Management Science and Engineering Vol.1 No.1 September 2007

REGIONAL GREEN INPUT-OUTPUT ACCOUNTING ANALYSIS:

WATER RESOURCE ACCOUNTING ANALYSIS OF NINGXIA PROVINCE OF CHINA

Lei Ming[1] **Gao Ying**[2]

Abstract: The problem of water resource and water environment is the first-line problem to solve in order to realize the sustainable development of China (PREC,CPPCC,2000). Based upon the theory of green input-output (Lei, 1999/2000) and consulting Ningxia Input-output Table of 1997 (Statistical Bureau of Ningxia (SBN), 1997), Ningxia Statistical Yearbook of 1998 (SBN, 1998) and the sample data of related enterprises provided by Ningxia Bureau of Statistics, this paper constructs an extended input-output table which contains 12 sectors such as agriculture and coal mining and processing, and water resource use and sewage discharge. The paper also does some basic accounting analysis on the Ningxia water resource and water environment.

Key words: green input-output accounting, water resource, green GDP, green charges

China is a country devoid of water resource. In China, the per capita water resource quantity is only 2200 cu.m, which is only the 1/4 of the world level. At present, there are 14 provinces and municipalities whose per capita water resource quantity is below the 1780 cu.m — — the water caution line acknowledged internationally(PREC,CPPCC,2000).

---

[1] Chair of Guanghua School of Management, Peking University, Ph.D. Professor, China.

Address: Guanghua School of Management, Peking University, Beijing,100871, P.R. China.

E-mail: leiming@gsm.pku.edu.cn

[2] Guanghua School of Management, Peking University, Ph.D,China.

Address: Guanghua School of Management, Peking University, Beijing,100871, P.R. China.

E-mail: gaoying@gsm.pku.edu.cn

* Received 28 May 2007; accepted 1 July 2007

Among them, Ningxia is one of the most water-lacking regions, with only 500 cu.m of per capita water resource quantity, which has reached the severe water-lacking line.(2) In Ningxia, precipitation, surface water and ground water are all very indigent. Its water resource is characterized by small quantity, inferior quality, uneven distribution and diversification between seasons. Meanwhile, water source pollution resulted from industry production makes worse the situation which has already been very austere. It is really a big subject for Ningxia government to establish reasonable water resource policy so as to ensure the region sustainable development.

The traditional computing methods didn't take into consideration the consumption and pollution of water resource, so there are some problems in price determination and tax policy. Based upon the theory of green input-output (Lei, 1999/2000) and *Ningxia Input-output Table of 1997* (SBN, 1997), *Ningxia Statistical Yearbook of 1998* (SBN, 1998) and the sample data of related enterprises provided by Ningxia Bureau of Statistics, this paper constructs an extended input-output table which contains 12 sectors such as agriculture and coal mining and processing, and water resource use and sewage discharge. The paper also does some basic accounting analysis on the Ningxia water resource and water environment.

1. THE BASIC FRAMEWORK OF REGIONAL GREEN INPUT-OUTPUT TABLE

We know that there are several types of regional green input-output table (Lei, 2000), but we have to select the following framework because of the insufficiency of data materials. The framework of the regional resource-energy-economics-environment green input-output table is shown as table1.

According to the general framework shown by table1 and basing on the Ningxia Input-output Table of both 40 sectors and 107 sectors in 1997 (SBN, 1997), Ningxia Statistical Yearbook 1998 (SBN, 1998), China Statistical Yearbook 1998 (CNBS, 1998) and other sample data provided by Ningxia Bureau of Statistics, we constructed the Ningxia Regional resource-energy-economics- environment green input-output table. The table contains 12 sectors as following: agriculture, coal mining and processing, metal and nonmetal minerals mining and dressing, papermaking-printing and cultural-educational goods, petroleum refining and coking, chemical products, nonmetal mineral products, metal smelting and pressing, production and supply of power, steam and hot water, production and supply of tap water, other industry and the tertiary industry. It also includes such two sectors as water resource use and sewage discharge.

Table 1 Regional resource-energy-economics-environment green input-output table

Table 1-a

	Final output			Input from Other Regions	Import	Total Output
	Regional Use	Output to Other regions	Export			
Resource use	Y^{e}_{i}					X^{e}_{i}
First Resource Sector	Y^{p11}_{i}	Y^{p12}_{i}	Y^{p13}_{i}	Q^{p11}_{i}	Q^{p12}_{i}	X^{p1}_{i}
Secondary Resource Sector	Y^{p21}_{i}	Y^{p22}_{i}	Y^{p23}_{i}	Q^{p21}_{i}	Q^{p22}_{i}	X^{p2}_{i}
Other Sectors	Y^{p31}_{i}	Y^{p32}_{i}	Y^{p33}_{i}	Q^{p31}_{i}	Q^{p32}_{i}	X^{p3}_{i}
Pollution Discharge	Y^{w}_{i}					X^{w}_{i}
Value-added						
Total input						
Practical Assets						
Environmental Assets						

Table 1-b

	Resource Recovery Sector	Primary Resource Sector	Secondary Resource Sector	Other Sectors	Pollution Control Sector
Resource use	u^{e}_{ij}	u^{p1}_{ij}	u^{p2}_{ij}	u^{p3}_{ij}	u^{w}_{ij}
First Resource Sector	q^{e1}_{ij}	q^{p11}_{ij}	q^{p12}_{ij}	q^{p13}_{ij}	q^{w1}_{ij}
Secondary Resource Sector	q^{e2}_{ij}	q^{p21}_{ij}	q^{p22}_{ij}	q^{p23}_{ij}	q^{w2}_{ij}
Other Sectors	q^{e3}_{ij}	q^{p31}_{ij}	q^{p32}_{ij}	q^{p33}_{ij}	q^{w3}_{ij}
Pollution Discharge	e^{e}_{ij}	e^{p1}_{ij}	e^{p2}_{ij}	e^{p3}_{ij}	e^{w}_{ij}
Value-added	N^{e}_{j}	N^{p1}_{j}	N^{p2}_{j}	N^{p3}_{j}	N^{w}_{j}
Total input	Z^{e}_{j}	Z^{p1}_{j}	Z^{p2}_{j}	Z^{p3}_{j}	Z^{w}_{j}
Practical Assets		$t^{e1}_{ij}(X^{e}_{i}-Z^{e}_{i})$	$t^{e2}_{ij}(X^{e}_{i}-Z^{e}_{i})$	$t^{e3}_{ij}(X^{e}_{i}-Z^{e}_{i})$	
Environmental Assets		$t^{w1}_{ij}(X^{w}_{i}-Z^{w}_{i})$	$t^{w2}_{ij}(X^{w}_{i}-Z^{w}_{i})$	$t^{w3}_{ij}(X^{w}_{i}-Z^{w}_{i})$	

where, u^{e}_{ij} : the amount of resource i consumed by resource recovering sector j to recover resource j; q^{ek}_{ij} : the amount of products of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry) consumed by resource recovering sector j; e^{e}_{ij} : the amount of pollution i emitted by recovering sector j; N^{e}_{i} : the value-added (labor wage, net social income, etc.) created by resource recovering sector i (including the depreciation in fixed assets); Y^{e}_{i} : the amount of consumption of resource i in final products; X^{e}_{i} : the total amount of consumption of resource i; Z^{e}_{i} : the total amount of recovery of resource i; U^{pk}_{ij}: the amount of resource i consumed by production-sector j, industry k (k = primary energy industry, secondary energy industry and other industry); q^{pkl}_{ij}: the amount of products of production-sector i, industry l (l = primary energy industry, secondary energy industry and other industry) consumed by production-sector j, industry k (k = primary energy industry, secondary energy industry and other industry);e^{pk}_{ij}: the amount of waste material i emitted by production-sector j, industry k (k = primary energy industry, secondary energy industry and other industry); N^{pk}_{j}: the value-added (labor wage, net social income, etc.) created by production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry) while producing product i (including the depreciation in fixed assets); Y^{pk1}_{i}: the final product of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry), for domestic use; Y^{pk2}_{i}: the final product of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry), for output to other regions in China; Y^{pk3}_{i}: the final product of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry), for export to rest of world; Q^{pk1}_{i}: the final product of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry) coming from other regions in China; Q^{pk2}_{i}: the final product of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry) coming from foreign countries; X^{pk}_{i}: the total final product of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry); Z^{pk}_{j}: the total input of production-sector j, industry k (k = primary energy industry, secondary energy industry and other industry), equaling to X^{pk}_{i} in values; u^{w}_{ij} : the amount of resource i consumed by pollution abatement sector I while tackling waste material j; q^{wk}_{ij}: the amount of products of production-sector i, industry k (k = primary energy industry, secondary energy industry and other industry) consumed by pollution abatement sector i while tackling waste material j; e^{w}_{ij} : the amount of waste material i emitted by pollution abatement sector i while tackling the waste material j; N_i^w : the value-added (labor wage, net social income, etc.) created by pollution abatement sector i while tackling the waste material j; Y_i^w : the amount of emission of pollutant i in the final products; X_i^w : the total emission of pollutant i; Z_i^w : the total amount of management of pollutant i; $t_{ij}^e = u_{ij}^p / X_i^e$: the proportion of resource i consumption of production sector j accounting for the whole consumption of resource i; $t_{ij}^w = e_{ij}^p / X_i^w$: the proportion of pollutant i emission of sector j accounting for the whole emission; $t^{ek}_{ij}(X^e_i-Z^e_i)$: the consumption of physical asset i caused by production sector j , industry k (k=primary energy industry, secondary energy industry and other industry) (expressed by the share of difference between consumption and recovery of resource i); $t^{wk}_{ij}(X^w_i-Z^w_i)$: the consumption of environment asset i caused by production sector j , industry k (k= primary energy industry, secondary energy industry and other industry) (expressed by the share of difference between emission and abatement of pollutant i).

2. DATA

2.1 Water Resource Use

According to the statistics of *Report on Environment Quality of Ningxia* [1] and *Environment Situation Gazette of Ningxia in 2000* [2], the basic water resource consumption of Ningxia in 1998, 1999 and 2000 is as follows. (see Table 2)

In addition, according to the *Report on Environment Quality of Ningxia*, we know that the proportion of total quantity of industry water use between 1997 and 2000 is 1:1.37, and the total quantity of industry water consumption is 1:1.21. Thus we can deduce that the total industry water use in 1997 was 348 million tons, and the total industry water consumption was 98 million tons.

Table 2 Quantity of water use and consumption

Table 2-a

	1998		1999			
	Water consumed (100 million m^3)	Proportion (%)	Water used (100 million m^3)	Proportion (%)	Water consumed (100 million m^3)	Proportion (%)
total	38.072	100	96.95	100	39.28	100
Agriculture use	36.347	95.47	90.23	93.1	37.54	95.6
Industry use	1.012	2.66	5.3	5.4	1.03	2.6
Life use	0.713	1.87	1.42	1.5	0.71	1.8

Table 2-b

	2000			
	Water used (100 million m^3)	Proportion (%)	Water consumed (100 million m^3)	Proportion (%)
total	87.2	100	38.4	100
Agriculture use	80.74	92.6	36.33	94.6
Industry use	4.77	5.4	1.19	3.1
Life use	1.69	1.93	0.88	2.3

From the data in the table 2 we can see that, during the three years from 1998 to 2000, the proportion of water used in agriculture, industry and life is becoming stable. We suppose that the proportion of water consumption among the three aspects of 1997 is just the same as 1998, and then through calculation we can estimate that the agriculture water consumption of Ningxia in 1997 was 3517 million tons and the life water consumption was 69 million tons. Because of the data insufficiency in 1998, we take the proportion of water use in 1999 as reference. Through calculation, we estimate the agriculture water use of Ningxia in 1997 was 6000 million tons and the life water use was 97 million tons.

Since we are short of exact statistical data, we can't gain the accurate quantity of water use among various industries in Ningxia. So we estimate by referring to some national data.

From the perspective of national sectors within industry and according to the data provided by water resource center of national construction ministry [3], we can see that the water use by the following 5 sectors—firepower electricity, textile industry, petroleum and chemistry, papermaking and metal smelting——accounts for the 45% of total industry water use. Among them, firepower electricity accounts for 25%, textile industry accounts for 6%, petroleum and chemistry accounts for 5%, papermaking accounts for 5% and metal smelting accounts for 4%. The agriculture water use in Ningxia mainly comes from Huanghe. To simplify the problem, here we suppose that the direct water use quantity of agriculture is equal to 6000 million tons, which is the agriculture water use. The industry water use and life water use in Ningxia mainly come from two resources——tap water and ground water. According to the data provided by water resource center of national construction ministry, we deduce the industry water consumption structure of the 3 main cities in Ningxia as shown in Table 3.

Table 3 Industry water consumption structure of main cities in Ningxia

	1999				1997			
	Water used（10 thousand m^3）		Charge on water resource（RMB/m^3）		Water used（10 thousand m^3）		Charge on water resource（RMB/m^3）	
	Tap water	Ground water	Tap water	Ground water	Tap water	Ground water	Tap water	Ground water
city1	787	3633	0.85	0.05	1133	3960	0.85	0.05
city2	290	5349	1.4	0.05	188	6392	1.4	0.05
city3	128	1035	1.35	0.05	185	967	1.35	0.05
total	1205	10017			1506	11319		
Tap water：ground water	1	8.31			1	7.52		

From the calculation in table 3, we know that the industry consumption of tap water and ground water in Ningxia is in the ratio of 1 to 8. Tap water is regarded as a kind of product produced by the industry of production and supply of tap water. So when we calculate the water volume used by various industries, we should deduct the consumption of tap water. In 1997, the total supply of tap water in Ningxia was 82.43 million tons. According to the data from *Development Planning of Chinese City Water-saving Technology Progress in 2010* (Houjie, 1998), we know the tap water using rate is about 95% on average, thus we can estimate that the volume of water used by the industry of production and supply of tap water was 86.768 million tons.

Additionally, according to *Development Planning of Chinese City Water-saving Technology Progress in 2010* (Houjie, 1998), we find that in 1995, the circular water using rate of firepower electricity industry in Ningxia was 68.63% and we take it as an estimation of that of 1997. Currently, in the papermaking industry of China, the circular water using rate of developed enterprises can reach 70% or so, but for most enterprises, the rate is only 20% or so. Papermaking industry is not a developed industry in Ningxia, so we take 20% as estimation. In reference to the industry of metal smelting and pressing, the circular water using rate of the whole industry has improved to 80% from 68% during the "seventh-five" and "eighth-five" period. The circular water using rate of the large-scale steel enterprises such as Baoshan steel company, Anshan steel company and Shoudu steel company has reached 95% or so. But among the 1800 national and regional medium-sized and small-sized metal smelting enterprises and steel factories, about 60% of them don't possess advanced technology and first-class management and the circular water using rate of them is below 40%. In Ningxia, there are not many large-sized smelting factories and the management level of them is just so-so. Here we take the average level——

80%——as estimation. In terms of petroleum and chemistry industry, the average circular water using rate of the whole industry in China in 1995 was 88.36%, the best level was 95.13% and the worst level was 60.32%. We take the industry average rate ——88.36% ——as the estimation for Ningxia. When it comes to chemistry industry, the situation is a bit more complicated. The circular water using rates of the various sub-industries of chemistry industry are as follows: chlorine alkali industry——60~80%; pure alkali industry——70~90%; chemistry fertilizer industry——50~80%; tincture industry——40~50% and the below; dope industry——50~70% ; daily-use chemistry industry——50~80%; rubber manufacturing—— 60~85%. We take the average——70%——as estimation for Ningxia in consideration of the distribution of the sectors within chemistry industry in Ningxia.

Having gained the above data, we use the formula——$Q_t = Q_f /(1-R)$——to calculate the volume of water used by the corresponding industries. (Q_t is the total water quantity, Q_f is the quantity of water used, R is the circular water using rate.) Then we deduct the tap water consump-tion in term of the ratio——1:8 between tap water and ground water, and get the water resource consumption. (see Table 4)

Table 4 Water consumption estimation of certain industries （1）

	Ratio of water fetching （%）	Quantity of water fetching (10 thousand tons)	Circular water using rate（%）	Quantity of water use (10 thousand tons)	Quantity of water resource use (10 thousand tons)
papermaking-printing and cultural-educational goods	5	490.00	20.00	612.50	544.44
petroleum refining and coking	5	490.00	88.36	4209.62	3741.89
chemistry	5	490.00	70.00	1633.33	1451.85
metal smelting and pressing	4	392.00	80.00	1960.00	1742.22
production and supply of power, steam and hot water	25	2450.00	68.63	7810.01	6942.23

We can't get enough statistical materials about the water use of the remaining 3 industries. Moreover, the 3 remaining industries don't belong to big water-consumers. So we calculate the total water fetching quantity through water fetching per 10000 RMB total production and take the average circular industry water using rate as estimation. According to the statistics of *Report on Environment Quality of Ningxia*, we find that in 1997, the water fetched was 127.65 tons per 10000 RMB total production, and the national average circular industry water using rate was 50%, thus we can get the water resource consumption of the other 3 main industries. (see Table 5)

Table 5 Water consumption estimation of certain industries （2）

	water fetching per 10000 RMB total production (10 thousand RMB)	Total industry total production (10 thousand RMB)	Quantity of water fetching (10 thousand tons)	Circular water using rate （%）	Quantity of water use (10 thousand tons)	Quantity of water resource use (10 thousand tons)
coal mining and processing	127.65	190643	2433.56	50.00	4867.12	4326.33
metal and nonmetal minerals mining and dressing	127.65	5588	71.33	50.00	142.66	126.81
nonmetal mineral products	127.65	94281	1203.50	50.00	2406.99	2139.55

Through the above results, we can estimate that the water use of other industry was 24.8096 million tons and the water resource use was 22.053 million tons. The total tap water use of the industry in

Ningxia was 38.667 million tons and the total supply of tap water in Ningxia in 1997 was 82.43 million tons, thus we put the remaining 43.763 million tons as the tap water consumption by life use. Above we have estimated that the total water volume for daily use in 1997 in Ningxia was 97 million tons, which is assumed as the total use by final consumption and the tertiary industry. Suppose that the ratio between ground water and tap water consumed by the tertiary industry is just the same as that of industry, that is, 8:1, and the water use regarded as final consumption (mainly water for daily use) all comes from tap water, then the tap water consumption of the tertiary industry is estimated to be 6.6546 million tons, the water resource use is 53.237 million tons and the tap water used by final consumption is 37.108 million tons.

Now, we have finished estimating the data of water resource use in the Ningxia regional resource-energy-economy-environment green input-output table. (see Table 6)

Table 6 Estimation of water resource use of various industiries Unit: 10 thousand tons

B^e_1	B^e_2	$B^e_{4、5}$	B^e_{10}	B^e_{11}	B^e_{12}	B^e_{13}	B^e_{14}	B^e_{24}	B^e_{26}	B^e_{28}	B^e_{43}	$B^e_{最}$
600000	4326.33	126.81	544.44	3741.89	1451.85	2139.55	1742.22	6942.23	8676.8	2480.96	5323.7	0

2.2 Sewage discharge

According to the data of 22 main industrial enterprises of Ningxia (here we take the data of 1996 as the estimation of that of 1997), we conclude the industry sewage discharge volume of Ningxia as follows. (see Table 7)

Table 7 Statistics of sewage discharge and control of Ningxia key industrial enterprises

Industry	enterprises	Waste water discharge volume (10 thousand tons)	Cost of waste water control (10 thousand RMB)	Total waste water volume (10 thousand tons)	Estimation of industry waste water discharge volume (10 thousand tons)	Total cost of waste water control (10 thousand RMB)	Estimation of cost of industry waste water control (10 thousand RMB)
coal mining and processing	MT 1	15	492	15	18.75	492	517.8947
Mining and dressing of metals	JS 1	26	1056	26	32.5	1056	1111.579
papermaking-printing and cultural-educational goods	ZZ 1	728	58	1912	2390	86	90.52632
	ZZ 2	264	0				
	ZZ 3	520	28				
	ZZ 4	400	0				
petroleum refining and coking	SY 1	85.56	2421	85.56	106.95	2421	2548.421
chemistry	HX 1	475.3	85	1007.06	1258.825	438.6	461.6842
	HX 2	219	48				
	HX 3	50	208.6				
	HX 4	20	97				
	HX 5	242.76	0				
nonmetal mineral products	FJ 1	15	0	56	70	16	16.84211
	FJ 2	41	16				
metal smelting and pressing	YL 1	135.5	130	405.4	506.75	584.5	615.2632
	YL 1	255	310.5				
	YL 2	4.9	144				
	YL 2	10	0				
	YL 3	0	0				
production and supply of power, steam and hot water	DL 1	350	3597	1266	1582.5	8187	8617.895
	DL 2	750	4030				
	DL 3	166	560				

The situation of the above 22 enterprises reflects the general status of the sewage discharge and control of Ningxia to a great extent. Although there are some other small enterprises in which exists the problem of sewage discharge and control, the control of sewage discharge mainly lie on these big enterprises. Therefore, we suppose that the sum of sewage discharge of the above enterprises accounts for the 80% of the total discharge of Ningxia and the sum of control cost accounts for the 95% of the total cost of Ningxia. Through this estimation we can calculate the sewage discharge and control cost of the various representative industries within Ningxia. According to Ningxia Statistical Yearbook 1998 (SBN, 1998), we know that in 1997, the total industrial waste water discharge of Ningxia was 94.49 million tons, so the waste water discharge of other industry was 34.8273 million tons. Additionally, according to the *Report on Environment Quality of Ningxia*, we find that in 1997, waste water discharged from daily life in Ningxia was 33.98 million tons and we take it as an approximation of the sewage discharge of the tertiary industry and final consumption. According to the Research Report by Chinese Water Net[4], the waste water discharged from daily life accounts for 5% of the total of all kinds of waste water. Thus we can deduce that in 1997, the waste water discharged from daily life in Ningxia was 6.4235 million tons and then the waste water discharged from the tertiary industry should be 27.5565 million tons. Agriculture is a big water consumer and a main sewage producer. Water pollution caused by agriculture is mainly resulted from the use of pesticide and chemistry fertilizer. This problem has already endangered the protection of water environment. But in contrast with the industrial waste water and daily life waste water, agricultural waste water is insignificant and here we neglect it.

Now, we have gained the data of sewage discharge in the Ningxia regional resource-energy-economy-environment green input-output table.(see Table 8)

Table 8 Estimation of waste water discharge of various industries Unit: 10 thousand ton

B^w_1	B^w_2	B^w_4	B^w_{10}	B^w_{11}	B^w_{12}	B^w_{13}	B^w_{14}	B^w_{24}	B^w_{26}	B^w_{28}	B^w_{43}	$B^w_{最}$
0	18.75	32.5	2390	106.95	1258.825	70	506.75	1582.5	0	3482.73	2755.65	642.35

3. ACCOUNTING ANALYSIS

According to the above Ningxia regional resource-energy-economy-environment green input-output table, we can do the following accounting analysis and simulation calculation.

3.1 Accounting of the green total index

In terms of the total output, the damage caused by external diseconomy (resource consumption and environment pollution) during the course of production can be seen as by-product, and meanwhile, the environment damage caused by final use can be seen as the by-product produced during the using course of the final product, so all these should be included in the total output. Therefore, we use the following formulae to calculate the total production of various industries and the corresponding green indices of the national economy.

$$X^p_{GT} = \sum X^p_{Gi} - P^w B^w_f, \quad X^p_{Gi} = X^p_i - P^e B^e_i - P^w B^w_i$$

where, X^p_G is the green total production (both sector and the whole); X^p is the total production (both sector and the whole); B^e and B^w respectively denotes the net water resource use which is equal to water resource use minus water resource recovery (including new water resource and water used circularly) and waste water discharge which is equal to waste water production minus waste water abatement (waste water completely treated or waste water abatement up to certain standard); P^e and

P^w respectively denotes the unit water resource recovery cost and the unit waste water abatement cost. For the sake of convenience, we substitute the water resource use charge and waster water abatement cost for them respectively from the perspective of policy analysis.

According to the data provided by *Environment Situation Gazette of Ningxia in 2000*, we know that in 2000, the water price of the self-flow irrigation zone had adjusted to 0.012 RMB per cube m. from the original 0.006 RMB per cube m. and the water price of ejecting irrigation zone had regulated to 0.01~0.012 RMB per cube m. from the original 0.006 RMB per cube m.. We use the average water price before moderation as the water price of agriculture irrigation water and suppose that the compensation fee for the unit water resource use in agriculture (i.e. resource tax) is 0.03 RMB/ton. We also suppose that the unit water resource compensation fee of various industrial sectors is 0.05 RMB/ton, which is the average value of that of the 3 main cities of Ningxia. Meanwhile, for the sake of simplicity, here we determine the unit waste water abatement cost (i.e. environment tax) according to the ratio of waste water abatement investment to waste water abatement volume of representative industrial enterprises and the estimation is 6.77 RMB/ton. We use it as an approximation of waste water abatement cost in 1997, see Table 9.

Table 9 Estimation of unit waste water abatement cost

Enterprise	**Total discharge of waste water (10 thousand tons)**	**Ratio of waste water abatement（%）**	**Waste water abatement volume (10 thousand tons)**	**Waste water abatement cost (10 thousand RMB)**
MT1	15	100	15	492
JS1	26	100	26	1056
ZZ1	728	0	0	58
ZZ2	264	0	0	0
ZZ3	520	20	104	28
ZZ4	400	0	0	0
SY1	85.56	24	20.53	2421
HX1	475.3	5.1	24.24	85
HX2	219	0	0	48
HX3	50	100	50	208.6
HX4	20	100	20	97
HX5	242.76	91.72	222.66	0
FJ1	15	46.67	7.00	0
FJ2	41	100	41	16
YL1	135.5	100	135.5	130
YL1	255	100	255	310.5
YL2	4.9	100	4.9	144
YL2	10	100	10	0
YL3	0	0	0	0
DL1	350	50	175	3597
DL2	750	100	750	4030
DL3	166	61.3	101.758	560
total			1962.59	13281.10
Estimation of waste water abatement cost (RMB/ton)				6.77

Basing on this estimation, we can calculate the green total production of various sectors. And meanwhile, we can also change the unit resource recovery cost and unit pollution abatement cost, thus do some simulation and compare the corresponding results.

In reference to total input, the resource consumption and environment pollution caused by production activities can be seen as a potential input by nature. Because of the existence of this input, the value added (initial input) of various industry sectors and the corresponding GDP will be influenced unavoidably. Meanwhile, the environment damage caused by final use can also be seen as the expense paid by GDP during the course of distribution and re-distribution and it naturally should be compensated by GDP. Therefore, we use the following formulae to compute the green indices of GDP. (Lei, 1999)

$$GDP_G = \sum N_{Gi}^p - P^w B_f^w \text{，} \quad N_{Gi}^p = N_i^p - P^e B_i^e - P^w B_i^w$$

where, GDP_G is the green GDP; N_G^p is the value added of various industry sectors in consideration of resource consumption and environment pollution; N^p denoted the value added produced by various sectors.

Table 10 Calculation of green total production and Comparison of simulation results under different taxes

Table 10-a

	agriculture	coal mining and processing	metal and nonmetal minerals mining and dressing	papermaking -printing and cultural-educational goods	petroleum refining and coking	Chemistry industry	nonmetal mineral products
Total production	728200.00	198545.38	13093.34	94149.60	152258.95	469930.45	159594.13
Green total production (1)	710200	198202.126	12866.975	77942.078	151347.804	461335.612	159013.253
Green total production (2)	692200	197985.81	12860.634	77914.856	151160.71	461263.02	158906.275
Green total production (3)	668200	197492.614	12742.978	70140.712	150441.072	457051.83	158466.22
Value added	448203.00	95891.61	7275.06	25654.08	47957.71	160876.46	58687.46
Green value added (1)	430203	95548.356	7048.6945	9446.558	47046.564	152281.622	58106.5825
Green value added (2)	412203	95332.0395	7042.354	9419.336	46859.4695	152209.03	57999.605
Green value added (3)	388203	94838.844	6924.698	1645.192	46139.832	147997.84	57559.55

Table 10-b

	metal smelting and pressing	production and supply of power, steam and hot water	Production and supply of tap water	Other industry	Total of the tertiary industry	total	Green total production/ Green GDP
Total production	361151.89	249013.96	5551.06	1315411.24	1252300.00	4999200.00	
Green total production (1)	357634.0815	237953.324	5117.22	1291709.11	1233378.065	4896699.65	4892350.94
Green total production (2)	357546.9705	237606.212	4683.38	1291585.06	1233111.88	4876824.81	4872476.1
Green total production (3)	355735.946	231800.514	3815.7	1280087.75	1223678.76	4809654.09	4803230.59
Value added	92044.42	95536.60	2647.47	378735.02	695691.11	2109200.00	
Green value added (1)	88526.6115	84475.9635	2213.63	355032.89	676769.1745	2006699.65	2002350.94
Green value added (2)	88439.5005	84128.852	1779.79	354908.842	676502.9895	1986824.81	1982476.1
Green value added (3)	86628.476	78323.154	912.11	343411.528	667069.87	1919654.09	1913230.59

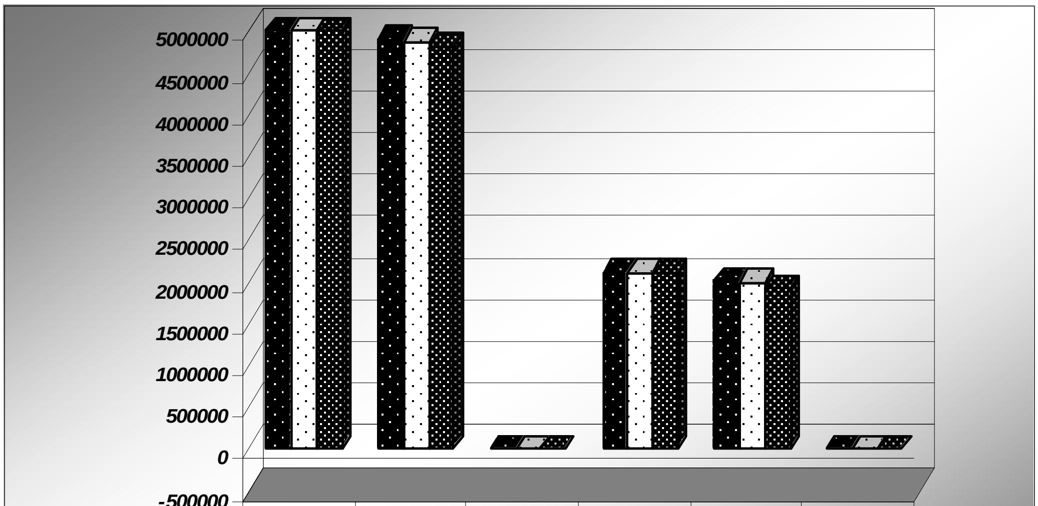
Just as the accounting of total production, we also tried three different cases of resource recovery cost and pollution abatement cost on the basis of practical calculation and then compared various simulation results.

Here, the first case is the calculation of the practical situation, i.e., the unit water resource compensation fee of agriculture irrigation water use is 0.03 RMB/ton, the unit water resource compensation fee of industry and the tertiary industry is 0.05 RMB/ton, the environment tax / unit water pollution abatement cost is 6.77 RMB/ton; the second case is the simulation on the improvement of resource tax, i.e., suppose that the unit water resource compensation fee of agriculture irrigation water use is 0.03 RMB/ton, the unit water resource compensation fee of industry and the tertiary industry is 0.10 RMB/ton, the environment tax / unit water pollution abatement cost remains to be 6.77 RMB/ton; the third case is the simulation on the improvement of both resource tax and environment tax, i.e., suppose that the unit water resource compensation fee of agriculture irrigation water use is 0.10 RMB/ton, the unit water resource compensation fee of industry and the tertiary industry is 0.20 RMB/ton, the environment tax/unit water pollution abatement cost is 10 RMB/ton.

The calculation results are shown in table 10. We generalize the results and show the variation situation of total production and value added in one table.

From table 10 we can see that there exists some false value in the traditional total indices after considering the water resource consumption and the environment damage (waste water discharge) during the course of production and consumption. In the light of practical situation, the false value in total production and value added respectively is 2.14% and 5.07% in term of simulation under the various unit resource recovery cost and pollution abatement cost (here it is embodied by the improvement of environment tax and resource tax), the extent of falsification is higher.

Table 11 Comparison between traditional indices and green indices Unit: 10 thousand RMB



	Total Production	Green Total Production	Changes (%)	Value-added	Green Value-added	Changes (%)
Real	4999200	4892350. 94	−2. 14	2109200	2002350. 94	−5. 07
Case (1)	4999200	4872476. 1	−2. 53	2109200	1982476. 1	−6. 01
Case (2)	4999200	4803230. 59	−3. 92	2109200	1913230. 59	−9. 29

3.2 Analysis on price simulation

During the course of constructing the resource-economy-environment green input-output table, we can feel that the main water source for various industry sectors in Ningxia is ground water and the agriculture irrigation water comes from Huanghe. Ningxia hardly depends on tap water for production and irrigation. This point can be further reflected from the following table which shows the main dependence relationship between the industry of production and supply of tap water and other various sectors.

While constructing the table, this paper did not take the asset stock into consideration, so we calculate the theoretical price of industry sector through the following formulae (Lei, 1999)：

$$P^p = G^p P^p + A^p P^p + F^p P^w + D_0^p + V^p + H^p + M^p$$

where, P^e , P^p and P^w respectively denotes the unit resource use compensation fee (resource tax), price of product and the unit pollution abatement cost (environment tax). D_0^p , V^p , H^p and M^p respectively indicates the depreciation value of fixed assets, compensation for laborers, tax turned in and profits calculated under different profit rates. G^p and F^p respectively shows the direct input coefficient of water resource use to other sectors and the direct input coefficient of waste water discharge to other sectors.

According to the traditional input-output table, the theoretical price of industry sector should be calculated as follows.

$$P^p = A^p P^p + D_0^p + V^p + H^p + M^p$$

Thus, in consideration of water resource recovery and water environment abatement, we can calculate the variation of theoretical prices of various national economy sectors resulted from anticipation through the following formula (Lei, 1999).(seeTable 12)

Table 12 The dependence of various industries on the industry of production and supply of tap water

Table 12-a

	agricul-ture	coal mining and process-ing	metal and nonmetal minerals mining and dressing	Papermaking print-ing and cultural-educational goods	Petrole-um refining and coking	Chemistry industry
Direct input coefficient	0.000000	0.000516	0.000438	0.000350	0.000273	0.001491
Total input coefficient	0.001371	0.003762	0.003089	0.003827	0.005337	0.005205
Direct dependence (RMB/ 10000 RMB)	0.0000	5.1631	4.3763	3.5040	2.7348	14.9139
Indirect dependence (RMB/ 10000 RMB)	13.7139	37.6245	30.8932	38.2707	53.3710	52.0452

Table 12-b

	nonmetal mineral products	metal smelting and pressing	Production and supply of power, steam and hot water	Production and supply of tap water	Other industry	Total of the tertiary industry
Direct input coefficient	0.001826	0.000939	0.001842	0.000364	0.000988	0.003490
Total input coefficient	0.005748	0.004964	0.005301	0.003499	0.007911	0.006224
Direct dependence (RMB/ 10000 RMB)	18.2563	9.3858	18.4182	3.6389	9.8806	34.8978
Indirect dependence (RMB/ 10000 RMB)	57.4819	49.6352	53.0098	34.9864	79.1053	62.2370

$$\Delta P^p = (I - A^p)^{-1}(G^p P^e + F^p P^w)$$

From the direct input coefficient of the green input-output table, we can deduce the following results.(see Table 13)

Table 13

Table 13-a

G^p	0.823949	0.021790	0.009685	0.005783	0.024576	0.003089
F^p	0.000000	0.000094	0.002482	0.025385	0.000702	0.002679

Table 13-b

G^p	0.013406	0.004824	0.027879	1.563089	0.001886	0.004251
F^p	0.000439	0.001403	0.006355	0.000000	0.002648	0.002200

According to the results and the formula above, we do some simulation on the industry price variation by changing the water resource use compensation fee and water pollution abatement cost. Here, the first case is the calculation of the practical situation, i.e., the unit water resource compensation fee of agriculture irrigation water use is 0.03 RMB/ton, the unit water resource compensation fee of industry and the tertiary industry is 0.05 RMB/ton, the environment tax/unit water pollution abatement cost is 6.77 RMB/ton; the second case is the simulation on the improvement of resource tax, i.e., suppose that the unit water resource compensation fee of agriculture irrigation water use is 0.03 RMB/ton, the unit water resource compensation fee of industry and the tertiary industry is 0.10 RMB/ton, the environment tax/unit water pollution abatement cost remains to be 6.77 RMB/ton; the third case is the simulation on the improvement of both resource tax and environment tax, i.e., suppose that the unit water resource compensation fee of agriculture irrigation water use is 0.10 RMB/ton, the unit water resource compensation fee of industry and the tertiary industry is 0.20 RMB/ton, the environment tax/unit water pollution abatement cost is 10 RMB/ton.

The results are shown in Table 14.

Table 14 simulation on price variation caused by resource tax and environment tax

Table 14-a

	Agricul-ture	coal mining and process-ing	metal and nonme-tal minerals mining and dressing	papermaking-printing and cultural-educa-tional goods	Petro-leum refining and coking	Chemis-try industry
Practical situation	0.074437	0.036972	0.032597	0.244410	0.036919	0.085602
Simulation 1	0.109771	0.045879	0.035857	0.247732	0.044091	0.095239
Simulation 2	0.178948	0.077250	0.056797	0.374537	0.072504	0.150326

Table 14-b

	nonmetal mineral products	metal smelting and pressing	Produc-tion and supply of power, steam and hot water	Produc-tion and supply of tap water	Other industry	Total of the tertiary industry
Practical situation	0.032814	0.054760	0.116680	0.079829	0.244578	0.235188
Simulation 1	0.039304	0.063401	0.146726	0.158319	0.293488	0.281092
Simulation 2	0.064997	0.103043	0.249172	0.315946	0.484983	0.464020

From the simulation results we can see that, the levy of water resource compensation fee and water pollution abatement fee by Ningxia government currently has not yet resulted in the big price variation of various industries. However, along with the improvement of the water resource compensation fee, especially when the water pollution abatement fee is improved together, the prices of various industries will change to a great extent and the industry like papermaking, power electricity and the tertiary industry that consumes large quantity of water will be influenced most. (see table14)

4. CONCLUSIONS & REMARKS

Based on the above analysis, we have the following conclusions.

1st. There are about 2.14% and 5.07% false value in 1997 Ningxia's total production and value added respectively after considering the water resource consumption and the environment damage (waste water discharge) during the course of production and consumption.

2nd. In practice, through the levy of water resource tax and fee we can arrive at the goal of saving water to a certain extent. However, the regulation of both tax and fee will bring certain influence on prices of other industries. Therefore, we must pay much attention to the variation range of the tax and fee. When it comes to the economy-behindhand region like Ningxia, water saving mainly depends on improving the water use efficiency and developing more water-saving technologies. Naturally, price modification policy should also be taken into account as an assistant measure.

Notes:

1. see Report on Environment Quality of Ningxia (1996-2000) published by Environment Protection Bureau of Ningxia during 1996 to 2000;

2. see Environment Situation Gazette of Ningxia in 2000 published by Environment Protection Bureau of Ningxia in 2000;

3. data from Water Resource Center of Construction Ministry, Water Resource Center of Construction Ministry;

4. data from Research Report of Chinese Water Net, Chinese Water Net: http://www.h2o-china.com.

REFERENCES

National Bureau of Statistics of China (CNBS), *China Statistical Yearbook 1998.* China Statistics Press. (in Chinese) ,1998,

Ming Lei, *Green Accounts under the Sustainable Development——Resource- Economics-Environment General Accounts.* Geology Press. (in Chinese), 1999

Ming Lei, 'Regional Green Input-output Accounts'. *Statistical Research*, 2000 , Vol.6. (in Chinese)

Statistical Bureau of Ningxia (SBN), *Ningxia Statistical Yearbook 1998*, Chinese Statistics Press. Beijing. (in Chinese)

Statistical Bureau of Ningxia, *Ningxia Input-output Model of 1997*, Chinese Statistics Press. Beijing. (in Chinese)

Houjie, *Development Planning of Chinese City Water-saving Technology Progress in 2010.* Wenhui Press. (in Chinese) ,1998

Population, 'Resource and Environment Committee of Chinese People's Political Consultative Conferences (PREC,CPPCC)', 2000, *Corpus of West Development and Water Resource.* Chinese Water Conservancy and Electricity Press. (in Chinese)