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# Cost-benefit Analysis and Payments For Watershed-scale Wetland Rehabilitation: A Case Study in Shandong Province, China

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**ABSTRACT:**The value of wetlands is receiving increasing attention and the Cost–Benefit Analyses (CBA) is essential to evaluate the long-term effects of wetland rehabilitation projects. In order to guarantee the water quality of the South-to-North Water Diversion Project of China (east route), the government of Shandong Province started a huge lakeshore wetland rehabilitation project in 2008. The CBA approach was used to evaluate the ecosystem services in the Nansi Lake watershed, in Shandong Province, China. A shadow project approach and market value approach were applied to estimate the economic values of restored wetlands. The results indicated that values of total net ecosystem service would increase each year after wetland rehabilitation and the net benefit varied with the types of the farmland. The increased amount of ecosystem value brought by the wetland rehabilitation project with three types of farmlands will be 747% for low-productive cropland, 257% for ordinary-productive cropland and 32% for vegetable field per hectare each year. The opportunity cost of farmers who enroll in the project will be 1,575 RMB (Chinese Currency, 6.8 RMB=US$1) for low-productive cropland, 10,027 RMB for ordinary-productive cropland, 40,560 RMB for vegetable field per hectare each year. These results provide decision makers with data on related benefits and opportunity cost of the wetland rehabilitation program in the Nansi Lake watershed.These results are important not only to certify the ecological significance of the project, but also to choose priority of restoring farmland areas and to determine the amount of payments for ecosystem services.

**Key words:** Cost-benefit analysis, Nansi Lake, Ecosystem services, Payments for ecosystem services, Wetland rehabilitation

## INTRODUCTION

Wetlands deliver a wide range of ecosystem services that contribute to human well-being, however the degradation and loss of wetlands are more rapid than that of other ecosystems (MEA,2005). Watershed-scale wetland rehabilitation needs huge investments and has tremendous impact on the local societyÿand thus the valuation assessment is important for decision-making of the plan and establishing standards of ecological compensation. Without a firm understanding of the value of the wetland system we are unlikely to make the appropriate choice and compromises needed to protect them.

Ecosystem service valuation can be a useful guide when measuring where there are trade-offs between society and the rest of nature and where they can be made to enhance human welfare (Farber *et al.*, 2002). More recently, monumental efforts increasingly recognize the critical role of ecosystem service valuation for sustainable development (MEA, 2003; MEA, 2005; Karimzadegan *et al.*, 2007; Sukhdev, 2008). Looking at the total economic value of a wetland essentially involves considering wetlands as economically productive systems, alongside other possible uses of the land (MEA, 2005). Valuation is particularly useful in settings where institutional arrangements are not functioning well to reflect the social costs of environmental degradation (Howarth and Farber, 2002). This information will usefully guide resource management and policy (Daily *et al.*, 2009). A project is considered to be justified only when total benefits exceed total costs. In practice, wetlands are always underestimated for many functions are not traded in markets and therefore remain un-priced (Turner *et al.*, 2000). Without guidance by the concept of value, decisions about conservation or restoration actions are probably unconscionable (Howarth and Farber, 2002).

The South-to-North Water Diversion Project is a key program for sustainable development in China,

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and the Nansi Lake serves as a buffer lake of the South-to-North Water Diversion Project (east route). In order to guarantee water quality of the South-to-North Water Diversion Project (east route), and to rehabilitate the degraded lakeshore wetland system, the government of Shandong Province started a huge lakeshore wetland restoration project in 2008. The CBAs of different types of farmlands which were considered to be converted to wetland in the watershed-scale wetland rehabilitation in Nansi Lake are important not only to certify the ecological significance of the project, but also to choose priority in restoring farmland areas and determining the amount of payments for ecosystem services. The present paper develops the case that ecosystem valuation can positively contribute to decision making and environmental policies, and be valuable for application.

The CBA is a typical economic method of choosing among a number of alternatives. The benefits and costs of a certain project are weighed up against each other and the project with the highest net value is recommended for adoption (Hansjürgens, 2004). The estimation of all values generated by environmental goods and services for the CBA of policies and projects has long been advocated (Pearce, 1993) and in the last decade, the CBA has been considered as the major evaluation system for sustainable development activities (Zhang *et al.,* 2009). The CBA expresses comparisons in monetary currencies, making alternative options easier to compare (Daily *et al.,* 2009). For the cost and benefit of the wetland rehabilitation project which occurred in different yearsÿwe introduced the CBA to reflect the long-term change trends of the project.

## MATERIALS & METHODS

Nansi Lake, the largest lake and inland wetland in North China, is located in the south-western part of Shandong Province, China (Fig. 2). It covers an area of 1,266 km$^2$. It is composed of four connected lakes, Nanyang Lake, Dushan Lake, Zhaoyang Lake and Weishan Lake. It is a typical shallow lake with an average depth of 1.46 m(Yang *et al.,* 2003), with 53 main tributaries.The study area for wetland rehabilitation is located on the estuary of Xinxue River to Nansi Lake. A project covering an area of 133 hectares was designed in 2005 for water purification and ecosystem rehabilitation (Zhang *et al.,* 2008), and data was recorded to evaluate wetland rehabilitation.

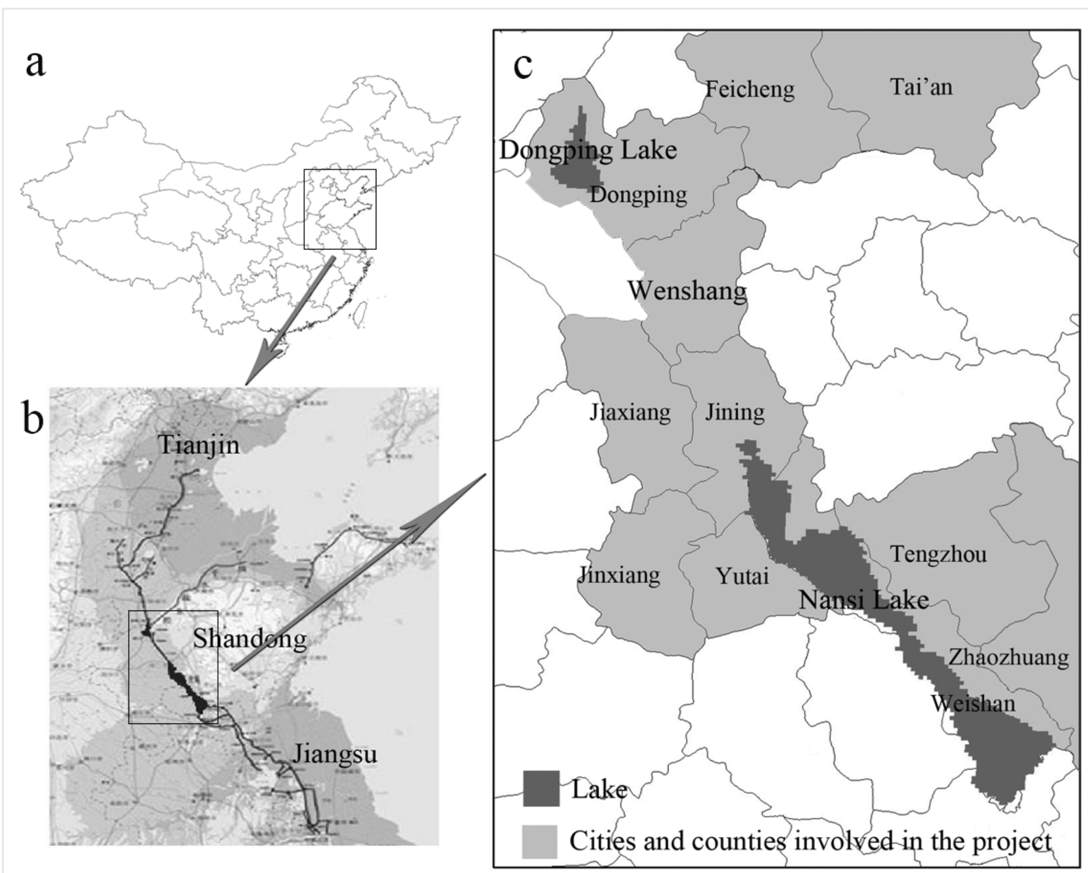


**Fig.1. Study area of lakeshore wetland rehabilitation in Nansi Lake watershed**

a.Map of China. b.Map of the South-to-North Water Diversion Project of China (east route) c.Cities and counties involved in the project

According to the "Water Pollution Prevention Planning of the South-to-North Water Diversion Project (east route) of Shandong Section", water quality of the lake should be better than Grade III of the "China surface water quality standard (GB3838–2002)" in 2007. In order to increase water quality, the government of Shandong Province, China, started a watershed lakeshore wetland rehabilitation project in 2008. In this project, the Nansi Lake watershed was comprised of Nansi Lake, Dongping Lake and rivers flow into them (Fig.1). It involves 18 counties, $3.79\times10^4$ hectares of farmland, and $9.10\times10^4$ households. The government pays farmers to transform their farmland to wetland to reduce non-point source pollution, improve water quality and restore the degraded wetland ecosystem. The area plans to transform and contain the farm lands within the range of Nansi Lake Dam and Dongping Lake Dam, and within the range of river dams of those rivers that flow into Nansi Lake. By the current ecological compensatory approach of Shandong Province, in the first year, there will be compensation with 100 percent net income of the farm from the last year to farmers who enroll in the project, and 60 percent in the second year. Beginning from the third year, there will be no compensation for farmers.

In 2008, detailed information of the farmlands which plan to transform to wetlands was collected by the environmental protection bureau of Shandong Province, and a database was established. The database information includes owner, position, economic returns, crops, pesticides and fertilizer use of all farmland. Farmland data used in this paper was from this database.

Ecosystem services are the benefits people obtain from ecosystems, including products such as food, fuel, and fiber; regulating services such as climate regulation and disease control; and nonmaterial benefits such as spiritual or aesthetic benefits (Assessment, 2003). Though many value classification types have been generated, some value types are still difficult to use in practice by decision-makers. Based on the classification of King (King *et al.*, 2000), and considering the availability of the data of China's wetlands and agricultural ecosystems, the ecosystem services are classified as direct use value, indirect use value, and non-use value (Fig.2) in this study (Arrow *et al.*, 1993; Costanza, 1997; King *et al.*, 2000; Turner *et al.*, 2000).

For the comprehensive CBA of projects and policies that involve environmental goods and services, the total ecosystem value (TEV) should be captured and weighed against the costs of conserving or providing such goods and services (Birol *et al.*, 2010). Here the CBA is as follow:

Benefit (B) refers to the value of the ecosystem service, if $B_i$ is the value of $i$th ecosystem service, then

$$B=B_1+B_2+B_3+\dots+B_n$$

Cost (C) is the ecosystem costÿincluding cost of acquisition, the management and operating cost, the opportunity cost, and other costs. If $C_i$ is the cost of $i$th ecosystem service, then

$$C=C_1+C_2+C_3+\dots+C_n$$

The following formula is used to calculate the net present value (NPV):

$$NPV=\sum_{t=0}^{T}\frac{(B_t-C_t)}{(1+r)^t}$$

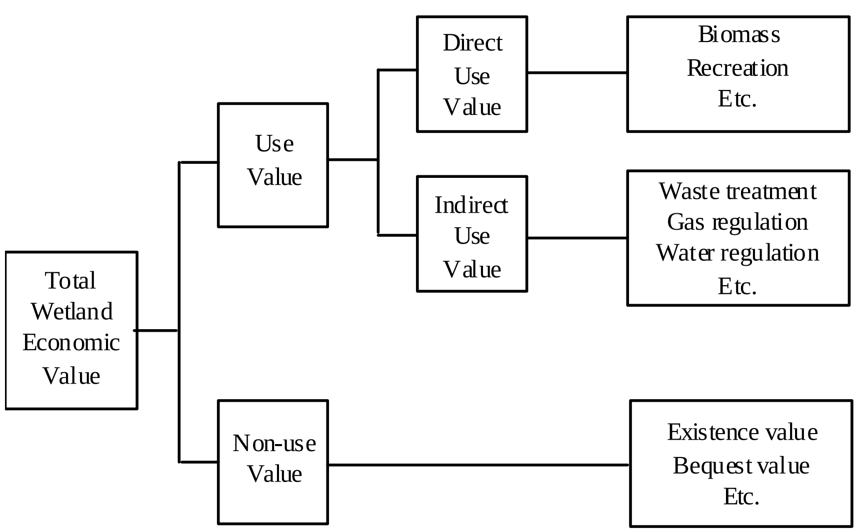


**Fig. 2. Wetland ecological economic value classification**

Where Σ is the sum of values, r is the discount rate, t is the time of the cash flow, and $B_t$ and $C_t$ are the benefit and cost in the *t*th year respectively during the project.In practice this value is expressed by the market price. Food and material production value $V_b$ is estimated by the market price method as follows:

$$V_b = \frac{1}{TA}\sum (P_i \times W_i - P_j \times W_j) \times A_i \qquad (1)$$

where $V_b$ is the material production value per unit (RMB $ha^{-1}$ $yr^{-1}$)$P_i$ is the price of the ith production (RMB $kg^{-1}$) , $W_i$ is the output of the product of the *i*th crop (kg $ha^{-1}yr^{-1}$) ,$A_i$ is the area of the ith crop($ha^{-1}$)and TA is the total area in the analysis (ha).

The value from gas regulation services due to the greenhouse gas storage/emission and oxygen production, is based upon the balance between photosynthesis and respiration of organisms in the study area (Guo *et al.*, 2001). The formula of photosynthesis and respiration is as follows:

$CO_2$ (264 g)+$H_2O$ (108 g)$\rightarrow$$C_6H_{12}O_6$ (180 g)+O (193 g) $\rightarrow$Amylase (162 g).

The photosynthesis process needs 1.63 g CO2 and releases 1.2 g oxygen to form 1 g of dry material. The gas regulation service value is as follows:

$$V_g = \frac{0.27}{TA}\sum (W_i' - GWP) \times A_i \times P_c + \frac{0.74}{TA}\sum W_i' \times A_i \times P_o \qquad (2)$$

$$W_i' = 1.63 Wi(1-R) \qquad (3)$$

where Vg is the gas regulation value per unit(RMB $ha^{-1}$ $yr^{-1}$); $W_i$, $A_i$, and TA are the same as in Eq. (1); $C_i$ is the carbon content of the yearly material production of the organisms (%); $P_c$ is the expenditure of fixing carbon (RMB $kg^{-1}$), and in this study is the average price of fixing carbon by artificial afforestation per unit weight (RMB $kgC^{-1}$) (Xue, 1997)and the carbon trading price (150$/tC) is used, and $P_o$ is the cost required to produce oxygen using industrial methods (RMB $kgO^{-1}$).GWP is the global warming potential from $N_2O$ and $CH_4$, The mean GWP value of a surface flow of constructed wetland from Teiter and Mander (Teiter and Mander, 2005) is adopted for the Nansi Lake wetlands while the GWP value of agricultural land is adopted as 19.21t/ha $y^1$ from Li (Li *et al.*, 2003) for farm land of Shandong Province. R represents moisture capacity.

Ecosystems can be a source of impurities in fresh water but also can help to filter out and decompose organic wastes introduced into inland waters ecosystems (Assessment, 2003). The value of wetland water quality improvement may be calculated from the cost of building a treatment works to perform the same processes (Barbier *et al.*, 1997). Negative value may occur when waste accumulation exceeds the purifying capacity of the ecosystem. For the valuation of waste treatment, the quantity of N0P washed away from cultivated land and N0COD removed by wetland was chosen.

The water purification service value is as follows:

$$V_{pa} = -\frac{1}{TA}\sum A_j(W_{fj} \times R_n \times L_n \times P_n + W_{fj} \times R_p \times L_p \times P_p + W_{cj} \times R_c \times L_c \times P_c) \qquad (4)$$

$$V_{pw} = W_n \times P_n + W_{COD} \times P_{COD} \qquad (5)$$

Where $V_{pa}$,$V_{pw}$ are the water purification service value of cultivated land and wetland (RMB $ha^{-1}$ $yr^{-1}$), respectively. TA is the same as in Eq. (1), $A_j$ is the area of the jth cultivated land ($ha^{-1}$). $W_{fj}$ is the use of Agricultural Fertilizers in jth cultivated land (kg $ha^{"1}$ $yr^{-1}$). $R_n$0$R_p$0$R_c$ are the net percent content of nitrogenous (TN)0phosphate (TP)0insecticide in nitrogenous fertilizer0phosphate fertilizer and farm insecticide respectively(%). $L_n$0$L_p$0$L_c$ are the loss rates of nitrogenous fertilizer0phosphate fertilizer and farm insecticide respectively which are washed away by the water flow. $P_n$0$P_p$0$P_c$ 0$P_{COD}$ are the expenses of removing nitrogenous0phosphate0insecticide and COD from water (RMB $kg^{"1}$), $P_n$0$P_p$ are adopted as 26.6 RMB/kg and 558.6 RMB/kg (Zhuang *et al.*, 2003), for China. Wn and $W_{COD}$ are the quantities that are removed from the water flow by wetlands based on the engineering design.

The disturbance and water regulations service provides flood control ability and water recovery from a drought period. The value of this service depends on the water storage capacity of the ecosystem and is estimated in the replacement cost method as follows:

$$V_w = C_C \times D \qquad (6)$$

where $C_c$ is the construction cost for local disturbance and water regulations facility per unit storage volume and D is the water storage capacity of the ecosystem. $C_c$ is adopted as 0.57 RMB /$m^3$ (Guo *et al.*, 2001) and D is equal to 2480 $m^3$/ha based on the engineering design. Wetlands are important for tourism because of their aesthetic value and the high diversity of the animal and plant life they contain (Assessment, 2005). When ecotourism resources are not traded in a market, non-market valuation approaches are applied to estimate their economic value (Upneja *et al.*, 2001). In Nansi Lake, ecotourism generates considerable income and plays a significant part in supporting local economies. In this study, the current value to estimate the economic value derived from ecotourism was adopted. The current ecotourism value $V_T$ is as follows:

$$V_T = \frac{1}{A_T}\sum E_T \times r \quad (7)$$

where $E_T$ is the total expense when tourists visit Weishan county, such as entry price to the site, costs of traveling to the site, and others. AT is the total used area of ecotourism and r is the ratio of ecotourism that is part of Weishan county's financial income, which is equal to 70 percent. Here we consider the total tourist income of Wenshan county of 2007 as $E_T$ and take the summation of water surface area and wetland plant area as $A_T$ according to the study of Li (Li *et al.*, 2008).

## RESULTS & DISCUSSION

Direct economic values here include the benefits derived from food, material production, and ecotourism, which arise from humans' direct utilization of the ecosystem. According to our statistical data, vegetable field0ordinary- productive cropland and low-productive cropland made up 7.19%061.33% and 30.76% of the total area in the analysis, and the net value of food and material production were 50,010019,477010,025 RMB per hectare in 2008, respectively. The order of value was vegetable field>ordinary-productive cropland>low-productive cropland > wetland.

As a traditional tourism area, there are rich natural landscape and cultural landscapes at Nansi Lake. According to statistics issued by the Weishan statistical bureau, tourism contributes 0.56 million RMB to the local fiscal revenue per annum. Considering the area used for tourism and the ratio of ecotourism in the total tourism revenue, the average recreation value of wetlands in Nansi Lake, was estimated to be about 4,877RMB $ha^{-1}$ $yr^{-1}$. Since agricultural land has very low recreation value in the area that was analyzed, this value was considered as zero.

Indirect use values in this study included water purification, water conservation, and gas regulation.

As the main destination goal of the program is improving water quality of Nansi Lake, the utility of water purification plays a vital role in decision making. The results of this survey showed that the wetlands played an important role in purifying the environment of Nansi Lake and created great value of water purification. The wetlands could remove 54kg TN and 900kg COD from the water flow every year, and its total water purification value was 20,606 RMB $ha^{-1}$ $yr^{-1}$. At the same time chemical fertilizers and pesticides are excessively used in cultivated land in Shandong Province. The amounts of chemical fertilizer used in vegetable field, ordinary-productive cropland and low-productive cropland were 560kg, 272kg, 230kg TN and 113kg, 55kg, and 47kg $ha^{-1}$ $yr^{-1}$, and the total negative values of water purification of the vegetable field, ordinary-productive cropland and low-productive cropland were 19,859, 8,940, and 7,367 RMB $ha^{-1}$ $yr^{-1}$ (Fig.3).

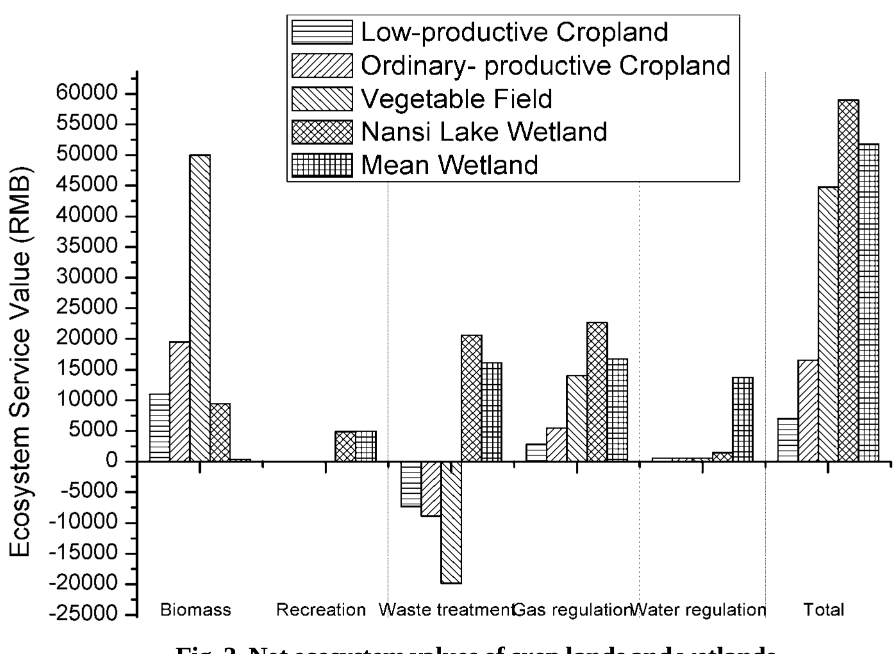


**Fig. 3. Net ecosystem values of crop lands and wetlands**

According to Eq.(2) (3),the gas regulation value, including carbon fixation , oxygen supply and the negative value of GWP, depend on the net weight of the biomass. Investigations pointed out that grain output was about 20%-51% of the total aboveground crop biomass in China, and farmers always use straw as fertilizer or even burn it for convenience. Based on the actual situation in practice, here only the net biomass removed from crop land and wetland into was taken into account when estimating the gas regulation value.

Wetlands have a huge capacity for storing water. In this case, economic value of this ecosystem service was assessed by calculating how much more the value of water was increased by the wetland system than by the crop land. Designed as a surface flow wetland, the water storing value of the Nansi Lake wetlands is larger than all of the three kinds of crop land but lower than the mean wetland. The result showed that the restored wetland had a water capacity of 2,480$m^3$ per hectare.

From the Fig.3, it can be seen that wetland created higher net ecosystem value than farmland, and vegetable fields had the highest net ecosystem value of the three kinds of crop lands, and the low-productive cropland was the lowest. All of the three kinds of crop lands generated negative water purification activity, which was due to the vast run off of chemical fertilizers and pesticides.

In this study, net ecosystem value of agricultural land was considered as the opportunity cost, and net ecosystem value of the wetland was regarded as the benefit of the wetland rehabilitation project. The long-term benefit and cost analysis results are shown in fig.4. From fig.4, it can be seen that at the beginning of the project, the NPV of conversion was low, and gradually increased each year. The conversion of low-productive cropland got the largest ecosystem service benefit, the ordinary-productive cropland was second, and vegetable field got the lowest ecosystem service benefit in the long-term. Thanks to the low ecosystem service value of low-productive cropland, it got a positive NPV in the 2nd year, the ordinary- productive cropland in the 3rd year, and the vegetable field got a positive NPV in the 7th year. The result indicated that 3 years after the conversion , for most of the agricultural land (about 92%) ecosystem, benefits gained from the project were in excess of opportunity costs, and 7 years after the conversion, the NPV of all agricultural land were positive, which indicated that the conversions were all considered feasible.

The economic impacts of ecology engineering were evaluated in two main aspects, total local economic income and peasant income. As direct use value of the ecosystem service value was usually figured as a part of the gross domestic product (GDP) in an administrative region, this kind of economic value was treated as total local economic benefits, biomass value was treated as peasant economic benefits, and the direct economic value of three crop lands as the opportunity economic cost. The NPV results are shown in Fig.5. It can be seen that the total local economic income of three types of cropland were more than peasant income. All the NPV of peasant income are negative, which indicated that households enrolling in the project would suffer income reduction. Only when conversion took place from low-productive cropland to wetland, was NPV of local economic income

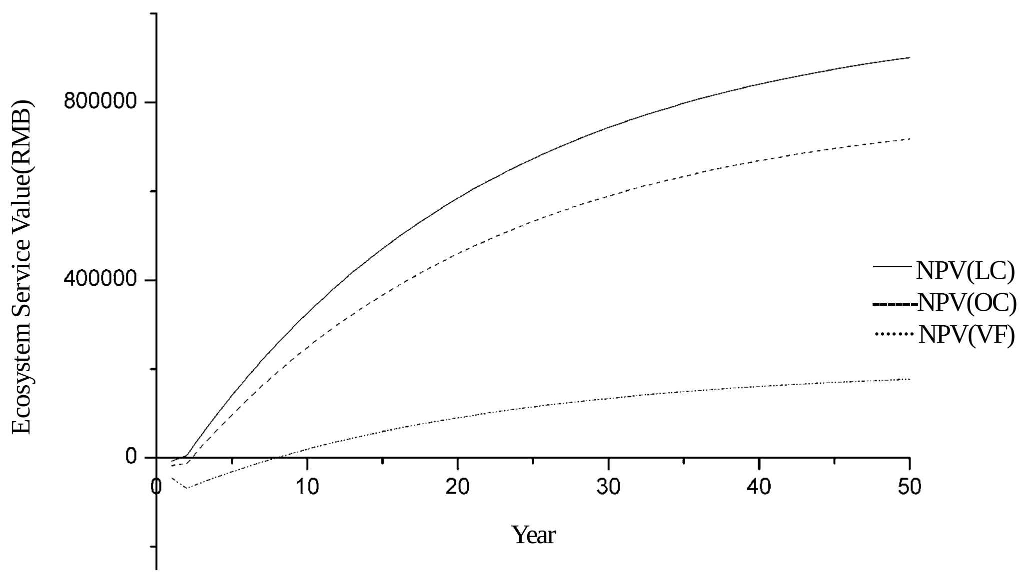


**Fig. 4. Net present value (NPV) analysis of ecosystem services benefits for the wetland rehabilitation project. LC, OC and VF are low-productive cropland, ordinary-productive cropland and vegetable field, respectively**

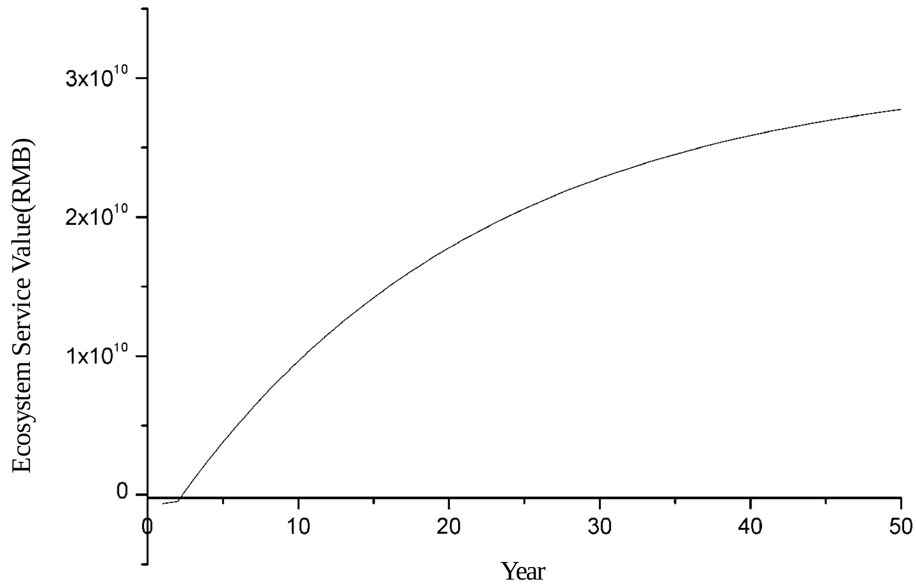


**Fig. 5. Net present value (NPV) analysis of ecosystem services benefits for the total region**

positive. This indicated that the local income of the low-productive cropland would be improved by the project, while the conversion of other two kinds of farm land would exert negative effects on the local economic income.

The ecosystem service value of low-productive cropland, ordinary-productive cropland and vegetable field increased 747%, 257% and 32%$ha^{-1}yr^{-1}$, respectively, and reached 59,000RMB$ha^{-1}yr^{-1}$. Compared with Xie's research result of the average economic value of terrestrial ecosystem services in China (Xie *et al.*, 2003) ( Fig.3 mean wetland), our results of wetlands were similar to the values of recreation, a little higher for the value of waste treatment, gas regulation and total value, tremendously higher for the biomass value and significantly lower for the water regulation value. The main reason is probably due to the choice of high economic value wetland plants in the wetland rehabilitation project and as one kind of surface flow wetlands, in order to improve water purification capacity, the designer of wetlands reduced water storage capacity in the design of the projects. In comparison, He (He *et al.*, 2005) calculated a value of 1,060 RMB$ha^{-1}yr^{-1}$ for China natural wetlands, and Tong (Tong *et al.*, 2007) calculated a value of 55,332 RMB ha-1yr-1 as the total potential ecosystem services value of the Sanyang wetlands. It can be seen that the lakeshore wetland rehabilitation project gives significant monetary benefits. The present study and previous studies all prove that wetland rehabilitation is ecologically and economically beneficial.

Because the cost and benefit of the wetlands occurred in different years (e.g. the cost of wetland constructing and replanting mainly occurred in the first year of the project, and ecosystem services value benefit occurred every year) and wetland ecosystem services value was low in the first year, the NPV was introduced to reflect the long-term change trends of the project. The results clearly show that the longer the wetland rehabilitation project persists, the more ecosystem services value benefits are obtained, but if the wetland rehabilitation persists less than 3 years, there will be not any ecological benefit compared with the farmland (Fig.4, Fig.5).

The cost and benefit analysis of the economic income effect by the wetland rehabilitation project showed the opposite trend (Fig.6.& Fig.7) to the ecosystem services value. In the first year of the project, thanks to the payments for ecosystem services (PES) from the Shandong Province government, the economic income of farmland households will increase a little, and two years later, after the end of PES, there will be an income reduction for all the three kinds of farmland households that participated in the project. Here the policy to increase ecosystem services meets the economic efficiency, as much ecological engineering faces. To be sustainable, ecological engineering should bring local communities a benefit larger than the previous environmental uses in the region. Particularly in rural areas, people may care more about societal and economic benefits, rather than the ecological integrity of the wetland ecosystem. When project payments end most of the land that was enrolled may be reconverted to crop production. The contradiction between economic income and ecosystem service value benefits would affect the wetland rehabilitation project's long-term success, and conservation benefits could not be sustained without continued conservation payments (Cooper and Osborn, 1998). If this problem could be properly solved, the aim of protecting the environment and increasing peasant income would both be attained.

PES has become an increasingly popular market-based instrument to translate external, non-market environmental services into financial incentives for landowners to preserve the ecosystems that provide the services (Engel *et al.*, 2008; Wünscher *et al.*, 2008)and for PES to work, it requires a secure long-

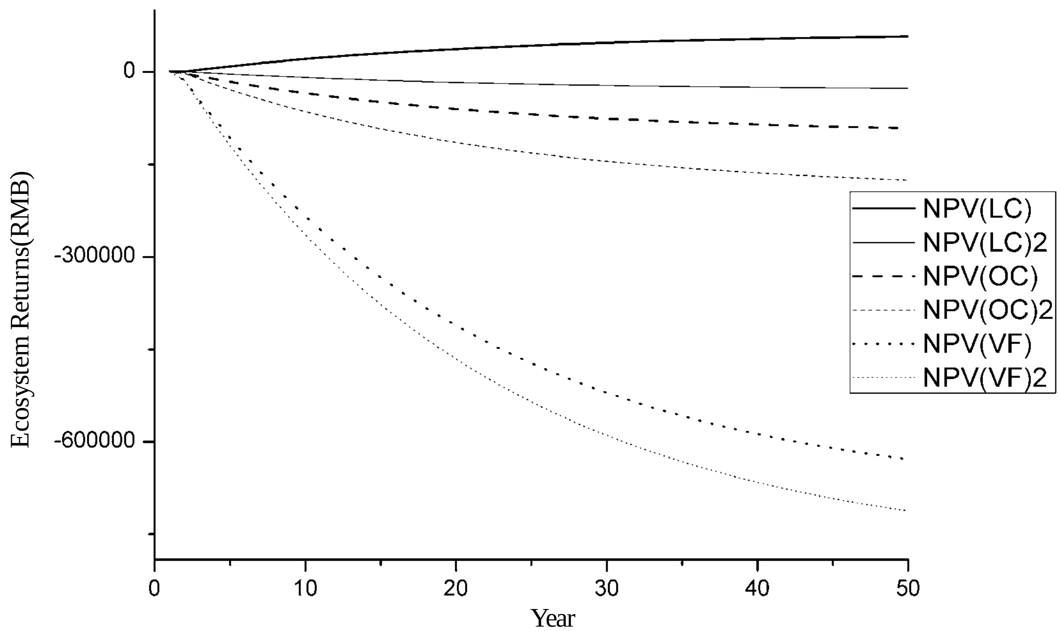


**Fig. 6. Net present value (NPV) analysis of total local economic income and local peasant income for the wetland rehabilitation project. NPV(LC), NPV(OC), NPV(VF) are the total local economic incomes of low-productive cropland, ordinary-productive cropland and vegetable field, and NPV(LC)2, NPV(OC)2, NPV(VF)2 are peasant incomes, respectively**

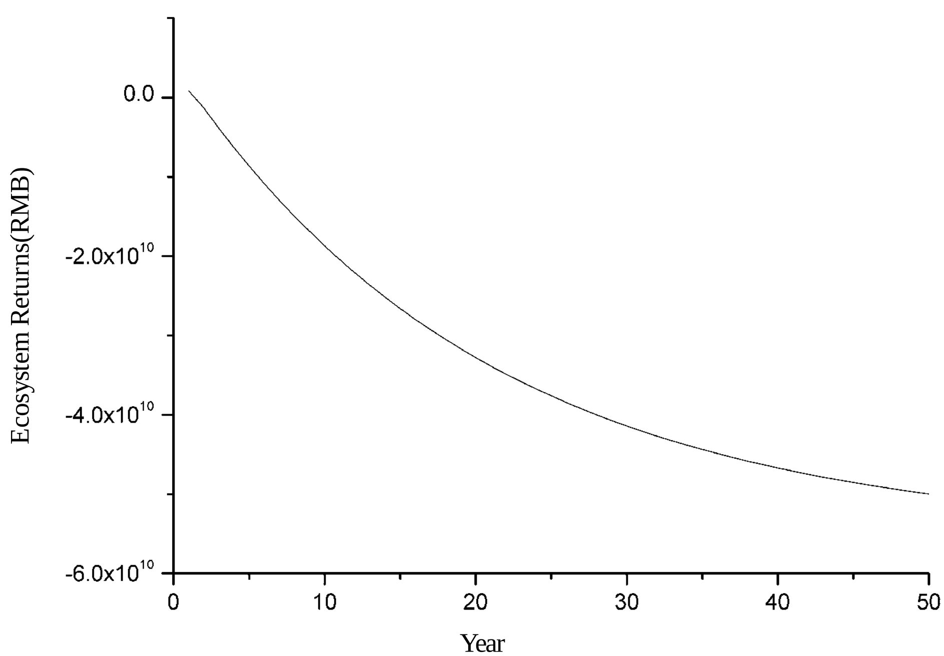


**Fig.7. Net present value (NPV) analysis of economic returns for the total region**

term source of financing (Pagiola *et al.*, 2010). The academic community has initiated research in the field of assessment of ecosystem services and has provided a strong theoretical basis for the PES mechanism and policy design (CCICED, 2007). In policy design and practice of PES, determination of compensation standards is the critical part. In this case, compensation standards in two values are discussed: direct investment and opportunity cost of upstream protectors and gains of the downstream beneficiaries. For the upstream area, after wetland rehabilitation, the opportunity cost will be $1.88\times10^8$ RMB each year, including reduction of biomass value and increase of tourist income. And for the downstream area, the wetland rehabilitation will reduce the cost of water purification at a value of $1.14\times10^9$ RMB, 6 times the upstream opportunity cost. The households who participated in the project will suffer an income reduction of 1,575 RMB $ha^{-1}$ for low-productive cropland, 10,027 RMB $ha^{-1}$ for ordinary-productive cropland, and 40,560RMB $ha^{-1}$ for vegetable field respectively each year, and reduce the cost of water purification at a value of 27,973 RMB $ha^{-1}$ for low-productive cropland, 29,545 RMB $ha^{-1}$ for ordinary-productive cropland, and 40,464 RMB $ha^{-1}$ for vegetable field each year. In addition, after wetland rehabilitation, each hectare of wetland will potentially increase the local tourist income at a value of about 4,877 RMB each year in the long-run.

Through the ecological value and economic income analysis above, the policy and compensation standards of PES for the wetland rehabilitation was designed. The PES policy should comprise two gradations: the PES of downstream area to upstream area and PES of downstream area government to the local households. In the determination of transfer payment amount, the practical mechanism is that the government of upper and lower reaches should determine it through negotiations. The reasonable payment amount should be greater than opportunity cost of upstream protectors ($1.88\times10^8$ RMB), and less than gains of the downstream beneficiaries ($1.14\times10^9$ RMB). And for the upstream government, the PES from the downstream government should be transferred to the households who participated in the project, to be more specific, the payments should be at least 1,575 RMB $ha^{-1}$ for low-productive cropland, 10,027 RMB $ha^{-1}$ for ordinary-productive cropland and 40,560 RMB $ha^{-1}$ for vegetable field respectively each year. Moreover, for the upstream government, there should be a payment to those households of 4,977 RMB $ha^{-1}$ from tourist income which comes from wetland rehabilitation.

## CONCLUSION

In summary, it can be concluded that the lakeshore wetland rehabilitation project in Nansi Lake generated obviously greater eco-services in all kinds of farmlands, and it could effectively reduce the lakeshore non-point pollution and effectively improve drainage areas water quality. On the other hand, this project maybe reduce the income of participants, and a long term PES mechanism is very necessary. A feasible framework of PES was established based on the ecological and economic analysis, and reasonable payment amount was calculated. If this PES mechanism could be established, the aim of protecting the environment and increasing income of the local peasant would both be attained.

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## REFERENCES

Arrow, K., Solow, R., Portney, P., Leamer, E., Radner, R. and Schuman, H. (1993). Report of the NOAA panel on contingent valuation. Federal Register, **58 (10)**, 4601-4614.

Barbier, E.,Acreman, M. and Knowler, D. (1997). Economic valuation of wetlands: a guide for policy makers and planners. (Gland, Switzerland: Ramsar Convention Bureau ).

Birol, E.,Koundouri, P. and Kountouris, Y. (2010). Assessing the economic viability of alternative water resources in water-scarce regions: Combining economic valuation, cost-benefit analysis and discounting. Ecol. Econ., **69 (4)**, 839-847.

CCICED, (2007). Eco-compensation mechanisms and polocies in China (Beijing: Science Press).

Cooper, J. and Osborn, C. (1998). The effect of rental rates on the extension of conservation reserve program contracts. Am. J. Agr. Econ., **80 (1)**, 184.

Costanza, R. (1997). The value of the world's ecosystem services and natural capital. Nature, **387**, 252-260.

Daily, G., Polasky, S., Goldstein, J.,Kareiva, P., Mooney, H., Pejchar, L., Ricketts, T., Salzman, J. and Shallenberger, R. (2009). Ecosystem services in decision making: time to deliver. Front. Ecol. Environ., **7 (1)**, 21-28.

Engel, S., Pagiola, S. and Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. Ecol. Econ., **65 (4)**, 663-674.

Farber, S., Costanza, R. and Wilson, M. (2002). Economic and ecological concepts for valuing ecosystem services. Ecol. Econ., **41 (3)**, 375-392.

Guo, Z., Xiao, X.,Gan, Y. and Zheng, Y. (2001). Ecosystem functions, services and their values-a case study in Xingshan County of China. Ecol. Econ., **38 (1)**, 141-154.

Hansjürgens, B. (2004). Economic valuation through cost-benefit analysis-possibilities and limitations. Toxicology, **205 (3)**, 241-252.

He, H., Pan, Y., Zhu, W., Liu, X., Zhang, Q. and Zhu, X. (2005). Measurement of terrestrial ecosystem service value in China. Chin. J. Appl. Ecol., **16 (6)**, 1122.

Howarth, R. and Farber, S. (2002). Accounting for the value of ecosystem services. Ecol. Econ., **41 (3)**, 421-429.

Karimzadegan, H., Rahmatian, M., Dehghani Salmasi, M., Jalali, R. and Shahkarami, A. (2007). Valuing Forests and Rangelands-Ecosystem Services. Int. J. Environ. Res., **1 (4)**, 368-377.

King, D., Wainger, L., Bartoldus, C. and Wakeley, J. (2000). Expanding wetland assessment procedures: linking indices of wetland function with services and values. (Washington, DC.: US Army Corps of Engineers Engineer Research and Development Center).

Li, C., Xiao, X., Frolking, S., Moore, B., Salas, W., Qiu, J., Zhang, Y., Zhuang, Y., Wang, X., Dai, Z., Liu, J., Qin, X., Liao, B. and Sass, R. (2003). Greenhouse gas emission from croplands of China. Quaternary Sciences, **23 (5)**, 493-503.

Li, Y., WANG, B. and Li, X. (2008). The Land Cover Classification and Characteristics of Nansihu Lake Based on SPOT5 Remote Sensing Image. Remote Sensing Technology And Application, **23 (1)**, 62-66.

MEA, (2003). Millennium Ecosystem Assessment, Ecosystems and human well-being: a framework for assessment. Washington, DC.: World Resources Institute.

MEA (Millennium Ecosystem Assessment) (2005). Ecosystems and human well-being: wetlands and water. Washington, DC.: World Resources Institute.

Pagiola, S., Zhang, W. and Colom, A. (2010). Can Payments for Watershed Services Help Finance Biodiversity Conservation? A Spatial Analysis of Highland Guatemala. Journal of Natural Resources Policy Research, **2 (1)**, 7-24.

Pearce, D. (1993). Economic values and the natural world. London: Earthscan.

Sukhdev, P. (2008). The economics of ecosystems and biodiversity. European Communities.

Teiter, S. and Mander, U. (2005). Emission of N2O, N2, CH4, and CO2 from constructed wetlands for wastewater treatment and from riparian buffer zones. Ecol. Eng., **25 (5)**, 528-541.

Tong, C., Feagin, R.,Lu, J., Zhang, X., Zhu, X., Wang, W. and He, W. (2007). Ecosystem service values and restoration in the urban Sanyang wetland of Wenzhou, China. Ecol. Eng., **29 (3)**, 249-258.

Turner, R., van den Bergh, J. C. J. M., Soederqvist, T., Barendregt, A., van der Straaten, J., Maltby, E. and Van Ierland, E. (2000). Ecological-economic analysis of wetlands: scientific integration for management and policy. Ecol. Econ., **35 (1)**, 7-23.

Upneja, A., Shafer, E., Seo, W. and Yoon, J. (2001). Economic benefits of sport fishing and angler wildlife watching in Pennsylvania. Journal of Travel research, **40 (1)**, 68-78.

Wünscher, T., Engel, S. and Wunder, S. (2008). Spatial targeting of payments for environmental services: a tool for boosting conservation benefits. Ecol. Econ., **65 (4)**, 822-833.

Xie, G.-d., Chun-xia, L., Yun-fa, L., Du, Z. and Shuang-cheng, L. (2003). Ecological assets valuation of the Tibetan Plateau. Journal of Natural Resources, **18 (2)**, 189-196.

Xue, D. (1997). Economic Valuation of Biodiversity- A Case Study on Changbaishan Mountain Biosphere Reserve in Northeast China. (Beijing: China Environmental Science Press).

Yang, L., Shen, J., Zhang, Z., Sun, Q. and Zhu, Y. (2003). Distribution and Ecological Risk Assessment for Heavy Metals in Superficial Sediments of Nansihu Lake. Journal of Lake Science, **15 (3)**, 252-256.

Zhang, D., Gersberg, R. and Keat, T. (2009). Constructed wetlands in China. Ecol. Eng., **35 (10)**, 1367-1378.

Zhang, J., Meng, F., Lu, Y., Jing, Y., Zhang, H., Zhang, B. and Zhang, C. (2008). Ecological assessment of lakeshore wetland rehabilitation on eastern route of South-to-North Water Transfer Project. Front. Environ. Sci. Engin. China, **2 (3)**, 306-310.

Zhang, J., Zhang, B., Jing, Y.-m., Kang, X.-S. and Zhang, C.-L. (2008). Design of Constructed Wetland in Xinxue River Estuary into Nansi Lake in Eastern Line of South-to-North Water Transfer Project. China Water & Wastewater, **214 (2)**, 49-51.

Zhuang, D., Wei-xin, O. and Deng-shan, D. (2003). Evaluation of the lake recovery area eco-economy benefit in Dongting Lake wetland. Journal of Natural Resources, **18 (5)**, 536-543.