Factor Analysis on Economic Development of Small Watershed in Mountainous Area of Beijing

Wang Dongmei[1]***, Li Yonggui***[2]***, Hou Xufeng***[2]***, Jiang Wenqiong***[1] and ***Li Zhongkui***[3]

[1]College of Soil and Water Conservation, Beijing Forestry University, 100083, Beijing, P. R. China
E-mail: wdmzbh@bjfu.edu.cn or wdmz_2000@yahoo.com
[2]The Hydraulic Resources Bureau of Beijing, 100036, Beijing, P. R. China
[3]China Academy of Forestry, 100091, Beijing, P. R. China

Abstract: This paper analyzes factors affecting economic development of small watershed, using methods of Contrast, Hypothesis Proof—test, AHP, based on field survey and data collection of Shixia watershed. The analysis concludes that the main factors affecting economic development of Shixia small watershed are not those of the nature, as sunlight, temperature and precipitation, but the social factors including management, technique and population etc. with management as the key. The analysis furthers identifying industry restructuring, technique service and investment strategy as pilot elements to economy development of small watershed in mountainous area.
Keywords: mountainous area, small watershed, economic development, affecting factors

The comprehensive harness and development of small watershed in mountainous area is thought not only as a pivot action to renovate land and manage rivers, but also a fundamental program eradicating poverty and prospering economy of the area, so as to help people get rich and live a comfortable life. This is of utmost importance for Beijing where mountainous area accounts for 62% of the total land area. In the research, Shixia watershed was selected as a field site. After careful field survey and detailed data collection at all levels from municipality to the grass root unit, from library to individual villager, the factors affecting economy development of small watershed was identified and compared based on analysis using methods of Contrast, Hypothesis Proof—test, AHP. The work and findings of the research are administered under the principles and guidance for people across China, which is regarded a mountainous country, to alleviate and eradicate poverty and get rich. The program was set as a demonstration comprehensive management project of small watershed in Beijing's mountainous area.

1 Site Information

Shixia watershed locates between 117°01′ to 117°07′E and 42°32′ to 42°38′N in Gaoling Township, at northeast of Miyun reservoir in northern mountainous area of Beijing. Its population in 1999 accounted 6 888 with labor power at 3 083 and household at 2 361. The total land area was 545.53 ha and 0.08ha per capita. The general national production of agriculture was 25.877 millions Yuan (RMB) and income per capita 2 433 Yuan.

The watershed is in the semi-arid region and of warm temperate-zone with monsoon where the average rainfall is 603.6 mm and 80% of which falls in the period from July to September. The lowest temperature of years is –17.502℃ in average, and the highest 36.0℃. The shining hours per year is 2 601.7, the frost-free period is 76 days long and the annual evaporation is about 1 480 mm.

2 Methodology

2.1 Field Survey and Collection of Raw Materials

By random sampling, 100 households in the watershed were selected as informants to answer s. And simultaneously, the collection basic information and figure of climate, economy, population, technical

management data from villages, township and city level agents were obtained. Field survey and monitoring of some data achieved by my colleagues in the project.

2.2 Data Analysis

The methods of Contrast, Hypothesis Proof—test and AHP were used.

Contrast: this is applied to compare those data of the project after implementation with those before implementation based on the field survey and data collection from related agents.

Hypothesis Proof—test: this is applied to questionnaire analysis to determine or test if the presumed hypothesis could be accepted[1].

Analytic Hierarchy Process: It is applied to weight analysis in layers constituting social factors in the research with combination of qualification and quantification[2].

3 Economy Increment of the Watershed

In recent years, significant results of development on economy, ecology and society envisaged in Shixia watershed. The key point of the paper is on the analysis of economy factors.

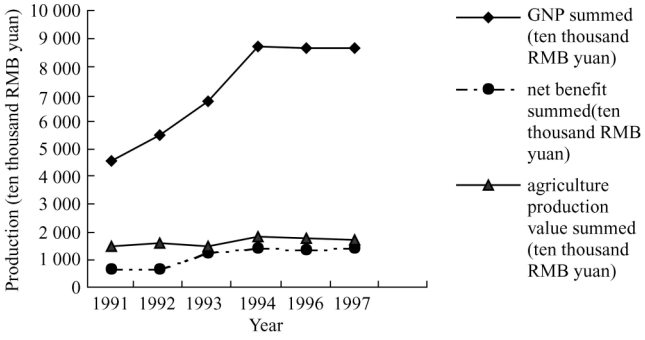

Fig. 1 Changes of the summed economy index

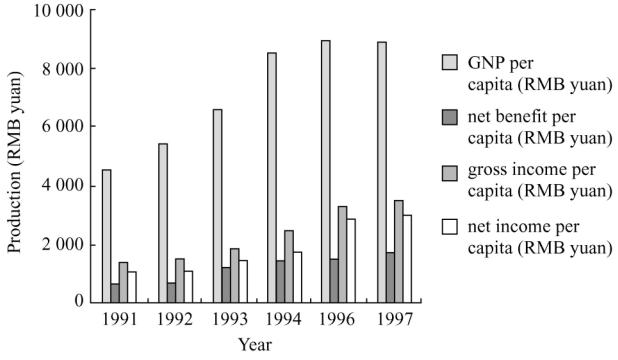

Fig. 2 Changes of the per capita economy index

Figure 1 showed that the GNP rose sharply from 1991 to 1994. The total net benefit in 1997 increased for 116.9% compared to that in 1991 and the annual rate of increase is about 20.4% in average. Figure 2 showed the increase of economy per capita. The net income per capita was increased from 1 031.26 Yuan in 1991to 2 984.32 Yuan in 1997, and the increasing rate is 189.4%.

4 Analysis of Affecting Factors

In general, the factors affecting economy development of small watershed could be divided into two types: the natural and the social.

4.1 Natural factors

Factors of soil, vegetation and geography are relatively constant in certain period, but those of climate are variable during the year and from year to year and, therefore, affecting the economy of the small watershed closely, among which the important ones are light, temperature and precipitation.

Table 1 The meteorological data

Year	1992	1993	1994	1996	1997	1998	$\bar{x}$	s	$\overline{X}$
Precipitation /mm	587.7	454.8	590.2	600.01	555.7	646.5	572.45	59.045	603.6
Aver temper /℃	11.1	10.95	11.8	10.5	11.6	12.0	11.325	0.5210	11.5
Max temper/ ℃	37.1	35.9	36.2	34.4	38.5	36.1	36.367	1.2432	36.0
Min temper/ ℃	–13.2	–17.7	–15.9	–17.4	–18.5	–18.9	–16.93	1.9206	–17.50
Sunlight/ h	2576	2633.7	2488.4	2427.9	2526.9	2200	2475.5	139.11	2601.7

The Hypothesis Proof—test was used to process the above meteorological data, in which average of collectivity of small sampling was adopted, and got the results as follows, $|t_{precipi}|$ =1.177; $|t_{avertem}|$ =0.751 1; $|t_{\max tem}|$ =0.660 1; $|t_{\min tem}|$ =0.662 4; $|t_{sunlight}|$ =2.028 8. The refashion area of double test is, $|t| > t_\alpha$, α=0.05, $t_\alpha(n-1)= t_\alpha(5)$=2.571, but $|t_{precipi}| < t_\alpha$ $|t_{avertem}| < t_\alpha$; $|t_{\max tem}| < t_\alpha$; $|t_{\min tem}| < t_\alpha$; $|t_{sunlight}| < t_\alpha$. H_0 ($\bar{x} = \overline{X}$) could not be refused.

It could be known from the analysis above that the 5 meteorological factors' variation is not significant in recent years. It is then thought that the major factors related to economy increase of Shixia watershed are not the yearly change of natural ones.

4.2 Investigation and analysis of social factors

The Soil and Water Conservation Station of Miyun County and the government of Gaoling Township had implemented a series of measures since the year 1992 to help peasants to eradicate poverty and get rich based on the abundance of resources and limiting factors.

4.2.1 Population

Table 2 displayed the number of household, population and labor force of the small watershed.

Table 2 The changes of population and labor force in the Shixia watershed

year	household	population	Farming labor force	% farming labor force to population
1991	3339	9 987	4790	47.96
1992	3273	10 028	4980	49.66
1993	3447	10 222	5105	49.94
1994	3565	10 156	4924	48.48
1996	3988	9 709	4446	45.79
1997	2825	8 057	3445	42.76

Table 3 The education level of the workforce

year	in the work force													
	whole or semi work force	% of the whole	illitera-cy or semi-ill itera-cy	% of the whole	primary school	% of the whole	junior middle school	% of the whole	senior middle school	% of the whole	polyte-chnic school	% of the whole	college	% of the whole
1991	252	100	20	7.9	61	24.2	123	48.8	43	17.1	5	2	_	_
1992	252	100	16	6.3	60	23.8	132	52.4	41	16.3	3	1.2	_	_
1993	250	100	17	6.8	60	24	120	48	47	18.8	6	2.4	_	_
1994	248	100	17	6.9	57	23	130	52.4	28	15.3	6	2.4	_	_
1996	253	100	12	4.7	49	19.4	124	49	48	19	15	5.9	5	2
1997	247	100	10	4.0	42	17	124	50.2	52	21.1	15	6.1	4	1.6

The table showed population decreases in the watershed as a result of family planning policy. For instance, the population decreased from 9987 in 1991 to 8 057 in 1997, which is thought lightening burden on land capacity. The farming work force decreased too and the ratio of farming work force to total population went downward at the rate of 1.89% in average. The surplus workforce might go out to engage in other employment. The culture level, however, rose in years and the illiteracy decreased gradually. The illiteracy rate decreased from 7.9% in 1991 to 4.1% in 1997 as shown in Table 3, for example. The farming work force with senior high school education or more increased for 9.7% in 1997 compared with that in 1991, for another.

4.2.2 Techniques

Since Shixia watershed was set as a demonstrating area of small watershed comprehensive management in 1992. Several principles were persisted including combinations of engineering measures with biological ones, valley engineering with slope ones, farming engineering with tillage measures, scientific test with production practice, harness with management and giving emphasis to construction of economic valley. The integrated harness applied to hill, water, field, forest and road in the watershed.

(1) Technical measures of engineering

The protecting engineering in the watershed mainly include valley block and store of water, flood drain engineering, water conservancy engineering to make peasants rich, preparation of farmland.

- Valley block and store of water, flood drain engineering: Up to June1998, 15 sets check dams of backbone engineering, 100 sets check dams of common engineering, 14 000 m draining ditch, 5 000 m land protection dam were built in the watershed.
- Water conservancy engineering to make peasants rich: During the period of project implementation, water diverting, water storing and water saving engineering were adopted to use the water resource efficiently and rationally. 3 sets of dyke dams, 3 large opening wells, 30 sets of sluice pond, 1 000 m long complete set of ditches were built. The water-saving irrigation started in 1996, with 333.33 hm^2 irrigated farmland and 333.33 hm^2 orchard developed till now. The combination of mini-tube flow, drip irrigation, sprinkling irrigation and tube irrigation was applied in the central area of demonstration, from which the limited water resources was used reasonably.
- Preparation of farmland: In the period from 1992 to 1998, 200 hm^2 of terraced field, 300 hm^2 of land in tillage measures, 800 hm^2 of level strip and 133.33 hm^2 of fish-scale pits were constructed.

(2) Bio-technical measures

It is thought that the biological measures are the major components for watershed management. In the process of comprehensive management of Shixia watershed, various measures of land preparation and tree and grass planting were conducted in line with different soil layer and slope in the watershed. The

main outcome of the measures could be described as the hill is standing in farmland wearing a green cap with fruit bearing at waist.

- Cultivation of economic forest: Development of fruit trees is an important way to promote economy development of mountainous areas. Based on the nature of Shixia watershed, 1 200 hm^2 of land was planted with fruit trees through construction of terrace, level strip, excavation of large hole in the place of middle and down slope, cove and branch and hair gullies. The standard orchard was constructed for 533.33 hm^2, including 66.67 hm^2 of apple, 13.33 hm^2 of pear, 400 hm^2 of chestnut, 53.33 hm^2 of apricot and plum. The implementation of these engineering aimed not only to develop fruit trees but also control soil and water loss effectively.
- Plant trees and grass to enlarge vegetation area: It is a major theme for comprehensive management of the watershed. 820 hm^2 of forest for soil and water conservation was made in 1997 and 94.67 hm^2 of grass was planted in 1998 and 1999 according to different elevation, soil quality and thickness of hills, with the vegetation area greatly increased.
- Enclose mountain to cultivate forest: It is an essential way to raise cover of vegetation. According to the topography, the high or far hills and mountain areas of thin vegetation, poor condition for plant to grow and with serious soil and water loss were closed constantly. From 1992 to 1998 enclosed mountain to cultivate forest accounted to 7 474.67 hm^2. Through the engineering and other measures mentioned above, an integrated protection system of soil and water conservation was formed, it also accelerates increase of yield and income.

4.2.3 Management

The thought of comprehensive management for Shixia watershed was formed through practice in about 10 years managing to achieve combined benefits of economy, environment and society within the productivity and capacity.

(1) Secure the investment

Expenditure of management for the watershed is from subsidy of the municipality, local input, self-raised money of peasants and research funds. Local peasants participated in the earth and stone engineering as a kind of input, the investment increased year by year, as shown in Table 4.

Table 4 The input in the Shixia small watershed

work amount(10^4 m^3)			labor(10^4)	investment(10^4Yuan) from			
year	earth & stone	concrete		country	county	village	total
1992	15.0		7.5	12.5	6.0	26.25	44.75
1993	17.0		8.5	20.0	10.0	29.75	59.75
1994	24.7		13.4	25.0	12.0	46.9	83.0
1995	24		12.0	25.0	12.0	42.0	79.0
1996	14		7.0	20.0	10.0	24.5	54.5
1997	14.69		8.38	28.9	34.0	50.28	113.18
1998	42.37	0.91	167.08	349.5	175.0	584.78	1109.28

It could be seen from Table 4 that the input of labor and investment increased year by year. The investment increased from 447.5 thousands Yuan in 1992 to 11092.8 thousands Yuan in 1998, the increasing rate is 23.78 times. The investment is mainly from villages.

(2) Policy, regulations and organization

From the comprehensive development and management in about 10 years, reasonable development was obtained in farming, forestry, animal husbandry, fishing, industry, communication and transportation, and service and trade as well. Old management system of economy was improved and transformed by diversified management. In the period the comprehensive management of the watershed the people in practice were trained to familiar with laws of forest, water resources, and soil and water conservation.

According to the local nature of the watershed special provision for cultivation and protection was constituted. Several tools like broadcast, inscription stone and poster were used to propagandize the related regulations, which makes the mass to execute and abide by the law, and to protect the properties of the watershed. Setting up organization to stand the principles made to protect the achievements and the environment is very important.

(3) Restructure industry

It could be seen from Table 5 that the proportion of agriculture/ industry + construction + communication/ commerce was changed from 1/2.35/0.07 in 1991 to 1/3.18/0.45 in 1997. The production of manufacturing and tertiary industries increased obviously as village and township enterprises developed vigorously. The profit in 1997 was 35.5% more than that in 1991. It illustrated the manufacturing and tertiary industries were paid more attention while the agriculture was developing.

(4) Management of technical service

The study of the demonstration area adhere to three combinations as comprehensive management with resource exploitation, laboratory test with technique extension, resources development with personnel training so as to accelerate establishing of the integrated technical service system and better the function of "hematopoiesis".

Table 5 The changes of production value in Gaoling Township (10^4 Yuan)

term	GNP	agriculture		industry		construction		communication		commerce		agriculture/industry+ construction+commu-nication/commerce
		product value	% of GNP	product value	% of GNP	product value	% of GNP	product value	% of GNP	product value	% of GNP	
1991	9 906	2 892.8	29.20	5 823	58.78	605	6.11	373	3.77	212.2	2.14	1/2.35/0.07
1992	11 845	2 714.3	22.91	7 360	62.14	890	7.51	622	5.25	259	2.19	1/3.27/0.1
1993	20 350	4 863.9	23	13 057	64.16	1 377	6.77	675	3.32	376.4	1.85	1/3.11/0.08
1994	20 129	5 833.6	28.98	11 467	56.97	2 250	11.18	202	1.01	376.4	1.87	1/2.39/0.06
1996	25 236	2 280.5	9.04	18 320	72.6	3 885	15.39	417	1.65	333	1.32	1/9.92/0.06
1997	26 724	5 778	21.62	15 531	58.12	1 555	5.82	1 265	4.73	2 595	9.71	1/3.18/0.45

- Establishing monitoring network: 22 runoff plots were selected on which several studies had been carried out. These includes soil and water loss in different slopes, effect of length and gradient of slope and vegetation coverage to soil and water loss, efficiency of soil conservation measures and benefit to water reservation, soil conservation and flood delay with sediment blocking from comprehensive management of small watershed.
- Technique training: From 1992 the technique training classes were conducted in the watershed on farming, forestry, animal husbandry, water conservancy and soil conservation. Up to 100 technicians were trained and now actively involve in farming, forestation, fishery, pastry and animal husbandry etc. serving as combined network of technique service and comprehensive harness and management.
- Application of science and technology in farming, forestation and animal husbandry: film technique, selected species, drought-proof technique and high-efficiency farming garden were applied in agriculture. Water conserving pill, forestation and anti-drought technique such as seedling cultivation in vessel, root protection, moisture protection by film, cultivation of apple and chestnut, introduction of selected species and raising survival rate and growth in forestation were applied in forestry. New varieties of pig, rabbit and chicken were introduced with obvious benefits.

(5) Infrastructure construction

From 1992 mechanical equipments were added annually, and road network links the hills in the watershed were built in 1996, which is convenient for transporting fruits to other places.

4.2.4 Sorting of social factors

To know the key factors affecting the economic development of the small watershed, AHP was introduced to sort the order of different factors. The result is shown in Table 6.

Table 6 The sorted results of social factors

factor	population		technique			management				sum
weight	0.0457		0.1655			0.7888				1.00
layer *C*	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	
weight	0.0 252	0.0 205	0.0 835	0.0 820	0.0 334	0.1 719	0.2 912	0.2 477	0.0 446	1.00

The results show that the order of the social factors affecting economy increase of small watershed was management (0.7888), technique (0.1655) and population (0.0457). The order of the specific factors are sorted as ①industry restructure (C_7=0.2912), ②science and technology extension (C_8=0.2477), ③rational arrangement of investment (C_6=0.1719), ④engineering measures (C_3=0.0835), ⑤biological measures (C_4=0.08200), ⑥ infrastructure construction (C_9=0.0446), ⑦ policy, regulation and organization (C_5=0.0334), ⑧raising personal quality (C_1=0.0251) and ⑨control of population increase (C_2=0.0205).

It could be known from the analysis above that the major factors affecting economy development of Shixia watershed are management, science and technology and population with management as the most important. Main elements of management include restructuring of industries, technical services and investment strategy.

5 Conclusion

(1) As the value of light, temperature and precipitation in average are not different significantly in these years, it is thought that the annual changes of the three factors are not the major factors affecting economic growth.

(2) The social factors related to the growth of economy in the watershed was identified to be population, including number, quality of work force, techniques, including engineering and biological one, and management, including policy, regulation, organization, fund raising, industry restructuring, science and technology extension and infrastructure construction. The order of the social factors affecting economy increase of small watershed was management (0.7888), technique (0.1655) and population (0.0457). The order of the specific factors are sorted as ①industry restructure (C_7=0.2912), ②science and technology extension (C_8=0.2477), ③rational arrangement of investment (C_6=0.1719),④engineering measures (C_3=0.0835), ⑤biological measures (C_4=0.08200), ⑥infrastructure construction (C_9=0.0446), ⑦ policy, regulation and organization (C_5=0.0334), ⑧raising personal quality (C_1=0.0251) and ⑨control of population increase (C_2=0.0205).

As Shixia watershed is typical in the mountainous region of Beijing, the result from it could have demonstrating effect to other small watershed of similar feature.

Reference

[1] Fu Jianren (1994), Statistics , China Forestry Press: Beijing, p. 127-134

[2] Zhao Huanchen, etc. (1986), AHP—a new decision making method, Science Press: Beijing.

[3] Li Huaipu (1989), Theory and methodology for small watershed management, Hydrology and Electric Power Press: Beijing, p. 163-172.

[4] Wang Dongmei, etc. (1999), Comprehensive evaluation of land productivity for small watershed system, Journal of Beijing Forestry University, No.5, vol. **21**, p51-56.

[5] Wang Lixian (1998), Watershed management of mountainous area toward 21st century, Mountain Research, **16**(1), p3-7.

[6] Wang Dongmei, etc. (1998), Studies on potential productivity of forest land in Huangjia Ercha small watershed of Loess hilly Area, Forest Research, No. 1, vol.11, p127-134