Analysis of the Changing Laws and Influencing Factors of Social and Economic Indicators in the Upper Reach of Han River Basin

Xiu Wei¹, Dengfeng Liu^{1,2,*}, Jinkai Luan¹, Mingliang Li³, Mu Lin⁴

¹State Key Laboratory of Eco-hydraulics in Northwest Arid Region of China, School of Water Resources and Hydropower, Xi'an University of Technology, Xi'an 710048, China

²Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59717, USA

³General Institute of Water Resources and Hydropower Planning and Design, Ministry of Water Resources, Beijing 100081, China

⁴School of Statistics and Mathematics, Central University of Finance and Economics, Beijing 100081, China

Copyright©2018 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract In the socio-hydrological system, the social processes, ecological processes and hydrological processes coupled together and interacted. The base of the analysis and modeling of socio-hydrological processes is the quantitative analysis of the social processes. The construction of the middle route of the South-To-North Water Diversion Project in China and the implementation of the Dan River ecological management project will have an important impact on the socio-economic development of the upper Han River basin in China. In order to reveal the changing laws of social and economic indicators in the Upper Reach of Han River, The social and economic processes in the Upper Reach of Han River are quantitatively analyzed. In this study, 12 socio-economic indicators, such as Total population, Gross domestic product (GDP), Per capita net income of farmers, Fiscal revenue, Common cultivated land area and Total grain output of the 29 counties in the upper reach of the Han River Basin are utilized. Based on the year of Han River Ecological Comprehensive Management, the indicators and their growth rates are analyzed by methods of one-dimensional linear regression, Mann-Kendall comprehensive test and cumulative departure. Economic indicator curves and mutation analysis shows that before and after the Han River Ecological Management, the total grain output changed from the decline trend to significantly decreased, the common cultivated land area has experienced from the reduction to the significant reduction, then to the relatively stable change, the oil-bearing crops output showed a slight upward trend, and the other economic indicators changed from the slow upward trend to a significant upward trend. Growth rates curves of socio-economic indicators and mutation analysis shows that, during and especially after the period of Dan River Comprehensive Management, all of growth rates of the

socio-economic indicators showed a downward trend in different ranges. According to the analysis results, some relevant ecological compensation suggestions are put forward for the Upper Reach of Han River Basin.

Keywords Han River Basin, Mann-Kendall Comprehensive Test, Linear Trend Analysis, Cumulative Departure, Ecological Management, Ecological Compensation

1. Introduction

In the socio-hydrological system, the ecological functions and environmental services, which are chosen to maintain, are determined by the preference of the society. Under the influence of human activities and climate change, the relationship between social system and human system is becoming increasingly close and coupled [1]. The protection and improvement of the ecological environment is the prerequisite, the foundation and the support of the water quality and water quantity. The southern region of Shaanxi Province, located in the upper reach of Danjiangkou, is an important water sources for the Middle Route of the South to North Water Diversion Project in china. In order to ensure "A river of water supply in Beijing", the ecological management water resources began. At present, a large number of scholars have shown that the Han River governance will limit the development of the industry, while the water source areas are mostly located in the Qinba mountain area where the economy is relatively poor in China. So it will affect the development of the water sources to a certain extent. Such as Li et al. [2] introduced development opportunities losses of water

resources protection for South-to-North Water Diversion Project from three aspects of the industrial development losses, farmers' income and fiscal revenue damage. Shi et al. [3] discussed the ecological compensation ways of Shaanxi water sources in the South-to-North Water Diversion Project, in which tree structure index system is established and evaluated by it, and concluded that the proportion of the poor is high, economic development is slow, per capita income of farmers is not high, fiscal revenue is low in the water sources. Wang et al. [4] based on the analytic hierarchy process as the main research method, establishing the hierarchy structure model of comprehensive impact assessment, the quantitative analysis and evaluation has been carried out in economic, social and ecological ways. The result was that implementation of the Middle Route of the South to North Water Diversion Project affects the economic development of the water source area in Shaanxi province to a great extent, the influence of this project are both positive and negative. Wang et al. [5] analyzed the influence of South to North Water Diversion Project on water source area by using the analytic hierarchy process, a hierarchical framework of economic indicators was established. The results show that the implementation of this project affects the secondary industry of the water source areas in Shaanxi province most, and the primary industry and the tertiary industry in sequence. Zhou et al. [6] investigated the ecological benefits brought by Dan-Feng County in Shaanxi Province watershed management and its' administrative inputs, and the results showed that the ecological governance would lead to slow development of county economy, and put forward to follow the principle of "who benefits, who compensation" and other recommendations. Li et al. [7] pointed out that ecological protection would limit the regional economic development and lead to the decline of some people's living standards. Based on the protection cost, the ecological "restoration cost" of the water source area should be compensated by water receiving area. Xiao et al. [8] analyzed the loss of development opportunity of water source protection and made the estimation, got the annual ecological compensation amount of the three cities in southern Shaanxi.

The base of the analysis and modeling of socio-hydrological processes is the quantitative analysis of the social processes. Therefore, this study takes the 12 economic indicators of 29 counties in the water source area of Shaanxi Province, compares the changes of the socio-economic indicators before and after Comprehensive Management of Han River Basin, and studies the relationship between the ecological management and the socio-economic indicators in the Han River Basin, and analyzed qualitatively the positive and negative feedback in the social processes on the background of ecological protection, then providing a basis for establishing the dynamic feedback network. Meanwhile, we put forward

some relevant suggestions and measures, which provides an important theoretical basis for establishing a complete ecological compensation standard system for the water source area.

2. Study Area

The Danjiangkou reservoir area and the upper reach of the Han River basin are the important water source areas for the middle route of the South-to-North Water Diversion Project. The Han River Basin in Shaanxi Province includes two major tributaries of the Han River and Dan River, covering 31 counties in Hanzhong, Ankang, Shangluo, Xi'an and Baoji. The total land area is 62,700 km², accounting for 65.9% of Danjiangkou Reservoir control area of 95,200 km², where there are 18 national poverty-stricken counties and 5 provincial poverty counties. The average annual runoff of Han river basin and Dan river basin in Shaanxi province is $270 \times 10^8 \text{ m}^3$, accounting for 70% of Danjiangkou reservoir average inflow of $388 \times 10^8 \text{ m}^3$ [9][10].

Figure 1. Map of the upper reach of Han River Basin

3. Data and Methods

3.1. Data

The original data in this study are from Shaanxi statistical yearbooks (1991-2016)[11], Shaanxi regional Yearbook (2016)[12], Shaanxi Yearbooks (1991-2016)[13][14][15], Hanzhong Yearbooks (1998-2013) [16], Ankang Yearbooks (1996-2015)[17], Shangluo Yearbooks (2000-2010)[18], Baoji Yearbooks (1999-2015)[19], Xi'an statistical yearbooks (1997-2015)[20]. The 12 indicators of social and economic

development in 29 counties of Ankang, Hanzhong, Shangluo, Xi'an and Baoji in Shaanxi Province were selected in the upper reach of Han River basin (above the Dan River). The socio-economic indicators are listed in Table 1.

Table 1. Socio-economic Indicators in Shaanxi Province

No.	Name of Economic Index	Unit
X1	Total population	person
X2	Gross domestic product (GDP)	10000yuan
X3	Fiscal revenue	10000yuan
X4	Per capita net income of farmers	yuan
X5	Social fixed assets investment	10000yuan
X6	Industrial added value	10000yuan
X7	Total output values of agriculture	10000yuan
X8	Common cultivated land area	hectare
X9	Total grain output	tons
X10	oil-bearing crops output	tons
X11	Fruit yield	tons
X12	Total livestock	10000heads

3.2. Study Methods

3.2.1. Linear Tendency Method

The trend of the socio-economic index series by the linear trend analysis method [21]. If the economic index variable is x_i , the t_i is corresponding time and the linear regression equation is established.

$$x_i = a + bt_i \quad (1)$$

Where, a and b are parameters.

3.2.2. Mann-Kendall Test (Following Called M-K)

The mutation test of data series was performed by Mann-Kendall test [22]. Its' basic principle: the definition of statistics UF_k and UB_k , and given a significant level (U_{α}), which can be found in the tables of critical value, when $UF_k > UB_k$, the sequence will appear trend of significant increase or decrease; all of UF_k will form a curve. While $UF_k = -UB_k$. If the value of A or B is greater than 0, it is on the rise, otherwise it will show a downward trend. If the two curves intersect between the thresholds, the point at which the intersection corresponds is the moment of the start of the mutation.

3.2.3. Cumulative Departure

The cumulative departure method [23] is a statistical method for discrete data points from the curve intuitive judgment trend, by first we calculate the economic indicators and the growth rate of the anomalies, and then get the cumulative departure curve by accumulating year by year, according to the time sequence, according to the trend of the curve, the approximate time of the economic index or the mutation rate of the growth rate is finally judged.

4. The Results and Analysis

4.1. Analysis of the Trends of Economic Indicators and Their Growth Rates

In 1999, in order to curb the increasing trend of soil erosion, Shaanxi Province as the one of first demonstrations to start the project of returning farmland to forest, Shaanxi Province promulgated the "Han River Dan river water pollution prevention and Control Ordinance" in 2005, and implemented since March 1, 2006. Then in 2006, the State Council approved the "The planning of water pollution control and soil and water conservation in Danjiangkou reservoir area and the upper reach of Han river basin" (the first phase is 2007-2010, the second phase is 2012-2016). Subsequently, the "Qinling ecological protection regulations" was introduced in 2007. In 2012, the construction of ecological civilization was put forward in 18th CPC National Congress. Under this background, three cities in southern Shaanxi actively promote the construction of ecological civilization and the development of ecological cycle, and actively build "China-Southern Shaanxi ecological civilization demonstration plot", in order to serve in the middle route of the South-to-North Water Diversion Project, and actively protect beautiful scenery of southern Shaanxi. Therefore, the paper takes the 1999 as the beginning of the project of returning farmland to forests, takes 2006 as the beginning of the comprehensive management of the Han River, take the 1999 and 2006 as the nodes to analyze the changes of socio-economic indicators before and after the ecological management of the Han River basin.

The economic indicators and their growth rates were analyzed by linear regression, the results are as follows (Fig 2(a) are the economic indicators curves, the Fig 2(b) are the corresponding growth rate curves).

Figure 2. Curve of total population (a) and its growth rate (b) (1991-2015)

According to Fig.2, the total population showed a steady increasing trend, and there was no obvious change around 2006. Its growth rate showed a slight upward trend before 2007, and showed a slight downward trend after 2007

Figure 3. Curve of GDP (a) and its growth rate (b) (1990-2015)

According to Fig.3, GDP showed an upward trend as a whole, and increased significantly after 2006. The overall growth rate can be divided into three stages: There was the decline stage from 1990-1999, and was the increased stage from 2000-2010 with an average increase of 2.11% / a, then the growth rate of GDP dropped significantly in 2011-2015 with an average decrease of 3.67% / a.

Figure 4. Curve of fiscal revenue (a) and its growth rate (b) (1994-2015)

According to Fig.4, fiscal revenue showed an upward trend as a whole, and increased significantly after 2006. Its' growth rate showed a downward trend during 1995-2005,

and increased significantly in 2006-2007, then growth rate showed a downward trend with the range of 2.74%/a during 2008-2015.

Figure 5. Curve of per capita net income of farmers (a) and its growth rate (b) (1993-2015)

According to Fig.5, the per capita net income of farmers increased significantly after 2006. The overall growth rate can be divided into three stages: There was the decline stage from 1994-2002, was the increased stage from 2003-2008, and the growth rate dropped significantly in 2009-2015, with an average decrease of 3.17% / a.

Figure 6. Curve of social fixed assets investment (a) and its growth rate (b) (1999-2015)

According to Fig.6, social fixed assets investment also increased significantly after 2006. Its growth rate showed an increased trend during 2000-2008, and reached a maximum of 4.87% in 2008, then the growth rate started to decline after 2009.

Figure 7. Curve of industrial added value (a) and its growth rate (b) (2000-2015)

According to Fig.7, industrial added value showed an upward trend as a whole, and increased significantly after

2007, Its growth rate showed an upward trend before 2010, and decreased significantly during 2011-2015, with an average decline of 9.8%/a.

Figure 8. Curve of total output values of agriculture (a) and its growth rate (b) (1990-2015)

According to Fig.8, total output values of agriculture of farmers increased significantly after 2006. Its overall growth rate can be divided into three stages: There was the decline stage from 1991-1999, was the increased stage from 2000-2008, and the growth rate dropped significantly in 2009-2015, with an average decrease of 2.44% / a.

Figure 9. Curve of common cultivated land area (a) and its growth rate (b) (1990-2015)

According to Fig.9, the cultivated land area showed a downward trend as a whole, and decreased more obviously from 1999 to 2003 than from 1990 to 1999, and tended to be stable after 2004. In a word, the cultivated land area has changed from decline to decline significantly to relative stability during the study period.

The change of its growth rate stay in step with cultivated land area and can be divided into three stages (The rate of change below 0 is the reduction rate, and above 0 is the growth rate): the reduction rate decreased sharply, with an average decline of 1.21%/a, after the implementation of the project of returning farmland to forestry in 1999, the changing rate of the growth rate tended to be steady after 2003.

Figure 10. Curve of total grain output (a) and its growth rate (b) (1990-2015)

According to Fig.10, The grain yield showed a downward trend as a whole, and before and after the project returning farmland to forestry (in 1999), the total grain output did not change significantly. Its' growth rate showed a slight downward trend before 2007 and a slight upward trend after 2007.

According to Fig.11, oil-bearing crops output showed an upward trend in general, and increased obviously after 1999, Its growth rate showed a slight upward trend during 1991-1999, then showed a downward trend during 2005-2015 as a whole, especially, dropped obviously after 2008 with an average decline of 1.76%/a.

According to Fig.12, the fruit yield showed an upward trend in general. Compared with the trend line before and after 2006, there was no obvious change; its' growth rate showed a downward trend as a whole, and the growth rate showed a slightly upward trend during 1998-2007, then deceased obviously during 2008-2015 with 2.11%/a.

Figure 12. Curve of fruit yield (a) and curve of its growth rate (b) (1997-2015)

Figure 13. Curve of the total livestock (a) and its growth rate (b) (1990-2015)

According to Fig.13, the total livestock (the livestock of sheep, pigs and cows) showed an increased trend as a whole. In which the total livestock in 1997 decreased suddenly because of changes of the statistics standard; and increased during 1998-2015 as a whole, then tend to be stable after 2009, which growth rate showed an decreased trend as a whole, during 2009-2015, the growth rate decreased obviously with 2.74%/a.

4.2. Analysis of the Trends of Economic Indicators and Their Growth Rates

In this study, the socio-economic indicators and their growth rates mainly analyzed by M-K test, the cumulative anomaly method is used to supplement and verify the results again, combining with the above two methods, the mutation results are as follows.

Table 2. Summary mutation years of socio-economic indicators

Socio-economic indexes	Mutation years	Changing trend
X1 Total population	None	
X2 Gross domestic product (GDP)	2006	Increased to significantly increased
X3 Fiscal revenue	2006	Increased to significantly increased
X4 Per capita net income of farmers	2006	Increased to significantly increased
X5 Social fixed assets investment	2006	Increased to significantly increased
X6 Industrial added value	2007	Increased to significantly increased
X7 Total output values of agriculture	2006	Increased to significantly increased
X8 Common cultivated land area	2000	Decreased to obvious decreased
X9 Total grain output	2000	Decreased to significantly decreased
X10 Oil-bearing crops output	2004	Increased to obvious increased
X11 Fruit yield	None	
X12 The total livestock	2007	Increased slowly to obvious increased

Table 3. Summary mutation years of growth rates socio-economic indicators

Growth rates of indexes (%)	Mutation years	Changing trend
X1	2000	Deceased to increased
X2	2004-2005	Deceased to increased
X3	2005	Deceased to increased
X4	2006	Deceased to increased
X5	2006	Deceased to increased
X6	2009	Deceased to increased
X7	2004	Deceased to increased
X8	2005	Deceased to increased
X9	2004-2006	Decline to slightly upward
X10	1999	decreased to increased
	2010	Increased to decreased
X11	2006-2007	Increased to decreased
X12	2007	Increased steadily to Increased obviously

As shown in Table 2, the mutation years of socio-economic indicators are consistent with the corresponding socio-economic indicators.

As shown in Table 3, the growth rate of the total population experienced the change from a slight decline to

a slight upward in 2000. The growth rates of cultivated land area and total grain output and changed from decline to slight increase in 2005 and 2004-2006 respectively. The mutation year of fruit yield, oil-bearing crops output, were consistent with the growth rates curve of corresponding socio-economic indicators; the mutation years of remaining socio-economic indicators were consistent with the curve of corresponding socio-economic indicators.

5. Results and Discussion

The socio-economic indicators and their growth rates in Shaanxi Province in the upper reach of Han River Basin were analyzed by linear trend, M-K test and cumulative anomaly method, and the results are as the following:

- (1) Curves of socio-economic indicators and mutation analysis shows that: the total population and fruit yield did not change significantly, oil production showed no significant upward trend; the cultivated land area and grain yield generally showed a downward trend, both from declining to significantly decreased in 2000; the remaining mutation years of economic indicators are consistent with the economic indicators with slow increasing to significant increasing during the period 2006-2007.
- (2) Growth rates curves of socio-economic indicators and mutation analysis shows that: the growth rate of the total population did not change significantly before and after 2006-2010, and the growth rate of cultivated land area increased; during and especially after the period of Dan River Comprehensive Management. The rest of growth rates of the socio-economic indicators showed a downward trend in different ranges during and especially after the period of Dan River Comprehensive Management, in which gross domestic product, fiscal revenue, per capita net income of farmers, social fixed assets investment, industrial added value declined evidently, the average value reached more than -3.0%/a, and the largest decrease of industrial added value reached to -9.8% / a. In addition, these socio-economic indicators changed from rising to falling in 1999, maybe because of the China West Development Strategy. Meanwhile, agricultural economic indicators, such as the growth rates of oil production, fruit production, and the total livestock had mutations during and after the period of ecological management.
- (3) In the background of comprehensive management of Han River basin. The mutation of the growth rate of total population in 2000 is mainly caused by the relaxation of family planning policy and the improvement of the economic and medical level.

For cultivated land, it decreased obviously after the implementation of returning farmland to forest, the region began to strengthen the land consolidation with the reduction of cultivated land, and it began to be relatively stable. Finally, the cultivated land may form a virtuous circle under the force of returning farmland to forest and land consolidation.

For grain yield, it had been declining during the study period, and showed an obvious downward trend in 2000. Its' growth rate began to rise slightly during the period of 2004-2006, with the improvement of the level of agricultural mechanization and the implementation of the government's policy of benefiting agriculture, which reduce the influence of cultivated land resource constraints in a certain extent,

The region would carried out the agricultural structure adjustment because of decrease of cultivate land and ecological protection, cash crops would grow more instead of grains. Though, fruit yields, oil-bearing crops increased as a whole, their growth rates showed a decreased trend, especially during and after Han River ecological management. So the cash crops keep in an unbalanced cycle.

For indicators such as GDP, fiscal revenue, industrial added value, per capita net income of farmers, which represent the level of economic development, they showed a significant upward trend under the national macro policy and the rapid development of science and technology level, however, their growth rates had decreased to a different degree during and after comprehensive reclamation of river basin. the results was consistent with previous studies and was in line with practical situation of water areas. so the Han River comprehensive management may have a negative feedback on the growth rates of indexes that reflect economic development.

- (4) The change of socio-economic was caused by the mutual influence and co-evolution of water resources system and socio-economic system. Its change cannot be simply attributed to the change of a given factor. The contribution rate of its impact needs to be further simulated and analyzed.

However, a large number of studies have shown that ecological management and protection will restrict the development of local regional economic, and the first and the second industry are limited. Industrial development opportunities loss and so on will also affect the speed of economic development. While some studies have shown that, in the long run, the ecological environment protection and construction of water source area can produce huge value of ecological services. So the behavior of human policy-ecological protection of water area, social economy is a dynamic feedback mechanism. We have made some following suggestions for ecological compensation.

- (1) Follow the principle of "who uses, who compensates; who benefits, who pays". Most of economic indicators just changed significantly

from during 2006-2007. It can be seen that the lag of economic development. Therefore, a reasonable long-term economic compensation mechanism should be set up in the water source area and the water receiving area as soon as possible [24].

- (2) Compensation for loss of industrial development and increased cost. The growth rate of industrial added value is the biggest decrease after Ecological Comprehensive Treatment. According to statistics from Shaanxi Provincial Department of Environmental Protection, during the "12th Five-Year Plan period" alone, more than 240 polluting enterprises were shut down in Shaanxi Province in the Han River Basin, and more than 30 construction projects that failed to comply with environmental protection requirements were suspended and reorganized[25]. It made the development of the backward Qinba Mountain more slowly, so the receiving area should compensate for the loss of opportunity for industrial development and give support to local enterprises.
- (3) Compensation for agricultural losses. Since the ecological management of the Han River Basin, the state had given various subsidies such as "grain subsidies" and "public welfare forest subsidies". However, cash crops such as growth rates of grain yield ,fruit yields, oil-bearing crops increased still showed a decreased trend, especially during and after Han River ecological management the current ecological compensation mechanism has problems such as insufficient compensation and low compensation level, so we should step up efforts to support the structural adjustment of local agricultural industries, help develop the special economy and green industries, and guide farmers to take the road of environmental protection development[26]. Meanwhile, the region should accelerate the adjustment of agriculture structure adjustment.

Acknowledgements

This work was partially supported by National Key R&D Program of China (2017YFC0405900) and National Natural Science Foundation of China (NSFC) (Grant No. 51779203, 51609270, 41330858). Funding was also provided by the Basic Research Plan of Natural Science of Shaanxi Province (2016JQ5105).

REFERENCES

- [1] Liu P, Feng M Y, Guo S L, Social hydrology research

- methods and difficulties. [J]. Water Resource Research. 5(6), 521-529.2016
- [2] Li H E, Xiao Y, Dang Z L. Assessment of development opportunity losses for water resources protection [J]. Journal of Northwest University (Natural Science), 40(02):339-342. 2009
- [3] Shi S J, Li H E, Liu L N, Dang Z L, Xiao Y. Present situation and Prospect of ecological compensation in water resource area of Middle Route Project of South to North Water Diversion [J]. Journal of Northwest University (Natural Science), 39(06):1084-1087. 2009
- [4] Wang X F, Wang J H, Zhao L. Comprehensive evaluation of the influence of Middle Route of South-to-North Water Diversion Project on the water source in Shaanxi. [J]. Journal of North west University (Natural Science Edition). 39(06):1075-1078.2009.
- [5] Wang J H, Wang X F, Zhao L. Evaluation of the influence on the economy of water source areas in Shaanxi province of middle route of South-to-North Water Diversion Project based on the analytic hierarchy process. [J]. Journal of Qufu Normal University, 36(01):104-108.2010.
- [6] Zhou J, Wang J M. Analysis on compensation mechanism of ecological governance in Dan River ——the survey of the governance of Dan-Feng County River Basin [J]. Agricultural Science and Technology and Information. (20):14-15. 2010.
- [7] Li H E, Pang M, Xiao Y, Shi S J. Study on ecological compensation amount of Shaanxi water area based on the value of water resources [J]. Journal of Northwest University (Natural Science), 40(1):149-154.2010.
- [8] Xiao Y. Study on ecological compensation amount of Shaanxi water area based on Middle Route of South-to-North Water Diversion Project. [D]. Xi'an University of Technology, 2009.
- [9] Research group of Shaanxi provincial Party School. Study on the benefit of compensation mechanism of water source protection area of Middle Route of South to North Water Diversion Project [J]. Journal of Theory Guide. (11):97-101.2006.
- [10] Liu L N, Liu S Z. Review and summary of the first stage project of soil and water conservation in Danjiang kou reservoir area and upper reaches in Shaanxi Province [J]. Soil and Water Conservation of china, (12):3-5. 2012.
- [11] Shaanxi Provincial Bureau of Statistics. Shaanxi statistical yearbooks, 1990-2015[M]. Xi'an: Shaanxi Statistics Press. 1991-2016.
- [12] CNKI:<http://tongji.cnki.net/kns55/navi/YearBook.aspx?id=N2017030065&floor=1>
- [13] CNKI:<http://tongji.cnki.net/kns55/navi/YearBook.aspx?id=N2014090169&floor=1> (2014)
- [14] CNKI:<http://tongji.cnki.net/kns55/navi/YearBook.aspx?id=N2007080495&floor=1###>
- [15] The Press of Shaanxi Yearbooks .Shaanxi Yearbooks, 1990-2015[M]. Xi'an: The Press of Shaanxi Yearbooks 1991-2016.
- [16] Local chronicles office of Hanzhong. Hanzhong yearbooks.1997-2012[M]. Xi'an: Shaanxi Statistics Press 1998-2013.
- [17] Local chronicles office of Ankang. Ankang yearbooks, 1995-2015[M].Xi'an: SANQIN Press of Xinhua Publishing Media Group in Shaanxi, 1996-2016.
- [18] Local chronicles office of Shangluo. Shangluo yearbooks, 2000-2009[M]. SANQIN Press of Xinhua Publishing Media Group in Shaanxi, 2001-2010.
- [19] Local chronicles office of Baoji. Baoji yearbooks, 1998-2014[M]. SANQIN Press of Xinhua Publishing Media Group in Shaanxi, 1999-2015.
- [20] Xi'an Bureau of Statistics. Xi'an statistical yearbooks , 1996-2015[M].Beijing: China Statistics Press 1997-2016.
- [21] Long H L, Wang H H. Relationship between climate change and urbanization in Urumchi in recent 50 years [J]. Geographical Environment Research in Yunnan, 25(04):10-14+21.2013.
- [22] Li G P, Zhou Q, Zhou Y Q. change and mutation analysis of Visibility in Baoji from 1981 to 2013 [J]. Jiangxi Journal of Agriculture, 28(12):94-99.2016.
- [23] Wang X R. Study on the ecological environment effect of the Han to Wei He water diversion project. [D] Xi'an University of Technology, 2016.
- [24] Shi S J, Li H E, Liu L N, Lin Q C. Study on ecological compensation model of Shaanxi water area in middle route of South to North Water Diversion Project [J]. Journal of Soil and Water Conservation, 23(05):147-151.2009.
- [25] Li C B. Make efforts to implement "Danjiang comprehensive management" project to ensure the clean water supply in Beijing [J]. Journal of Soil and water conservation of china, (12):85.2012
- [26] Pan S J. The clean water supply in Beijing [N]. People's Daily, 2007-04-12(016).