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Rationality of Xinjiang to undertake textile industry based on water resources carrying capacity

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ABSTRACT

As the main production area of high-quality cotton in China, Xinjiang is the core region to undertake the transfer of textile industry in the eastern region during the 13th Five-Year Plan period, to build a national textile industry base, and to build Silk Road Economic Belt. Because of drought, uneven distribution of water resources, and fragile ecological environment in Xinjiang, the textile industry, as a high water-consuming industry, is of great significance to formulate industrial development policies, implement water resource management, and guarantee the sustainable development of ecological environment in Xinjiang by studying the pressure of water resources brought by the construction and development of industrial chain. In this paper, firstly, the characteristics of water resources development and utilization in Xinjiang are analyzed in order to clarify the current situation of water consumption in different counties and districts there based on scarcity and efficiency; then, the current situation of water consumption in textile-related industries in Xinjiang is made clear by analyzing the composition of water consumption in cotton planting and textile industry in China and Xinjiang; and finally, the pressure of water resources for undertaking textile industry in Xinjiang in the future is analyzed and the future development policy of textile industry in Xinjiang based on water resources is put forward by forecasting water demand of cotton planting and textile industry.

Keywords: Water resources; Textile industry; Undertaking; Rationality; Xinjiang

1. Introduction

As the largest textile and apparel producer and exporter in China, China's textile industry has entered an unprecedented dilemma after the financial crisis. Influenced by low external demand, rising trade costs, impact of cost advantage in Southeast Asia, the transformation of the domestic textile industry, and arduous task of environmental protection [1], the output growth rate of China's textile industry has further slowed down, and textile export successively dropped for the first time in 2015 and 2016, with the decline increasing year by year. In 2017, China's textile industry began to warm up after the US withdrew from

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Trans-Pacific Partnership Agreement, but the overall situation is still severe [2]. Since 2009, the State, the Ministry of Industry and Information, and the local governments in the central and western regions have issued a series of policies to promote the transfer of textile industry to the central and western regions, but it is still in a small-scale "trial stage", because the increase of production costs in the central and western regions is slower than that in the eastern regions. Since 2015, the implementation of national strategies such as the "Belt and Road" initiative, Beijing–Tianjin–Hebei Co-development, and Yangtze River Economic Belt has promoted the textile industry "going global" and the development of textile industry in Xinjiang to become the new focus of regional textile industry structure in the 13th Five-Year Plan period. As a base of high-quality cotton production in China, Xinjiang enjoys a high advantage in raw materials, abundant rural surplus labor, and sufficient human resources for future development of textile and apparel industry. In addition, as it is located in the core area of the Silk Road Economic Belt, with the construction of land infrastructure, it has important strategic significance to open trade channels in Central Asia and Europe [3,4].

Textile industry is a typical labor-intensive industry with high energy consumption, water consumption, and pollution. However, the fragile ecological environment in Xinjiang is affected by water shortage and hard water quality, and there are only printing and dyeing enterprises in Shihezi area, which cannot support the construction of the whole textile industry chain in Xinjiang. Besides, the transfer of the textile industry will pose a higher challenge to the water ecological environment in Xinjiang in the future. Moreover, the supply conditions and development and utilization characteristics of water resources will also restrict the development of the textile industry in Xinjiang [5,6]. Therefore, it is of great significance to correctly understand the present situation of water supply in Xinjiang and the characteristics of development and utilization, and to predict the new water pressure brought by the transfer of textile industry, so as to guide the Xinjiang region to undertake the textile industry, to do a good job in water supply, water-saving, and water treatment, and to formulate the regional development strategy corresponding to the characteristics of water resources in Xinjiang [7,8].

2. Development and utilization characteristics of water resources in Xinjiang

Located in the hinterland of the Eurasian continent, Xinjiang Uyghur Autonomous Region, with an arid climate, is an important part of the largest arid region in the world—arid region in Central Asia, and has typical temperate continental climate. The annual average precipitation in Xinjiang is 195.3 mm, including 295.9 mm in North Xinjiang, 71. 3 mm in South Xinjiang and 52.6 mm in East Xinjiang, with uneven distribution of water resources [9]. From 2000 to 2015, the average annual total water resources were 91.77 billion m^3, mainly concentrated in the counties (cities) directly under Ili Prefecture, Bayingol Mongolian Autonomous Prefecture, Hetian Prefecture, and Aletai Prefecture. Xinjiang mainly includes 12 secondary water resource areas. The inland river area in Central Asia with the largest water yield modulus (water quantity per unit area) is 232,600 m^3/km^2, while the desert area in the smallest Tarim Basin is only 20 m^3/km^2. Water resources in Xinjiang mainly come from natural precipitation, glacier, and snow meltwater, which account for more than 45% of the total runoff in Xinjiang [10,11]. The natural and geographical conditions of Xinjiang determine the fundamental difference between the structure of water resources development and utilization and the wet plain area in the east, that is, the development and utilization of water resources are mainly concentrated in the oasis area [12–14]. In 2015, the per capita water consumption in Xinjiang is 2,478.2 m^3/person, 6 times the national average, ranking first in all provinces and cities, hence Xinjiang is not short of water in terms of per capita quantity. However, there are large desert areas in Taklimakan Desert and Gurbantunggut Desert in Xinjiang, where average water resources are less. Under the current situation of uneven space-time distribution of water supply, large water demand and rough water consumption, the study on the contradiction between water supply and demand and development and utilization of water resources in Xinjiang is the basis for analyzing its ability to undertake the transfer of textile industry [15–17].

2.1. Data sources and evaluation methods

In this paper, index system is mainly constructed from two perspectives of scarcity and utilization efficiency of water resources to analyze the characteristics of water resources development and utilization in Xinjiang (Table 1). First, the analysis of water scarcity is mainly based on the equilibrium model of water supply and demand to analyze the supply, demand, and supply-demand balance of water resources within a certain region [18–20]. Secondly, the utilization efficiency of water resources can be measured by the ratio of water demand to actual water consumption, which fails to fully explain the actual utilization mode of water resources [21,22] (Fig. 1). Therefore, in this paper, the utilization efficiency of water resources in Xinjiang is mainly evaluated by the ratio of water demand to water consumption and the water consumption of 10,000 yuan gross product, and the utilization index of water resources of a single factor such as agriculture, animal husbandry, industrial water use efficiency, and water habits is specifically analyzed. The data used in this paper are mainly from Xinjiang Water Resources Bulletin, Xinjiang Statistical Yearbook, China County Statistical Yearbook (County Volume), etc. The standards used in this paper are mainly from Xinjiang Uygur Autonomous Region Local Standard – Agricultural Irrigation Water Quota (DB65/3611-2014).

2.2. Evaluation results of water scarcity

The total water supply of Xinjiang Uygur Autonomous Region in 2015 was 57.718 billion m^3, accounting for 62.9% of the total water resources. Surface water supply is the main water supply in all regions, and most of the surface water supply is diversion. Only Karamay has a large water transfer proportion and Shihezi mainly provides reservoir water storage. Xinjiang has an uneven distribution of water resources supply space, which basically presents the basic

Table 1
Evaluation index system of water resources development and utilization

Primary indicators	Secondary indicators	Tertiary indicators
Scarcity	Water supply	Total amount of water supply
	Water demand	Agricultural water demand
		Industrial water demand
		Urban and rural water demand
		Animal husbandry water demand
		Ecological water demand
Utilization efficiency	Water utilization	Total amount of water utilization
	Efficiency	Water consumption per 10,000 yuan of GDP, water consumption per 10,000 tons of grain output, water consumption per 10,000 yuan of gross animal husbandry output value, water consumption per 10,000 yuan of industrial added value
	Usual practice	Daily domestic water consumption per capita

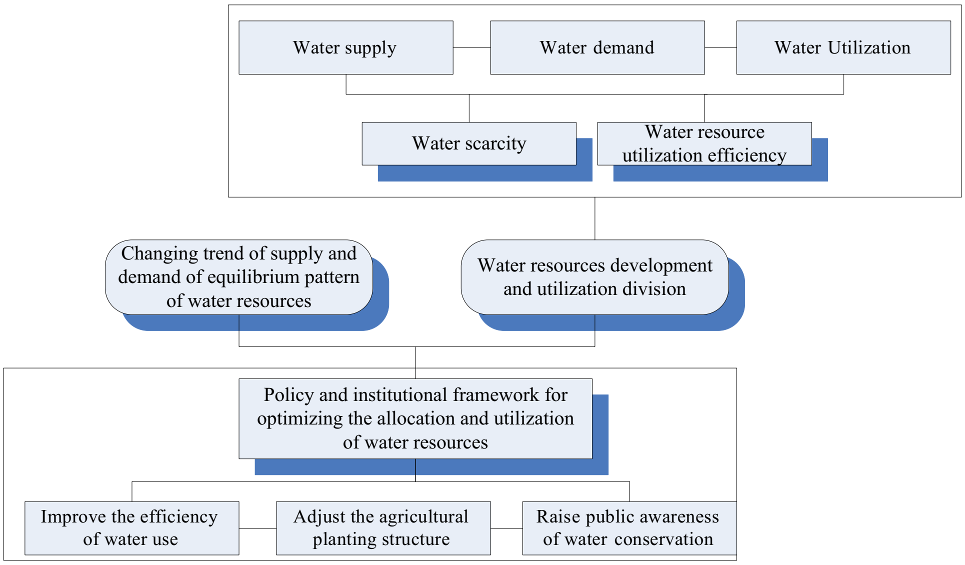

Fig. 1. Technical route of optimizing and adjusting the utilization of water resources.

characteristics of "more in the north than south, more in the west than east". Regionally, in 2015, the water supply of North Xinjiang was 21.258 billion m^3, with a water production modulus of 54,000 m^3/km^2; that of South Xinjiang was 34.039 billion m^3, with a water production modulus of 33,000 m^3/km^2.

The water demand of Xinjiang Uygur Autonomous Region in 2015 is mainly calculated based on land-use and land-cover change (LUCC) data, local industry water rating standards, and related research, to determine the rated water demand of each type of land, and to sum up the water demand based on administrative division scale. Bayingolin Mongol Autonomous Prefecture and Jingxian County have large total water demand, reaching 9.66 billion m^3, and it has the largest subalpine alpine meadow in China, Bayanbulak Grassland, which has a large demand for agriculture, animal husbandry, and ecological water resources. Among the single factor water demand, the areas with large agricultural water demand mainly concentrate on cotton planting areas such as Shawan County and Wusu City in Tacheng area, while the areas with large industrial water demand mainly concentrate on cities such as Urumchi, Karamay, and Korla, while the areas with large ecological water demand mainly include Ruoqiang County and Fuyun County which are located in key ecological function protection areas [23].

On the comprehensive supply and demand side, the total water demand in Xinjiang is 166.39 billion m^3, while the total water supply in Xinjiang in 2015 was 57.718 billion m^3, with a gap of 108.672 billion m^3. 77% of counties and districts are water scarce areas, and the regions with higher degree of scarcity are mainly located in Kizilsu Kirghiz Autonomous Prefecture and Kashgar, with obvious differences within the regions. For example, Kashgar has obviously uneven water resources development and utilization, including counties with abundant water resources, such as Jiashi County, and regions with scarce water resources, such as Shache County. Generally speaking, water resources are scarce in most areas of Xinjiang, and the existing water supply is far from meeting the water demand for social economy and ecological protection [24,25].

2.3. Evaluation results of water resource utilization efficiency

Based on the comparison of water demand and actual water consumption of each county, combined with water consumption of 10,000 yuan GDP, water consumption per grain output, water consumption per unit of total production value of animal husbandry, and water consumption per unit of added value of industry, the Xinjiang region is divided into water resource high-efficiency utilization area and low-efficiency utilization area [26,27]. Generally speaking, only Urumchi, Karamay, and Quining have higher water consumption of 10,000 yuan gross product than the national average, and the water demand is greater than the actual water consumption. The remaining counties are areas with lower water utilization efficiency. From the perspective of single factor, the water consumption per unit industrial output value of each county in Xinjiang is relatively large, especially in Moyu county and Pishan County in Hotan area of Shache County in Kashgar region, which is far higher than the national average level. The areas with high water efficiency for agriculture are mainly located in Xinjiang Corps and Tacheng area, while the water consumption per unit grain yield in North Xinjiang is lower; the water efficiency for animal husbandry in North Xinjiang is significantly higher than that in South Xinjiang. Except Urumchi and Karamay, the daily water consumption per capita in Xinjiang is larger, because the awareness of water saving in most areas is low, especially in Ili Kazakh Autonomous Prefecture and Altay, the daily water consumption per capita is 6 and 14 times the national average, respectively. Therefore, in most areas of Xinjiang, water resources are scarce and inefficient, so it is urgent to improve the carrying capacity of water resources and achieve sustainable development. The potential is great for future development of areas with abundant water resources and high efficiency of utilization. In particular, the layout of textile industry needs to consider both the supply conditions of water resources and the pressure on local water resources caused by their migration. Therefore, when introducing or building textile industry enterprises, not only should the existing status of water resources development and utilization be considered, such as selecting areas with high water efficiency and low water scarcity as far as possible, but also water resources management should be strengthened.

3. Current situation of water resources utilization in cotton planting and textile industry in Xinjiang

Textile industry, as a traditional industry in Xinjiang, has played an important role in promoting the social and economic development of Xinjiang for a long time. Since the reform and opening up, the advantages of transportation, labor cost, capital, and policies in the eastern coastal areas have led to the gradual adjustment of the textile industry structure in Xinjiang, focusing on the upstream links such as cotton planting, raw material supply, and cotton textile processing. After the financial crisis, the textile industry in the eastern part of China has gradually lost its advantages and transferred to the central and western regions at a faster speed since 2006. After 2015, Xinjiang has entered a period of rapid development and become an important region to undertake the textile industry throughout the country. Textile industry, as a high water consumption and pollution industry, has different demand for water resources in different production links. While undertaking the eastern textile industry, the development of textile industry should be rationally laid out according to the water resources demand of different links, and the water resources supply conditions in Xinjiang.

3.1. Current situation of water consumption for cotton planting and textile industry in China

Since the founding of the People's Republic of China, the cotton planting has generally moved from the east (Beijing, Tianjin, Hebei, Shandong, Heilongjiang, Jilin, and Liaoning) to the middle (Henan, Shanxi, Inner Mongolia, Sichuan, and Yunnan) and then to the west (Shaanxi, Gansu, Ningxia, Qinghai, Tibet, and Xinjiang), has gathered in Xinjiang especially after the 1990s. In 2018, cotton output in Xinjiang reached 5.111 million tons, accounting for more than 5/6 of the country (Fig. 2). At the same time, the downstream industry of cotton planting is also the textile and clothing industry vigorously developed in Xinjiang at present, which is also a high water consumption and water pollution industry. In conjunction with global warming, it is more necessary to carry out comprehensive research and judgment in combination with regional water resources carrying capacity, water environment carrying capacity, and their evolution trend, so as to reasonably determine the industrial development scale and spatial layout.

Textile industry, as the traditional pillar industry and important livelihood industry of our national economy, is also a typical high water consumption and high pollution industry. According to National Industries Classification, textile industry can be divided into textile manufacturing, printing, and dyeing, chemical fiber, clothing, textile machinery manufacturing, and other industries. According to the China Textile Industry Development Report, China's textile industry includes 12 sub-industries, such as chemical fiber, cotton textile, wool textile, silk, linen textile, filament weaving, printing and dyeing, knitting and clothing. In the textile industry, the upstream industrial chain includes the supply and primary processing of raw materials such as cotton, wool, cashmere, silk, and chemical fibers, while the midstream industrial chain includes the production processes of spinning, weaving, printing and dyeing, and washing, while the downstream industrial chain includes the manufacture, operation and sale of apparel, home textiles, and industrial textiles, as well as textile supporting industries such as textile machinery, design, and exhibition (Fig. 3).

Spatially, textile enterprises in China are mainly concentrated in the eastern coastal areas, especially in Shandong, Jiangsu, Zhejiang, Guangdong, and Fujian provinces; Zhejiang has the highest export delivery value, followed by Jiangsu, Shandong, and Guangdong. In 2016, the main business income of the textile industry in the east still accounted for 73% of the country, while that in the middle and west increased from 17.92% in 2010 to 25.06% since

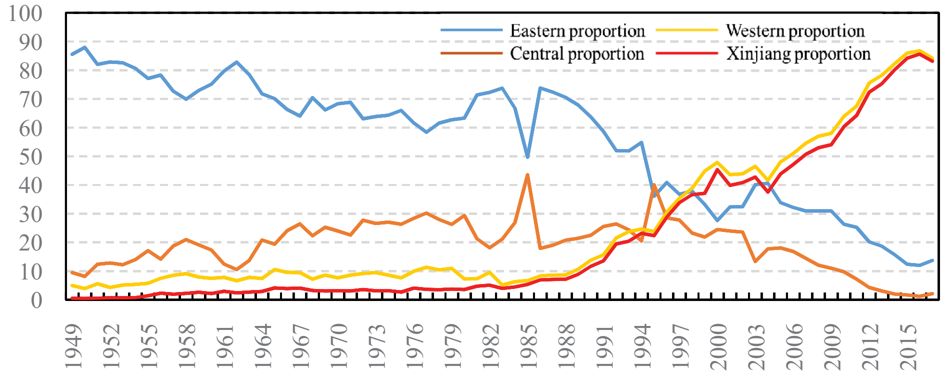

Fig. 2. Variation of cotton yield proportion in China (1949–2017).

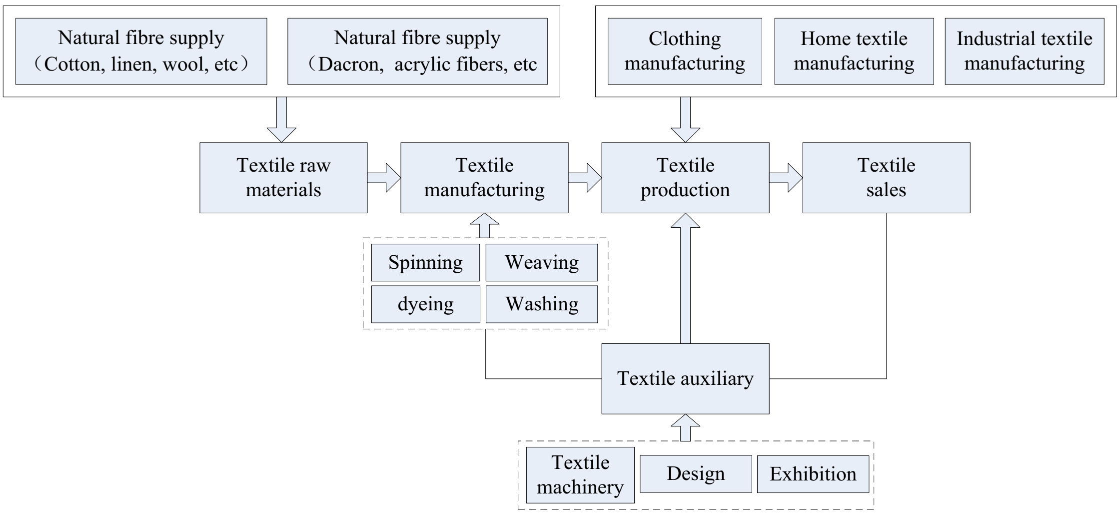

Fig. 3. Textile industry chain.

the introduction of the Textile Industry Adjustment and Revitalization Plan in 2009. For a long time, the eastern coastal areas have made full use of the market and basically formed a complete industrial chain model from raw materials to final products. In contrast, the textile industry in the central and western regions is still underdeveloped. Most of the main textile industrial products are still concentrated in the eastern region, for example, in 2015, the output of printing and dyeing cloth in the eastern region accounted for 96% of the country; ramie cloth was mainly produced in the central region, accounting for 92.5% of the country; silk was mainly produced in the western region, accounting for 56% of the country's output; and end products such as clothing were also concentrated in the eastern region, accounting for 90% of the country's output (Table 2).

According to the Water Efficiency Guidelines for Key Industries issued jointly by the Ministry of Industry and Information Technology, the Ministry of Water Resources, the National Bureau of Statistics, and the National Water Conservation Office in 2013, water consumption in textile enterprises mainly includes water for pretreatment of various fabrics, dyeing, preparation of printing solutions, and rinsing water, as well as rinsing water for finished fabrics. A large amount of water is consumed in most sectors of the textile industry. In 2015, the total water consumption of textile enterprises above state designated scale reached 8.65 billion tons, accounting for 2.36% of the national industrial water consumption; the total freshwater intake was 3.14 billion tons, accounting for 8.1% of the national industrial water intake. In 2014, the water consumption ratio of textile industry, chemical fiber manufacturing, and clothing industry was 47.0:50.0:3.0, while the water intake ratio was 79.0:16.0:5.0.

Among them, the industry with the largest water consumption in textile industry is printing and dyeing industry, followed by chemical fiber industry and textile manufacturing. In the printing and dyeing industry, it mainly uses chemical processing, water as the medium of wet processing to dye and print all kinds of fabrics. Generally, the process of fabric printing and dyeing requires 4–7 times of water washing in dry or wet processing, so a large amount of steam is also required. In addition, a large number of difficult-to-degrade materials and wastewater will also be produced in the production process of the printing and dyeing industry, so it has the largest water consumption and drainage in the textile industry. In terms of products, water consumption in printing and dyeing industry mainly includes water for cotton printing and dyeing products,

Table 2
Proportion of main textile products output in China in 2015 (in %)

	Textile	Dyeing cloth	Wool	Woollen woven fabric	Linen
Western	75.23	96.09	80.88	79.66	58.59
Central	17.71	1.68	13.43	11.33	2.28
Eastern	3.53	1.63	3.96	6.72	8.44
North-eastern	0.55	0.19	1.19	1.99	22.63
	Ramie fabric	Silk	Spun silk	Silk and interlace	Silk quilt
Western	0.10	28.09	78.21	51.32	50.86
Central	92.50	5.53	1.82	1.99	35.78
Eastern	7.40	56.00	19.97	34.92	7.69
North-eastern	0.00	1.71	0.00	0.08	1.59
	Non-woven	Tyre fabrics	Clothing	Woven garments	Down jacket
Western	65.94	88.18	90.87	70.18	58.33
Central	20.10	9.67	13.90	17.37	34.10
Eastern	2.54	0.00	3.15	4.56	2.35
North-eastern	4.93	0.00	2.40	2.96	1.24
	Tailored suit	Shirt	Knitwear	Pulp for chemical fiber	Chemical fiber
Western	52.57	80.84	84.13	30.88	91.51
Central	39.09	5.54	9.93	11.61	2.75
Eastern	3.38	3.78	1.53	38.55	3.75
North-eastern	2.76	6.04	1.76	0.90	1.38

wool, hemp, silk screen printing and dyeing products, chemical fiber printing and dyeing products, and water for jeans, among which cotton printing and dyeing products have large output and water consumption. In the chemical fiber industry, water is mainly used in the production process of polyester fiber, and the dry process is used to produce melt spinning, during which the water consumption of air conditioning is large. Besides, on the textile industry, the spinning and weaving of natural fiber, chemical fiber, and mixed fiber are mainly carried out by physical methods. In order to ensure the processing quality, a large amount of water for air conditioning and air humidification is needed. The water consumption in the production process of clothing industry is less, mainly concentrated in the workshop air conditioning and clothing ironing. In order to regulate water consumption and promote water conservation in the industry, the revised Water Intake Quota Part 4: Textile Dyeing and Finishing Products were published in 2012, which stipulates that the water intake of an enterprise shall not exceed the quota value in actual application. Provinces and cities have also formulated water intake quota standards for products such as cotton, linen, chemical fibers, and blending machine fabrics in light of local economic development. The standards in the middle and east regions are basically close to the national quota, while the water intake quota for similar products in the west region is slightly higher than the national standard.

As the main water-consuming link of textile industry is printing and dyeing, the water consumption pattern of national textile industry can be basically judged by comparing the differences between printing and dyeing products and water quota standards for printing and dyeing (Fig. 4). In the Chinese textile industry, water consumption for printing, and dyeing industry is mainly concentrated in the east coast, of which Zhejiang Province consumes the largest amount of water, exceeding 500 million m^3, and most provinces in the central region has a small water consumption for printing and dyeing except for Hubei Province. Printing and dyeing industry accounts for a very small part or is missing in the industrial chain in the western region, which consumes little water. Despite the abundant water resources in the eastern coastal area, the water quality is deficient, and the textile printing and dyeing industry not only consumes more water, but also pollutes water resources to a high degree, resulting in high water environment pressure on the Huaihe River, Haihe River, Pearl River, and other catchments. During the 13th Five-Year Plan period, China's textile regional industrial structure adjustment will promote the further development of textile industry in the central and western regions, where the shortage of water resources will be an important weak link for the pattern adjustment of textile industry.

3.2. Current situation of water consumption in cotton planting and textile industry in Xinjiang

Xinjiang, as the main cotton growing area in China, accounted for 53.5% of the planting area and 67.3% of the output in 2016. According to varieties and fiber length, cotton in China is divided into fine-lint cotton and long-lint cotton, in which the output of Xinjiang long-lint cotton accounts

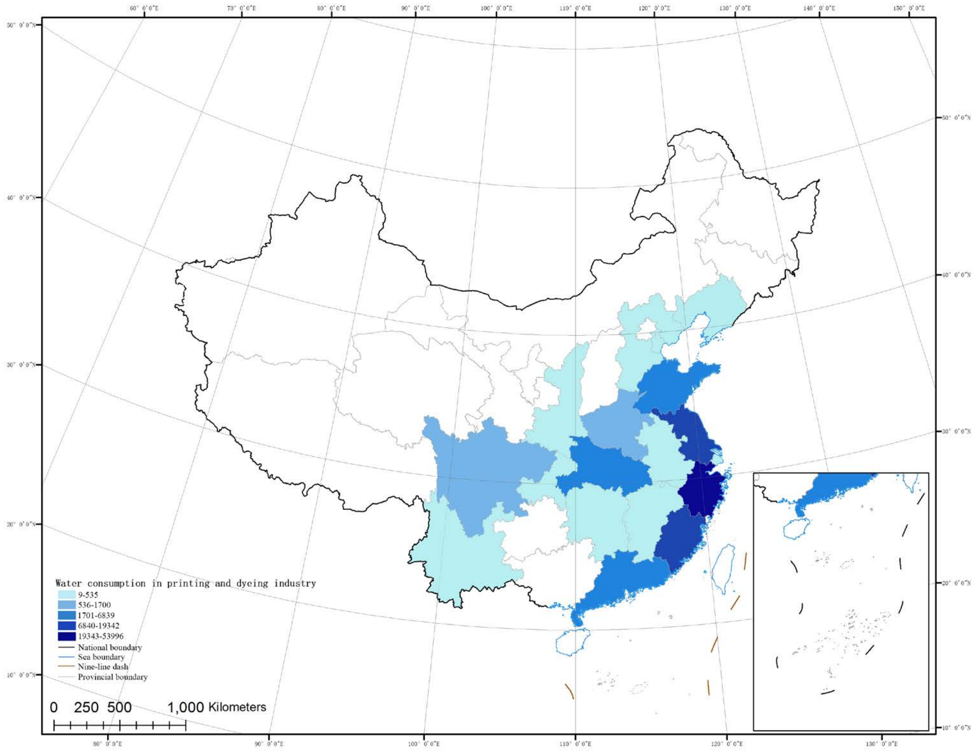

Fig. 4. Distribution of water consumption in textile printing and dyeing industry of major provinces and cities in China in 2015.

for more than 90% of the country, and five long-lint cotton varieties, Xinhai 43, Xinhai 45, Xinhai 37, Xinhai 35, and Xinhai 24, are only planted in Awat County and villages and towns of Aksu City, South Xinjiang (China Cotton Quality Analysis Report 2015/2016, 2016). Cotton requires more water for planting and irrigation. Regularly, at the irrigation guarantee rate of 50%, the average irrigation water for cotton per mu is more than 300 m^3. Xinjiang is a typical arid and water-shortage area, and it consumed 57.718 billion m^3 water totally in 2015, which exceeds the national total water consumption control target of 51.5 billion m^3, of which agricultural irrigation water accounts for 94% of the total water consumption (Fig. 5).

After the founding of New China, Xinjiang began to build a textile industry to produce printing and dyeing cloths, worsted wool, and knitted fabrics needed by local residents. After reform and opening up, textile industry has become one of the pillar industries in Xinjiang. In 1998, the number of employees in textile industry in Xinjiang reached 15%, while the rapid rise of eastern coastal areas has seriously impacted the development of textile, dyeing, clothing, and home textile industries in Xinjiang, hindering the extension, and development of the industry. As a result, textile industry employees accounted for only 1.8% of the total area in 2016. After 2000, Xinjiang textile industry made structural adjustment and vigorously developed cotton spinning industry. As the upstream of the textile industry chain, cotton spinning industry includes cotton breeding, planting, circulation, and processing. Textile products in Xinjiang are mainly concentrated in the initial processing stage, such as cotton yarn, cotton cloth, etc.

4. Forecast and suggestion for water consumption of cotton planting and textile industry in Xinjiang

4.1. Water consumption forecast of cotton planting and textile industry in Xinjiang

In this paper, the current situation of textile industry water in Xinjiang is divided into two parts: raw material planting water and industrial water. According to statistics, the main products of textile industry in Xinjiang were yarn, cloth, wool, clothing, etc., and the water consumption of textile industry was about 9.6 billion m^3 according to water quota standard in 2015. In order to build a water-saving society, the most stringent water resource management system is implemented. In 2012, Xinjiang established a planning water resource demonstration system to ensure that the planning layout and water resource carrying capacity are suitable. The forecasting methods of water demand mainly include quota method, trend method, correlation method, and water balance method. The product quota method is mainly used in this paper to make a simple prediction of water demand. According to the 13th Five-Year Development Plan of Textile Industry of Xinjiang Uygur Autonomous Region, by 2020, the cotton spinning will have a capacity to produce 18 million spindles (including air spinning), 30,000 tons of knitted goods, 15 million sets of household textile products, 500 million sets of clothing and apparel, which will together consume a total of 1–1.2 million tons of cotton. At the same time, according to the 13th Five-Year Plan for textile industry, water consumption of 10,000 yuan industrial added value will decrease by 20% and that of knitted fabrics will be decreased to 80 m^3/t by 2020. According

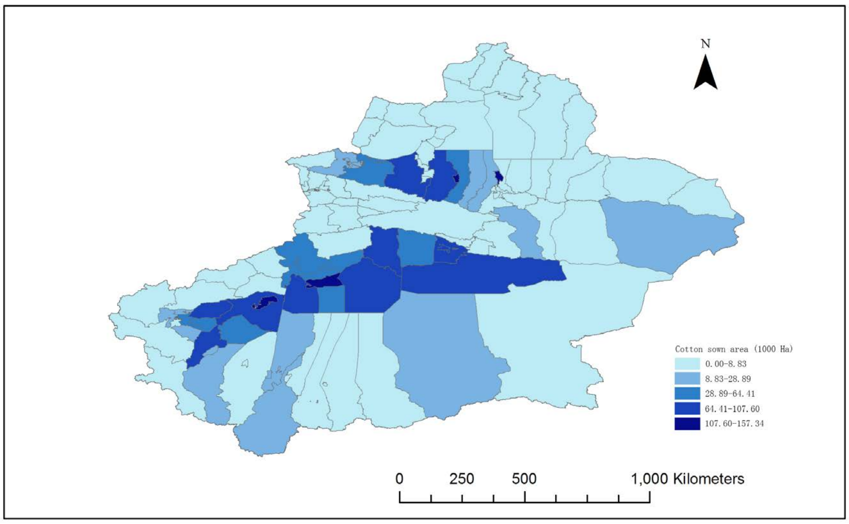

Fig. 5. Distribution of cotton planting area in counties and districts of Xinjiang in 2015.

to the current water intake quota of textile enterprises per unit and some water intake quota to meet the standard in the future, it is roughly estimated that by 2020, the water consumption of Xinjiang textile industry is expected to be 2.27 million m^3, more than twice that of current textile industry.

Cotton planting in Xinjiang is mainly concentrated in Xinjiang Corps, Usu, and Shawan counties in Tacheng area, Shaya, and Kuqa counties in Aksu area, etc., which show the obvious zonal distribution in northern Xinjiang, and arc distribution in southern Xinjiang along northern and Western Taklimakan Desert. According to different topographical features and irrigation characteristics, cotton planting in Xinjiang is divided into 16 irrigation zones. Due to different water quotas for crops in different zones, the water requirement for cotton planting in Xinjiang is estimated to reach 17.5 billion m^3, which is close to 1/3 of the total water consumption control target of 55.02 billion m^3 in 2020.

Therefore, although the current water consumption of textile industry in Xinjiang is small and much less than that of printing and dyeing in the eastern coastal areas, cotton planting consumes a large amount of water resources, which not only accounts for a large share of agricultural irrigation water, but also exceeds the water intake of printing and dyeing industry in Zhejiang Province, which consumes the largest amount of water. The water resources saved by reducing the planting area of cotton and strengthening the application of water-saving irrigation technology can be supplied to the newly added water consumption in textile process through speeding up the transformation from the upstream industrial chain such as raw material planting and primary product processing to the downstream industrial chain such as textile manufacturing and clothing manufacturing.

4.2. Suggestions on the strategic development of cotton planting and textile industry in Xinjiang based on water consumption forecast

Since 2014, with the continuous promotion of the "Belt and Road" initiative, the support to Xinjiang's clothing and textile industry has increased to an unprecedented level. The preferential policies of the state on textile industry in Xinjiang cover many aspects such as funds, taxes, freight, cotton, and so on. In terms of raw materials, a pilot cotton target price reform in Xinjiang has been launched since 2014 to implement quota subsidies; in terms of funds, a special fund for the development of textile and clothing industry has been set up; in terms of taxation, the VAT paid by textile and clothing enterprises has been used to support the development of textile and clothing industry; in terms of transportation expenses, the scope of freight subsidy for cotton textiles has been extended, for example, further increasing the freight subsidy for textile and apparel out of China, making the freight basically the same as that for sea transportation through special freight subsidy for international transportation to the west, supporting the centralized construction of high-standard printing and dyeing wastewater treatment facilities in Aksu, Korla, and Shihezi, and subsidizing the operation costs for a certain period of time. In 2015, the new fixed assets investment in the new textile industry was three times that of the previous year, and the textile and garment industry was 4.5 times that of the previous year. From January to June 2017, the fixed assets investment in the textile industry in China was 613 billion yuan, an increase of 91.11% year-on-year, of which the textile industry investment in Xinjiang accounted for 4% of the country, and the fixed assets investment completed was 24.364 billion yuan, an increase of 48.1% over the same period last year. The textile industry in Xinjiang has entered an upward development period. According to the Textile Industry Development Plan (2016–2020) formulated by the Ministry of Industry and Information Technology, during the 13th Five-Year Plan, Xinjiang will construct a base of high-quality cotton, yarn, and cotton cloth to vigorously develop labor-intensive industries such as clothing, home textile, and knitting. Because of uneven spatial and temporal distribution of water resources in Xinjiang, fragile oasis ecosystem, and great restriction of ecological resources and environment on the development of textile industry, it is not only necessary to adjust the water supply structure to suit the intermediate and high water-consuming industries such as printing, dyeing, and weaving, but also to put forward higher requirements for clean production and wastewater treatment in the future development of textile industry in Xinjiang, in order to basically build up the national important cotton spinning industry base, clothing and apparel production base in the northwest region and core area of Silk Road Economic Belt and distribution center for export to the west by 2020.

In terms of industrial chain layout, cotton textile industry, such as wool textile and linen textile, is mainly laid out in Korla Economic Development Zone, Yili, Tacheng, Shihezi, Aletai, Urumchi; clothing and home textiles are mainly laid out in three labor-intensive areas, namely Kashgar, Ili, and Turpan; and the most water-consuming printing and dyeing industry (including the whole industrial chain project with printing and dyeing links and separate printing and dyeing items) is mainly laid out in three comprehensive textile industry bases, Shihezi, Aksu, and Korla, as well as the National Economic and Technological Development Zone in Alear City and the Caohu Textile Industry Park. According to the analysis on the current situation of water resources development and utilization, it is found that the contradiction between supply and demand of water resources in Shihezi, Aksu, and Korla is small, with water resources gap of only 70, 146, and 572 million m³ respectively, ranking in the 5th, 8th, and 20 places with small water resources gap, and the adjustment of water resources development and utilization structure is less difficult.

5. Conclusions and prospect

For Xinjiang, undertaking the transfer of the textile industry in the eastern coastal areas, upgrading the original textile industry structure, and developing the whole industrial chain projects from the planting of raw materials, cotton spinning and processing, printing and dyeing, garment manufacturing are the key points for the future economic and social development. As a high water consumption industry, the background conditions of water resources, and the current situation of development and utilization in the receiving area play an important role in restricting the development of textile industry in the future. However, most areas in Xinjiang have uneven distribution of water resources, which are characterized by unbalanced supply and demand of water resources, high scarcity, and low water efficiency in most counties. In addition, except for Xinjiang Corps and Tacheng area, other areas have relatively low agricultural water use efficiency; the industrial water use efficiency is generally not high in the whole Xinjiang; the water use efficiency of animal husbandry in North Xinjiang is higher than that in South Xinjiang; and the general awareness of water-saving is low in most areas.

The environmental water demand of different industrial chains in textile industry differs greatly, among which the printing and dyeing industry has the largest water consumption. At present, the textile industry in Xinjiang is still in the stage of planting, supplying, and initial processing of raw materials with a low water consumption of about 9.6 million m³. However, the water consumption for cotton planting is huge, and the water demand for cotton planting in Xinjiang reaches 13.395 billion m³. Water demand of textile industry in Xinjiang will reach 22.7 million m³ in the future. The water supply structure can be changed by reasonably controlling the cotton planting area, improving the cotton quality, and changing the irrigation mode, so as to supply the agricultural irrigation water saved to the development of the textile industry, thus reducing the pressure of the textile industry on the water resources of Xinjiang. From the perspective of planning the industrial layout, the printing, and dyeing industry with large water consumption is also reasonably distributed, basically in the areas with small contradiction between supply and demand of current water resources.

Therefore, the change of water supply structure can promote Xinjiang water resources to undertake the task of undertaking the transfer of textile industry and constructing the textile industry chain. However, it should be noticed that during the industrial transfer, wastewater discharged from the production process of textile industry and population agglomeration brought by the development of textile and clothing industry will also cause great risk pressure on the local water ecological environment. Meanwhile, the per capita daily water consumption in Xinjiang is high, which is not conducive to the sustainable development of water resources.

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References

[1] H. Meng, Z.Z. Wang, J.B. Li, Y. Zhou, Z. Xiao, Evolvement of spatial pattern of textile in Pan-Yangtze River Delta at processing industry chain, Econ. Geogr., 37 (2017) 107–113.
[2] H. Biemans, C. Siderius, A.F. Lutz, S. Nepal, B. Ahmad, T. Hassan, W. von Bloh, R.R. Wijngaard, P. Wester, A.B. Shrestha, W.W. Immerzeel, Importance of snow and glacier meltwater for agriculture on the Indo-Gangetic Plain, Nat. Sustainability, 2 (2019) 594–601.
[3] C.D. Xiao, S.J. Wang, D.H. Qin, A preliminary study of cryosphere service function and value evaluation, Adv. Clim. Change Res., 6 (2015) 181–187.
[4] M. Huss, R. Hock, Global-scale hydrological response to future glacier mass loss, Nat. Clim. Change, 8 (2018) 135–140.
[5] J. Gao, T.D. Yao, Collapsing glaciers threaten Asia's water supplies, Nature, 565 (2019) 19–21.
[6] S. Wang, B.J. Fu, R. Bodin, J. Liu, M. Zhang, X. Li, Alignment of social and ecological structures increased the ability of river management. Sci. Bull., 64 (2019) 1318–1324.
[7] M. Beniston, M. Stoffel, Assessing the impacts of climatic change on mountain water resources, Sci. Total Environ., 493 (2014) 1129–1137.
[8] W. Immerzeel, A. Lutz, M. Andrade, A. Bahl, H. Biemans, T. Bolch, S. Hyde, S. Brumby, B.J. Davies, A.C. Elmore, A. Emmer, M. Feng, A. Fernández, U. Haritashya, J.S. Kargel, M. Koppes, P.D.A. Kraaijenbrink, A.V. Kulkarni, P.A. Mayewski, S. Nepal, P. Pacheco, T.H. Painter, F. Pellicciotti, H. Rajaram, S. Rupper,

A. Sinisalo, A.B. Shrestha, D. Viviroli, Y. Wada, C. Xiao, T. Yao, J.E.M. Baillie, Importance and vulnerability of the world's water towers, Nature, 577 (2019) 364–384.
[9] Y.C. Lan, Y.P. Shen, S.F. Wu, Changes of the glaciers and the glacier water resources in the typical river basins on the north and south slopes of the Tianshan Mountains since 1960s, J. Arid Land Resour. Environ., 21 (2007) 1–8.
[10] W. Immerzeel, V. Beek, P. Bierkens, Climate change will affect the Asian water towers, Science, 328 (2010) 1382–1385.
[11] Y.P. Shen, H.C. Su, G.Y. Wang, W.M. Mao, S.D. Wang, P. Han, N. Wang, Z.Q. Li, The responses of glaciers and snow cover to climate change in Xinjiang(I): hydrological effects, J. Glaciol. Geocryol., 35 (2013) 513–527.
[12] F.M. Azmi, N.S. Tajudin, R. Shahari, C.N.A. Che Amri, Early growth response and nutrients quality of Fig (*Ficus carica* L.) planted on bris soil effected by chicken manure amendments, J. Clean WAS, 4 (2020) 46–50.
[13] Q. Wang, A.M. Bao, Q.X. Yi, Discussion on the available water resources index for major function zoning in Xinjiang, Resour. Sci., 34 (2012) 613–619.
[14] V. Radic, R. Hock, Glaciers in the earth's hydrological cycle: assessments of glacier mass and runoff changes on global and regional scales, Surv. Geophys., 35 (2014) 813–837.
[15] M. Marwan, A. Ahmed, A.M. Sahilah, Detection of HBLD toxin gene by *Bacillus cereus* isolated from meat curry food samples in Malaysian restaurants, Environ. Ecosyst. Sci., 4 (2020) 51–55.
[16] M.Z. Deng, D.H. Qin, H.G. Zhang, Public perceptions of climate and cryosphere change in typical arid inland river areas of China: facts, impacts and selections of adaptation measures, Quat. Int., 282 (2012) 48–57.
[17] H.D. Pritchard, Asia's shrinking glaciers protect large populations from drought stress, Nature, 569 (2019) 649–654.
[18] M. Huss, B. Bookhagen, C. Huggel, D. Jacobsen, R.S. Bradley, J.J. Clague, M. Vuille, W. Buytaert, D.R. Cayan, G. Greenwood, B.G. Mark, A.M. Milner, R. Weingartner, M. Winder, Toward mountains without permanent snow and ice, Earth's Future, 5 (2017) 418–435.
[19] F. Reda, B. Bashir, Bottled water sold in the Tripoli markets: challenges and shortcomings, Water Conserv. Manage., 4 (2020) 63–67.
[20] Y.J. Wang, D.H. Qin, Influence of climate change and human activity on water resources in arid region of northwest china: an overview, Adv. Clim. Change Res., 13 (2017) 483–493.
[21] J. Liu, J.C. Huang, H.X. Lin, A literature review on regionalization of water resource service function of cryosphere in China, Arid Land Geogr., 41 (2018) 751–760.
[22] H.-X. Lin, J.-C. Huang, C.-L. Fang, X.-X. Qi, Y.-Q. Chen, A preliminary study on the theory and method of comprehensive regionalization of cryosphere services, Adv. Clim. Change Res., 10 (2019) 115–123.
[23] J. Peng, H.X. Lin, Y.Q. Chen, T. Blaschke, L.W. Luo, Z.H. Xu, Y.N. Hu, M.Y. Zhao, J.S. Wu, Spatial evolution of urban agglomeration in China during 2000–2012: a nighttime light approach, Landscape Ecol., 35 (2020) 421–434.
[24] R.R. Wijngaard, H. Biemans, A.F. Lutz, A.B. Shrestha, P. Wester, W.W. Immerzeel, Climate change vs. socio-economic development: understanding the future South Asian water gap, Hydrol. Earth Syst. Sci., 22 (2018) 6297–6321.
[25] T. Yao, G. Wu, B. Xu, W. Wang, J. Jing, B. An, Asian water tower change and its impacts, Bull. Chin. Acad. Sci., 34 (2019) 1203–1209.
[26] H.X. Lin, J.C. Huang, C.L. Fang, J. Liu, X. Qi, Y. Chen, Regionalization of cryosphere water resource service, Desal. Water Treat., 168 (2019) 394–404.
[27] X.M. Wang, J.L. Zhang, S.W. Liu, Socioeconomic significance of Asian water tower in high Asia region, Bull. Chin. Acad. Sci., 34 (2019) 1332–1340.