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Eco-environmental benefit assessment of China's South-North Water Transfer Scheme——the middle route project

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Abstract: This paper assess the eco-environmental benefits that may come from the middle route project of China's South-North Water Transfer Scheme(SNWT) with principles and methods of eco-economics and planning reports of SNWT's middle route project. Some benefits were calculated in monetary units. To make sure that the results can be comparable with normal monetary indices, concrete assessment objects and the parameters are prudently selected according to the major characteristics of the project and its water import region. Primary assessment revealed that in different project construction stages, the benefit could be more than 13.07 billion RMB Yuan in 2010 and 19.79 billion RMB Yuan in 2030, respectively. The monetary value tends to increase with social-economic development. To realize these potential benefits, however, calls for more endeavors.

Keywords: China's South-North Water Transfer Scheme(SNWT); the middle route project of South-North Water Transfer(MRPSNWT); assessment; ecosystem services; monetary indices

Introduction

In order to alleviate severe water shortages in north China, Chinese central government have started to implement the South-North Water Transfer Scheme(SNWT), which will transfer water from Yangtze River basin in the south to Huang-Huai-Hai (Yellow River, Huaihe River and Haihe River) watershed in the north through the eastern, middle and western route projects. The middle route project of South-North Water Transfer(MRPSNWT) will be constructed in 2010 and enlarged in 2030.

Because SNWT was raised to satisfy the water demand of economic development in north China, how to decrease its environmental damage is the central topic of researches on the scheme's eco-environmental effects, especially for water export areas. So in different literature related to eco-environmental influences of MRPSNWT(Liu, 2002; Wang, 1991; 2002; 1995; Wu, 1994; Jiang, 1992; Biswas, 1983), eco-environmental benefits have been touched upon but not as deeply studied as damages.

However, if we review the projects in the framework of economic-environmental complex system, MRPSNWT is a mammoth project through which man-made capitals are substituted for natural capitals. To analyze the project more comprehensively and run it properly, its eco-environmental benefits should be evaluated. This study attempt to assess eco-environmental benefits of MRPSNWT and value them in monetary units with relevant eco-economics principles and planning reports.

1 General layout of MRPSNWT

The principal part of eco-environmental benefits that come from MRPSNWT is that more accessible water will be helpful to alleviate or prevent the deterioration of ecosystems in its water import region. Proper assessment of these benefits must be associated with the general situation of the project and its water import region(Fig.1).

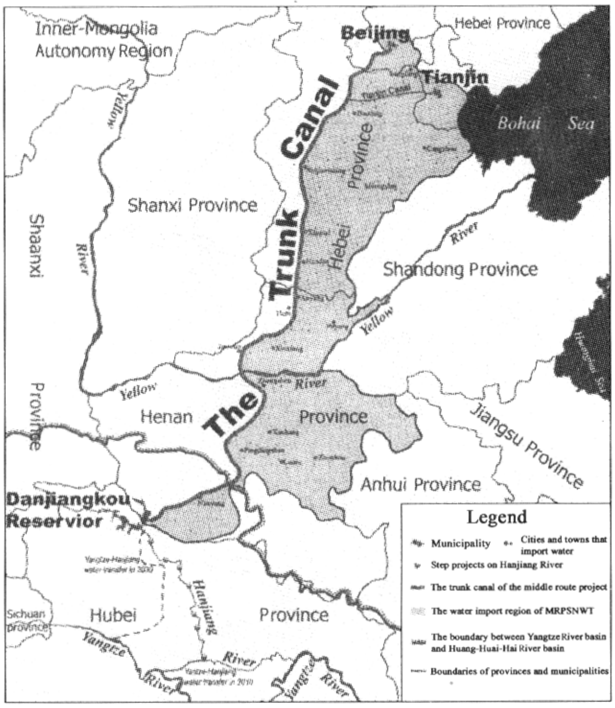

Fig.1 The middle route project of South-north Water Transfer(MRPSNWT)

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Planning reports revised in 2001—2002[1,2] reveal that the trunk canal of MRPSNWT will spread from Danjiangkou Reservoir on the Hanjiang River, a tributary of Yangtze River, to Beijing along the western edge of Nanyang Basin and North China Plain. The overall length is 1421 km in which both 1267 km trunk canal and 154 km Tianjin Canal are included. Four major river systems of China will be crossed from south to north: Yangtze River, Huaihe River, Yellow River and Haihe River. The investment of construction would be enormous because all canals will be excavated and cross each road or river by means of bridges or tunnels in order to insure high water quality. The whole canal will be padded all along the route for the purpose of seepage control and roughness-reduction. But operational cost will be relatively less because the water can flow by itself from the water export region to the water import region.

The project will be constructed in two stages. The first stage will be completed in about 2010 and the second stage in 2030. In the first stage, major engineering projects are the upraising of the Danjiangkou Reservoir's big dam, the excavation of the trunk canal and Tianjin Canal and compensative measures for impacts on water utilization along the middle and lower reaches of Hanjiang River such as step water resource hinges, water transfer from Yangtze River to Hanjiang River and some additional navigation regulating works and so on. The static investment in this stage will be 109.90 billion RMB Yuan. After the accomplishment of this stage, average annual gross water delivery capability will be 8.96 billion m^3 and the net quantity is about 7.99 billion m^3 with evaporation and leakage deducted. In the second stage, the trunk canal will be enlarged and its average annual gross water delivery capability will increase to 12—13 billion m^3. The static investment in the second stage will be 24.40 billion RMB Yuan.

The area of water import region is about 151000 km^2 and includes almost all plain areas of Beijing municipality, Tianjin municipality, Hebei Province and Henan Province. Due to the limitation of water quantity in Hanjiang River, the project cannot meet all the requirements of planned water import areas: it can only provide water for municipal and industrial use in Beijing, Tianjin, and 18 cities and 128 county seats located in Hebei and Henan. More than 70% of total transferred water will be conveyed to areas in Haihe River basin that lies north to the Yellow River.

The region is a part of temperate monsoon climate zone in eastern Asia. Its average annual temperature is 11.5—14.9℃ and average monthly temperature is higher than 25.8℃. Average annual rainfall is 658.3 mm but distributes unequally among years and months. Regional rivers are seasonal and natural lakes are rare because water systems are mainly formed by waterfall. Both Nanyang Basin in the southern area of Henan Province and North China Plain have flat land and fertile soil. Original terrestrial vegetation of the region is temperate deciduous forest, but it has been reclaimed for thousands of years as a result of its favorite natural conditions and artificial vegetation, mainly farmlands, dominated the region (Editorial Board of Vegetation Map of China, CAS, 2001; Xu, 2001).

It is a densely populated region. There are about 108 million people in this region and 29% of them live in urban areas. It is predicted that the population will amount to 120 million in 2010 and 135 million in 2030 and urbanization rate will reach 47% and 59% respectively. Regional economy is also active. The GDP of this region is 802.9 billion RMB Yuan and tends to increase by 7.7% annually by 2010 and 5.3% from 2010 to 2030.

Regional water demand has increased rapidly because of population growth and social-economic development. The gap between water demand and supply has become wider and wider since the 1960s. Now total regional water supply in average years (guarantee probability $P = 50\%$) is 27.83 billion m^3 or 23.49 billion m^3 in half-dry years($P = 75\%$), but total regional water demand is 36.13 billion m^3 or 41.19 billion m^3 respectively. Even with improvement of water saving and reuse plan considered, it can be predicted that water shortage in this region will reinforce itself in future where urban water shortfall will grow up to 7.80 billion m^3 in 2010 and 12.81 billion m^3 in 2030($P = 95\%$).

2 Eco-environmental benefits of MRPSNWT

Intense human activities in North China Plain have obviously changed the characteristics of natural water cycle. In the collateral water cycle of national-economic complex system, cities and industries are usually in predominance when competing for water because they have better water withdrawal establishments and can pay higher water price. So the water for municipal and industrial use with higher dependable rate would occupy a portion of water for agriculture and environment when the total water resource is in short supply. Furthermore, agriculture would use a part of water for environment and eco-environment becomes the final casualty of competing for water because of these "squeeze out" effects.

Nowadays water exploitation for social-economic use accounts for 64.0% of total water resource in the water import region of MRPSNWT and in Haihe River basin the number even rises to 80.2%. As the flux of artificial collateral water cycle and the water used out of stream way

[1] Ministry of Water Resource, P.R.C, 2002. Overall Planning Report of China's South-North Water Transfer; [2] Yangtze River Water Resource Committee, Ministry of Water Resource, 2001. Annex Ⅷ of China's South-north Water Transfer Scheme Overall Planning: the Middle Route Project of SNWT

increases and the ratio the water used in social-economy to eco-environment rises, a series of environmental deteriorations have emerged and become worse and worse.

The lack of water for environment directly results in the shrinkage of surface water and the overexploitation of groundwater, which will lead to the falling off of the groundwater level, the discontinuity of the current in stream channels, the shrinkage of lakes and wetlands and the decrease of the water flowing into the ocean, and so on. The most typical example is that the length and the frequency of the Yellow River's breakup have been increasing year by year since the 1970s. In Haihe River basin, about 45% river courses are dry to bedrock more than 300 days a year and the area of lakes and reservoirs has decreased to 3852 km^2 while the area of natural wetlands was more than 9000 km^2 in 1950s[3]. The underground funnels surrounding cities have connected each other to a broad area along the Beijing-Guangzhou railway and is declining deeper and deeper. This has conduced to ground subsidence and the deterioration of underground water quality.

Major ecosystems have degraded because of water shortage. Once prosperous freshwater ecosystems are destroyed by the drying up of lakes and rivers; unique estuary ecosystems collapse because of less and less water flowing into the ocean; terrestrial ecosystems retrogress as water conditions becoming tense up. Ecosystem services decrease with ecosystem degradation while pollution and calamity increase.

SNWT will be an important and basic facility for mitigating the existing crisis of water resources in North China and improve regional eco-environment accordingly. One characteristic which distinguishes MRPSNWT from the other two route projects is that transferred water will not be delivered to non-urban areas for eco-environmental improvement, but to cities and towns for municipal and industrial usages. So only a little part of eco-environmental benefits will come directly from the project. However, if water supply for urban living and industries increases, "squeeze out" effects will be relieved and the trend of regional eco-environmental exacerbation can be abated or even turned reverse. Therefore, eco-environmental benefits in water import region can be classified into two types:

(1) Direct benefits that come from municipal water used for urban environmental improvement including benefits from urban greenbelt enhancement, water exchange of lakes and rivers in urban areas, ground water recharge inner cities. Transferred water will produce these benefits with two approaches: (a) physical improvement of urban environment, for example, underground water exploitation controlling and replenishment will prevent ground subsidence; more water in river course will reduce sandy stagnation and water pollution; (b) more ecosystem services will be provided by enhanced ecosystems in urban areas that are mainly urban greenbelt and urban wetlands.

(2) Indirect benefits that come from the alleviation of "squeezed out" effect in water competition. The water demand of municipal and industrial use is inelastic but has predominance to compete for enough water. When total water supply can not meet water demand, it will squeeze other water use sectors out. The project will alleviate it and more water will be accessible to agro-ecosystem or other ecosystems in rural areas. Corresponding to this feedback mechanism the supply of ecosystem services in the water import region will actually increase because of MRPSNWT.

3 Methodologies and data

Residents living in the water import region of MRPSNWT will enjoy more ecosystem services and other eco-environmental benefits, but the quantity is not clear. We can assess them in monetary units to get a direct and comparable result but it is hard to implement because of their attribute of being public or quasi-public goods. Furthermore, relations among all kinds of benefits make it uneasy to avoid repetition in the calculation of their values. To assess these benefits properly, we must consider China's situation and choose appropriate methods and parameters.

Favorable eco-environment is important and prominent for people's living and social development. Nevertheless, it is not money's essential function to express the importance of goods or services. What monetary units are used to express are the prices of commodities that are set by supply and demand(Heal, 2000). Individual preferences are revealed by consumers' demand and producers' supply in practical markets. Some eco-environmental improvement can enter practical markets and be traded in practice, but more kinds cannot. To express eco-environmental costs and benefits quantitatively with monetary units, various methods have been designed.

The demand of eco-environmental services will increase along with social-economic development while the supply tends to decrease, thereby compensative measures will be collectively taken with artificial and human capitals that can be exchanged in practical markets with currency. These measures are used to get more natural capitals and harvest more services(material production included). Therefore, eco-environmental benefits can be indirectly measured in monetary units. However, benefits coming from eco-environment are complex and direct market parallels are not easy to discover, so some methods and their results are closer to practical markets while others are farther. Consequently, comparability among the results of different methods is blemished. This study will carefully choose concrete objects

[3] Research Board of Haihe River Water Ecological Restoration, 2002. Report on the Water Ecological Restoration of Haihe River Basin

and corresponding parameter to insure our evaluation close to practical markets in China. Furthermore, the economic assessment chains to eco-environmental benefits of MRPSNWT will be lengthened because most of them are indirect benefits that will come from the alleviation of "squeezed out" effect. It is also necessary to choose objects and parameters carefully in order to cut the chains as short as possible.

The alteration of accessible water and relevant eco-environmental services will result in chain reaction in social-economic system because they are essential conditions of societal survival and development. Theoretically speaking, countable general equilibrium model (CGE) is desirable to assess them; but data restriction makes it infeasible. We will value individual kinds of benefits in particular area with chain reactions excluded and add them up with weighting coefficients of ecosystems' area. As for temporal scale, annual benefits will be evaluated as the analysis foundation. Ecosystem services will be chosen as idiographic objectives to evaluate in our study. There are overlaps between benefits coming from physical improvement of environment and ecosystem enhancements but the former have a narrower spectrum and change more easily with spatial and temporal scales. Our methods can be generalized into the following equation:

$$B = \sum_i B_i = \sum_i \sum_j B_{ij} = \sum_i \sum_j (A_i \cdot SP_{ij})$$
$$= \sum_i \sum_j \left(\frac{W_i}{Q_i} \cdot C_{ij} \cdot P_{ij} \right),$$

where B is the monetary value of annual eco-environmental benefits come from MRPSNWT; B_i is benefits annually coming from ecosystem i; B_{ij} is the value of service j annually provided by ecosystem i; A_i is the area of ecosystem i that could be prevented from degrading because of MRPSNWT; SP_{ij} is the value of service j provided by the particular area of ecosystem i; C_{ij} is the annual productivity of service j provided by ecosystem i; P_{ij} is the market price of service j provided by ecosystem i or its unit cost of substitute projects or its shadowing price; W_i is the amount of transferred water used for enhancing ecosystem per year; Q_i is the annual water demand of particular area of ecosystem i.

The methodology is partial, static and primary, but with it we can get indicative number and preferably avoid repetitive calculation.

Transferred water of MRPSNWT will be distributed among 5 major ecosystems and underground water replenishment according to planning reports of the project, eco-environmental restoration plan of water resource management departments and the main characteristics of the water import region.

(1) According to planning reports of MRPSNWT[1,2,4,5], each year there will be about 2.24 billion m^3 transferred water used for urban eco-environmental improvement including urban greenbelt enhancement, water exchange of lakes and rivers in urban areas and underground water replenishment after the completion of the first stage in 2010. From 2030 the number will increase up to 2.79 billion m^3/a as a result of the second stage project. The areas of greenbelts and wetlands in cities to be improved are also listed in planning reports. The eco-environmental effects of underground water replenishment are ignored in this study because they are complex and few data can be collected, for example, the damage of ground subsidence are closely connected with building conditions, which has no reliable data.

(2) According to the water eco-environmental restoration plan[3,5] drawn by water resource commission of Haihe River, about 0.56 billion m^3 water will be used to wetland restoration per year since 2010 because of MRPSNWT's stage I project and about 4.32×10^4 hm^2 wetlands will be maintained or restored. After 2030, they will increase up to 1.30 billion m^3/a and about 1.00×10^5 hm^2 respectively. This part water will come from the alleviation of "squeeze out" effects.

(3) Other ecosystems in the water import region will be maintained or improved because of the alleviation of "squeeze out" effects, too. In respect of the fact that regional ecosystems have been deeply influenced by human activities and dominated by artificial ecosystems after centuries-old reclamations, agro-ecosystem and artificial forest ecosystem will be chosen as representative ecosystems. Remainder water will be allotted between them according to their proportions of future water demand forecasted in the planning reports of MRPSNWT. Future water use quotas of farming are also given in planning reports[2]. The annual water demand for maintaining particular area of forest in North China Plain can be found from relevant research (Zhang, 2002).

According to planning reports and above analyses, average water transferred each year can be distributed among different approaches for eco-environmental improvement as shown in Table 1.

Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997; Ouyang, 1996). This is a sweeping definition that includes not only less-appreciated but critical life-support services, goods harvested and traded in the economic system. Only a part of them will be investigated due to data restriction and

[1], [2] see page 309, and [3] see page 310; [4] Planning Reports of Urban Water Resource Management in Henan, Hebei, Beijing and Tianjin;
[5] Yangtze River Water Resource Committee, Ministry of Water Resource; Yangtze River Water Conservancy Bureau, 2001. Special Report IV of Planning Reports for the Middle Route Project of SNWT: Ecological and Environmental Impact Research

the principle of overlap exclusion in our research. All parameters are selected or calculated by the direct market method, substitute project method or shadow price method in accordance with the principle of closing to practical markets.

Table 1 The distribution of annually transferred water

Units: $10^8 m^3$, $10^4 hm^2$

Water use types	2010—2030		After 2030	
	Water amount	Improved area	Water amount	Improved area
Urban greenbelts	6.59	13.18	7.75	15.50
Urban wetlands	12.33	4.10	16.67	6.49
Underground water recharge	3.45	—	3.45	—
Subtotal of urban area	22.37	—	27.87	—
Other wetlands	5.60	4.32	13.00	10.00
Artificial forests	8.03	31.74	13.53	53.49
Farmlands	43.90	126.15	57.06	181.16
Subtotal of rural area	57.53	—	83.60	—
Average net quantity of water	79.90	—	111.47	—

(1) Carbon sequestration, air purification, water adjustment and atmosphere adjustment are chosen as representative ecosystem services coming from forests and scattered temperate mixed forest regarded as representative ecosystem of urban greenbelts. As for forest in rural areas, temperate deciduous forests used for farming shields are typical.

Atmosphere adjustment is an outstanding service of forest regardless of their urban or rural location, but their concrete contents are different. Air temperature adjustment is a primary function of urban greenbelts while to keep farmland away from meteorological disasters is fundamental among services provided by forest planted in rural areas of North China Plain. It has been found out through investigation that the air temperature adjustment capability of urban greenbelts in North China Plain is 6.50×10^{10} J/hm^2 per year (Chen, 1998) while to adjust one billion joule heat with air conditioner about 0.66 RMB Yuan must be spent for electricity[6]. Experiments in Huang-Huai-Hai Plain showed that prevention forests could increase the productivity of croplands by 4%—8% or even higher because the damage of natural calamities such as strong winds, dry-hot winds in boundary months of spring and summer (Wu, 1997; Zhou, 1999b). In 2000 the average grain productivity of the water import region is 8536.98 kg/hm^2 [7] and the mean price of wheat, corn and rice is 1008 RMB Yuan/t[8]. Moreover, the area ratio between protection forest and protected farmland is set as 1:20 (Zhou. 1999a; 1999b; Wu, 1997; 2001).

Carbon sequestration is selected as a typical kind of ecosystem service because Chinese government has approved the Kyoto Protocol. A hectare of needle-leaf forest can absorb 22 tons of carbon dioxide per year at least and deciduous broad-leaf forest can absorb 14 t/a at least (Kukelmeisister, 1993; Wang, 2002a; Chen, 1998). To plant trees for the sequestration of one-ton carbon about 250 RMB Yuan at the price level of 1990 need be input in China (Xue, 1997). Sulfur dioxide and dust absorption are selected as representative air purification services of forests. A hectare of needle-leaf forest can absorb 33.20 tons of dust and 215.60 kilograms of SO_2 per year while deciduous broad-leaf forest can absorb 10.20 tons of dust and 88.65 kilograms of SO_2 per year. To cut one ton of dust 170 RMB Yuan must be spent and to cut one ton of sulfur dioxide needs 600 RMB Yuan (Editorial Board of China Biodiversity Research, 1997). The parameters of water adjustment are that the average annual water conversation capability is 1105 m^3/hm^2 in the warm temperate zone and the average investment for reservoir construction is 0.67 RMB Yuan/m^3 in China (Zhou, 1999a; 1999b; Xue, 1997).

(2) Reed marshes are regarded as representative wetlands of wetlands in rural areas because the water supply for rivers in North China Plain will come from the eastern route project of SNWT. Ecosystem services such as biomaterial production, pollutant reduction, water adjustment and habitat are considered. Wetlands in urban areas are analyzed similarly to the former, but the functions of biomaterial production and habitat are ignored.

Reed is typical and steady-going product of wetland and other products such as fishes are ignored. The average annual productivity of reed is 7 t/hm^2 (Xiao, 1995) and the price is 395 RMB Yuan/t (Xiao, 2001). The value of habitat is set as the average investment for the construction of Shuanghekou natural conversation area, about 237.5 RMB Yuan/hm^2; water purification service counts for about 1135 RMB Yuan/hm^2 according to the compare analysis of water resource price in more than 40 Chinese cities and the average value of wetland water adjustment in China is about 1226 RMB Yuan/hm^2 by substitute project method (Xiao, 2001).

(3) The ecosystem service provided by farmlands is mainly cereal production. In Huang-Huai-Hai Plain, 1 hm^2 of irrigated croplands can produce about 6000—6750 kg each year while the productivity of croplands which can not receive enough water is only 1500—2250 kg when other conditions and resources are provided as well. Therefore, the annual mean production increase of cropland is 4500 kg/hm^2 (Wang, 1995).

The prices of some parameters are not at the level of 2000 and modulated according to price indices of China (National Bureau of Statistics of China, 2001; 2002; Bureau of Statistics of Henan, 2001).

The values of ecosystem services that can be supplied by

[6] See the website of Shanghai Greening: http://www.lvhua.com; [7] See the website of Chinese Foods: http://www.grain.gov.cn; [8] See the website of National Bureau of Statistics of China: http://www.stats.gov.cn/ and Sanming Agriculture web: http://www.ny155.com/scfx/59.htm

ecosystems in the water import region of MRPSNWT are listed in Table 2.

Table 2 Value of ecosystem services annually supplied Unit: RMB Yuan/hm^2

Ecosystems/services	Production	Carbon sequestration	Air purification	Atmosphere adjustment	Pollutant reduction	Water adjustment	Habitat
Urban greenbelts	—	2094.48	6450.28	4274.37		1263.26	
Urban wetlands			—		1135.00	1226.00	
Other wetlands	2765.00		—	—	1135.00	1226.00	237.50
Artificial forests		1629.52	3049.48	10325.95		1263.26	
Farmlands	4536.00		—	—	—	—	—

Notes: "—" means the supply of service is uncertain and blank means relevant data absence

4 Results and discussion

According to above methodologies and data, it is computed that the average annual eco-environmental benefits that will come from the first stage project of MRPSNWT from 2010 on can be about 13.07 billion RMB Yuan and about 19.79 billion RMB Yuan after the second stage project of MRPSNWT completed in 2030. These benefits are listed in detail in Table 3 and Table 4.

Table 3 Average annual eco-environmental benefits in 2010—2030 Unit: 10^8 RMB Yuan

Items	Production	Carbon sequestration	Air purification	Atmosphere adjustment	Pollutant reduction	Water adjustment	Habitat	Total
Urban greenbelts	—	2.76	8.50	5.63		1.66		18.56
Urban wetlands			—		0.47	0.50		0.97
Other wetlands	1.19		—	—	0.49	0.53	0.10	2.32
Artificial forests		5.17	9.68	32.77		4.01		51.63
Farmlands	57.22		—	—	—	—	—	57.22
Total	58.42	7.93	18.18	38.41	0.96	6.71	0.10	130.70

Notes: "—" means the supply of service is uncertain and blank means relevant data absence

Table 4 Average annual eco-environmental benefits since 2030 Unit: 10^8 RMB Yuan

Items	Production	Carbon sequestration	Air purification	Atmosphere adjustment	Pollutant reduction	Water adjustment	Habitat	Total
Urban greenbelts	—	3.25	10.00	6.63		1.96		21.83
Urban wetlands			—		0.74	0.80		1.53
Other wetlands	2.77		—	—	1.14	1.23	0.24	5.36
Artificial forests		8.72	16.31	55.24		6.76		87.02
Farmlands	82.17		—	—	—	—	—	82.17
Total	84.94	11.96	26.31	61.86	1.87	10.74	0.24	197.92

Notes: "—" means the supply of service is uncertain and blank means relevant data absence

To evaluate eco-environmental costs and benefits in monetary units so as to compute "Green GDP" is an important issue which has attracted economists and ecologists. Studies on the increase and decrease of ecosystem services have been paid a great deal of attention in 1990s, especially after 1997 when global ecosystem service and natural capital evaluation was published by Costanza and others. Many aspects of ecosystem service evaluation such as objectives, methods and tools have been discussed and ardently argued from the viewpoints of fundamental theories and principles of economics and ecology and(Pritchard, 2000; Starrett, 2000; Costanza, 2000; Chavas, 2000; Heal, 2000; Ludwig, 2000). That is cheering but far away from gratifying because it is just a beginning; many fields are still blank and a lot of works need to be done. Complex functions of ecosystem have only been classified and investigated as pilot studies and much more researches are necessary to ecologists; as for economics, the supply and demand alteration of ecosystem services at a particular temporal and spatial scale have not been concluded carefully and some methods are even fatally flawed from the very beginning(Zhao, 2000; Heal, 2000; Ludwig, 2000). Researches also blossom in China(Ouyang, 2002; Xiao, 2000); more work needs to done for more appropriate methodologies and more detailed data, too.

Comprehensive assessment of regional ecosystem services is more difficult than the evaluation of services produced by a single kind of ecosystem. The results of this study are primary but indicative because two fundamental principles are followed.

First, only services that have been recognized and at least partly replaced with relevant compensative measures are included in our concrete objectives for evaluation, which means these services are not only supplied by ecosystems but also collectively demanded by residents living in a particular region. To evaluate all the services provided by regional ecosystems is nonsense but to evaluate its incremental change is possible and instructive for collective decision-makings. If incremental changes of services can not be found being partly compensated with actual or feasible artificial tools it is not appropriate to measure them in monetary units, the measurement living in economic system.

Second, not all kinds of ecosystem services can be replaced with artificial or human capital input partly because of unique characteristics and partly because of unbearable high cost. Some services are important but we can not evaluate them for this reason. For instance, if a species of animal or bird extinct we will lose it forever. There are some kinds of inner value or existence value but we can not express it in monetary units properly. Therefore, results or parameters calculated by contingent value method should not be added to values assessed with direct market or substitute project methods.

As a result of these principles and the purpose to avoid repeated calculation, only five kinds of representative ecosystems and their typical services are chosen for our quantitative evaluation and relevant parameters are selected according to the national situation of China including both the situation of regional eco-environment and social-economic development. The values of ecosystem services provided by particular area of ecosystems are much less than those of most similar researches due to our prudential requirements.

First, this study is carried out with direct or substitute market methods and willingness to pay (WTP) method is avoided because its results can not be compared or added up with results derived from the former. Furthermore, the latter is far away from the practical market. Too many services are easily included in the monetary evaluation (Ouyang, 2002) because they are supplied by ecosystems and recognized by scientists. When we evaluate them in monetary indices we must consider practical demand as well as their supply. WTP may be potential demand, but far away from practical demand. It reveals the growing trend of eco-environmental benefits' monetary value, but the results of WTP method are much easier to change because of tiny factors. Values calculated with contingent method is abandoned in this research but it usually makes up 70% or even more of values in many researches (Xue, 1997). Both methods and parameters are chosen captiously in this study complying with our principle and data restriction.

Second, although average data were used in the calculation of distributed water amount and the capabilities of ecosystems' supply, only parameters in accordance with the national situation of developing country are selected. For example, the substitute cost of carbon sequestration is set as the investment of planting trees while the carbon tax rate in Sweden, USD150/tC (Editorial Board of China Biodiversity Research, 1997), is abandoned.

Results computed by the same principles and methodologies tend to increase as time goes by. Two major factors will contribute to the trend. First, the water shortage in the water import region of MRPSNWT will be alleviated but not eradicated by the project. Only the water supply-demand gap of urban areas can be filled by it while rural areas will still suffer from insufficient water supply. As long as the water use efficiency can not be upgraded by technological and economic development enough to balance the increase of water demand, the strained situation that ecosystem services supply is restricted by water accessibility will long last. The task is not easy to solve due to the dense population in this region and the whole China. Second, the demand of ecosystem services will rise along with social-economic development and the value provided by particular area of ecosystems will rise too. People will ask for more kinds and amount of ecosystem services as their income increases. In the region where ecosystems are dominated by human's initiative activities such as farming, planting and water reservoir construction, more and more value will be attached to ecosystem services as these ecosystems can be changed more easily than natural ones. More ecosystem services will also be recognized and compensated with artificial inputs as the human pressure on regional eco-environment increases. Furthermore, the value of compensative measures for similar amount of ecosystem services will increase as well and parameter difference of carbon sequestration between RMB Yuan 250/tC and USD 150/tC is a good example.

5 Conclusions

In this paper, eco-environmental benefits of MRPSNWT have been assessed partially and statically. Some useful opinions on the project can be concluded from the elementary study.

First, the investment of MRPSNWT is very high but primary static cost-benefit compare from the viewpoint of ecological economics shows that the benefit is much more than the cost. All of investment can be regarded as the cost including artificial capital expenditure and possible eco-environmental damage in the water export region, which will be compensated by some investment. The static investment in the first stage of the project is 109.9 billion RMB Yuan, which can be taken back in 10 years with benefits. Even if the factual input is twice as the planned, the result is essentially same. As for the enlargement project in the second stage, the compare result is clearer. The project can be constructed and operated as an "ecological project" that has much more comprehensive definition than eco-environmental protection of Hanjiang River basin and the area where the trunk canal will be constructed, which is often stressed by officials.

Second, potential eco-environmental benefits are substantive but needs more endeavors to realize than the project construction itself. More than 85% of benefits will come from the alleviation of eco-environmental water squeezed out by other water uses, especially municipal and industrial uses. The latter uses have remarkable predominance over the former in water competition. To realize potential eco-environmental benefits, both the regulation of aggressive water use in urban areas and ecosystem prompt measures in rural areas are urgently needed. To improve water use efficiency through price hikes and quota management needs more political will and better management techniques while ecosystem enhancement needs both water use regulation and more studies and practices on ecosystem management. For example, the composition of croplands and artificial forests should have more diversification. Some scientists have advised that the second stage project can be constructed as water transfer from the trunk canal to Yellow River and then to Baiyangdian lake, which means eco-environmental water can be increased directly(Pan, 2001).

One of the fundamental data resources of our study is the planning reports of SNWT and the central government of China has formally declared the middle route project launched according to these reports. The study can tell the society with quantitative assessment that the eco-environmental benefits of MRPSNWT are potentially vast but need more endeavors than the project construction itself.

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