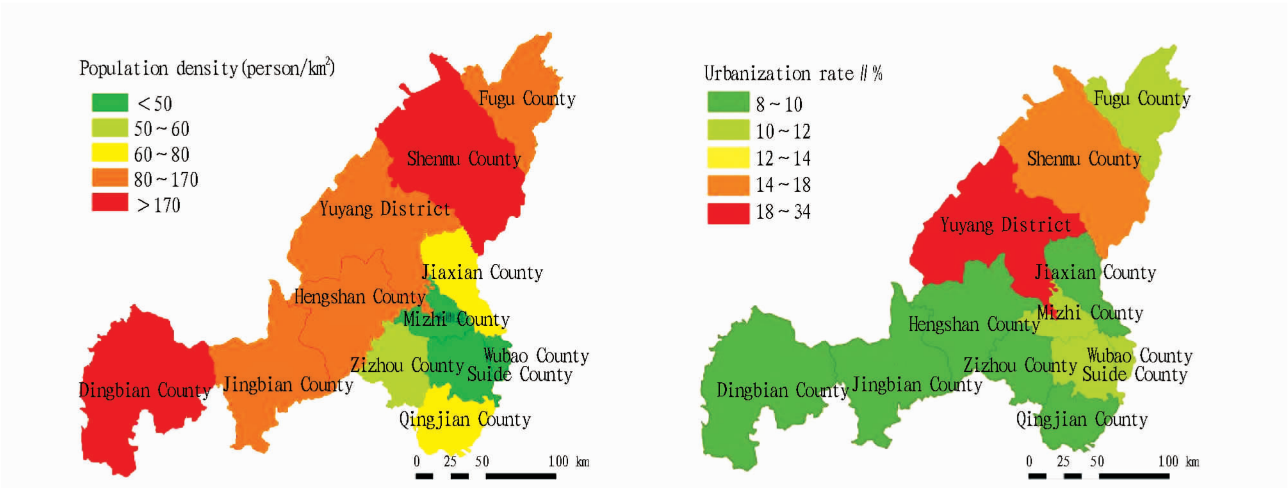

Fig.3 The population density and urbanization characteristics in Yulin City in 2010

The prediction is performed in accordance with the type of water consumption, and the water demand is divided into domestic water demand, production water demand outside rivers, ecological water demand outside rivers, and water demand inside rivers. With 2010 as the base year, we use the per capita water consumption method to predict the water demand in 2015 and 2020, respectively. It is calculated as follows:

$$W_{prediction} = W_{production} + W_{life} + E_{water}$$

$$W_{production} = GDP_n \cdot U_{GDP}/P_{total}$$

$$W_{life} = P \times (w_{per\ capita} \pm \Delta w) = P_{urban} \cdot \alpha_{urban} + P_{rural} \cdot \alpha_{rural}$$

where $W_{prediction}$ is the total water demand in the predictive year; $W_{production}$ is the production water demand in the predictive year; W_{life} is the real total domestic water demand; E_{water} is the ecological water demand; GDP_n is the GDP value in the predictive year; U_{GDP} is the water demand per 10^4 yuan of GDP in the predictive year; P_{total} is the total population in the predictive year; $w_{per\ capita}$ is the per capita water consumption in the current year; Δw is the per capita water consumption adjustment, which can be derived from the trend of per capita water consumption curve; P_{urban} and P_{rural} are the total population in urban and rural areas, respectively; α_{urban} and α_{rural} are the water quota for urban and rural population, respectively. According to the socio-economic indicators and water prices, combined with domestic water habits and present water consumption level, we refer to the urban water standards that have been developed by the construction department and draw on the domestic water quota in the similar region at home and abroad, to develop the domestic water quota for urban and rural residents. With the domestic water demand in 2010 as a benchmark, we use per capita water consumption plus trend approach to predict the water demand in 2015 and 2020, and correct the predictive value according to the changing trend of per capita water consumption to ensure that the results are more realistic.

(i) Domestic water demand. With 2010 as the base year, the permanent population of various regions in Yulin City is predicted according to the urbanization rate, and the urbanization rate in 2015 and 2020 is predicted at 52% and 60%, respectively. In accordance with *Urban Domestic Water Consumption Standards* (GB/T 50331-2002), coupled with domestic water use habits and present water use level, we refer to the urban water consumption standards that have been developed by the construction department and draw on the domestic water quota in the similar region at home and abroad[14], to develop the urban and rural domestic water quota respectively. It is recommended that the urban and rural domestic water demand quota should be 119 L/person · d and 51 L/person · d in 2015, respectively; the urban and rural domestic water demand quota should be 134 L/person · d and 56 L/person · d in 2020, respectively. The domestic water demand in 2015 and 2020 is estimated at 99.147 million m^3 and 12.591 million m^3.

(ii) Production water demand. (a) Agricultural water demand. Taking into account the scattered irrigated area and high level of irrigation in Yulin City, it is very difficult to reduce water consumption per mu and further improve irrigation efficiency. It is recommended that the agricultural water consumption should maintain the status quo, that is, the agricultural growth depends mainly on technical progress, system innovation, and improvement of management level. According to the agricultural development indicators and proposed quota in Yulin City, the water demand in different years is predicted, as shown in Table 4.

Table 4 The predictive results of agricultural water demand in Yulin City in different years Unit: 10^8 m^3

Year	P=50%			P=75%			P=95%		
	Farm irrigation	Forestry, animal husbandry and fishery	Total	Farm irrigation	Forestry, animal husbandry and fishery	Total	Farm irrigation	Forestry, animal husbandry and fishery	Total
2010	6.72	0.98	7.69	7.58	1.01	8.59	8.42	1.05	9.47
2015	5.50	1.70	7.20	6.33	1.81	8.14	7.16	1.90	9.06
2020	5.54	1.94	7.48	6.49	2.09	8.58	7.26	2.18	9.45

(b) Industrial water demand. The mining industry with huge water demand in Yulin City mainly includes the exploitation of coal, oil, and natural gas. The water consumption quota per unit of product uses the specified value of *Shaanxi Provincial Industry Water Quota* (2010 revision): the thermal power water demand is determined in accordance with the installed capacity, annual use hours and installed water quota; coal and salt chemical industry involves many products, and it lacks the water quotas for some products, so it is predicted according to the annual coal and salt chemical industry trends. (c) Construction water demand. It is calculated based on the water consumption per 10^4 yuan of output value. In Yulin City, the construction water demand was 16 m^3/10^4 yuan in 2009. Through analysis, with the series of total construction output value during 2001 to 2009 as the regression samples, we estimate the total output value in 2015 and 2020 through the linear regression and predict the construction water demand at 888.6308 million m^3 in 2015 and 1381.9822 million m^3 in 2020. (d) The tertiary industry water demand. It is calculated based on the water consumption per 10^4 yuan of output value. Based on the analysis of present situation of water consumption, we predict the water demand in different years. With the series of total tertiary industry output value during 2015 to 2010 as the samples for trend extrapolation, the tertiary industry water demand in Yulin City is predicted at 44.0407 million m^3 in 2015 and 109.8368 million m^3 in 2020.

(iii) Ecological water demand. Ecological water demand mainly includes urban ecological water demand and rural ecological water demand. Rural ecological water demand has been considered in the rural domestic water quota, and it is no longer repeated here. The urban ecological landscaping is determined based on the urban population and per capita ecological landscaping water demands. Based on the actual situation in Yulin City, according to the size and needs of economic and social development, the urban ecological water demand is mainly focused on green space water demand. The urban per capita green space area in Yulin City is predicted at 7.5 m^2 and 9 m^2 in 2015 and 2020, respectively; the ecological water demand in Yulin City is predicted at 148.4009 million m^3 in 2015 and 244.389 million m^3 in 2020. The water demand statistics in different years can be shown in Table 5.

Table 5 The water demand statistics in different years in Yulin City Unit: 10^8 m^3

Year	Domestic water demand	Production water demand			Ecological water demand	Total		
		P=50%	P=75%	P=95%		P=50%	P=75%	P=95%
2010	0.75	12.17	13.06	13.94	0.76	13.67	14.57	15.45
2015	0.99	16.53	17.46	18.39	1.48	19.00	19.94	20.86
2020	1.26	22.40	23.49	24.36	2.44	26.10	27.19	28.06

4.1.4 Trend analysis of per capita water resources. According to the statistics of per capita water resources from 1980 to 2010, the spatial distribution of water resources and population in Yulin City is extremely uneven, and the per capita water consumption is at a low level in the country. The amount of water resources per capita in Yulin City decreased from 1180 m^3 in 1998 to 892 m^3 in 2010, with an average annual decrease of 2.3%. The amount of water resources per capita in 67% of counties or districts in the city is less than 1000 m^3, and now it has reached the internationally recognized Malin Falkenmark water scarcity standards[15]. The county with the lowest per capita water resources (only 227 m^3) is Zizhou County. Wubao County has the most prominent contradiction between population and water resources, the average amount of water resources per capita for many years is only 218.17 m^3/person, and residents' daily consumption of water is not guaranteed. Shenmu County has rich water resources, and the average amount of water resources per capita for many years is 2484.5 m^3/person, followed by Yuyang District (2407.67 m^3/person). Dingbian County and Jingbian County are in the state of periodical water shortage.

In this paper, with water resources data and socio-economic statistics in 2010 as the basic data, we analyze the sustainable conditions of water resources for population development from water supply and per capita water resources. Based on the predictive results of water demand in different years, we use the carrying capacity of water resources and moderate urban population scale model, to calculate water amount carrying capacity c_1 (person), water quality carrying capacity c_2 (person), moderate urban scale pr (person), and overloading degree z. The per capita sewage discharge sp (t) takes the per capita discharge in Yulin City in

2012 (9.22 t/person). The minimum dilution ratio of water of rivers with self-purification capacity is generally 20, and the self-purification capacity of the river can be calculated based on wc = 0.05 ws. The calculated results of model are shown in Table 6.

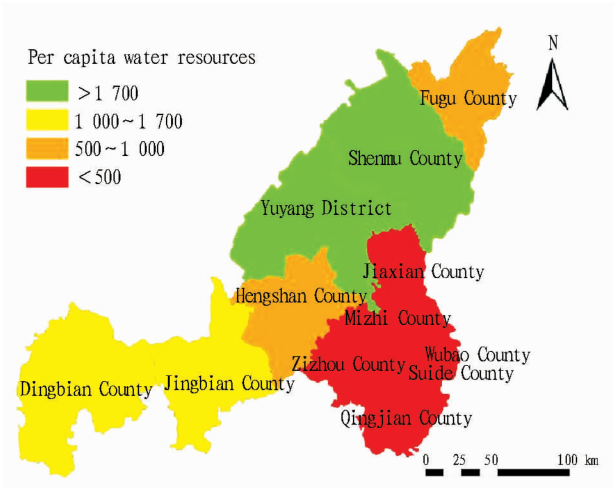

Fig.4 Spatial distribution of per capita water resources in Yulin City in 2010

4.2 Calculation of population carrying capacity of water resources in Yulin City According to the calculation of water amount and quality carrying capacity in Yulin City, the water overloading will be the main type for Yulin City in the future. By calculating the degree of overloading, z value is between 1.02 and 1.08; the population carrying capacity of water resources is in overload condition, and the degree of overloading shows a worsening trend over the time. With the data in 2010 as the reference data, based on the unary linear regression analysis of population growth trends, we calculate the future urban and rural population carrying capacity of water resources, as shown in Table 7. The results show that within the next decade, the urban population in Yulin City will be in the overloading condition, and over the time, the overloading remains high; the rural population will be in the carrying scope of water resources in the next decade, and the carrying capacity shows a growing trend. In 2015, the degree of overloading of urban population carried by water resources will reach 1.89; in 2020, the degree of overloading will drop to 1.73, with grim overloading situation. Urbanization is an inevitable trend in the future, so the future regional economic agglomeration will inevitably lead to population growth, thereby increasing conflict between man and water resources, and mutual restraint between urbanization and water resources.

Table 6 The carrying capacity of water resources and moderate regional population scale in Yulin City Unit: 10^4 people

Years	c_1	c_2	pr	p	z
2010	356.36	364.33	356.36	364.50	1.02
2015	450.60	385.32	385.32	401.31	1.04
2020	505.51	403.88	403.88	434.81	1.08

Table 7 Moderate urban and rural population scale and the degree of overloading in Yulin City Unit: 10^4 people

Year	Urban population			Rural population		
	Carrying	Prediction	Degree of overloading	Carrying	Prediction	Degree of overloading
2010	83.38	97.80	1.17	272.98	266.70	0.98
2015	110.48	208.68	1.89	262.64	192.63	0.73
2020	151.18	260.89	1.73	253.90	173.92	0.69

5 Conclusions and discussions

In this paper, through the theoretical summary of concept, connotation, indicator system and model method concerning the carrying capacity of water resources, we use the prediction model of moderate population development scale in Yulin City to analyze and calculate the population carrying capacity of regional water resources. The results show that within the next decade, water resources in Yulin City will be in the overloading state especially for urban population, the degree of overloading shows a worsening trend over the time, and there is some room for carrying rural population. Conspicuously, the blind pursuit of urbanization and population in Yulin City as an energy and chemical industry base can not guarantee the sustainable regional development; on the contrary, setting excessively high urbanization rate will cause an obstacle to the sound development of the city. The future growth of domestic and industrial water consumption is bound to crowd out the irrigation water, and the reservoirs with the original design features of irrigation are changed for domestic or industrial water supply, so that the agricultural water supply can not be guaranteed. Furthermore, large-scale resource development not only causes a lot of conflicts in water consumption between various national economic sectors, creates enormous ecological pressures. In the future, in order to further alleviate the severe water shortage of Yulin City relying heavily on coal chemical industry, salt chemical industry and coal power, it is necessary to include the industrial carrying capacity and ecological carrying capacity of water resources into the study to make the research results more accurate. In addition, from the perspective of industrial economy and ecological environment, it is necessary to focus on the movement of population gravity center and spatial layout to solve the water pressure, thereby increasing the potential for carrying capacity of water resources and providing a scientific basis for creating water security system.

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there is problem in ecosystem of ethnic culture, their living condition will have crisis. Through the above analysis, at the same time of keeping their culture core, the Beidong people integrate their local and ethnic culture with Han people culture and modern culture. These are manifested in their family temple, full - scale drama, Yang drama, marriage customs, religious belief, sacrifice, and funeral ceremony, which jointly form colorful Beidong people. Apart from inheriting cultural features of their ancestors, the Beidong people absorb foreign culture actively and passively, and innovate upon their ethnic culture, forming their unique cultural quality. However, with transformation of society, unique features of local ethnic culture and diversity are gradually disappearing. Therefore, the study on local knowledge of ethnic cultural ecology is helpful for revealing special features of ethnic cultural ecology and favorable for protecting, passing down and developing culture from the perspective of innovation and rebuilding, instead of simple protection of cultural heritage. Besides, it is also favorable for correctly recognize and treat the relationship between ethnic traditional culture and foreign culture and economic and social development, to promote economic development and construction of spiritual civilization of ethnic minority areas.

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