Global Water Partnership(China) WACDEP

Work Package Three Outcome Report

To increase the Benefits of Water Investment For Regional and National Development

---A case study of Shaanxi Province

Research Office of Shaanxi Provincial People's Congress

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Abstract

Water is not only the indispensable and irreplaceable natural resources for human survival and development, but also very important strategic resources. Water is the infrastructure and the basic industry of the national economic and social development. With the economic growth, the pressure on scarce resources and ecological environment protection is highlighted. The need for government at all levels to speed up the water investment and improve people's welfare is pressing. Therefore, a comprehensive assessment of water investment in Shaanxi Province is of great practical significance.

Relatively speaking, Shaanxi Province is short of water resources with less total amount and per capita share. In addition, the spatial distribution of water resources is also extremely unreasonable: the southern part of Shaanxi Province which is part of the Yangtze River basin takes up over 70% while the northern part which is highly populated with fast industrial development only shares 30% of it. The conflict between the demand for water resources and the distribution, to some extent, restrict the social and economic development.

The Shaanxi Provincial Government has put the water sector in an important place. It is even so from 2010 to now with a dramatic increase on investment, reaching a total investment amount of 22.408 billion RMB in 2013. While the investment increases, the investors have shown a tendency of diversification: there is a significant increase of private investment and credit financing ration accompanied with the increase of investment from the central and provincial governments and cities. Seen from the perspective of investment direction, the flood control project takes the priority of the investment, which accounts for more than 30%. In recent years, the investment priorities have apparently leaned towards water sources and key projects, followed by investment in rural and urban water supply and drainage and irrigation projects.

In the last ten years (2002-2012), the normative research and empirical research on water investment of Shaanxi Province demonstrated that, water investment has guaranteed people’s life and property security, gradually solved the water resources problem and reduce the pressure in the

social and economic development of different areas in Shanxi Province, improving the situation on water, promoting the development of industry, agriculture and urban water supply, boosting the employment and economic growth, enhancing the urbanization level. The solution has promoted the sustainable development of water resources which has gained obvious economic and social benefits. By using the econometric analysis, the study shows that the progress on flood control, urban and rural water supply and power generation are in prudent increase, achievements have been made in water conservation and irrigation, but unstableness remains. This has confirmed that water investment in Shaanxi Province has achieved good benefits.

The progress and achievement on water investment performance achieved owe thanks to the Shaanxi Provincial Government for attaching great importance to it and the consistent large amount of investment from the central and provincial governments and cities. It also owes its gratitude to the diversified investors, the creative investment channels, the perfection of systems and mechanisms and the enhancing of awareness for evaluation and assessment. Meanwhile, it should also be noted that there is still room for improvement for the water investment: comprehensive planning should be addressed while taking care of the investment on key projects, the supervision and management of the use of funds should be improved and the local matching funds need to be guaranteed.

The study suggests that it is advisable to continue to enlarge the scale of investment through multiple channels, speed up the system reform of water investment and financing, improve the water fund management, strengthen the management and supervision and the performance evaluation. It is also sensible to allow the public to participate in the water resources exploitation via publication so as to form the national water-saving awareness and further improve the work on water investment in Shaanxi Province.

Content

I. Water Resources Overview in Shaanxi Province

1. Status Quo

1.1 Water resources zones

Shaanxi Province lies in the hinterland in northwest China, spanning from 105°29'E to 111°15'E, and from 31°42'N to 39°35'N. With a distance of 200 to 500 km from east to west and 870 km from north to south, Shanxi occupies an area of 205,600 square km. It is divided by Qinling Mountains and run through by the Yangtze River and the Yellow River. On the south of Qinling Mountains lies the drainage basin of the Yangtze River, which covers 72,300 square km; on the north of Qinling Mountains lies the drainage basin of the Yellow River, which covers 133,300 square km.

The whole province has large latitudinal span. As for the terrain, its middle part has a higher altitude than its northern and southern parts, and its western part has a higher altitude than its eastern part. It has a variety of landforms. It is divided into three parts by Qinling Mountains and the North Mountain. The north part is the Loess Plateau. The middle part is the Graben Basin (plain). The south part is the fault-block mountain areas (Qinba Mountainous area). The province has a total of 172,300 square km of hilly region and 33,300 square km of plain.

Within the province, main tributaries of the Yellow River include Kuye River, Wuding River, Yanhe River, Weihe River, Jing River, Luohe River, YiLuohe River, etc; and tributaries of the Yangtze River include Han River, Dan River and Jialing River. There are 4,296 rivers with a drainage area larger than 10 square km, 2,518 of them in the drainage basin of the Yellow River and 1,778 in that of the Yangtze River.

There are 560 rivers with a drainage area larger than 100 square km; 64 rivers larger than 1,000 square km; 14 rivers larger than 5,000 square km; and 8 rivers larger than 10,000 square km. Weihe River is the largest river in the central Shanxi plain. With its source in Gansu Province, Weihe River flows through Gansu, Ningxia and Shanxi provinces. Jing River and Luohe River

converge into it from the north. Each of these rivers has a long watercourse and large capacity. Han River is the largest river at the south of Shanxi Province. It snakes through Qinling Mountains and Bashan Mountain. The Yellow River marks the boundary between Shaanxi and Shanxi provinces which is as long as 719 km. The river flows through gorges in Shaanxi and Shanxi provinces, and then it passes through Longmen before it flows into Guanzhong and the Feng River Valley.

According to the standard national demarcation for water resources, the Yellow River basin and the Yangtze River basin are both among the 10 first-level water resource regions in China. The two first-level regions can be further divided into 6 second-level regions, 14 third-level regions, and 27 fourth-level regions, as is shown in the table 1-1.

Table 1-1 Water Distribution in Shaanxi Province

First-level region	Second-level region	Third-level region	Fourth-level region
The Yellow River	From Hekou Village to Longmen	Upstream from Wubao north bank	Upstream from Wubao north bank
		Downstream from Wubao, north bank	Wuding River
			Tributaries on the north of Shanxi
	From Longmen to Sanmenxia City	Upstream of BeiLuohe River from Zhuangtou	Upstream of Beiluohe from Nanchengli
			From Nanchengli to Zhuangtou
		Upstream of Jinghe River from Zhangjiashan	Malian River, Puhe River, Honghe River
			Heihe River, Daxi River, Jinghe River
		Upstream of Weihe River from Baoji Gorge	Upstream of Weihe River from Baoji Gorge, north bank
			Upstream of Weihe River from Baoji Gorge, south bank
		Weihe River: from Baoji Gorge to Xianyang	From Baoji Gorge to north bank of Xianyang
			From Baoji Gorge to south bank of Xianyang
		Weihe River: from Xianyang to Tongguan	From Xianyang to the north bank of Tongguan
			From Xianyang to the south bank of Tongguan
		Trunk stream section from Longmen to Sanmenxia City	Trunk stream section from Longmen to Tongguan City
			Trunk stream section from Tongguan to Sanmenxia City
	From Sanmenxia City to Huayuankou	YiLuohe River	NanLuohe River
	Enclosed basin	Enclosed basin	Enclosed basin
The Yangtze	Jialing River	Upstream from Guangyuan Zhaohua	Fengxian District

River			Jiagan District
		Qujiang River	Qujiang Heyuan District
		Downstream from Guangyuan Zhaohua	Maobahe River District
	The Hanjiang River	Upstream from Danjiangkou	The Hanjiang River: upstream from Wuhouzhen
			From Wuhouzhen to Shiquan
			From Shiquan to Baihe
			Middle reaches of Hanjiang River
			Danjiang River: upstream from Jingziguan
			Danjiang River: downstream from Jingziguan

Data source: Comprehensive Plan and Report about Water Resources in Shanxi Province in 2008

1.2 Available water resources

According to the hydrological data collected between 1956 and 2000, the average amount of water resources in Shaanxi Province stands at about 42.33 billion cubic meters. The Yellow River and the Yangtze River has 11.66 billion and 30.67 billion respectively, accounting for 27.5% and 72.5% of the total amount respectively. The northern, middle and southern part of Shaanxi Province has 4.04 billion, 8.23 billion and 30.06 billion cubic meters of water resources, accounting for 9.5%, 19.4% and 71.1% of the total respectively. Details about the water resources in Shaanxi Province can be found in Table 1-2.

Table 1-2 Assessment Results of Water Resources in Shaanxi Province (from 1956 to 2000)

Name of the region	Area（10,000 km^2）	Average precipitation		Average amount of surface water resources		Average amount of groundwater resources（10,000 m^3）	Average amount of water resources		Amount of water resources per unit area (10,000 m^3/k m^2)
		Depth（mm）	Volume（10,000 m^3）	Depth（mm）	Volume（10,000 m^3）		The total amount (10,000 m^3)	percentage (%)	
The middle Shaanxi	55384	647.6	3586850	118.4	656016	468738	823262	19.4	14.9
The northern	80290	454.3	3647852	39.1	313558	213926	403566	9.5	5.0
The south Shaanxi	69929	894.7	6256868	428.2	2994568	624921	3006011	71.1	43.0
In total	205603	656.2	13491570	192.8	3964142	1307585	4232839		20.6
The Yellow River	13330	5600.6	7051611	914.2	906982	680442	1165861	27.5	8.7
The Yangtze River basin	72302	4038.5	6439964	2331.5	3057161	627141	3066979	72.5	42.4
In total	20560	656.2	13491570	192.8	3964143	130	4232839	100	20.6

Data source: Comprehensive Plan and Report about Water Resources in Shaanxi Province in 2008

From 1956 to 2000, the average annual precipitation is 13.49 billion m^3, which translates into 656.2mm. The basin of the Yellow River has 70.5 billion m^3, or 529.0 mm precipitation, and the Yangtze River basin has 64.4 billion m^3, or 890.7 mm precipitation, taking up 52.3 and 47.7 percent of the total respectively. Northern Shaanxi Province has an annual average precipitation of 36.5 billion m^3 or 454.3 mm; the corresponding data for central Shaanxi Province are 35.9 billion m^3 and 647.6 mm; in southern Shaanxi Province the data are 62.6 billion m^3 and 894.7 mm. The precipitation of the three regions makes up 27.0, 26.6 and 46.4 percent of the total respectively.

Shaanxi Province has 39.64 billion m^3 of annual surface water resource, which is equal to 192.8 mm of runoff depth. That of the Yellow River basin is 9.07 billion m^3, or 68.0 mm, and that of Yangtze River is 30.57 billion m^3, or 422.8 mm. The gross amount of groundwater in Shanxi amounts to 13.08 billion m^3, including 6.8 billion m^3 in the Yellow River basin and 6.27 billion m^3 in the Yangtze River basin. From 1956 to 2000, Shanxi Province has an annual amount of 10.9 billion m^3 entering its border.

1.3 Usable water resources

The total quantity of available water resources in Shaanxi Province adds up to 16.27 billion m^3, including 7.16 billion m^3 in the Yellow River, which accounts for 44 percent of the total, and 9.11 billion m^3 in the Yangtze River, which accounts for 56 percent of the total. Details can be found in Table 1-3 and Table 1-4

Table 1-3 Quantity of Available Water in Different Administrative Regions in Shaanxi Province

Unit: 10,000 m^3

Administrative region	Surface water	Groundwater	Recycling quantity	The total amount	Available surface water	Exploitable shallow groundwater	Recyclable amount	Total amount of available water
Central	656016	468738	301492	823262	321913	282812	54578	550147

Northern	313558	213926	123918	403566	126337	57110	33251	150196
Southern	2994568	624921	613478	3006011	898380	63694	35209	926865
In total	**3964142**	**1307585**	**1038888**	**4232839**	**1346630**	**403616**	**123038**	**1627208**

Data source: Comprehensive Plan and Report about Water Resources in Shanxi Province in 2008

Table 1-4 Table of Available Water Resources in River Basins in Shaanxi Province

Unit: 10,000 m³

River system	Area of drainage basin（km^2）	Volume of annual runoff	Available surface water	Exploitable shallow groundwater	Recycling quantity	Total amount of available water
TuWeihe River	3253	36387	13980	6820	5115	15685
Kuye River	8645	55387	9500	889	889	9500
Wuding River	29662	120859	56310	30580	20794	66096
Qingjian River	3468	15223	2400	299	299	2400
Shiwang River	2141	7735	2270	282	282	2270
Yanhe River	5891	22582	8000	995	995	8000
BeiLuohe River	25154	90479	42590	18369	5878	55081
Jinghe River	43216	176142	62200	813	813	62200
Weihe River	106498	823089	303200	264268	42283	525185
YiLuohe River	2476	58631	12000	2917	2917	12000
Jialing River	19206	366548	165680	2546	2546	165680
Hanjiang River	23805	1123041	678990	47845	23020	703815
Danjiang River	2766	57238	41710	13020	13020	41710
Others			10000	14786	5000	19786
In total	**276181**	**2953341**	**1346630**	**403616**	**123038**	**1627208**

Data source: Comprehensive Plan and Report about Water Resources in Shanxi Province in 2008

1.4 Water quality

（1）Natural water chemical characteristics

River water in Shaanxi Province mostly belongs to the carbonate type. From north to south, it varies from sodium salt to calcium salt, as is shown in Table 1-5.

Table 1-5 Hydro Chemical Type of Rivers in Shaanxi Province

Hydro chemical type	C_{I}^{Ca}	C_{II}^{Ca} 、C_{II}^{Na}	C_{II}^{Na} 、C_{III}^{Na}	Cl_{II}^{Na} 、Cl_{III}^{Mg}
Different zones	The south of Shaanxi, Qinling Mountains, the middle plain in Shaanxi, including upstream from Danjiangkou, Guangyuan Zhaohua, and from Qingjiang River to the Black River.	The middle plain in Shaanxi, the northern part of Weihe River from Baoji to Xianyang.	The south of northern Shaanxi, the east of central Shaanxi plain, upstream of Weihe River from Baoji Gorge, including Beiluohe River, middle and lower reaches of Jinghe River, Weihe River from Xianyang to Tongguan.	North of Shaanxi, upstream of the Yellow River from Wubao, west bank.

Data source: Comprehensive Plan and Report about Water Resources in Shaanxi Province in 2008

The average PH value of rivers in Shaanxi Province ranges from 7.1 to 8.5, displaying faint alkalescency. The PH value increases from south to north. In the north the PH of river water is between 7.9 and 8.5, while in the south of Weihe River, Hanjiang River and Danjiang River, the PH value stands at 7.6 to 7.9.

（2）Sediment charge

The sediment charge of rivers in Shanxi varies greatly from year to year. There is a big gap between the maximum and minimum sediment charge. The sediment charge of Weihe River's main stream is 4 to 7, Beiluohe River's main stream 6 to 14, Luohe River's main stream around 4, and Wuding River's main stream 4 to 7. In the drainage basin of Yangtze River, the maximum to minimum ratio is larger than that in the Yellow River, which basically ranges between 10 and 60. The maximum is detected at Danjiang River Jingziguan Station, which is 366, and sediment charge in Jialing River's Ciba Station also reaches up to 267.

The river with largest sediment runoff in the Yellow River region is actually Beiluohe River, whose annual sediment runoff is above 35 million tons. The actual sediment runoff of Weihe River is relatively small, which is 15.24 million tons. Nanluohe River has the lowest sediment runoff, which is 0.77 million tons. In the Yangtze River basin, the river with the largest sediment runoff is Hanjiang River, whose sediment runoff is 27.42 million tons. It is followed by Jialing River and Danjiang River, whose actual sediment runoff is 8.83 and 4.03 million tons respectively.

（3）Major pollutants

In 2008, the total sewage discharge in Shanxi is 1.09 billion m^3, including 676 million m^3 of industrial wastewater and 344 million m^3 of domestic wastewater. The discharge of major pollutants such as COD and ammonia nitrogen are 294,000 and 23,500 tons respectively. As to geographical distribution, the Guanzhong area discharges the bulk of pollutants in Shaanxi Province. Its wastewater discharge, COD discharge and ammonia nitrogen discharge takes up 75.8, 84.7 and 80.2 percent of the total respectively, and the numbers are increasing at a rapid speed.

In recent years, the proportion of domestic wastewater is on the rise. Certain river reaches or areas are prone to be polluted because domestic wastewater is discharged in intensive short periods and that river reaches have limited permissible quantity of pollutants.

Major surface source pollution in Shanxi come from water loss and soil erosion, fertilizer, rural domestic wastewater and solid wastes as well as sewage produced from the breeding industry. Shaanxi Province has an area of land totaling 205,600 k ㎡, among which the area subject to water and soil erosion is 137,500 k ㎡, accounting for 67 percent of the whole area. Water and soil erosion leads to decline in soil fertility, and meanwhile pollutants enter the river. Shaanxi Province is a big agricultural province, whose farmland amounts to 2.83 million h ㎡. Fertilizers and pesticides are widely used on the farmland. Only few of them are decomposed or assimilated by the plants, and the rest remains in soil and water, causing severe pollution problems. Rural domestic wastewater and breeding industry wastewater also pose great threats to the safety of drinking water and that of agriculture and ecosystem.

2 .Water Resources Development and Utilization in Shaanxi Province

2.1 Water supply and use

In 2012, the total water supply in Shanxi reaches 8.80 billion m^3, among which 5.4 billion m^3 or 61 percent is provided by surface water projects, 3.34 billion m^3 or 38 percent is provided by groundwater projects, and 60 million m^3 or 1 percent is provided by other water sources. The Yellow River basin contributes 6.17 billion m^3 water resources and the Yangtze River basin contributes 2.64 billion m^3.

In 2012, the total water consumption is 8.80 billion m^3, among which agricultural water consumption is 5.82 billion m^3 or 66.14 percent, industrial water consumption is 1.33 billion m^3 or 15.11 percent, domestic water consumption is 1.22 billion m^3 or 13.86 percent, water for public use in urban areas is 0.25 billion m^3 or 2.84 percent and water requirement for ecology environment is 0.18 billion m^3 or 2.05 percent. Agriculture is the biggest water consumer, and it is followed by industrial consumption and domestic consumption.

Total water consumption in Shaanxi Province has not changed for much, but the water consumption mix has undergone big changes. Because of water shortage, Shaanxi Province has been putting much emphasis on water saving in agriculture. So water spent on farmland irrigation has been on the decrease from 6.685 billion m^3 in 1980 to 5.82 billion m^3 in 2012, saving a total of 865 million m^3 of water. But water consumption in other industries has been on the increase. Since the reform and opening-up, Shaanxi Province has accelerated in its urbanization. Its industry has made great progress, and its domestic and industrial water consumption has also witnessed a rapid growth. From 1980 to 2008, water consumption has grown by 624 million m^3, registering an annual increase of 3.31 percent. Water consumption has almost doubled during the 28 years.

2.2 Water resources development and utilization

All the water resource in Shaanxi Province aggregates 42.33 billion m^3, including 11.66

billion m³ in the Yellow River basin and 30.67 billion m³ in the Yangtze River basin. Surface water resource totals 39.64 billion m³, including 9.07 billion m³ in the Yellow River basin and 30.57 billion m³ in the Yangtze River basin. Shallow groundwater resource in Shaanxi Province attains 13.08 billion m³, among which 4.036 billion m³ is exploitable, including 3.399 billion m³ in the Yellow River basin and 637 million m³ in the Yangtze River basin.

According to Shaanxi Province Water Resource Survey and Assessment and 2008 Shaanxi Province Water Resource Communique, in 2008 the total water supply in Shaanxi Province is 8.546 billion m³. Water transferred from the mainstream of the Yellow River reaches 304 million m³. The yearly water supply within the province is 8.242 billion m³, including 4.719 billion m³ surface water, 3.012 billion m³ shallow groundwater, 423 million m³ deep confined water and 88 million m³ water from other sources.

The total water consumption aggregates 5.026 billion m³, consuming 4.825 billion m³ water within the province, including 3.419 billion m³ in the Yellow River basin and 1.406 billion m³ in the Yangtze River basin. Total surface water consumption is 2.888 billion m³, including 1.694 billion m³ in the Yellow River basin and 1.194 billion m³ in the Yangtze River basin.

In terms of the ratio of surface water consumption to the total water consumption, the exploitation rate of surface water in Shaanxi Province is 7.3 percent, that of the Yellow River basin being 18.7 percent and that of Yangtze River basin being 3.9 percent. In terms of the ratio of surface water supply to exploitable surface water, the exploitation rate in Shaanxi Province is 35 percent, that of Yellow River basin being 58.1 percent and that of the Yangtze River basin being 23.5 percent. In terms of exploitable water, the exploitation rate of groundwater is 74.6 percent, that of Yellow River basin being 77.5 percent and that of the Yangtze River basin being 59.5 percent. The use ratio of water resource in Shaanxi Province is 11.4 percent, the Yellow River basin 29.3 percent and the Yangtze River basin 4.6 percent.

2.3 Water resources use efficiency

According to statistics, in 2010 the water consumption per capita in Shaanxi Province is 224 m^3, water consumption of per unit of GDP is 30.74 m^3 (10,000 yuan), water consumption per ten thousand yuan in industrial added-value is 26 m^3. Water consumption per acre is 305 m^3. Average domestic water consumption per head in urban areas is 136 L per day, and that in rural areas is 63 L per day.

In order to illustrate the water consumption level, comparison will be drawn between Shaanxi and Gansu, Shanxi, Henan, Shandong, Hubei, Sichuan and Chongqing provinces as regards water resource condition, geographical condition and development condition of socio-economy. From the comparison, it can be known that the water resource per capita in Shaanxi Province is only 49.78 percent of the national average, while its per capita GDP is 90.46 of the national average. Water consumption per head is 50.9 percent of the national average, and water consumption per unit of industrial added value is 28.89 of national average. Compared with national mean value, its urban residents' water consumption is 70.47 percent; irrigation water per acre is 72.45 percent. The overall water usage level is higher than national average, and the efficiency is also higher. Compared with neighboring provinces and cities, its water utilization efficiency is much higher than that of Gansu, Hubei, Sichuan and Chongqing provinces. But it is lower than Shanxi, Henan and Shandong. As a whole, its efficiency is above average. Details can be found in Table 1-6.

Table 1-6 Major Water Use Index for Some Provinces in 2010

	Per capita GDP(10,000 yuan)	Per capita water consumption (m^3)	water consumption per 10,000 industrial	water consumption per acre for farmland irrigation(m^3)	Domestic water consumption per head in urban areas	Domestic water consumption per head in rural areas

			added value(m^3)		(L/d)	(L/d)
National average	2.999	450	90	421	193	83
Shaanxi	2.713	224	26	305	136	63
Gansu	1.611	476	86	559	199	50
Shanxi	2.628	182	27	217	110	44
Henan	2.445	238	46	168	138	58
Hubei	2.791	503	174	396	190	78
Shandong	4.111	233	14	216	110	71
Sichuan	2．118	284	67	378	170	67
Chongqing	2.76	301	70	251	243	70

Data source: 2011 China Water Resources Yearbook

2.4 Water security status

（1）Water shortage

It is estimated that in central Shanxi about 349 million m3 ecology environment water is occupied by other use. According to water utilization condition in different cities and districts, squeezed ecology environment water is roughly estimated and shown in table 1-7.

Table 1-7 Water Shortage in Shaanxi Province

Unit: 10,000 m3

Administrative regions	Outer river water deficit			Squeezed water for ecology environment in inner river	total water deficit
	Water shortage	Groundwater overdraft	Water shortage in outer river		
Xi'an	16750	16312	33062	14000	47062

Tongchuan	5339		5339	700	6039
Baoji	9940	2278	12218	5200	17418
Xianyang	19558	7001	26559	9800	36359
Yangling	451		451		451
Weinan City	43590	4671	48261	5200	53461
Hanzhong City	3243		3243		3243
Ankang City	11057		11057		11057
Shangluo City	5776		5776		5776
Yan'an City	7486		7486		7486
Yulin City	16317		16317		16317
In total	**139508**	**30262**	**169770**	**34900**	**204670**

Data source: Comprehensive Plan and Report about Water Resources in Shanxi Province in 2008

（2）Quality and safety of supplied water

It is estimated that substandard supplied water in Shaanxi Province is up to 384 million m3, including 290 million m3, or 75.59 percent substandard surface water and 94 million m3 or 24.41 percent substandard groundwater. Substandard water for agricultural irrigation makes up 68.42 percent of all the substandard water. More details can be found in Table 1-8.

Table 1-8 The Water Quality of Supplied Water in Shanxi

Sector	Total substandard water		Substandard surface water		Substandard groundwater	
	amount (100 million m3)	percentage	amount (100 million m3)	percentage	amount (100 million m3)	percentage
Urban areas	4320	11.26	1250	4.31	3070	32.76
Rural areas	7800	20.32	2350	8.10	5450	58.16
Agriculture	26260	68.42	25410	87.59	850	9.08
In total	**38380**	**100**	**29010**	**100**	**9370**	**100**

Data source: Comprehensive Plan and Report about Water Resources in Shanxi Province in 2008

In conclusion, in Shaanxi Province water is comparatively in short supply. Water resources

aggregate and per capita hold of water resources are both low. The geographical distribution is also rather unbalanced: southern Shanxi possesses 70 percent of the total water resources, while densely populated and industrialized central and northern Shanxi are only in possession of 30 percent of the water resources. The contradiction between demand and distribution hampers the social and economic development. Moreover, water pollution is rather severe in Shaanxi Province, and groundwater overdraft has also triggered serious problems for ecological environment. Global climate changes and large-scale economic development have also aggravated the situation. Water resources have become a bottleneck that restrains Shanxi's further development.

Therefore, on the principle of planning and coordination, justice and equity, efficient use and balanced configuration, Shaanxi provincial government launched a series of water projects construction, such as transferring water from Hanjiang River to Weihe River, transferring water from Honghe River to Shihe River, Yan'an Yanchuan water project, Yushen industrial water supply project as well as Daquan water diversion project, so as to resolve the problems of unbalanced distribution and alleviate pressure in central and northern Shaanxi Province. On the other hand, projects in Dongzhuang reservoir, Heiheting reservoir, Lijiahe resevoir, wudinghe reservoir, Jiaoyan reservoir and Guxian reservoir can not only effectively prevent floods, but also mitigate problems such as pressure on water supply, water pollution and land desertification.

II. Water Investment Overview in Shaanxi Province

1. Water investment status

Water investments from 2001 to 2013 can be found in table 2-1. It can be observed from Picture 2-1 that from 2001 to 2005, investment in water conservancy was about 2.7 billion yuan; from 2006 to 2009, investment has steadily increased step by step, and investment reached 5.398 billion yuan in 2009; in 2010, investment reached up to 11.809 billion yuan, 2.2 times that in 2009, marking that Shaanxi Province has entered a stage of fast-increasing investment.

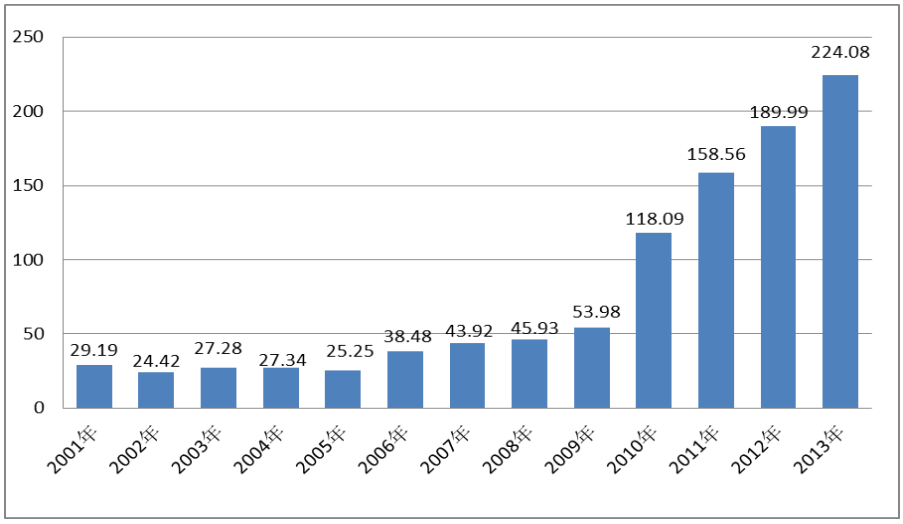


Table 2-1 Completed Water Investment during 2001 to 2013 in Shaanxi Province

(Unit: 100 million yuan)

2. Water investment sources

During 2006 to 2013, major investors for water projects include funds from the central government, provincial government, municipal government, credit, loans and private investment. Details can be found in Table 2-1.

It can be known from Table 2-1 that after 2008, funds from the central government has gradually taken up the bulk of the total investment, and increased rapidly ever since. In 2009 it accounts for 59 percent of the total investment and leveled at around 35 percent after that. Funds from provincial government also increased fairly rapidly, accounting for about 20 percent of the total investment. In 2008 and 2009 funds from municipal government stood at a relatively low level, but it started to increase since 2010 and reached 18 percent in 2013. After 2009, credit funds augmented at fast speed and surpassed funds from provincial and municipal government in 2013 to reach 23 percent. Private investment has undergone considerable fluctuations: it was the

major source of investment in 2006, but rested in doldrums during 2007 to 2009; it recovered after 2010 and gradually increased to 13 percent in 2013.

Table 2-1 Water Investment Sources in Shaanxi Province during 2006 to 2013

Unit: 100 million yuan

Year / Source	2006		2007		2008		2009	
	Investment	Proportion	Investment	Proportion	Investment	Proportion	Investment	Proportion
Central government	8.42	21.94%	13.26	30.19%	25.76	56.10%	31.83	58.98%
Provincial government	6.53	17.02%	10.78	24.54%	12.57	27.37%	18.02	33.39%
Municipal government	9.83	25.62%	13.82	31.47%	7.32	15.94%	3.26	6.04%
Credit funds	0	0.00%	0	0.00%	0		0.3	0.56%
Private investment	13.59	35.42%	6.06	13.80%	0.27	0.59%	0.56	1.04%
In total	38.37	100%	43.92	100%	45.92	100%	53.97	100%
Year / Source	2010		2011		2012		2013	
	Investment	Proportion	Investment	Proportion	Investment	Proportion	Investment	Proportion
Central	40.8	31.83%	52.56	33.15%	67.96	36.54%	71.8	32.04%

government								
Provincial government	24.27	18.93%	39.05	24.63%	45.82	24.64%	36.94	16.49%
Municipal government	22.63	17.65%	21.45	13.53%	30.05	16.16%	36.49	16.28%
Credit funds	26.63	20.77%	29.13	18.37%	25.31	13.61%	52.08	23.24%
Private investment	13.86	10.81%	16.37	10.32%	16.84	9.05%	26.77	11.95%
In total	128.19	100%	158.56	100%	185.98	100%	224.08	100%

Data source: Shanxi Water Resources Yearbook from 2006 to 2013

3. Water investment direction

Shaanxi provincial water investment direction from 2006 to 2013 is shown in Table 2-2.

Table 2-2 Shaanxi provincial water investment direction from 2006 to 2013

Unit: 100 million yuan

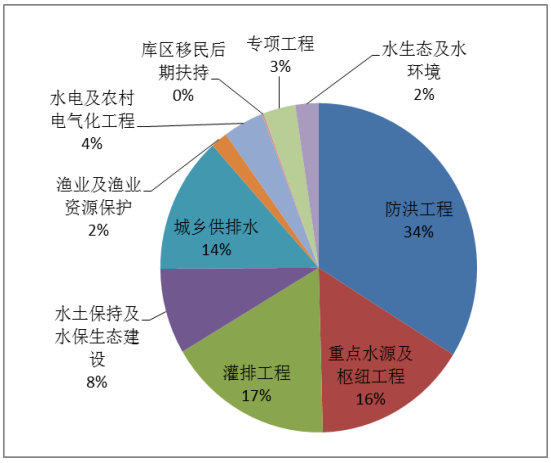
Project	2006	2007	2008	2009	2010	2011	2012	2013
Flood control projects	6.54	13.10	8.64	5.15	14.54	45.64	64.32	72.60
Water supply and discharge in urban and rural areas	3.24	12.76	11.65	12.67	21.01	20.08	25.48	34.16
Key water source and pivotal projects	2.88	3.11	4.91	9.31	26.78	35.83	29.88	31.43
Irrigation and drainage projects	11.43	8.04	10.08	18.73	23.25	28.39	32.12	30.4

Water and soil conservation and ecological construction	2.98	3.24	7.09	6.53	6.77	5.25	15.98	15.99
Water ecology and water environment	0	0	0	0	8.9	10.06	4.5	10.07
Hydroelectricity and rural electrification projects	4.58	1.85	0.12	0.69	5.1	2.09	7.84	9.73
Follow-up support for people relocated from reservoir areas	0.12	0.24	0.2	0.1	5.63	0.4	0.35	8.48
Fishery and protection of fishery resources	0.08	0.19	0.21	0.22	3.18	2.96	3.25	5.82
Special projects	6.52	1.39	3.02	0.59	2.92	7.88	6.26	5.40

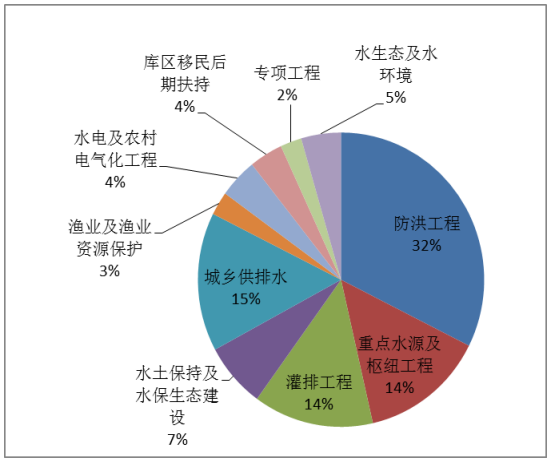
Data source: 2013 Shanxi Water Conservancy Development Statistics Communique

3.1 Water investment direction in recent 2 years

Investment mix of recent 2 years is shown in picture 2-2 and picture 2-3.



Picture 2-2 Investment mix in 2012

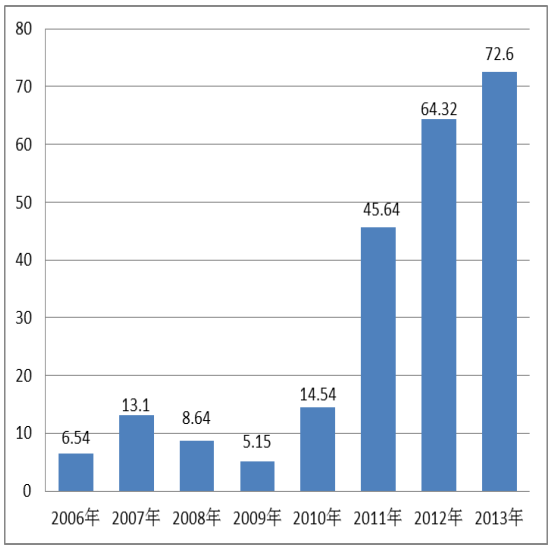


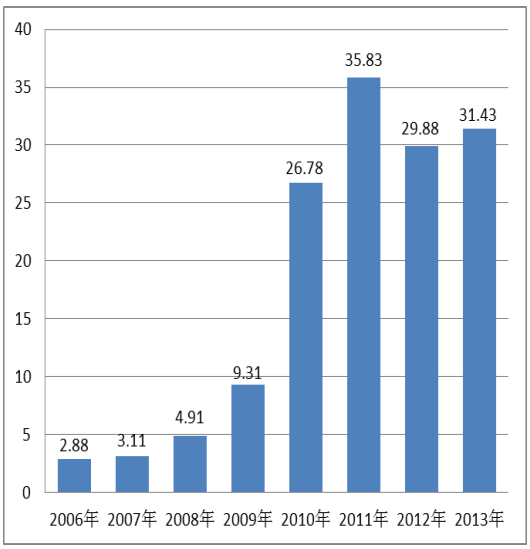
Picture 2-3 Investment mix in 2013

It can be observed from Picture 2-2 and 2-3 that in recent years, flood control projects, key water source and pivotal projects, water supply and discharge in urban and rural areas as well as irrigation and drainage projects occupied a large proportion, amounting to 70 percent in total. Flood control projects ranked No.1, making up 30 percent of the total investment in the past 23 years. And the other three categories of investment made up 15 percent of the total investment. Water and soil conservation projects made up 7 percent in 2013, and hydroelectricity investment made up about 4 percent. The other four categories were below 4 percent.

3.2 Investment in 6 major areas

In accordance with the proportion of water conservancy investment in Shaanxi Province from 2006 to 2013, we mainly analyze 6 major investment orientations: flood control projects, key water source projects, irrigation and drainage projects, water and soil conservation, water supply in urban and rural areas and hydroelectricity, as is shown from Picture 2-4 to Picture 2-9.





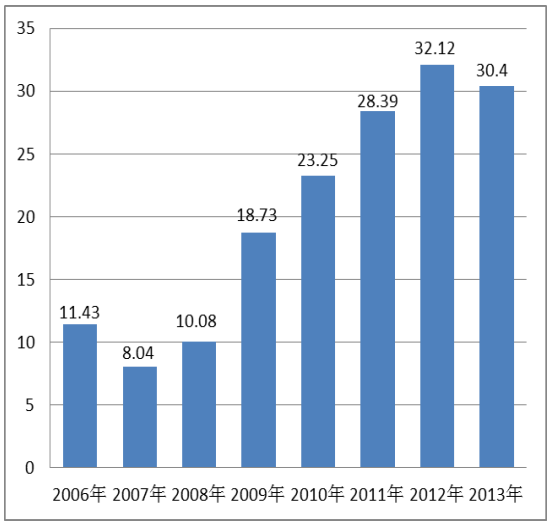
Picture 2-4 Changes in investment in flood control projects (Left)

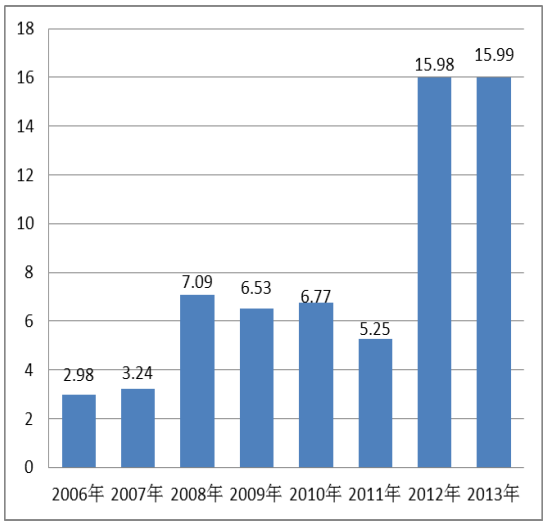
Picture 2-5 Changes in key water source projects (right)

(Unit: 100 million yuan)

It can be known from Picture 2-4 that during 2006 to 2009 investment into flood control projects fluctuated greatly: in 2009 it was 515 million yuan, making up 9.5 percent of the total investment, while in 2007 it was 1.31 billion yuan, making up 29.8 percent; after 2010, investment into flood control projects increased remarkably; investment in 2010 was 3.1 times that in 2009; in 2013 the investment reached 7.26 billion yuan, 11 times that in 2006, making up 32.39 of the total investment.

It can be observed in Picture 2-5 that investment in key water conservancy and pivotal projects began to rise markedly since 2010. In 2010 investment into this area was 2.678 billion yuan, 2 times that in 2009. During 2010 to 2013, the investment in this area stood at around 3 billion yuan, making up 14 percent of the total investment in 2013.





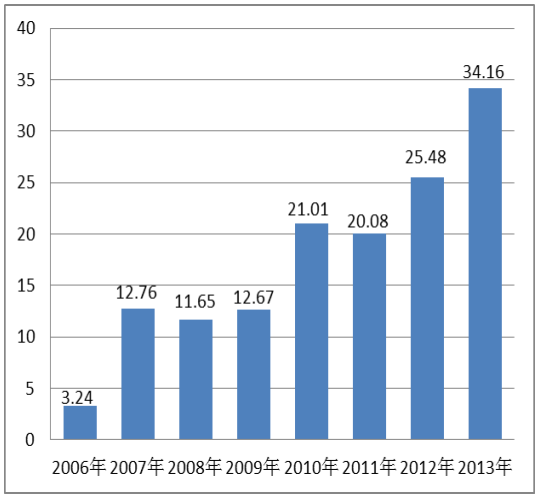
Picture 2-6 Changes in Irrigation and Drainage Projects (left)

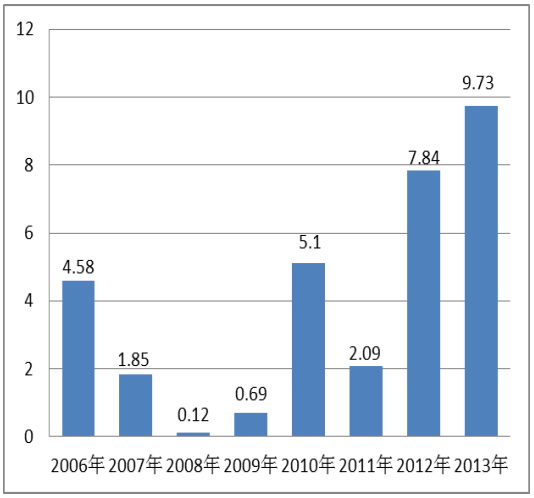
Picture 2-7 Changes in Investment in Water and Soil Conservation Projects (right)

(Unit: 100 million yuan)

It can be known from Picture 2-6 that during 2006 and 2013 investment in irrigation and drainage was in the upward trend. Investment increased from 1.143 billion yuan in 2013 to 3.04 billion yuan in 2013, making up 13.57 percent of the total investment in 2013.

It can be known from Picture 2-7 that during 2006 and 2007 there was only altogether 300 million yuan investment in water and soil conservation projects, while during 2008 and 2011 the number was maintained around 500 to 700 million yuan, almost equal to the number in 2012. A remarkable rise in the investment can be noticed in 2013, when the investment increased to 1.6 billion yuan, making up 7.14 percent of the total investment.





Picture 2-8 Changes in investment in water supply in urban and rural areas (left)

Picture 2-9 Changes in investment in rural hydroelectric projects (right)

(Unit: 100 million yuan)

It can be seen from Picture 2-8 that during 2006 and 2013 investment into water supply and discharge in urban and rural areas was as a whole in an upward trend, and the investment underwent a big elevation every 2 years. Till 2013 the investment reached 2.416 billion yuan, occupying 15.24 percent of the total investment in 2013.

It can be seen from Picture 2-9 that investment in rural electrification has been standing at a low level, with the maximum value being 973 million yuan in 2013, only occupying 4.34 percent of the total investment.

III. Evaluation on Water Investment in Shaanxi Province

The Contradiction of economic growth versus resource exhaustion and ecological environment protection as well as the economic transformation in Shaanxi Province during the 12th Five-Year Plan period (2011-2015) requires more water investment.

Compared with general investment such as incorporation investment, water investment has special economic benefits: (1) external benefits. Water projects invested by government or private parties can usually bring benefits to common people who haven't invested directly in the

cause. So its social benefits are in general much more than its economic benefits. (2) Incomparable benefits: We cannot compare the benefits of capital appreciation brought about by investment in land with that brought about by investment in clean water sources. (3) Macroeconomic benefits of investment in water projects have the features of scale economy. Obviously, 100 small water projects each worth 100 million yuan cannot be compared with a large-scale project worth 10 billion yuan.

For all the difficulties in objectively, precisely measuring the comprehensive benefits of water projects, we can still analyze their promoting effects on macroeconomic development and improvement on people's life, so as to make an overall assessment of investment in water projects. This chapter can be divided into two parts: the first part qualitatively analyzes water investment pulling effect on regional economic growth, accelerating effect on urbanization and promoting effect on agricultural growth as well. This part mainly reveals in what respects water conservancy investment deeply influences our economic life. The second part combines data concerning investment in key directions and analyzes benefits of major water conservancy projects.

1. Impact of water investment on economic and social development in Shaanxi Province

1.1 Key water projects overview

Since 2008, a series of key water projects in Shaanxi Province have begun construction, including Yulin Yuqi plugging reservoir project, Lijiahe reservoir project, Heihetingkou reservoir project, Dongzhuang reservoir project, transferring water from Hanjiang River to Weihe River project, Weihe comprehensive renovation project, agricultural irrigation facility construction project, Yan'an Nangoumen reservoir project and Yellow River diversion project in north Shaanxi Province. These key projects can have vital influences on the economic and social development in Shanxi in

the future.

（1）Yulin Yuqidu Reservoir project

Yuqidu reservoir is situated at upper reaches of Wuding River, 12 km from Hengshan Village. It is the last reservoir on the mainstream of Wuding River.

Yuqidu reservoir is a large-scale backbone water source project at Yulin Energy and Chemical Engineering Base. It is mainly in charge of providing water for production and life for Yuheng Industrial District, Yumisui Salt Industrial District and the town. It also has the functions of irrigation, blocking sediments, flood control and electricity generation. The reservoir controls an area of 10,751 km2, occupying 35.6 percent of the Wuding River basin. There are dams like Xinqiao, Jinjisha and Batuwan on the upper reaches. During 60 years of operation the average volume of runoff is 328 million m3, and its annual sediment runoff is 4.36 million tons. It has a capacity of 389 million m3, a flood control capacity of 62 million m3, a regulation storage capacity of 110 million m3, dead storage capacity of 8 million m3 and a storage capacity for sedimentation of 209 million m3. After the completion of the project, it will be able to provide 156 million m3 water for Yuheng industrial district and Yumisui industrial district, and provide 44 million m3 farmland irrigation water for Leihui Channel, Xianghui Channel, Dinghui Channel and Zhinv Channel on the lower reaches. If the reservoir is to operate for another 60 years, it can block 210 tons of sediments.

Yuqidu reservoir has a project time limit of 42 months, with a budget of 2.2 billion yuan. The project started construction since 2010, and started filling since Sept. 2011. It is expected to be finished in 2013.

（2）Lijiahe Reservoir project

Lijiahe reservoir is located on the middle reaches of Wangchuan River, which is a tributary of Bahe River in Lantian Village, Xi'an City. The site is in Lijiahe, 23 km from Lantian Village. It is built for providing water for urban life and industrial water demand. It can also supply water for

Zhuliang Airplane City temporarily before the completion of transferring water from Hanjiang River to Weihe River project. This project consists of two parts: reservoir pivotal project and water delivery project.

The reservoir pivotal is composed of dam, channels, spillway tunnel on the left bank and the power station behind the dam. The reservoir has a total capacity of 55 million m3, including 44 million m3 of regulation capacity. The total installed capacity of the power station is 4,200 kW. The water delivery project is composed of the main channel, approach channel, and water delivery channel on the north and south. The total length of channels adds up to 70.6 km.

Lijiahe reservoir has a project time limit of 40 months, with a total budget of 2.086 billion yuan. In 2010 it started construction. It is expected to be completed in 2013 and start impoundment in 2014.

（3）Heihe River Tingkou Reservoir Project

Tingkou Reservoir is situated on Heihe River, a first-level tributary of Jinghe River, 2.0 km from the intersection of Heihe River and Jinghe River, 18 km from Changwu Village, 15 km from Chenxian Village. It principally provides water for industrial and domestic usage, and also has functions of flood control and power generation. It is a backbone water source project in Chenchang Mining Field.

Tingkou Reservoir has a total capacity of 243 million m3, initial regulation capacity of 183 million m3, and ultimate regulation capacity of 31 million m3.

It is mainly composed of dam, spillway channel, drainage tunnel, etc. The dam is built with homogeneous concrete with a height of 48.6 m. The reverse regulation reservoir is situated at the lower reaches 1.5 km from Tingkou Reservoir. It has a total of 9.86 million m3, regulation capacity of 7 million m3. The normal storage level is 920.3 m and the maximum height is 65.2 m.

Tingkou Reservoir can provide 73.78 million m^3 water, and Zhongyuangou Reservoir can provide 7.43 million m3. They have a combined water supply of 81.21 million m3. 73.90 million

m^3 is provided for large and middle enterprises in Binchang Mining District and 7.34 million m^3 is provided for two villages. The estimated investment is 1.68 billion yuan. The project is poised to be completed in Sept. 2011, and the body project is expected to begin in 2012 and completed in 2015.

（4）Dongzhuang Reservoir project

Dongzhuang Pivotal Project is situated at the end of the gorge on lower reaches of Jinghe River. Liquan Village lies on its right bank and Chunhua Village lies on its left. It is 20 km from the Jinghuiqu Dam and 90 km from the intersection between Jinghe River and Weihe River. The dam covers a drainage basin of 43,138 km2, making up 95 percent of the total drainage basin. Annual volume of runoff is about 1.904 billion m3.

Dongzhuang Reservoir has a total capacity of 3.008 billion m3, flood control capacity of 420 million m3, flood regulation capacity of 838 million m3, sediments blocking capacity of 2.02 billion m3. The normal storage level is 786.00 m. The pivotal project consists of dam, flood discharge holes, plunge pool, water diversion buildings and holes reserved for sediments discharge. It is a dome dame made of concrete with a height of 228 m and installed capacity of 60 MW.

Dongzhuang Reservoir is mainly in charge of flood control and sediments reduction. It can also provide water, generate electricity and improve ecological envrionment. After the completion of the reservoir, it can reduce floods, improve the flood-control ability of Jinghe River and Weihe River, and create favorable condition for reducing erosion at lower reaches of Weihe River. The reservoir can provide irrigation water for 1.26 million acres of farmland as well as over 2 million m3 of water for life and production in the north of Weihe River. The power station can generate 203 million kW·h electricity, bringing about remarkable economic benefits.

Dongzhuang Reservoir has a project time limit of 8 years and an estimated investment of 8 billion yuan. The preliminary design was finished in 2013 and its construction began in 2014.

（5）Hanjiang River to Weihe River water diversion project

The project spans the Yellow River basin and the Yangtze River basin and goes through Qinling Mountains. It is mainly composed of Huangjin Gorge, Qinling Water Delivery Tunnel and Sanhekou hydro-junction. The project plans to build Huangjin Gorge hydro-junction and Sanhekou Hydro-junction for water storage. And the water will be delivered to central Shanxi through a 98.3-km tunnel. The project diverts a total of 1.505 billion m3 of water, including 500 million m^3 from Hanjiang River's tributary Ziwu River, 1.005 billion m3 from Huangjin Gorge Reservoir. The maximum water carrying capacity is 70 m3/s. The total capacity of the reservoir is 946 million m3, the installed power of water pump is 157,900 kW and the installed capacity of the power station is 165,000 kW.

The project provides water for 4 key cities: Baoji, Xianyang, Xi'an and Weinan; 13 villages: Yanglin Pilot Zone, Meixian Village, Zhouzhi, Wugong, Xingping, Huxian, Jingyang, Sanyuan, Gaoling, Chang'an, Yanliang, Lintong, Huaxian, Huayin. It can indirectly provide water for Energy and Chemical Engineering Base in northern Shanxi.

This water diversion project is a backbone project of the South-to-North Water Diversion Project. And it is a key project for realizing optical allocation of water resources in Shanxi. It has great significance in resolving water shortage in central Shaanxi Province and the development of Energy and Chemical Engineering Base in northern Shaanxi Province. The project has a time limit of 11 years and its estimated static investment amounts to 16.78 billion yuan. The total investment is 18.72 billion yuan. Its construction began in Dec. 2011.

（6）Hongyan River to Shitou River water diversion project

Hongyan River to Shitou River water diversion project is carried out in Taibai Village, Shanxi Province. It is an inter-river diversion project. This project diverts water from Hongyan River, which is situated on the south of Qinling Mountains. The water is delivered through tunnels in Qinling Mountains into Taochuan River, which converges into Shitou River. The body of the

project consists of water diversion pivot and water delivery tunnel. The water diversion pivot is situated in Guanshan Village, 8 km southeast of Taibai Village. The dam controls a drainage basin of 376 km2, and it has an average runoff volume of 364.4 million m3. The water diversion pivot is composed of flood discharge gate, sand scouring gate, entrance gate, retaining dam at both banks as well as ecological discharge pipes. The water delivery tunnel is as long as 19.71 km, with a maximum water carrying capacity of 13.5 m^3/s.

This project has an average annual water volume of 92 million m3. Along with the natural runoff volume of Shitou River, it can provide up to 266 million m3 of water, including 95 million m3 to Xi'an, 45 million m3 to 37 acres of farmland in Yuanqimei, and 126 million m^3 to Xianyang, yangling, Xingping, Wugong and other cities. The project will resolve the contradiction of water supply between central and western Shanxi, and optimize the water allocation in Weihe River basin. The project began construction in Aug. 2008 and will be completed in 2014.The estimated investment is 714 million yuan.

（7）Weihe River comprehensive renovation project

Weihe River renovation project is one of the key projects of the 12th Five-Year Plan in Shanxi. It starts from Shouyinshui pivot in Baoji and ends in Tongguan by Weihe River. It has an overall length of 388 km, involving Baoji, Yangling, Xianyang, Xi'an and Weinan. The overall renovation of Weihe River includes 4 parts: flood control project, obstacle clearing in river channel, water pollution prevention and ecological landscape construction. Through widening dikes, clearing up water channels, renovating banks, water regulation, afforestation and pollution regulation, it can achieve the goals of building a solid dam, discharging floods, clearing up the river and building a beautiful landscape.

The project will widen the dike by 432.4 km, build 43.2 km of new dikes, build 37 new bridges and clear up 280.43 km of beach areas. It will also afforest 474 km of dike; build 5 landscapes, 55 parks, 26 monitoring sections. Its estimated investment is 24.8 billion yuan. From

2011 to 2013 the key work is to carry out flood control project and clear up beaches, and that from 2012 to 2015 will be building ecological landscapes and water pollution prevention projects.

（8）Agricultural irrigation project

The project is initiated from Nov. 6, 2012, with a total investment of 6.27 billion yuan, including loans of 3.8 billion yuan from China Development Bank. It is one of the largest water conservancy projects built through domestic loans. The project has influences on 164 large and middle scale irrigated area over 10,000 acres. Through 5 years of construction, it can help restore 5.466 million acres of irrigated land and add 572,700 acres of irrigated land.

（9）Yan'an Nangoumen Reservoir

Yan'an Nangoumen Reservoir is located at lower reaches of Hulu River, a tributary of Luohe River in Huangling Village, Yan'an City. It is 3 km from the river mouth, 20km from Huangling Village. It is mainly composed of Nangou Reservoir Pivot Project and Luohe River to Hulu River Water Diversion Project. Nangoumen Reservoir has a capacity of 197 million m3 and regulation capacity of 90.2 million m3. Nangoumen Reservoir consists of dam, spillway channel, water diversion and sediment discharge holes, power station and other buildings. The dam is built by homogeneous concrete with a height of 66 m. The spillway channel is as long as 467 m, with a maximum runoff volume of 289 m^3/s. The height of flood discharge hole at its right bank is 803 m, and it has a maximum runoff volume of 468 m^3/s. The hole is as long as 795 m, and its section is a 6.0*8.0 round vault. The water diversion hole at its right bank is as long as 1,250 m, with a designed runoff volume of 9.1 m3/s. The body of the hole is 1,212 m long, with a diameter of 2 m. The power station is located at a distance of 1.3 km from the dam; supporting an installed capacity of 2,800 kW with 2 mixed flow hydraulic turbine generators. The project can be divided into Majiahe water diversion project and water diversion tunnel. The dam of Majiahe project has a height of 11.3 m. It is an open delivery tunnel which is set at the right bank of Luohe River. The body of the hole is 6.12 km long, and its section is a 3*3.6 round vault.

After the completion of this reservoir, it will be able to provide 116.75 million m3 water for life and production in Yan'an, Huangling Village and Jiaokouhe Village, and provide 7.07 million m3 water for Longtaiyuan irrigated area in Huangling Village. The project has a time limit of 51 months with an estimated investment of 1.686 billion yuan.

（10）The Yellow River water diversion project in northern Shaanxi Province

The Yellow River Water Diversion Project in Northern Shanxi includes 2 parts: Yellow River diversion project in Yanchuan and diversion project in Yulin Daquan. It mainly provides water for industrial parks in Yan'an and Yulin as well as other cities. The project uses the mainstream of Yellow River and Qingjian River as the water sources. It draws a total of 17.99 million m3 water every year, including 12.37 million m3 from the Yellow River and 5.62 million m3 from the Qingjian River. Water is drawn from Yellow River through Wangjia Channel first-level pump station, with a flow of 0.88 m3/s. Water is drawn from Qingjian River through low dam diversion, with a designed flow of 0.85 m3/s. The diversion dam is stone dam with a height of 3.5 m, 129.72 km of water delivery line, including 117.96 km of channels, 16.9 km of tunnels. Gaojiawan can process 64,000 m3 water in a time and water processing factories in Yaodian and Yongping both have a capacity of 4,000 m3. Wangjiaqu-Gaojiawan adopts 3-level water delivery; Qingjianhe River-Gaojiawan adopts 1-level water delivery; Gaojiawan-Yongping and Gaojiawan-Yaodian both adopt 3-level water delivery. Along the channels Baishuhu regulation Reservoir is built. It has a capacity of 5.56 million m3. And there is also a Kangjiagou Emergency Reservoir, with a capacity of 1.55 million m3. After the completion of the project, it can supply 15.64 million m3 water to cities and industries. The project has a time limit of 26 months, with an estimated investment of 1.02 billion yuan.

Yulin Daquan Water Diversion Project draws 587 million m3 from the mainstream of Yellow River. It crosses Huangfuchuan River, Qingshui River, Shaliang River, Boniu River, Wulanmulun River, Tuweihe River and some mountains. It provides water for Duanzhai Thermal Power Base,

Qingshuichuan Coal-electricity integration project, Miaogoumen Coal-electricity integration Project, Dianta, Shenmu and toher villages. It finally enters the Toudao River, a tributary of Yuxi River, converging with water system in Yulin and Yuheng. Water is drawn from Daquan between Qiangtou and Huangfukou on the Yellow River. The water is diverted through pump, with a flow of 75 m3/s. The main diversion line is as long as 158.1 km. It has 7 levels of water pumping stations. Every station has a lift of 65 to 92 m. And they have a total lift of 494.2 m. The installed capacity totals 315,000 kW.

Three reservoirs are built along the line to settle, block and regulate sediments. Qingshuixiang Regulation Reservoir is situated at Guqida Ditch at the right bank of Qingshui River, 15.35 km from Daquan Pump. It has a capacity of 9.6 billion m3. The dam is built by homogeneous concrete and has a height of 62 m. A sediment blocking dam is built 3.7 km from the reservoir, the dam is 26.5 m high. Gongcaowan Regulation Reservoir is situated 6 km from Yaozhen Reservoir, with a capacity of 26.22 million m3. The stone dam is built through wet masonry with a height of 27.5 m. The project has a construction time of 5 years with an estimated investment of 5.49 billion yuan.

1.2 Impact of water investment on local economic growth

Water is an indispensable natural resource for every industry. Shaanxi Province has an unbalanced water distribution. 71.1 percent of its water resources are distributed in underdeveloped southern area, while central Shaanxi Province, the key area for economic development, has only 19.4 percent of the total water resources. And the northern Shaanxi Province, where energy and resource sectors are booming, only disposes of 9.5 percent of the total water resources. The contradiction between the distribution of water resources and economic demands is so salient that it has become an important factor that limits the regional development in Shaanxi Province. Especially for central and northern Shaanxi Province, water

shortage has become a first and foremost problem for economic development and environment improvement. It should be attached with more attention, so as to maintain a steady socio-economic development. Taking Hanjiang River to Weihe River water diversion project as an example, we will discuss the impact of water investment on local economy.

Picture 3-1 Recipient Areas in the Hanjiang River to Weihe River Water Diversion Project

(1) Improvement of water supply condition provides steady and reliable water sources of cities in need of water. After the completion of the project, it can provide water for 4 cities: Xi'an Xianyang, Weinan and Yangling, as well as 11 county-level cities: Chang'an, Huxian, Lintong, Zhouzhi, Xingping, Wugong, Jingyang, Sanyuan, Gaoling, Yanliang and Huaxian, and 4 industrial parks: Gaoling Jinghe Industrial Park, Jingyang Industrial Park, Fufeng Food Industrial Park, and Meixian Changxing Weaving Industrial Park.

(2) Through raising the water carrying capacity of central and northern Shanxi, industrial production along the line will be upgraded and improved because of improvement of water

resources. Adjustment to industry structure and productivity can also be realized. With the improvement of water supply and urban infrastructure, tertiary industry will have more growing potential.

(3) The Hanjiang River to Weihe River Water Diversion Project itself has attracted an inflow of billions of capital from government and other industries. The project can produce a large number of employment opportunities every year. For example, the direct labour force demand, posts created through production that appears along with the project and services provided for the project. After the completion of the project, with the improvement of water resources condition along the line, these areas will have better investment environment and be able to attract more investment to develop its advantaged industries.

Central and northern Shaanxi Province are important economic regions that are blessed with rich natural resources and human resources. They have great potentials. However, due to water shortage, these areas haven't given full play to their potentials, and they haven't been able to develop at full speed. After the implementation of the Hanjiang River to Weihe River Water Diversion Project, the water shortage in central and northern Shaanxi Province can be mitigated. Water supply pressure in cities can be alleviated. A better environment can be created for these areas in order to foster economic growth and improve people's life.

1.3 Impact of water investment on urbanization

The rate of urbanization reflects to an extent the urbanization and economic development level of a district. In 2011, the urbanization rate of Shaanxi Province was 35.58 percent, slightly higher than the national average, which was 34.71 percent. With the continuous socio-economic development, industrial growth and acceleration of urbanization, the demands for water resources are also increasing at an alarming pace.[2] Water resources not only have decisive influences on the scale, functions and layout of cities in Shaanxi Province, but also become a

factor that can restrain the industrial structure and layout in Shaanxi Province. If water supply for cities cannot be ensured, the development scale of cities and industries will be constrained, which goes against the industrialization and urbanization roads of Shaanxi Prrovince.

Investment in water conservancy can renovate reservoirs and divert water between different river basins, so as to resolve the vital problem of water shortage in the development of cities. In recent year, Shaanxi Province has gradually increased its investment in key water source projects, with a focus on solving water supply problems. As is seen in Table 3-1, the investment into water supply projects and the amount of supplied water have increased year by year, marking a notable improvement in its water supply capacity. The stable rise in water supply for production and life has effectively eased the pressure on water resources, and facilitated the expansion of cities and the elevation of urbanization level in Shanxi.

Table 3-1 Water Supply from Water Projects in Shaanxi Province from2004 to 2012

Year	Investment （100 million yuan）	Water supply （100 million m3）	Industrial water （100 million m3）	Domestic water （100 million m3）	Water supply capacity （10,000 t/d）
2004	3.47	75.53	12.46	11.02	3.01
2005	3.77	77.1	13.85	11.5	3.56
2006	3.24	80.36	11.09	11.21	5.72
2007	12.76	83.16	10.74	11.48	11.2
2008	11.65	85.46	12.85	12.2	15.3
2009	12.67	84.34	11.48	13.01	20.43
2010	21.01	83.39	11.76	13.18	82.03
2011	20.08	87.75	13.23	14.21	111.56

2012	25.48	88.08	13.35	14.76	119.97

Data source: Shaanxi Water Resources Yearbook from 2004 to 2012

Water shortages mainly occur in central and northern Shaanxi Province, where the process of industrialization and urbanization has become more and more constrained by water shortage. The construction of water conservancy can, to a large extent, alleviate water shortages. Take the Hanjiang River to Weihe River Water Diversion Project as an example. The project can not only solve the water supply problems for 5 cities including Xi'an Baoji, Xianyang, Weinan and Yangling, as well as other 26 villages, and promote the development of industrialization and urbanization in central Shanxi, but can also help northern Shanxi, where water shortage is even more severe. The Energy and Chemical Engineering Base in northern Shanxi has been developing rapidly, but in a few years the available surface water and groundwater will be exhausted. The amount of water drawn from the Yellow River is under strict restriction of the nation. So through the Hanjiang River to Weihe River Water Diversion Project, northern Shanxi can get more water from Weihe River. The Hanjiang River to Weihe River Water Diversion Project has reduced the restricting effects of water on the development of northern Shanxi, which is profoundly significant for the urbanization process in Shanxi.

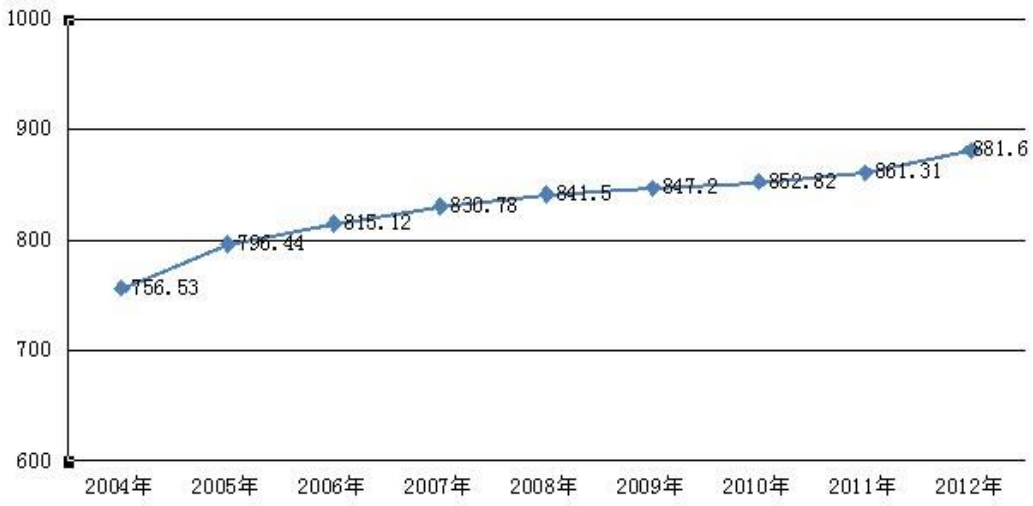
1.4 Impact of water investment on agricultural development

Investment in water conservancy has a direct and remarkable influence on agricultural production. Water conservancy is the basic condition for agricultural production, especially for Shanxi, where droughts and excessive rains happen frequently and irrigation consumes a large amount of water. Water conservancy is a factor of decisive importance in the development of grain production, forestry, fishery and husbandry. Drought and water shortage can cause crop failure, livestock lacking drinking water and eventually lead to poverty. It hinders the development of agriculture. Water conservancy projects can prevent droughts and floods, and

effective solve the problem of agricultural water at the same time. They improve the condition for agricultural production, and help farmers get bumper harvest.

For instance, the Water-Saving and Renovation Project of Comprehensive Development in Medium-sized Irrigated Area carried out in Shaanxi Province can, to a large extent, boost efficiency, increases output and help farmers get more incomes. The project concerns four irrigated areas: Yangxiandang River in Hanzhong, Lingao Reservoir in Weinan City, Linshi, and Dali Village in Weinan City. With a total investment of 65.6742 million yuan, the project built a total of 101.314 km of channels, and built and renovated 631 buildings. After the completion of the project, its annual water supply capacity attains 17.4724 million m3 with an annual increase of 6.3448 million m3. It can support another 49,400 acres of irrigated farmland and improve irrigation in an area of 115,600 acres. Each year the growth in grain production is 5.5 million kg, growth in oil plants and other cash crops is 10.5253 million kg, and growth in output value is 28.3197 million yuan. The project can effectively improve local irrigation conditions, promote the development of an agriculture of good quality, high production, good efficiency and low consumption. It raises the use efficiency of water and hence promotes sustainable development.

From 2004 to 2012, Shaanxi Province has reaped bumper harvests for 9 consecutive years, which should be attributed to a batch of water conservancy projects. By virtue of various water conservancy projects in rural areas, Shaanxi Province has increased irrigated land by 906,800 acres, built and renovated a total of 583,700 acres of farmland and developed 974,000 acres of water-saving irrigation farmland. The Picture 3-2 shows the changes in the area of water-saving irrigation farmland from 2004 to 2012. It can be seen from the picture that the area of water-saving irrigation farmland has kept increasing for 9 years in a row, which bears proof to the driving effects of investment in water conservancy projects on agricultural development.



Picture 3-2 Changes in the Area of Water-saving irrigation farmland from 2004 to 2012

(1,000 hectares)

1.5 Overall evaluation

Over last decade, investment in water conservancy projects in Shaanxi Province has got fairly good results. Water investment increased year by year, and maintained rapid growth between 2010 and 2013, providing strong support for the construction of various water conservancy projects. Yulin Yuqidu Reservoir Project，Lijiahe Reservoir Project, Heihe Tingkou Reservoir Project, Dongzhuang Reservoir Project, Hanjiang River to Weihe River Water Diversion Project,Hongyan River to Shitou River Water Diversion Project, Weihe River Comprehensive Renovation Project, Agricultural Irrigation Facility Construction Project and other key water conservancy projects increased the water supply capacity of Shanxi by 1.3 billion m3. They also created 1.79 million acres of irrigation farmland, 4.88 million acres of water-saving irrigation farmland, built and consolidated 1,230 km of dikes and restored 33,000 k ㎡ of water and soil erosion land. By the end of 2012, the irrigation farmland in Shanxi reached 1,417,500 hectares, including 1,277,180 hectares of effective irrigated area and 881,600 hectares of water-saving irrigation area. A total of

6,641,3 km of dikes has been built, along with 331 water gates, which offer protection to a population of 10.3 million and arable land of 546,330 hectares. A total of 9,512,300 hectares of water and soil erosion land has been restored, including 3,494.01 hectares in small river basins. 617 power stations have been built, with a installed capacity of 1,086,700 kWh. A total of 25,000 drinking projects have been carried out in rural areas, raising availability of tap water in rural areas from 34.4 percent at the end of the tenth Five-Year Plan to 77 percent, solving the drinking water problem for 18.47 million people. Water projects in Shaanxi Province effectively alleviated the relative shortage of water and resolved the problem of unbalanced water distribution. It stabilized and promoted socio-economic development, industrial and agricultural production and people's life in Shaanxi Province.

Investment in water conservancy projects can effectively ease the pressure on water resources in Shaanxi Province, improve regional water supply, foster industrial development and even enhance employment and economic growth. It also promotes the development of city clusters and boosts urbanization level. It can also promote agricultural development and reasonable and sustainable development of water resources at the same time. In all, investment in water conservancy projects is inseparably interconnected with the development of national economy. The former provides supports in aspects of security, capital and environment for the latter, while the latter can provide more funds for the former.

2. Quantitative analysis of water investment from 2002 to 2013

Through establishing a performance-appraising system, quantitative analysis is carried out on irrigation, flood control, power generation, conservation of water and soil as well as water supply in rural and urban areas, so as to form a dynamic evaluation to the investment in water conservancy projects in Shanxi.

2.1 Evaluation index

Abiding by the principle that is comprehensive, systematic, accessible and quantitative, the assessment system is built. The index mainly reflects investment in 5 aspects: irrigation, flood control, power generation, conservation of water and soil, and water supply in rural and urban areas. Specific index can be found in Table 3-2.

2.2 Evaluation methods

Since the system incorporates a lot of indexes, indexes are correlated with each other, and statistics are also inter lapped in one way or another, it is quite different to determine the weight of each index. So we adopt the method of Principal Component Analysis (PCA). PCA explains the variance and covariance of variables through their linear combination, in order to realize data compression and data interpretation. To concentrate the information about a group of variables on several indexes to describe the inner structure of the data is a kind of dimension-reduction method. It can use a few indexes to represent a large amount of raw data, and reflect as much as possible the information about the raw data. This method avoids the subjectivity and information overlapping of some traditional evaluation methods. It is convenient to get a comprehensive and objective evaluation result through this method. This method has been applied into practical use by many statisticians in our country. And it has produced satisfying results.

Table 3-2 Principal evaluation indexes of water investment in Shaanxi Province

Irrigation X1	Power generation X2	Flood control X3	Water and soil conservation X4	Water supply in urban and rural areas X5
Total investment in irrigation and drainage X11	Investment in hydroelectricity X21	Investment in flood control X31	Investment in water conservation X41	Investment in water supply in urban and rural areas X51
Effective irrigated area X12	Number of small power stations in rural areas X22	Length of dikes X32	Area of water and soil erosion land X42	Amount of water supply X52
Increment of effective	Installed capacity of	Length of up-to-standard	Area of restored water and	Agricultural water X53

irrigated land X13	hydroelectric station X23	dikes X33	soil erosion land X43	
Area of effective irrigated farmland X14	Increment of small hydro power stations X24	Protected population X34	Increment of restored land X44	Industrial water X54
Increment of effective irrigated land X15	Increment of installed capacity X25	Protected arable land X35	Reduced restored land X45	Water supply for domestic use X55
Area of yields despite droughts or excessive rains X16	Annual power generation X26	New dikes X36	New soil-retaining dams X55	Water for ecological environment X56
Irrigation and drainage by electromechanicals X17	Total income by selling electricity X27	Number of water gates X37	Restored area in small river basins X56	Increment of up-to-standard population X57

			Restored small river basins X57	Water supply capacity X58

2.3 Evaluation

1). Evaluation on irrigation projects

--Data standardization

In order to eliminate the differences in units and order of magnitudes and facilitate our calculation, the raw data must be processed. The raw data and standardized data are shown in Table 3-3 and Table 3-4.

Table 3-3 Raw data about irrigation in Shaanxi Province

Year	Investment in irrigation and drainage (100 million yuan)	Effective irrigation area (1,000 hectares)	Increment in area of effective irrigation land (1,000 hectares)	Real irrigation area (1,000 hectares)	Changes in effective irrigation area (1,000 hectares)
2002	7.5	1314.73	29.36	1057.88	-0.22
2003	6.69	1298.8	29.73	1050.76	-15.93
2004	6.72	1302.85	29.41	1060.19	4.05
2005	6.78	1308.82	29.32	1098.5	5.96
2006	11.43	1306.18	38.41	1076.65	-2.64
2007	8.04	1301.99	23.26	1071.72	-4.19
2008	10.08	1301.4	26.2	1090.7	-0.5
2009	18.73	1293.29	22.34	1101.68	-8.13
2010	23.25	1284.87	27.08	1083.66	-8.41

2011	28.39	1274.34	28.49	1061.95	-10.53
2012	32.12	1277.18	27.56	1053.89	2.84

Data source: China Water Resources Yearbook, China Agriculture Yearbook from 2002 to 2013

Table 3-4 Standardized data about irrigation in Shaanxi Province

Year	Investment in irrigation and drainage	Effective irrigation area	Increment in effective irrigation area	Real irrigation area	Changes in effective irrigation area
2002	-0.94939	1.38205	0.25639	-0.81047	0.4744
2003	-1.0381	0.15887	0.34482	-1.26039	-1.84931
2004	-1.03482	0.46985	0.26834	-0.73789	1.10598
2005	-1.02824	0.92749	0.24683	1.38481	1.3885
2006	-0.51895	0.72554	2.4194	0.17413	0.11645
2007	0.15244	0.40382	-1.20155	-0.09903	-0.11282
2008	0.27511	0.35851	-0.49887	0.95262	0.43298
2009	0.28058	-0.26421	-1.42144	1.56101	-0.69559
2010	0.77564	-0.94145	-0.28855	0.56255	-0.73701
2011	1.3386	-1.71928	0.04845	-0.64037	-1.05058
2012	1.74713	-1.50121	-0.17382	-1.08696	0.92701

--Correlation judgment between indexes

Use SPSS to judge the correlation between indexes. Calculate the relevant matrix, and the correlation intensity of different indexes can be observed. (Table 3-5) It can be know from Table 3-5 that among the 7 indexes, only X1, X12, X13, X14, and X15 are correlated. It is proved that

these 5 data have strong correlation. So we can choose these 5 data for PCA.

Table 3-5 Correlation matrix of indexes about irrigation in Shaanxi Province

	Investment in irrigation and drainage	Effective irrigation area	Increment in effective irrigation area	Real effective irrigation area	Changes in real effective irrigation area
Investment in irrigation and drainage	1	-0.885**	-0.359	-0.024	-0.161
		0.000	0.278	0.945	0.637
	11	11	11	11	11
Increment in effective irrigation area	-0.885**	1	0.268	0.177	0.364
	0.000		0.426	0.602	0.271
	11	11	11	11	11
Increment in effective irrigation area of this year	-0.359	0.268	1	-0.266	0.131
	0.278	0.426		0.429	0.700
	11	11	11	11	11
Real effective irrigation area	-0.024	0.177	-0.266	1	0.163
	0.945	0.602	0.429		0.632
	11	11	11	11	11
Changes in real effective irrigation	-0.161	0.364	0.131	0.163	1
	0.637	0.271	0.700	0.632	

area	11	11	11	11	11

** on .01 level there is significant correlation

3）Calculated contribution rate and accumulating contribution rate

We can use SPSS to calculate the eigen value, contribution rate and accumulating contribution rate of the data. (Table 3-5) It can be known from Table 3-6 that we should only take 2 principal components, abiding by the principle that the eigen value should be greater than 1. The accumulating contribution rate of the 2 component is 69.734 percent, which reflects main information about the raw data. To be more specific, the contribution rate of the first component is 43.541 percent and that of the second one is 26.193 percent.

Table 3-6 Results from PCA about irrigation in Shaanxi Province

Element	Initial eigen value			Load in quadratic sum			Rotated quadratic sum		
	In total	Variance %	Accumulating %	In total	Variance %	Accumulating %	In total	Variance %	Accumulating %
1	2.204	44.077	44.077	2.204	44.077	44.077	2.177	43.541	43.541
2	1.283	25.658	69.734	1.283	25.658	69.734	1.310	26.193	69.734
3	.858	17.165	86.900						
4	.575	11.500	98.399						
5	.080	1.601	100.000						

It can be known from Table 3-7 that the investment in irrigation, effective irrigation area and

effective irrigation area of the year have higher value on the first component, which proves that the first component mainly reflects these indexes; increment in effective irrigation value and real effective area have higher value on the second component, which proves that the second component mainly represents these indexes.

Table 3-7 Load matrix of initial elements about irrigation in Shaanxi Province

Item	Element	
	1	2
Investment in irrigation and drainage (100 million yuan)	-.882	.231
Effective irrigation area (1,000 hectares)	.951	-.020
Increment in effective irrigation area	.394	-.704
Real irrigation area (1,000 hectares)	.260	.833
Changes in real effective irrigation area	.527	.257

4) Calculation and Synthesis of Principal Components

In SPSS, we can directly calculate the value of the two components.

In the following part we will calculate the ratio of variance of contribution rate to the total contribution rate.

First component: 43.541/69.734= 0.624

Second component：26.193/69.734= 0.376

So we can get the model of the synthesized principal component: F=0.624F1+0.376F2

So we obtained the value of synthesized principal components. (Table 3-8)

Table 3-8 Synthesized principal component value about irrigation in Shaanxi

Year	First component	Second component	Synthesized component F
2002	1.00264	-0.66428	0.37588
2003	-0.15306	-1.55242	-0.67922
2004	0.8205	-0.48709	0.32885
2005	1.43495	0.99274	1.26868
2006	0.93238	-1.15298	0.14828
2007	-0.10417	0.57085	0.14964
2008	0.2372	1.03429	0.53691
2009	-0.35709	1.62863	0.38954
2010	-0.84711	0.42244	-0.36976
2011	-1.6495	-0.56332	-1.24390
2012	-1.31305	-0.23346	-0.90489

2). Evaluation on hydroelectricity projects

Use SPSS to analyze the correlation between indexes about hydro power. We can known from the results of statistical analysis, the 7 indexes have strong correlation. So we can choose the 7 indexes for PCA. Abiding by the principle that the character value should be greater than 1, we can choose 2 components to carry out PCA.

Among them, installed capacity, number of small power station, new installed capacity,

annual power generation and electricity revenue have higher value on the first component, proving that it mainly reflects these indexes; investment and new small power stations have higher value on the second component, proving that it mainly represents these indexes. The accumulating contribution rate of the 2 indexes is 88.712 percent. Among them, the contribution rate of the first component is 61.054 percent, and the contribution rate of the second component is 27.658 percent. In the following part we are going to calculate the ratio of variance of contribution rate to the total contribution rate:

First component: 61.054/88.712= 0.688

Second component：27.658/88.712= 0.312

So we can get the model of the synthesized principal component: F=0.688F1+0.312F2. So we obtained the value of synthesized principal components. (Table 3-9)

Table 3-9 Synthesized principal component value about hydroelectricity in Shaanxi

Year	First component F1	Second component F2	Synthesized component F
2002	-1.54093	-0.79087	-1.30709
2003	-0.85671	-0.20548	-0.65368
2004	-0.65498	-0.89686	-0.73040
2005	0.05206	-0.56417	-0.14007
2006	-0.49620	-0.40195	-0.46682
2007	-0.45902	0.86473	-0.04631
2008	-0.33428	1.18227	0.13854
2009	0.24106	1.32299	0.57839

2010	0.96210	0.26795	0.74569
2011	1.27602	0.98499	1.18529
2012	1.81087	-1.76360	0.69644

3). Evaluation on flood control projects

Use SPSS to judge the correlation between indexes. It can be known from the statistical analysis that among the 7 indexes, only total investment, length of dikes, accumulating length of dikes, protected population, new dikes and new water gates are correlated. It is proved that these 6 data have strong correlation. So we can choose these 6 data for PCA. Abiding by the principle that the character value should be greater than 1, we can choose 2 components to carry out PCA.

Among them, length of dikes, protected population, and new dikes have higher value on the first component, proving that it mainly reflects these indexes; investment in flood control, length of dikes and number of water gates have higher value on the second component, proving that it mainly represents these indexes. The accumulating contribution rate of the 2 indexes is 95.312 percent. Among them, the contribution rate of the first component is 50.715 percent, and the contribution rate of the second component is 44.598 percent. In the following part we are going to calculate the ratio of variance of contribution rate to the total contribution rate:

First component: 50.715/95.312= 0.532

Second component：44.598/95.312= 0.468

So we can get the model of the synthesized principal component: F=0.532F1+0.468F2. So we obtained the value of synthesized principal components. (Table 3-10)

Table 3-10 Synthesized principal component value about flood control projects in Shaanxi

Year	First component F1	Second component	Synthesized

		F2	component F
2002	-1.02938	-0.10170	-0.59523
2003	-1.35929	0.38897	-0.54110
2004	-1.21624	0.32872	-0.49320
2005	-0.6977	-0.52021	-0.61463
2006	-0.35152	-0.58235	-0.45955
2007	-0.22865	-0.32296	-0.27279
2008	0.87152	-1.12257	-0.06171
2009	1.24936	-0.86418	0.26022
2010	0.94399	-0.59492	0.22378
2011	1.11741	1.02284	1.07315
2012	0.70050	2.36837	1.48106

4). Evaluation on water and soil conservation projects

Use SPSS to analyze the correlation between indexes about water and soil conservation. It can be known from the statistic analysis that among the 7 indexes, only total investment in water and soil conservation, area of water and soil loss land, accumulating restored area of water and soil loss land, new area of water and soil loss land, reduced restored area of water and soil loss land, and new soil-retaining dams are correlated. It is proved that these 6 data have strong correlation. So we can choose these 6 data for PCA.

Abiding by the principle that the character value should be greater than 1, we can choose 2 components to carry out PCA. Among them, investment in water and soil conservation, accumulating restored area and new soil-retaining dams have higher value on the first component, proving that it mainly reflects these indexes; area of water and soil erosion, new

restored area and reduced area of water and soil erosion have higher value on the second component, proving that it mainly represents these indexes. The accumulating contribution rate of the 2 indexes is 81.081 percent. Among them, the contribution rate of the first component is 40.627 percent, and the contribution rate of the second component is 40.454 percent. In the following part we are going to calculate the ratio of variance of contribution rate to the total contribution rate:

First component: 40.627/81.081= 0.501

Second component：40.454/81.081= 0.499

So we can get the model of the synthesized principal component: F=0.501F1+0.499F2. And we obtained the value of synthesized principal components. (Table 3-11)

Table 3-11 Synthesized principal component value about water and soil conservation projects in Shaanxi Province

Year	First component F1	Second component F2	Synthesized component F
2006	-0.68772	-1.1694	-0.92808
2007	-1.08158	-1.01654	-1.04913
2008	-0.99562	1.64094	0.32002
2009	-0.16612	0.82301	0.32746
2010	0.75587	-0.46027	0.14902
2011	0.63960	0.07278	0.35676
2012	1.53556	0.10949	0.82395

5). Evaluation on water supply projects in urban and rural areas

Use SPSS to analyze the correlation between indexes about water and soil conservation.

It can be known from the statistical analysis that among the 8 indexes, only total investment

in water supply in urban and rural areas, water supply of this year, water supply for domestic use, water supply for ecological environment and up-to-standard population of the year are correlated. It is proved that these 5 data have strong correlation. So we can choose these 5 data for PCA.

Abiding by the principle that the character value should be greater than 1, we can choose 2 components to carry out PCA. Among them, water supply of this year, water supply for domestic use and water supply for ecological environment have higher value on the first component, proving that it mainly reflects these indexes; total investment in water supply in urban and rural areas and up-to-standard population of the year have higher value on the second component, proving that it mainly represents these indexes. The accumulating contribution rate of the 2 indexes is 90.767 percent. Among them, the contribution rate of the first component is 46.412 percent, and the contribution rate of the second component is 44.355 percent. In the following part we are going to calculate the ratio of variance of contribution rate to the total contribution rate:

First component: 46.412/90.767= 0.511

Second component：44.355/90.767= 0.489

So we can get the model of the synthesized principal component: F=0.511F1+0.489F2. And we obtained the value of synthesized principal components. (Table 3-11)

Table 3-12 Synthesized principal component value about water supply in urban and rural areas

Year	First component F1	Second component F2	Synthesized component F
2002	-0.36656	-0.97668	-0.66491
2003	-2.27588	0.46195	-0.93708
2004	-0.41744	-1.03484	-0.71935

2005	0.07951	-1.36395	-0.62634
2006	0.43576	-1.23974	-0.38356
2007	0.01676	0.09255	0.05382
2008	0.11020	0.40962	0.25661
2009	-0.23913	1.19603	0.46266
2010	-0.23563	1.40282	0.56557
2011	1.50714	0.18251	0.85940
2012	1.38527	0.86974	1.13318

6) . Overall evaluation

Use SPSS to analyze the correlation between all the indexes about water conservancy investment, including 5 aspects: irrigation, flood control, electricity generation, water supply and water conservation. Follow the 4-step procedure: standardizing data, judging the correlation between the data, calculating contribution rate and choosing main components, and at last formulating synthesized principal component. An overall PCA is carried out with 6 principal components. Details can be found in Table 3-13.

Table 3-11 Synthesized principal component value about water investment in Shaanxi

Year	Component F1	Component F2	Component F3	Component F4	Component F5	Component F6	Synthesized

							component F
2002	-1.15524	-0.91574	1.41081	0.13945	0.91225	0.43638	-0.63674
2003	-1.001	-1.18125	0.56294	-0.07835	-2.11264	0.39005	-0.79851
2004	-0.68671	-0.729	-1.21333	-0.15821	0.46356	0.48864	-0.62003
2005	-0.6432	0.80564	-1.47157	-0.08918	0.8203	1.51631	-0.36656
2006	-0.38163	0.23543	-0.25145	-2.15179	0.31473	-1.5759	-0.43519
2007	-0.31004	0.16404	-0.52219	0.87216	0.02128	-1.91382	-0.21645
2008	-0.11292	1.17046	1.36217	0.55181	0.81044	0.2361	0.29924
2009	0.18698	1.18453	0.5943	1.00594	-0.2876	-0.37078	0.38321
2010	0.66883	0.22344	-1.09078	1.02358	-1.13248	-0.00133	0.37055
2011	1.45108	0.79043	0.56349	-1.44211	-0.82065	0.87915	0.94538
2012	1.98386	-1.74799	0.05561	0.3267	1.01081	-0.08478	1.07510

2.4 Results Analysis

2.4.1. It can be known from Table 3-10 that the performance of investment in flood control projects has been gradually increasing. In 2011, the performance took a great leap from minus value to positive value. It can be found out that the investment in flood control projects has been keeping its good momentum. In recent years, Shanxi has been putting more and more human resources, material resources and funds in to the construction of flood control projects. Dikes, water gates and reservoirs have been gradually completed to ensure the safety of a larger population and more arable land. The investment has brought about good results.

2.4.2 It can be observed from Table 3-8 that the performance of investment in irrigation has fluctuated from 2002 to 2012. Why did the performance fluctuate while the investment has increased year by year? We think the main reasons are: firstly, the performance lags behind the

investment, namely the effects of the investment can only be embodied after several years; secondly, in recent years the effective irrigation area has been on the decline, which is caused by urbanization and water and soil erosion, the reduced area of farmland; thirdly, Shaanxi Province has relatively underdeveloped irrigation technology, which leads to an average performance; fourthly, irrigation mostly uses shallow water, which is under the influence of precipitation, making the performance under its sway too:

2.4.3 It can be known from Table 3-12 that, performance of investment in water supply has increased steadily from 2002 to 2012, and it took a great leap from negative value to positive value in 2008, and attained its maximum value in 2012. It can be observed that with the increase in investment, the water supply volume and capacity in Shanxi have both been expanding, solving the problems of drinking and using water for more people. The investment has begot good results.

2.4.4 It can be seen from the Table 3-11 that performance of investment in water and soil conservation has undergone great fluctuations from 2006 to 2012, which proved the performance to be unstable. Water and soil conservation is always a difficult work which has high requirement on investment and technology. And it is also susceptible to environment conditions. The unreasonable industrial and agricultural production caused vegetation degradation. Frequent droughts and floods aggravated the soil and water losses. The ecological environment worsened and the difficulty for preventing water and soil losses increased. In addition, reclamation of mountainous area, overgrazing, deforestation and large-scale projects in recent years has also cause water and soil losses. All the above-mentioned reasons led to the fluctuations in the performance of investment in water and soil conservation.

2.4.5 It can be known from the Table 3-9 that the performance of investment in hydro-electricity has increased from 2002 to 2012. In 2008, it changed from negative value to positive value, which proves that investment in hydro-electricity has brought about good results. With the increasing

investment, installed capacity of hydropower stations has been gradually increased, and small hydropower stations have been put into use. Generated electricity and revenue have increased year by year. Moreover, thanks to advanced technology, the efficiency has also been enhanced. All these reasons contribute to the improvement of performance concerning investment in hydro-electricity.

2.4.6 It can be known from the Table 3-13 that the performance of investment in water conservancy projects has increased from 2002 to 2012. In 2008, it changed from negative value to positive value, which proves that investment in water conservancy projects has brought about good results. As investment in water conservancy projects in Shaanxi Province increased year by year, various social causes have been carried out. Water investment in Shaanxi Province has brought about remarkable results and it will provide solid support for socio-economic development of Shaanxi Province.

IV. Experiences on Water Investment and Existing Problems in Shaanxi Province

1. Experiences on water investment

1.1 Support by central and provincial governments with investment on key areas

Shaanxi Province located in the west of China is short of water resources, but the provincial government has attached great importance to water projects. In the "11th Five-Year Plan" period, Shaanxi Province has completed the construction of 4 projects, namely, Lijialiang reservoir of Yulin, Huangshitan reservoir of Ankang, Jianyu reservoir of Weinan, Caitugou reservoir of Shenmu county; it has also started 6 key projects, including Hongyan river to Shitou river water diversion project, Lijiahe reservoir of Xi'an, Wanggedu reservoir of Yulin, Nangoumen reservoir of Yan'an, the extension of water supply of Dingbian and Tingkoushui reservoir of Xianyang. Meanwhile, Shaanxi Province has sped up the preparatory work of a number of key projects, such as Dongzhuang reservoir of Jin River. During the "Eleventh Five-Year Plan ", 2.556 billion RMB has been invested in the key water conservancy projects, which is 125.8% higher than the 2.032 billion RMB made in the "10th-Five-Year Plan". The overall scale of the investment has reached 10.078 billion RMB, with a total storage capacity of 1.063 billion cubic meters. It has increased the volume of water supply by 693 million cubic meters, the new irrigation area by 133,400 acres and the annual energy output has reached 44.2 million-kilowatt. This has greatly relieved the conflict between water shortage and economic and social development in Shaanxi Province. In recent years, Shaanxi Province has also implemented several projects, such as the comprehensive harnessing project of Weihe River, the agricultural irrigation projects and Han River to Weihe River water diversion project, focusing on issues such as flood control, irrigation and water supply.

1.2 Increasing water investment with growing benefits

Since 2001, the investment on Shanxi Province water conservancy construction has increased year by year with fast-growing investment in recent years. In 2001, the investment on Shanxi Province water conservancy construction was 2.919 billion RMB and the number has increases to 22.408 billion RMB by the year 2013 with an average annual growth rate of 18%. This is even so in past four years with an average annual increase of up to 43% on the water investment. For more details, please refer to Figure 4-1.

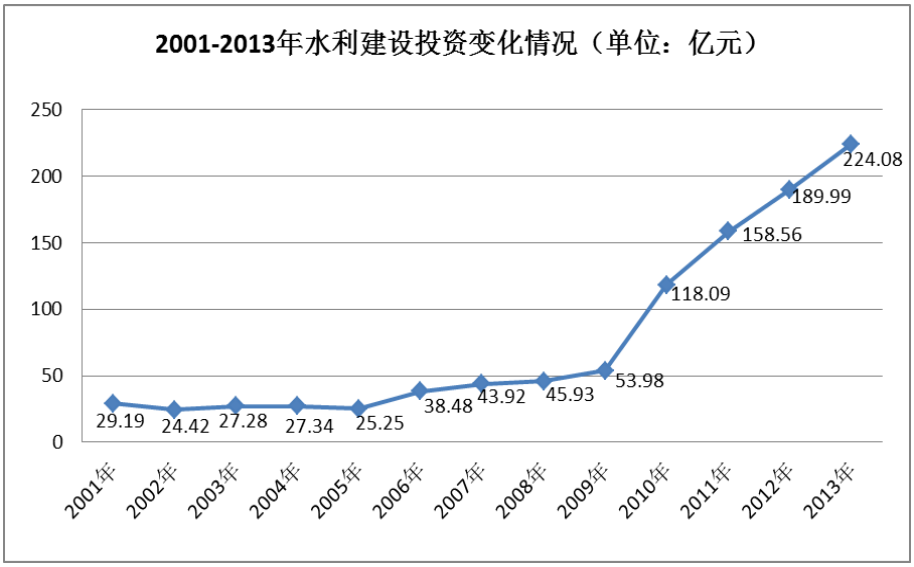


Figure 4-1 Changes of the water investment in Shaanxi Province

The increase of water investment benefits in Shaanxi Province largely owes its thanks to the rapid growth of the investment volume. With the increase of its volume, the benefits of the water investment are increasing annually whose overall benefits are promising.

1.3 Multiple investments with growing private credit funds

Prior to 2009, water investment in Shaanxi Province was largely supported by the central and provincial governments funding with little came from municipal and county levels, which resulted with the single major investor. Started from 2010, investment from municipal and county levels and private sector have witness a prudent growth in the share, with a total investment of around 15% and 10% in the water investment in the recent three years. Significant changes started from 2010, the increase of credit funds was faster. By 2013, the credit funds have taken up 23% of the total investment, exceeding the provincial government funding, ranking second right after the central government investment. The water investment in Shaanxi Province has attracted an increasing number of private capital and credit funds, which makes the composition of the major investors more diversified.

1.4 Systems, mechanisms, evaluation and examination improved

The institutional mechanism for water projects construction in Shaanxi Province is improving. The modern construction management system with its core on "the responsibility system of project legal person, public bidding and construction supervision system", which has been gradually promoted outside large-medium sized water projects to various water projects, helping to form standardized management on water projects. It gradually establishes The inspection and acceptance management system has been gradually established combining the legal person and governmental inspection and acceptance, which contributes to the smooth implementation of

the projects to ensure the quality and investment benefits.

The supervision on quality and safety of Shanxi Province water conservancy construction is strengthened. The water administrative departments at all levels have to stick to the principles of putting quality and safety as the priority, strengthening the quality and safety supervision to ensure the smooth implementation of large-scale water conservancy construction. Meanwhile, the cultivation and supervision of the major investors in Shaanxi Province is intensified. The water administrative departments at all levels have effectively regulated the market order of water projects construction by strictly examining and approving the qualification, strengthening the registration management, strictly controlling the admittance of the water projects construction market, strengthening the market dynamic supervision on investors, promoting the integrity system.

The stipulation of the Annual Target Responsibility Supervision and Assessment of Shaanxi Provincial Water Resources Department has made the assessment more standard and scientific. The assessment department makes the procedures into a flowchart which consists of three parts, i.e. organization, assessment and use of the results. Meanwhile, it combines the assessment practice and the actual work to further the study of the Enforcement Regulation and specify the standards for the addition/deduction of points and disciplinary requirements, as well as methods for supervision, examination, information exchange and feedback accompanied by suggestions on improving the work efficiency of departments. The key aims which have been assigned to different departments were listed as the items for administrative examination, served as the principal basis for ranking of each department by the end the year, forming a long-term mechanism which helps the complete of different aims in a all-rounded way.

2. The Existing problems

2.1 Comprehensive planning and coordination needed for water investment

Normally, flood control is the key water projects. Currently, it is a major investment policy on water in China to give funds to watershed flood control projects with approval. The first major investment made by Shaanxi Province on water is flood control. In 2011, the investment volume of flood control was 4.562 billion RMB, taking up 29%; in 2012, the investment volume went up to 6.431 billion RMB, taking up 35%. Flood control, key water resources project and irrigation project are the three major investment areas for Shaanxi Province , which takes up nearly 70% of the total. Water conservation, hydropower, water ecology and water environment share a lower percentage, which takes up about 14% in 2012. Although Shaanxi Province has serious problem of soil erosion, it is also an important agricultural province whose ecological environment is severe. The water conservation and water ecological environment affect the sustainable use and development of water resources, therefore it is necessary to consider each

aspect of overall planning.[1] In addition, the flood control project of Shaanxi Province paid more attention to the comprehensive improvement of large rivers such as Weihe River and Han River than those small rivers, which resulted in very low standards for flood control in many cities, towns and small-medium size rivers, easily causing flood disasters. In terms of the disasters caused by extreme weather in the recent years, it was often the small-medium size river that led to flood.[2] Therefore, particular stress needs to be made based on the overall planning of investment architecture and direction to avoid restriction of development of the water conservancy investment due to unreasonable causes.

2.2 Supervision and management of fund use need to be strengthened

The provincial government, as the major sector for allocation of water funds, has two problems as regarding the allocation and use of the capital. First, the projects construction planning in the early stage was inadequate and unscientific, which caused many changes in the actual practice, leading to decision-making mistakes. The unscientific planning directly led to arbitrary implementation, target deviation and a waste of resources. Second, phenomena such as irregular and unreasonable use of funds in the allocation process, even overstating of expenditures to get construction funds, misappropriation of the funds, have influenced the regular implementation of projects. These problems will lead to unreasonable and irregular allocation and use of the funds, affecting the efficient use of money, which requires improvement on the fund supervision and management.

2.3 Examination and management of matching funds need to be strengthened

The matching funds do not come in full amount in the water projects construction in Shaanxi Province. The successfully established projects often require multiple levels of government funding, however, it is quite common that many county-level government matching funds do not come in full amount. The water special funds are guiding subsidies. Whether they can be effective or not depends on the implementation of matching funds. However, in the actual operation, due to local financial difficulty, it is difficult for the matching funds to come in full amount. The special funds for water are made as the dominant fund. Some departments even have deficit due to temporary benefits, causing “holes” that are difficult to compensate. Therefore, this requires the supervising departments at all levels to strengthen the supervision of water projects construction funds to ensure that the matching funds come in full amount timely and guarantee the completion of the construction with due quality.

VI. Recommendations

1. Further expanding multiple investment scale

The amount of the water investment can directly influence the final performance. The top priority of the water investment in Shaanxi Province is the flood control project. With the increasing investment to the flood control projects, its performance has been improved significantly. From 2002-2009, the investment volume for flood control in Shaanxi Province remains around 500 to 900 million RMB with low performance. However, the investments in 2010, 2011 and 2012 quickly rose to 1.454 billion, 4.564 billion and 6.432 billion with significant improvement on performance. In addition, the performance of urban and rural water supply has also increased along with the increased investment. Therefore, it is necessary to enlarge the scale of investment through multiple channels and increase investment so as to improve the performance of water projects construction.

The work can be conducted from the following key aspects: first, since the central and provincial governments are the main sectors of investment in water projects construction, it should try harder for the Central Government investment in water projects construction. Meanwhile, the local governments should set up a synchronized growth mechanism of water investment and social investment, increasing the financial support for water investment to ensure long-term, sustainable and stable growth of water investment. Second, innovate means for public finance investment, establish viable financial investment channels and give full play to the extra budgetary funding, such as extracting 10% from benefits of land transfer for farmland water facilities construction which gives full play to the comprehensive benefits of the land management funds, e.g land using charges. Third, further improve the policies for water projects construction funds, extend the collection period and broaden the sources of increased scale. To perfect the system of paid use of water resources, regulate the standard for water resource charges reasonably, expand the scope and strengthen the collection, use, and management.

2. Further speeding up reform on water investing and financing systems

The major water investors in Shaanxi Province has witnessed gradual shift towards diversification, with credit financing and private investment taking up higher proportion, which has successfully promoted the construction and development of water projects. However, the matching funds are still difficult to come in full amount, mainly due to the limited fund of the local governments. Therefore, how to innovate the means of financing and reform the

investment and financing systems will be, to a large extent, influence the development of water projects construction. While making the full use of the central and provincial governmental funding, the local governments should speed up the investment and financing systems reform on water and promote the marketization of water investment: on the one hand, stabilize and expand the existing sources of funding; on the other hand, actively open up new investment channels. The impact of market is not only feasible but also necessary. For example, to make full use of the transferred national debt from the central to local, the governmental bonds and bank loan, giving play to the market mechanism, expanding financing channel for water conservancy; to innovate the ways of projects construction, clear the operating management on water projects, attract enterprises to cooperate in the form of sole proprietorship, joint venture, BOT or BT; to build a financing platform, establish water investment company, raise water projects construction funds to support public welfare and key quasi-commonweal water projects. In addition, it is also possible to finance from banks by the future benefit pledge earned by such projects as water supply and power generation and the future benefit pledge earned from the reserved land.

3. Improving water resources management

As for the management issues on water conservancy construction investment, good care should be taken strictly in accordance with the relevant provisions of the State. It is necessary to strengthen the supervision and regulation of the water conservancy funds to ensure that the investment has made its full use. First, better the water fund management system. Regulation should be conducted from the perspectives of the supervising subjects, content, means and responsibility investigation. Local governments of all levels should actively explore the fund management according to the established regional management system. The feasible practice should be converted into norms to ensure the perfection of the fund management system. Second, establish a multi-regulatory structure. A multi-faceted financial supervision system should be established: it is not only about the responsibilities of the local water departments at all levels for water projects construction, but also to establish a group of experts responsible for professional guidance and management of the projects construction. Meanwhile, the social community supervision system should be established to conduct overall monitoring of the investment, quality, efficiency and risk of the water conservancy projects at all levels. The direct beneficiaries of the project should be considered as the supporting system to the approval, construction and acceptance of the water conservancy projects. Third, to strengthen the supervision and management on key projects. As for water projects with a large amount of funds and investment cycle which closely related to people's livelihood, more attention should be paid on the management of using funds.

4. Strengthening management, supervision and evaluation of water projects construction

In order to actualize the water investment benefit and let it to play its role, effective project management and performance evaluation are essential. As for the management problems of water projects in Shaanxi Province, they can be addressed from the following areas for improvement. First, in terms of construction management, the management should strictly follow the provisions of the relevant national, provincial and municipal infrastructure regulations, in accordance with procedures and fulfilling their responsibilities. Second, in order to ensure the long term benefits of the project, the operation and management mechanism of the water projects should be bettered based on the former management system reform, relating itself with requirements such as the county is supervised by province regarding the financial system, so as to further specify and standardize the construction and management systems at different levels. Third, compensation mechanism of public welfare projects should be established. The maintenance fund should be raised according to the responsibilities of different levels, building a maintenance system which is market-oriented, professional and social, taking care of the functions of the established and newly-established projects to ensure safe and efficient operation. Forth, to strengthen the process management and supervision, increasing the evaluation efforts to ensure that the water projects construction will complete on time with high quality and quantity. Fifth, take various ways of evaluation on the performance of the water projects construction and post evaluation to better wield the benefits.

5. Rational water resources development

In the actual investigation, it is found that some local governments and departments take projects in a rush and blunt investment regardless of the price to earn the water investment, ignoring the benefits of the projects, resulting in a loss and waste of local resources and national investments. The development of water sector is not only important to the local economic and industrial development, but it also has an impact on regional ecological environment and culture. For example, with Ankang, Hanzhong, Shangluo and other places taking advantage of the water resources and building hydropower stations at the same time, the public is increasingly dissatisfied with the negative impacts of the hydropower development. Therefore, when planning water projects, we should not only take the economic factors into account, but also think about its impact on the ecological, cultural and social environment. Human beings should consider the power of Nature and should not blindly use human power to transform it, not to say exploit it against Nature's law, which will eventually be punished by it. Therefore, we need to resolutely safeguard the seriousness and authority of water projects development planning against herd phenomenon, any waste of resources or any damage to the ecological environment.

6. Further conserving water and raising water use efficiency

Shaanxi Province is short of water resources, but the reasonable use of water requires not only increasing sources, but also reducing them. Therefore, water-saving should be used as a strategic and fundamental measure, which can be carried out from the following aspects. First, establishing a water resource management system with water management as the core. To take water management as the core, be guided by the theory of water rights and water markets, implement the stringent water resources management system, conduct water volume control and curb the unreasonable demands; make reasonable water allocation plans; conduct strict access and use to water. Second, promoting water-saving irrigation. Currently, agricultural water supply in Shaanxi Province has accounted for above 60% of the total water use; however, the increase of food production will rely on the expansion of the effective irrigation areas, which will further increase the agricultural water supply. Therefore, scientific water irrigation development plan should be made to integrate water-saving, small-size farmland water facilities construction in key counties, rain water irrigation and pastoral water management; to better the water irrigation input mechanism and let different parties to show their enthusiasm; to vigorously promote tube irrigation, drip irrigation , sprinkling irrigation, trickle irrigation and micro irrigation and develop the kind of agriculture with high quality, high yield, efficient and low energy consumption. Third, giving full play to the leverage of price in water saving. Gradually conduct water price reform, to set differential pricing to different sources and different types of water resources while increasing the use of the reclaimed water to improve the circulation of water use. In addition, it is necessary to improve the social awareness on water-saving via all means to form a long-term water-saving mechanism gradually.

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