Supplementary Document:
Detailed Economic Analysis

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People's Republic of China:
Jiangxi Ganzhou Rural Vitalization and Comprehensive Environment Improvement Project

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I. INTRODUCTION

1. The economic analysis completes least cost and benefit cost analyses on proposed Outputs. Analyses have been conducted in accordance with Asian Development Bank's (ADB) Guidelines for the Economic Analysis of Projects (2017).[1]

2. The Ganzhou Municipal Government (GMG) of Jiangxi Province has requested ADB funding for the Jiangxi Ganzhou Rural Vitalization and Comprehensive Environment Improvement Project (the project). The project will support Ganzhou Municipality in green economic development, rural sanitary and solid waste management, soil and water resources improvement, and disease management.

II. MACRO-ECONOMIC CONTEXT

3. The Yangtze River Economic Belt (YREB) is one of the three key economic growth engines in the People's Republic of China (PRC). Its nine provinces and two specially administered municipalities account for over 40% of the population, 40% of freshwater resources, and about 45% of the country's economic output. Development since the 1980s, is concentrated in downstream coastal areas. Development of the middle and upper reaches has lagged. These areas still face significant challenges because of (i) weak coordination of strategic planning; (ii) increasing pollution and pressure on natural resources; (iii) slow adoption of green development; and (iv) limited integration of waterways, ports, and intermodal logistics. To manage these challenges, the Government of the PRC formulated the YREB development plan 2016–2030.[2] Based on this plan, the Asian Development Bank (ADB) and the government adopted a framework to prioritize:[3] (i) institutional strengthening and policy reform; (ii) ecosystem restoration, environmental protection, and management of water resources; (iii) inclusive green industrial transformation; and (iv) construction of an integrated multimodal transport corridor. This project is part of the YREB.

4. In February 2018, the State Council of the PRC issued a policy on rural vitalization as a driver for PRC's modernization goals and building a moderately prosperous society.[4] The policy is intended to establish an institutional framework, modernize rural areas, and beautify the countryside. Under this policy, local governments formulate and implement plans to improve public services and promote environmental protection. ADB and the PRC Government signed a memorandum of understanding on August 2018 to support this strategy, setting a goal of mobilizing $6 billion in investments by 2022 in priority areas including (i) rural waste management; (ii) agriculture modernization and increase productivity; (iii) rural industries, (iv) rural public services; and (v) knowledge support and capacity development.

5. Ganzhou Municipality (Ganzhou), on the Gan River watershed in the middle reaches of the Yangtze River, is a large agricultural prefecture-level municipality in Jiangxi Province. It has three districts, one county-level city, and 14 counties. The project includes Ganxian district and Xingguo, Shicheng, Huichang, Ningdu, and Yudu counties located. Ganzhou is deemed poor and has weak institutional capacity on environmental management. It had a population of 9.8 million in 2018 and a land area of 39,380 square kilometers.

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[1] ADB. 2017. *Guidelines for the Economic Analysis of Projects,* Manila.

[2] Government of the PRC. 2016. Outline of the Yangtze River Economic Belt Development Plan, 2016–2030. Beijing.

[3] ADB. 2018. Framework for the Asian Development Bank's Assistance for the Yangtze River Economic Belt Initiative: 2018–2020. Manila

[4] Government of the PRC. 2018. National Strategic Plan for Rural Vitalization, 2018–2022. Beijing

6. The total gross domestic production (GDP) of Ganzhou Municipality in 2018 was 280.7 billion CNY, having grown at an average annual rate of 12.2% since 2010. Primary, secondary and tertiary industries account for 12.1%, 42.5% and 45.3% of the total GDP in 2018, respectively. Per capita GDP of Ganzhou Municipality increased from 13,397 CNY in 2010 to 32,429 CNY in 2018 but remains well below National and Jiangxi Provincial averages. Ganzhou's per capita GDP ranks last among the 11 municipalities in Jiangxi Province. The average annual disposable income of urban residents, at 32,163 CNY, is nearly three times that of rural residents, 10,782 CNY. Since 2012, in response to the poverty reduction strategies emphasized by the central government of PRC, GMG has prioritized the investments to drive the development of poor areas and improve the livelihood of rural population. The poverty rate has reduced from 23.45% in 2012 to 2.45% in 2019.[5]

III. SECTOR CONTEXT

7. The Gan River watershed has experienced increasing environmental and ecological degradation due to poor urban and rural sewage management. The water quality of Gan River in Ganzhou is classified as Class III, the minimum allowable level of water quality considered suitable for municipal water use. While urban wastewater treatment has improved, 80% of rural sewage remains untreated and is discharged directly to rivers. Public toilet access in towns and rural areas is inadequate.

8. Dumping of solid waste into water bodies is widespread, contaminating waterways and the local environment. Existing sewage treatment facilities and solid waste management systems are unable to meet the water quality and environmental requirements of the growing tourism services. Operation and maintenance (O&M) of the facilities is a concern due to lack of local government funding and community engagement.

9. Flooding is also a problem in Ganzhou. Flood control infrastructure is inadequate or damaged. Capacity for environmental management and flood protection is insufficient. Existing environmental and flood monitoring, information management and enforcement systems are outdated or impaired and require urgent upgrading. Moreover, these systems are no coordinated across municipal jurisdictions.

10. Indicators of ecological impairment include unproductive wetlands and forests' that have lost their capacity to attenuate erosion. GMG is reforesting areas to prevent soil erosion, but a lack of monitoring capacity impedes effective forest management, especially with regards to fire prevention and pest control.

11. There is a pressing need to provide improved livability, health, and livelihood outcomes for the local communities and address losses from flood and soil erosion impacting an estimated 2.0 million rural residents in Ganzhou. Ganzhou is considered an under developing municipality. But there is no sustainable financing mechanism for investments in water pollution control and improved livelihoods in rural areas.

IV. RATIONALE

12. The Yangtze River Economic Belt (YREB), comprising nine provinces and two specially administered municipalities, accounts for over 40% of the population, 40% of freshwater resources, and about 45% of the country's economic output. While the YREB has benefited from

[5] Ganzhou Municipal Statistical Yearbook 2019.

extensive development since the 1980s, economic growth in the middle and upper reaches of the Yangtze River Basin lags that of the coastal areas. The basin still faces significant challenges, because of: (i) weak institutional coordination for strategic planning; (ii) increasing pollution and pressure on natural resources; and (iii) slow transformation to green development. To manage these challenges, the Government formulated the YREB Development Plan, 2016–2030. ADB and the Government have agreed to adopt a programmatic approach, prioritizing: (i) institutional strengthening and policy reform; (ii) ecosystem restoration, environmental protection, and management of water resources; and (iii) inclusive green industrial transformation.

13. Rural transformation has lagged urban development in the YREB. As a result, income inequality is still persistent in rural areas of lesser-developed middle and upper reaches of the Yangtze River Basin. The majority of rural wastewater and wastes are directly discharged to the water system without treatment and disposal. As the rural economy expands, more regulatory, administrative, and environmental management challenges will require stronger institutional capacity. ADB supports PRC's rural vitalization strategy to promote rural development, and green and inclusive growth through governance reform, wastewater and waste management, rural-urban integration, and ecosystem protection.

14. Gan River is a major branch of Yangtze River Basin, with an area within Ganzhou of 36.4 thousand square kilometers, (44.8% of the total watershed area). The river originates at the confluence of the Zhang and Gong Rivers and is the largest tributary of Poyang Lake and flows north into the Boyang Lake, one of two largest lakes connected to Yangtze River. Lake Poyang, the second largest lake in the PRC, is largely affected by high levels of nutrient pollution loads from the Gan River, which also degrade the aquatic ecology in rural areas of the Gan River.

15. Ganzhou is a large agricultural prefecture-level municipality in the south of Jiangxi Province occupying the upper portion of the Gan River watershed. It had an estimated population of 9.7 million in 2017 and a land area of 39,380 km2. Ganzhou lags in economic development, with a gross domestic product (GDP) per capita ranking low among the 11 municipalities of the province. During the past decade, Ganzhou has suffered from heavy rains and floods. There is thus a pressing need to provide improved livability, health, and livelihood outcomes for the local communities in Ganzhou. Ganzhou has been selected as a demonstration area to exhibit rural environment improvement and green development for the following reasons: (i) it is a largely rural municipality with substantial agricultural and forestry development potential; and (ii) is a national ecological pilot zone having unique tourism resources and environmental advantages.

16. Regulatory, institutional, and technical capacities for environmental management and flood protection, at the municipal, district and county levels, are inadequate. Current environmental monitoring and regulatory enforcement; the environmental information management system; the river water quality monitoring; and the flood control and early warning systems are outdated or impaired requiring urgent upgrade. There are only a few automatic water quality monitoring stations in the Gan River, and testing equipment are insufficient. In addition, there are no effective collaboration mechanisms for water resource management, no effective information dissemination systems, and no advocacy and public participation forum for environmental and health issues.

17. There are no sustainable financing mechanisms for investments in water pollution control and improved livelihoods in rural areas. Green agriculture technologies and practices to reduce nonpoint source pollution for green development are not widely applied. Financing mechanisms are not designed to support green developments such as village-based eco-friendly businesses. Sustainable green financing has not been established.

18. Point source pollution (urban and rural sewage) is negatively affecting the water quality of Gan River, which is currently classified as Class III. While progress has been made on urban wastewater treatment, rural sanitation coverage is still quite limited with 80% of rural sewage remaining untreated and discharged directly into rivers. Access to public toilets in townships and rural areas is inadequate. Dumping of solid waste into water bodies is common. Existing sewage treatment facilities and solid waste management systems cannot meet the water quality and environmental requirements of the growing tourism services. Facilities' maintenance is a concern due to a lack of funding from GMG.

19. Flood infrastructure and management systems are inadequate in the Gan River. River protection infrastructure is weak due to insufficient river embankments and non-structural protection measures. The riverine ecosystem's resilience is also impacted by weak forest management, undermining the forests' capacity to control and attenuate soil erosion. Some wetland areas have no productive use. The GMG is working to identify the most effective types of vegetation and reforestation for water conservation and prevention of soil erosion.

20. The local enterprises in Ganzhou have limited access to financial services for green development and rural revitalization initiatives. Commercial banks and non-bank financial institutions cannot meet the growing financing needs of SMEs and eco-friendly enterprises in the region due to their limited operational and risk management capabilities. A green financing mechanism will adopt a financial intermediation loan (FIL) modality in cooperation with a local commercial bank and will prioritize funding for business and activities that promote green agriculture, sustainable forest management, environmental protection, and climate change adaptation and mitigation measures.

21. The project is aligned with the following impact: rural vitalization in the YREB realized [YREB Development Plan, 2016–2030 (footnote 1) and National Strategic Plan for Rural Vitalization, 2018–2022 (footnote 4)]. The project will have the following outcome: living environment of rural areas along the Gan River improved.

22. The Project Outputs are:

Table 1 Project Outputs

Output	Description
Output 1: Institutional capacity and knowledge on environmental management enhanced	(i) Environmental monitoring and management capacity strengthened (ii) Project management support and knowledge sharing (iii) Topic Research
Output 2: Green development and financing mechanisms piloted	(i) Establishment of a green finance mechanism for environmental protection and rural vitalization (ii) Green agriculture development demonstration project (iii) Eco-tourism demonstration project
Output 3: Rural waste and sanitation management improved	(i) Rural wastewater treatment and drainage system improvement (ii) Rural solid waste management (iii) Rural drinking water system improvement
Output 4: Water and soil conservation practices improved	(i) River rehabilitation (ii) Wetland restoration and soil conservation (iii) Forest quality improvement

V. METHODOLOGY

23. **Parameters and assumptions.** The following assumptions apply to all analyses:

(i) Economic benefits and costs are based on a domestic price numeraire in Q4 2020 prices;
(ii) Capital costs are based on engineering cost estimates;
(iii) Capital costs include physical contingencies of 8% but not price contingencies, interest during construction or depreciation;
(iv) Calculations to remove tax from FSR costs assume VAT of 3% on construction, 6% on consulting services and 13% on goods and equipment.
(v) Project costs and benefits are estimated on a with- and without-project basis;
(vi) Residual asset values are treated as benefits at the end of the project life;
(vii) Traded outputs are valued at CIF border prices adjusted for transport cost differentials and converted to economic prices using a shadow exchange rate factor of 0.996.[6] Non-traded outputs are valued at domestic market prices;
(viii) A shadow wage rate factor of 0.9 is used to convert the financial wage rate to an economic opportunity cost of labor.[7]
(ix) Project costs and benefits are evaluated over a 20-year period following project commissioning.

24. Sensitivity tests include: (i) 10% increase in capital costs, (ii) 10% increase in O&M costs; and (iii) 10% decrease in benefits, (iv) stressors in tests i, ii and iii combined, and (V) 10% reduction in growth. Sensitivity indicators and switching values were calculated.

25. **Project Costs**. The estimates of base costs for capital investments and annual O&M costs were obtained from the project feasibility study reports. The average annual O&M cost for all components following project completion is assumed to be 2% of the project investment cost. The economic costs include (i) capital costs of civil works, equipment, materials, land acquisition and resettlement, physical contingencies; and (ii) the cost of operation and maintenance (O&M), including the cost of asset repair and maintenance at 1% of the investment cost. The overall project investment cost is CNY 2,128.5 million ($ 323.0 million) with an economic cost of CNY 2,070.3 million ($ 314.2 million).[8] The estimated costs of the project outputs are as follows:

Table 2 Output Costs (CNY 000s)

Output	Financial	Economic*
Output 1 - Environmental monitoring and management capacity strengthened	77,982	73,341
Output 2 - Green development mechanisms piloted	390,178	384,264
Output 3 - Rural waste and environmental sanitation management	554,001	536,732
Output 4 - Water and soil conservation practices improved	1,106,304	1,075,992
Total Project Cost	2,128,465	2,070,329

* Exclude inflation, price contingencies and financing costs.

26. **Project Benefits.** The benefits of project components will be evaluated for outputs 2, 3 and 4. The approach to benefit valuation is summarized in this section and detailed descriptions of valuation methodologies are provided in Annex C.

[6] See Annex A.
[7] See Annex A.
[8] Cost of components that were subject to the economic evaluation. Excludes price contingencies and financing costs.

27. **Output 1: Institutional capacity and knowledge on environmental management enhanced**. Major components are capacity building programs in environmental monitoring and management, project management support and research. This component is not subject to economic evaluation, but output costs are included in the overall project economic evaluation.

28. **Output 2: Green development and financing mechanisms piloted.** This output focuses on greening of agriculture while supporting rural livelihoods. Major components and approaches to valuation are as follows:

(1) A green financing mechanism and associated intermediary loan projects at municipal and county levels to support access of local farmers and small and medium-size enterprises to cooperative banks' credit lines for agribusiness and crop production activities. Program will prioritize funding for business and activities that promote green agriculture, sustainable forest management, environmental protection, and climate change adaptation and mitigation measures.

(2) Green farming to reduce chemical and fertilizer use for agriculture through promotion of eco-friendly practices; design of green standards and piloting of traceability systems for organic products for support to eco-friendly businesses. Larger capital components include (1) greenhouse structures covering 4,000 mu and 4,000 sets of integrated water and fertilizer control systems using drip irrigation in Ningdu County; involving 2.8% of county vegetable production lands.

(3) Rehabilitation of 131.042 km of existing irrigation canals/ditches in the terraces in twelve villages in Ganzhou. To resolve water and soil erosion problems, causing lost production and ecological degradation.

(4) Enhancements at 11 villages frequented by tourists to promote eco-tourism and rural economic development in Shicheng and Dayu Counties. Enhancements include extensive roadside afforestation and restoration of traditional building facades.
Valuation of this output covers net farm income increases associated with new greenhouses and revenues from increased tourist traffic:

a. Greenhouse benefits are estimated as the net increase in crop revenues. Crop values are calculated at border (CIF) prices net of transport costs from Ganzhou to Dalian. Existing vegetable crops are valued at CNY 5,124/mu.[9] Based on recently completed analysis of greenhouse production[10] greenhouse crops were assumed to be peppers, melon, squash, cucumbers, eggplant and strawberries. Production costs were updated for inflation to 2021. FOB crop prices were determined from a web-based search of current prices on Alibaba (3 to 6 observations for each crop). These were converted to CIF border prices using conversion factors provided by the OECD.[11] Average net crop revenues from greenhouse operations were estimated to be CNY 13,559/mu. The crop revenue increase is CNY 8,435/mu.

b. The analysis of increases in tourism revenue is based on tourism statistics for

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[9] Crop production and gross value data from the Ganzhou Statistical Yearbook, 2019 (Tables 4-5 and 4-21). Crop production costs are not available, so this crop value represents gross income.
[10] ADB. 2020. *TA-8879 PRC: Heilongjiang Jiamusi Irrigation and Drainage System Modernization*. Manila.
[11] OECD.STAT CIF-FOB margins data, International Transport and Insurance Costs of Merchandise Trade (ITIC).

Ganzhou.[12] For the 5-year period from 2013-18, tourist numbers increased by 33% annually and per capita tourism expenditures grew by 5% annually (at constant 2018 price levels). Tourist traffic and per capita expenditures were forecast forward to 2109 at these rates and assumed to remain fixed thereafter. The share of total tourist revenues for project counties was assumed to be proportional to the share of hotel rooms in those counties, 9.5%, giving an estimate of at 13.6 million tourists per year spending an average of CNY 1,080 per visit. Tourism traffic to the townships was conservatively assumed to increase by 1% because of investments in the 11 villages, resulting in an annual increase of CNY146.9 million. This is the direct expenditure associated with tourism.[13]

29. **Output 3: Rural waste and sanitation management improved.** This output will improve the quality of life for both rural communities in Ganzhou. Major components are:

a. Improve rural domestic wastewater treatment and sanitation –15 new domestic wastewater treatment plants (WWTPs) with a total design capacity of 12,000 m3/day, and 361.85 km of associated sewage pipes in 15 villages in Nankang District, Yudu County, Dayu County, and Shangyou County. The design capacity of each WWTP ranges from 300 m3/day to 2,500 m3/day. The household connection rate will reach over 90% after project completion. The new service population is estimated to be 136,200 people (40,800 households).

Valuation of benefits realized by villagers receiving new WW services are based on willingness-to-pay (WTP) using a benefits transfer approach and results of a CV study dealing with rural wastewater services, conducted in 2020 in Hunan.[14] This study, conducted in Pingjiang County of Hunan Province is considered appropriate for benefits transfer because the study area is a rural community close to the project area (400 km). Key explanatory variables were adjusted to reflect Ganzhou HH conditions. Detailed calculations are shown in Annex C, Section B (pg22). The estimate of household WTP for wastewater services is CNY 16.4 per month or CNY 197 per year (0.21% of HH disposable income).

Health related benefits are evaluated for this output based on published data on avoided costs.[15] This analysis complements the SW and WW WTP analysis. Considering the possibility of double counting if both approaches to benefits assessment are used, the rationale for this analysis is the likelihood that rural village residents are poorly informed about the health effects of poor sanitation and will underestimate their WTP accordingly. After adjustment of the original data for inflation and demographic characteristics, the total per capita benefit was estimated to be CNY 153/year or CNY 593/year. This measure of benefit double counts WW management benefits of CNY 16.43 per month or CNY 197 per

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[12] Ganzhou Statistical Yearbook. 2019 (tables 8-14, 8-15) provide estimates of numbers of domestic and foreign tourists and their expenditures.

[13] The total direct, indirect and induced income effect, which is the appropriate measure of this benefit, was not estimated at the time of the analysis. The multiplier required for this calculation, 2.962 (Yang, Y., Timothy, F. J., and Altschuler, B. (2018). Explaining regional economic multipliers of tourism: does cross-regional heterogeneity exist? Asia Pacific Journal of Tourism Research, 23(1): 15-23), Direct expenditures are therefore an underestimate of this benefit.

[14] Hunan Miluo River Disaster Risk Management and Comprehensive Environmental Improvement Project (ADB TA 9753 PRC, Project Number: 53042-001)

[15] Economic Assessment of Sanitation Interventions in Yunnan Province, People's Republic of China A six-country study conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI) September 2012, THE WORLD BANK Water and Sanitation Program East Asia & the Pacific Regional Office.

year; amounting to only 33% of the estimated health benefits. This disparity is likely caused by incomplete information on the part of survey respondents. We therefore include only 1/3rd of estimated health benefits in our analysis of WW management benefits, CNY 197 per year (0.21% of HH disposable income). (Appendix C Section E).

b. Improve solid waste management - construct a domestic solid waste treatment center (300 t/d), a kitchen waste treatment plant (50 t/d), and 8 solid waste transfer stations, renovate 4 existing solid waste transfer stations, and raise public awareness on solid waste management. This component services 1,343,200 people (418,460 households) in Shicheng, Chongyi and Shangyou Counties.

Valuation of benefits realized by villagers receiving new SW services is based on willingness-to-pay (WTP) using a benefits transfer approach and results of a CV study dealing with village solid waste services, conducted in Yunnan.[16] This study concerns similar service improvements to the current project, and it is in a rural county 1900 km due west of Ganzhou. It is an appropriate candidate for benefits transfer. WTP for the project area was estimated using income and HH statistics for the project site updated to 2020 price levels. Detailed calculations are shown below. The resulting estimate of household WTP, at 2020 prices, is CNY 27.3 per month or CNY 327 per year (0.34% of HH disposable income). (Appendix C Section C).

c. Improved water supply - construct two water supply plants, including one in Shishang Village of Shishang Town with a capacity of 20,000 tons per day and one in Sunwu Village of Qingtang Town with a capacity of 5,000 tons per day. This component services 115,770 people (38,200 households).

Valuation of this benefit is based on WTP for WS service improvements using a benefits transfer approach. The CV study dealing with rural water supply in China was located in Hubei Province on the Yangtze River about 800 km from Ganzhou.[17] It is considered an appropriate candidate for benefits transfer analysis. WTP for the project area was estimated using income and HH statistics for the project site updated to 2020 price levels. The HH WTP for SW services is CNY 26.96 per month at 2011 price levels or CNY 33.38 per month or CNY 401 per year (0.42% of HH disposable income) at 2020 price levels. (Appendix C Section D).

30. **Output 4: Water and soil conservation practices improved.** Output 4 will enhance the flood prevention capability and improve the environmental quality of the watershed. Major components are:

(1) River rehabilitation – river dredging, river revetment rehabilitation and river embankment construction along 132.51 kilometers of stream.

(2) Wetland restoration and protection - The total planning area is 224 hectares (ha). The main activities include wetland habitat restoration and protection.

(3) Water and soil conservation – Measures to control overland runoff and soil erosion

[16] H. Wang et al. 2011. *Municipal Solid Waste Management in Small Towns, An Economic Analysis Conducted in Yunnan, China*. *Policy Research Working Paper*. 5767. The World Bank Development Research Group, Environment and Energy Team.
[17] J. Jianjun et al. 2016. Measuring the willingness to pay for drinking water quality improvements: Results of a contingent valuation survey in Songzi, China. Journal of Water and Health · January 2016. doi: 10.2166/wh.2016.247

will benefit stream water quality and protect watershed soils and landscapes. Measures include 238 ha of productive forests (fruits, tea, walnuts, waxberry) and 1,512 ha of ecological forests.

(4) Forest Rehabilitation and Protection – Measures under this component will improve forest quality and protect forest from diseases and fire. The total planning area is 10,200 hectares (ha). The main activities include diseased tree removal, tree planting and fire protection.

31. Benefits from investments in wetlands and forests include ecological goods and services. These benefits are valued using unit values derived from published research:

a. Several published valuation studies were reviewed as a source of information to assign value to wetland benefits. The study selected for valuation considers material production, water supply, environment purification, disturbance regulation, gas regulation and biodiversity support.[18] This study was selected here since it considers restoration of a degraded riverine wetland in south China as does the current project. The total value assumed for ecological goods and services, CNY 38,409 at 2020 price levels, omits water supply and environment purification values since these are considered separately. (Annex C Section G).

b. Benefits from the proposed forest areas are associated with carbon fixation, oxygen production, air quality impacts, soil formation, recreation, and biodiversity. Several published valuation studies from the PRC were reviewed as a source of information to assign value to these benefits. A study by Shixiong et.al. (2019) was selected since it is the most recent work and it distinguishes planted from natural forests.[19] The value for planted forests, CNY 18,346/ha, is used for evaluation. (Annex C Section H).

32. Components will attenuate flood flows up to the 10- or 20-year return period flood depending on location. This will reduce flood damages incurred by flood plain farms, but insufficient information was available to evaluate this benefit.

33. Components under outputs 2, 3 and 4 also improve water quality benefiting downstream urban residents who rely on the Gan River system for their water supply. Valuation of this benefit is based on WTP using a benefits transfer approach. Source research was done in Huaping Co. in Northern Yunnan, a county level city like Ganzhou.[20] Both are more southerly cities, and both are on rivers having impaired water quality. Estimated WTP for the policy site is CNY 115/month for 5 years. At 2020 price levels this amounts to CNY171/month. This estimate, once converted to an ongoing payment assuming a 6% discount rate, is CNY 43.2/month. On an annual basis, the WTP is CNY 519/year or 0.54% of HH disposable income. This benefit is apportioned across outputs 2 (0.7%), 3 (3.9%), and 4 (95.4%) since components of these outputs all improve river water quality. Apportionment is based on phosphorus loading reductions related to streambank erosion control, WW treatment improvements and runoff attenuation by wetland and forest areas. (Annex C Section F).

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[18] C. Tong, et al. 2007. *Ecological Engineering 29.* pp 249-258 Ecosystem service values and restoration in the urban Sanyang wetland of Wenzhou, China. 249–258. Other studies reviewed are described in Annex C Section F.

[19] C. Shixiong, et al. 2019. *Difference in the net value of ecological services between natural and artificial forests in China. Conservation Biology*. Volume 00, No. 0, 1–8.

[20] H. Wang, et al. .2013. *Journal of Environmental Management 131.* Willingness-to-pay for water quality improvements in Chinese rivers: An empirical test on the ordering effects of multiple-bounded discrete choices. Pp 256–269.

VI. DEMAND ANALYSIS

34. Population growth forecasts will influence capacity designs for wastewater (WW), solid waste and water supply (WS) services. They also affect estimates of the benefits of increased tourism activity and benefits associated with WW, SW, WS and WQ enhancements. Growth assumptions are evaluated to confirm they are reasonable.

35. Historical population growth rates for Ganzhou are as follows:

Table 3 Population growth

Period	Urban	Rural
2008-18, 10 years	4.6%	-0.2%
2013-18, 5 years	8.3%	-1.2%

Source of data: Ganzhou Statistical Yearbook. 2019, Table 2-2 Population in urban and rural areas over the years

36. For new WW and SW services, a growth rate of 0.0% was assumed for rural villages and 7.0% for central villages in towns or townships. The overall growth rate for all WW and WS service areas is 0.70% based on reported service populations in 32030 and 2019 in the FSR.

37. FSR growth rate assumptions for rural villages, at 0.0% instead of the -1.2% historical rate, results in a 2% to 12% increase in the forecast service population. This discrepancy is reasonable considering the forecast uncertainty and the need for excess capacity to service maximum day demand.

38. The per capita water supply quota in the towns is 120 liters per capita day (lpcd). This is not assumed to change over the forecast period and there is no allowance for peak demands. Total demand is based on the permanent population with allowance for population increases during holidays. The demand forecast is therefore reasonable.

39. WW and SW components are designed to upgrade services for the rural population. New WW treatment facilities are all small-scale plants with capacities ranging from 300 to 2,500 m3 per day servicing rural township settlements of 700 to 8,000 HHs. These treatment facilities service several villages. The design standards for these systems assume 100 lpcd water demand and a sewage return flow of 80% which seems reasonable. The FSR also assumes a pipe network collection rate of 90% implying a 10% loss of sewage through leakage. Usually, the opposite assumption is applied with a factor for pipe inflow/infiltration that increases the flow of sewage into the treatment plant. WW demand forecasts therefore may be conservative.

40. While most rural HHs have indoor flush toilets, they rely on poorly managed septic tanks. After project completion, the service connection rate will exceed 90%.

41. Benefit calculations for water quality reflect the WTP of beneficiaries in the downstream urban area of Ganzhou. Annual urban population growth over the last 5 years was 8.3% (Table 3). A zero-growth rate is conservatively assumed for the urban population. Benefits associated with WW, SW and WS services is assumed to be 0.0%.

42. Total and domestic tourism visits grew 33%/year from 2039-18.[21] The analysis assumes

[21] Ganzhou Government. 2019. *Ganzhou Statistical Yearbook.* Ganzhou. Table 8–14 Statistics on Tourism.

that this rate of growth continues to 2019 and conservatively assumes a zero growth beyond 2019.

VII. LEAST COST ANALYSIS

43. When cost data are available, the least cost analysis uses a life-cycle cost approach to compare costs of design options over a 20-year period of operations. Costs included in the analysis are base costs and operation and maintenance costs. Present values (PVs) are used as summary measures of cost effectiveness. A discount rate of 9% is the assumed social opportunity cost. In some cases, a qualitative approach is used to identify a preferred option; usually when issues such as technical feasibility or capacity to achieve required outcomes are involved.

44. Findings are summarized below. Most comparisons are qualitative in nature based largely on technical considerations.

45. **Water Supply:** Water supply systems are provided for 2 towns: Shishang and Qingtang. Existing reservoirs are selected as sources of supply for these systems based on proximity and raw water quality. An analysis of alternative sources is not provided in the FSR. Technologies are subject to screening based on performance and cost however the cost analysis is qualitative. Following tables summarize the comparative analysis:

Water Supply treatment plant – coagulant mixing			
Option	Advantages	Disadvantages	Preferred
Water pump mixing	- Simple - Good mixing performance - External power not needed - Suitable for water plants within 120m of the first-stage pump room	- More difficult to operate - synchronisation with dosing equipment automatic dosing is difficult - Low centrifugal force	No
mechanical mixing	- Better mixing effect - Small head loss - Mixing not affected by changes in water volume - Suitable for water plants of all sizes	- Consume kinetic energy of water - Management and maintenance are more complicated - Requires a mixing pool	No
Tubular static mixer	- Simple, easy to maintain and manage - No tank required - Good mixing in the design flow range - External power not needed - Suitable for water plants of all sizes with little change in water volume	- Water volume changes affect mixing efficiency - Large head loss	Yes

Water Supply treatment plant – flocculation			
Option	Advantages	Disadvantages	Preferred
Mechanical flocculation	- highly adaptable to changes in water volume	- domestic equipment is poor quality causing high maintenance, while imported equipment is	No

		expensive and has a maintenance cost	
Folded plate Hydraulic flocculation tank	- Short flocculation time - Good performance - Suitable for plant with little change in water volume	- Complicated structure - Changes in water volume affect performance	No
Grid Hydraulic flocculation tank	- Short flocculation time - Better performance - Simple structure - Suitable for plant with little change in water volume	- Changes in water volume affect performance	Yes

Water Supply treatment plant – sedimentation			
Option	Advantages	Disadvantages	Preferred
Advection sedimentation tank	- Simple, easy to operate and manage - More stable, adapts well to changing turbidity	- Large footprint - high cost	Yes
Inclined tube (plate) Sedimentation tank	- High efficiency - Small footprint - Lower cost	- Inclined tubes (plates) have short lifespan, frequent replacement - Does not adapts well to changing turbidity	No
	-	-	

Water Supply treatment plant – filtration			
Option	Advantages	Disadvantages	Preferred
Rapid sand filter	- Stable, reliable operation - Applicable to large, medium, and small water plants - filter material is readily available and inexpensive	- the area of a single pool can be large, and the pool body is relatively shallow. - Many valves - Requires back flushing equipment	No
Siphon filter	- No need for large valves - No need for back-flush pump or tank - Easy to automate operation	- Complex civil works - Deep pool required - water is wasted during backwashing - back washing is not easy to control	No
Valveless filter	- No need to set up valves - Automatic flushing - can be made in complete sets	- filter layer can't be seen during operation - Inconvenient sand cleaning - The area of a single pool is small. - Back-flushing effect is poor, - water is wasted during backwashing	no
Dual layer filter	- Dual-layer filter has high capacity to trap sediment - Air-water backwashing is rapid and effective - Low water consumption is small - simple civil works	- complex equipment, - High power use, - high cost - Higher head loss	No

Water Supply treatment plant – filtration			
Option	Advantages	Disadvantages	Preferred
	- no loss of filter material during backwashing		
V type filter	- Stable and reliable operation - sand filter material is readily available and inexpensive - High filter bed capacity resulting in a long operating cycle and high filtration rate - technology is mature and widely used in large and medium-sized water plants	- more equipment required - civil works requirements are high - pool depth is deeper than the ordinary fast filter	Yes

Water Supply treatment plant – Selection of disinfectant			
Option	Advantages	Disadvantages	Preferred
liquid chlorine	- low cost - limited infrastructure required - widely used	- toxic disinfectant by-products (organic halides) - less effective against organic matter	
Ozone	- can oxidize organic matter and kill microorganisms without producing organic halides -	- unstable and must be prepared on site - High investment and operating cost	
Chlorine dioxide	- a stronger disinfection effect than chlorine - more effective at removing Fe2+, Mn2+, taste and odors - maintains higher residual chlorine in distribution system	- unstable and must be prepared on site -	Yes

Water Supply – Pipe			
Option	Advantages	Disadvantages	Preferred
Steel	- Good hydraulic performance - High strength, good impact resistance and excellent performance. - Adaptable to geological conditions. - Locally available	- Requires anti-corrosion treatment - Heavy	No
Fibreglass/steel	- Good hydraulic performance - Not susceptible to corrosion - Strong adaptability to geological conditions. - Light weight, - suitable for excavation and construction on narrow roads. - Locally available	- Water pressure resistance, external pressure resistance and impact resistance are moderate	No
Ductile iron	- Good hydraulic performance	- heavy	Yes – for transmission

Water Supply – Pipe			
Option	Advantages	Disadvantages	Preferred
	- Not susceptible to corrosion - High hardness, tensile, compressive strength, high impact resistance - Strong adaptability to geological conditions. - Locally available		
Concrete	- High hardness, tensile, compressive strength, high impact resistance - Locally available	- Hydraulic performance moderate - Requires anti-corrosion treatment - poor adaptability to geological conditions. - heavy	No
Polyethylene (PE)	- Good hydraulic performance - Not susceptible to corrosion - Strong adaptability to geological conditions. - Light weight, simple to lay - suitable for excavation construction on narrow roads and horizontal directional drilling construction. - Locally available	- Large size pipes have moderate hardness, tensile strength, compression strength and impact resistance -	Yes – for distribution

46. **Wastewater**: Technologies are subject to screening based on performance and cost however the cost analysis is qualitative. Following tables summarize the comparative analysis:

Wastewater - treatment process			
Option	Advantages	Disadvantages	Preferred
Oxidation ditch	- mature process, widely used - simple process, few structures, easy to operate - stable sludge - good treatment performance	- high energy use - large footprint -	No
Biological contact oxidation	- high treatment efficiency - Low sludge output, no sludge expansion and sludge return, - simple to operate - resilient and adaptable - fast start-up - low energy use	- filler blockage with high BOD loads - Complex, - operation is more difficult	No
Sequencing batch reactor (SBR)	- simple process flow and low cost - stable - resistant to shock load - easy operation and maintenance	- intermittent and periodic operation, - high requirement for automatic control - increased power consumption	Yes

Wastewater - treatment process			
Option	Advantages	Disadvantages	Preferred
		- low nitrogen and phosphorus removal efficiency - sludge stability is not as good	
Moving bed biofilm reactor	- improved treatment efficiency of organic matter - strong impact load resistance - general sludge concentration It is 5-10 times that of ordinary activated sludge	- prone to blockage - new technology	Yes
Integrated membrane technology process	- improved treatment effect and treatment load per unit area - improved efficiency of nitrogen and phosphorus removal - enhanced impact load resistance - low sludge output and reduced sludge treatment costs - easy to operate and maintain - low energy use	- higher operating temperature required - very sensitive to too high or too low temperature -	No
Constructed wetland	- Simple, low cost - easy to operate and maintain - Aesthetic appeal of planted area -	- large footprint - vulnerable to pests and diseases - improper results in poor treatment outcome	No

Wastewater – Pipes			
Option	Advantages	Disadvantages	Preferred
Polyethylene (HDPE)	- Good Hydraulic performance - High corrosion resistance - Good Impact resistance - Good Thermodynamic Performance - Easy to transport and lay	- High cost	Yes – pressurized pipes
Un-plasticized Polyvinyl Chloride (UPVC)	- Good Hydraulic performance - High corrosion resistance - Good Thermodynamic Performance - Easy to transport and lay -	- Poor Impact resistance - Good Thermodynamic Performance - Less easy to transport and lay - Brittle - Normally used for residential	Yes - residential

Wastewater – Pipes			
Option	Advantages	Disadvantages	Preferred
Steel belt reinforced polyethylene (MRP)	- Good Hydraulic performance - High corrosion resistance - Good Thermodynamic Performance -	- High cost	Yes – small pipes, <=300mm
cast iron	- Good Hydraulic performance - high impact resistance, - high pressure bearing capacity	- Needs anti-corrosion treatment - Heavy, more difficult to transport and lay	

47. **Irrigation and drainage for agriculture**:

Green development mechanisms – Drainage			
Option	Advantages	Disadvantages	Preferred
Use original ditches, canals, and roads	- minimize ownership adjustments	- not conducive to large-scale mechanized operations - fails to achieve the design purpose of this project.	No
Ideal design following Ministry, Province, and City regulations	- meets regulatory requirements	- not based on needs of the administrative village and village group - difficult to adjust ownership	No
Design base don community consultation and following Ministry, Province, and City regulations	- based on needs of the administrative village and village group - ownership adjustment is easier - meets the requirements of large-scale mechanized operation	-	Yes

Green development mechanisms – Irrigation			
Option	Advantages	Disadvantages	Preferred
open channel irrigation	- low investment, - low operating costs, - suitable for various crops.	- relatively large, occupied land area	Yes
low-pressure pipeline irrigation	- energy and water efficient - land and labor saving - low investment - quick results	- not suitable for large-scale mechanized operation - easy to damage pipes with machinery	No
spray drip irrigation	- small footprint - water saving - high degree of automation, - uniform irrigation; - strong adaptability to terrain - reduced labor	- high investment and operating costs - clogging of drippers - not suitable for large-scale mechanized operations - easy to damage pipes with machinery	No

VIII. BENEFIT-COST ANALYSIS

48. Net present values (NPV) and economic internal rates of return (EIRR) were calculated for outputs 2, 3 and 4 using the methods and parameters discussed above. A summary of results is provided in Table 4. For the base case analysis of all outputs except Output 2 have an EIRR above 9%. The overall project EIRR is 11.7%.

Table 4 Summary of the Economic Evaluation

	EIRR (%)	NPV (CNY thousand)
OVERALL PROJECT	11.7	930.61
Green development mechanisms	8.6	-37,61
Rural waste and environmental sanitation management	15.4	337.24
Water and Soil Conservation Practices Improved	21.6	1,547.85

Source: TA Consultant's estimates

49. Sensitivity analysis was undertaken to test the sensitivity of the estimated EIRRs of the proposed outputs to adverse changes in key variables and to confirm their economic viability under unfavorable conditions. Four risks are considered: (i) an increase of 10% in capital cost; (ii) an increase of 10% in operating and maintenance costs; (iii) a 10% decrease in benefits; (iv) a combination of tests (i), (ii) and (iii); and (v) a 10% reduction in growth. A summary of sensitivity tests for the overall project are provided in Table 5. EIRR exceeds 9% for all tests.

Table 5 Sensitivity Test Results – Overall Project

		EIRR	NPV	Sensitivity Indicator	Switching Value*
BASE CASE		11.7%	930.6		
I.	Increase investment cost 10%	10.7%	610.8	0.89	129%
II.	Increase operating cost 10%	11.6%	908.3	0.05	417%
III.	Reduce benefits 10%	10.5%	508.8	1.01	-22%
IV.	All 3 cost/benefit impacts	9.5%	164.9	1.91	na

* The percentage change in the parameter causing EIRR to fall to 9.0%

50. Detailed results for individual Outputs are presented below. Cash flow projections for the base case EIRR calculations are provided in the appendix.

51. **Output 2: Green development and financing mechanisms piloted.** Results of the economic evaluation for this output are provided in Table 6. EIRR is below 9%. This result is considered acceptable since only the greenhouse component of the green agricultural measures can be evaluated while measures like green financing mechanisms, rehabilitation of drainage works, and reduction of chemical inputs could not be readily evaluated. Moreover, the evaluation of tourism related benefits is very conservative.[22]

[22] Analysis of benefits from increased tourism expenditures assumes only 1% increase in tourism activity due to project investments and it further assumes a 0% growth for tourism traffic even though growth over the 5 years up to 2018 averaged 33%. With these assumptions, EIRR for output 2 Green

Table 6 Economic Evaluation – Green development mechanisms

Item	EIRR (%)	NPV (CNY million)
Base Case	8.6%	-37.6
1. Increase investment cost 10%	7.8%	-128.5
2. Increase operating cost 10%	8.5%	-46.5
3. Reduce benefits 10%	7.6%	-128.2
4. All 3 cost/benefit impacts	6.7%	-228.5

Source: TA Consultant's estimates

52. **Output 3: Rural waste and sanitation management improved.** Results of the economic evaluation for this output are provided in Table 6Table 6. EIRR exceeds 9% for all tests.

Table 7 Economic Evaluation – Rural waste and environmental sanitation management

	EIRR (%)	NPV (CNY million)
Base Case	15.4%	337.2
1. Increase investment cost 10%	14.2%	292.0
2. Increase operating cost 10%	15.4%	337.2
3. Reduce benefits 10%	14.0%	254.0
4. All 3 cost/rev impacts	12.8%	208.8
5. Reduce growth 50%	15.4%	337.2

Source: TA Consultant's estimates

53. **Output 4: Water and soil conservation practices improved.** Results of the economic evaluation for this output are provided in Table 8Table 6. EIRR exceeds 9% for all tests.

Table 8 Economic Evaluation – Water and Soil Conservation Practices Improved

	EIRR (%)	NPV (CNY million)
Base Case	21.6%	1,547.9
6. Increase investment cost 10%	20.1%	1,455.7
7. Increase operating cost 10%	21.5%	1,540.9
8. Reduce benefits 10%	20.0%	1,299.8
9. All 3 cost/rev impacts	18.5%	1,200.0
10. Reduce growth 50%	21.6%	1,547.9

Development is 8.6%. This approach does not account for multiplier effects, which will increase the benefit associated with increased expenditures, or costs of production in the tourism sector, which decrease the benefit. The following alternative scenarios were tested:
(a) Consider the tourism sector income multiplier in Hunan of 2.693 (Yang, Y., Timothy, F. J., and Altschuler, B. (2018). *Explaining regional economic multipliers of tourism: does cross-regional heterogeneity exist?* Asia Pacific Journal of Tourism Research, 23(1): 15-23). The income multiplier estimates indirect and induced income effects that occur because of the direct increases in tourism expenditures. With this change, EIRR for output 2 increases to 17.9%. Sensitivity analysis indicates that the multiplier must fall below 1.05 to push output 2 EIRR below 9%. The lowest tourism sector income multiplier in the cited reference is for Hebei at 1.63.
(b) Assume that tourism sector growth is 5%/year rather than 0%. EIRR for output 2 increases to 13.3%. Sensitivity analysis indicates that tourism growth must fall below 0.5% to push output 2 EIRR below 9%. As noted above historical growth rates for tourism traffic are 33%.

Table 8 Economic Evaluation – Water and Soil Conservation Practices Improved

	EIRR (%)	NPV (CNY million)

Source: TA Consultant's estimates

IX. POVERTY IMPACT ANALYSIS

54. The economic benefits generated from the project will be allocated to stakeholders, as shown in Table 9. The distribution of costs and benefits among stakeholders relies on estimates of incremental benefits and cost generated by the main project outputs. All financial and economic benefits and costs are expressed in present value terms (9% discount rate). The total net benefit is estimated to be CNY 4,389 million. Low income and poor households comprise 0.37% of the beneficiary population. Based on the proportion of poor beneficiaries for each project output the total benefit accruing to the poor is estimated to be CNY 23.0 million and the poverty impact ratio is calculated as 0.005.

Table 9 Benefit Distribution and Poverty Impact Analysis (CNY millions)

Present Value	Financial NPV*	Economic NPV*	Difference	Distribution of Benefits/Costs			
(at 9%)	(1)	(2)	(2)-(1)	Consumers	Construction Labor	Government / economy	Total
Benefits	0.0	4,218.1	4,218.1	4,218.1			4,218.1
Revenue	0.0	0.0	0.0	0.0			0.0
Intangible benefits		4,218.1	4,218.1	4,218.1			4,218.1
Costs	3,458.1	3,287.5	-170.6		-13.6	-157.0	-170.6
Capital	2,909.6	2,753.4	-156.3			-156.3	-156.3
O&M	295.5	294.7	-0.7			-0.7	-0.7
Taxes	0.0	0.0	0.0			0.0	0.0
Unskilled labor	253.0	239.4	-13.6		-13.6		-13.6
Net benefits	-3,458.1	930.6	4,388.7	4,218.1	13.6	157.0	4,388.7
Proportion of poor**				0.004	0.50	0.004	
Net benefits to the poor				15.6	6.8	0.6	23.0
Poverty impact ratio							0.005

* Measured as NPV at 9%
** based on social impact assessment in benefiting villages

ANNEX 1. PRICE CONVERSION FACTORS

A. Shadow exchange rate factor

Based on ADB**:**

Shadow Exchange Rate Factor Estimates, 2014–2017

EAST ASIA

Country	2014	2015	2016	2017
Mongolia	1.02	1.02	1.02	1.02
People’s Republic of China	1.01	1.01	1.01	

Source: Asian Development Bank

Note: The formula used for this table is presented on page 103 of the ADB 2017 Guidelines for the Economic Analysis of Projects.

B. Unskilled labor

The calculation of a conversion factor for unskilled labor could not be completed due to time and data limitations. A factor of 0.95 was assumed based on a comparison of the hourly earnings of rural and low-income urban HHs.

ANNEX 2. ANNEX B: EIRR TABLES

Output 2 - Green development mechanisms (CNY thousands)

				Project EIRR	**10.34%**
				NPV	**136,725**
Year	Capital Investment	Project Sales Revenues	Non-capital costs	Total eco benefits	Net Annual Value
2022	-656,911	0	0	0	-656,911
2023	-302,139	0	0	0	-302,139
2024	-30,917	0	0	0	-30,917
2025	-6,128	0	0	0	-6,128
2026	-6,128	0	0	0	-6,128
2027	-6,128	0	-5,813	182,014	170,073
2028	0	0	-15,232	182,014	166,782
2029	0	0	-16,073	182,014	165,941
2030	0	0	-16,073	182,014	165,941
2031	0	0	-16,073	182,014	165,941
2032	0	0	-16,073	182,014	165,941
2033	0	0	-16,073	182,014	165,941
2034	0	0	-16,073	182,014	165,941
2035	0	0	-16,073	182,014	165,941
2036	0	0	-16,073	182,014	165,941
2037	0	0	-16,073	182,014	165,941
2038	0	0	-16,073	182,014	165,941
2039	0	0	-16,073	182,014	165,941
2040	0	0	-16,073	182,014	165,941
2041	0	0	-16,073	182,014	165,941
2042	0	0	-16,073	182,014	165,941
2043	0	0	-16,073	182,014	165,941
2044	0	0	-16,073	182,014	165,941
2045	0	0	-16,073	182,014	165,941
2046	0	0	-16,073	182,014	165,941
Residual	361,479				361,479

Output 3 - Rural waste and environmental sanitation management (CNY thousands)

				Project EIRR	**15.39%**
				NPV	**337,235**
Year	Capital Investment	Project Sales Revenues	Non-capital costs	Total eco benefits	Net Annual Value
2022	-85,641	0	0	0	-85,641
2023	-247,197	0	0	0	-247,197
2024	-152,603	0	0	0	-152,603
2025	-32,885	0	0	0	-32,885
2026	-14,792	0	0	0	-14,792
2027	-10,829	0	-7,182	140,224	122,213
2028	0	0	-10,071	140,224	130,153
2029	0	0	-12,908	140,224	127,316
2030	0	0	-12,908	140,224	127,316
2031	0	0	-12,908	140,224	127,316
2032	0	0	-12,908	140,224	127,316
2033	0	0	-12,908	140,224	127,316
2034	0	0	-12,908	140,224	127,316
2035	0	0	-12,908	140,224	127,316
2036	0	0	-12,908	140,224	127,316
2037	0	0	-12,908	140,224	127,316
2038	0	0	-12,908	140,224	127,316
2039	0	0	-12,908	140,224	127,316
2040	0	0	-12,908	140,224	127,316
2041	0	0	-12,908	140,224	127,316
2042	0	0	-12,908	140,224	127,316
2043	0	0	-12,908	140,224	127,316
2044	0	0	-12,908	140,224	127,316
2045	0	0	-12,908	140,224	127,316
2046	0	0	-12,908	140,224	127,316
Residual	194,997				194,997

Output 4 - Water and Soil Conservation Practices (CNY thousands)

				Project EIRR	**21.57%**
				NPV	**1,547,855**

Year	Capital Investment	Project Sales Revenues	Non-capital costs	Total eco benefits	Net Annual Value
2022	-181,362	0	0	0	-181,362
2023	-406,283	0	0	0	-406,283
2024	-367,454	0	0	0	-367,454
2025	-127,493	0	0	0	-127,493
2026	-20,232	0	0	0	-20,232
2027	-16,870	0	-1,829	418,114	399,416
2028	0	0	-7,707	418,114	410,407
2029	0	0	-13,481	418,114	404,633
2030	0	0	-13,481	418,114	404,633
2031	0	0	-13,481	418,114	404,633
2032	0	0	-13,481	418,114	404,633
2033	0	0	-13,481	418,114	404,633
2034	0	0	-13,481	418,114	404,633
2035	0	0	-13,481	418,114	404,633
2036	0	0	-13,481	418,114	404,633
2037	0	0	-13,481	418,114	404,633
2038	0	0	-13,481	418,114	404,633
2039	0	0	-13,481	418,114	404,633
2040	0	0	-13,481	418,114	404,633
2041	0	0	-13,481	418,114	404,633
2042	0	0	-13,481	418,114	404,633
2043	0	0	-13,481	418,114	404,633
2044	0	0	-13,481	418,114	404,633
2045	0	0	-13,481	418,114	404,633
2046	0	0	-13,481	418,114	404,633
Residual	401,395				401,395

Overall Project (CNY million)

Project EIRR **12.17%**
NPV **1,104,950**

Year	Capital Invest.	OM costs	BENEFITS									Net Annual Value
			WS	WW	SW	Green Agric.	Tour'm	WQ	Forest	Wet-land	Health	
2022	-1243.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1243.1
2023	-1150.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1150.8
2024	-740.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-740.0
2025	-363.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-363.5
2026	-176.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-176.7
2027	-143.5	-15.0	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	581.9
2028	0.0	-44.2	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	696.2
2029	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2030	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2031	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2032	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2033	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2034	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2035	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2036	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2037	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2038	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2039	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2040	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2041	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2042	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2043	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2044	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2045	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
2046	0.0	-54.6	15.3	8.0	82.5	33.7	146.9	192.6	225.7	8.6	26.9	685.7
Residual												1368.5

ANNEX 3. ANNEX C: ECONOMIC BENEFITS

A. INTRODUCTION

1. This annex documents work completed on project benefits for the Jiangxi Ganzhou Rural Vitalization and Comprehensive Environment Improvement Project. The work was undertaken to provide a means of estimating the benefits associated with the Project outputs.

2. Following sections of this appendix deal with the valuation of wastewater improvements, water supply improvements, health benefits, instream water quality improvements, wetland, and afforestation.

B. WILLINGNESS TO PAY FOR WASTEWATER SERVICE IMPROVEMENTS

3. A CV study dealing with rural wastewater services was conducted in 2020 for the Hunan Miluo River Disaster Risk Management and Comprehensive Environmental Improvement Project (ADB TA 9753 PRC, Project Number: 53042-001). This study, located in Pingjiang County, Hunan Province is about 400 km from Ganzhou, is considered an appropriate candidate for benefits transfer.[23] WTP for the project area was estimated using income and HH statistics for the project site. Detailed calculations are shown below. The resulting estimate of household WTP for wastewater services is CNY 16.4 per month or CNY 197 per year.

Table 10 WW WTP Regression Results

Regression model – OLS, Dependent variable = **Ln (WTP)** N = 531, R-bar squared = 0.378, F[5,422] = 30.302 P(F) > F* = 0.00000					
Regressor	**Definition**	**Coefficient**	**Standard Error**	**z**	**Prob │z│>Z***
Constant	Constant	-0.2096	0.45894	-0.46	0.6479
ENUMR2	Enumerator ID 1	.47540***	0.09484	5.01	0
ENUM345	Enumerator ID 2	-.59957***	0.06674	-8.98	0
TN_SANY	Township=Sanyang	.35808***	0.11728	3.05	0.0023
A18EDU5	Respondent education = Junior College and above	.25196**	0.10774	2.34	0.0194
A18EDU1	Respondent education = primary	-.15879**	0.07278	-2.18	0.0291
A110OC08	Respondent occupation = Responsible for housework	-.29137***	0.10455	-2.79	0.0053
LN_HHINC	Ln (HH income, CNY/year)	.31215***	0.04029	7.75	0
Agreement with: (strong agreement = 1, strong disagreement = 0)					
B7GOVRES	"wastewater is the government's responsibility"	-.65404***	0.19083	-3.43	0.0006
B7AFFORD	"I can't afford any new expenditure"	-.48708**	0.20252	-2.41	0.0162

[23] M. Fortin, 2020. Supplementary Document 13: Detailed Economic Analysis. Project Number: 53042-001 July 2020, Hunan Miluo River Disaster Risk Management and Comprehensive Environmental Improvement Project. See Annex C: Economic Benefits, Part B. Willingness to Pay for Village Wastewater Service Improvements.

Table 10 WW WTP Regression Results

Regression model – OLS, Dependent variable = **Ln (WTP)**
N = 531, R-bar squared = 0.378, F[5,422] = 30.302 P(F) > F* = 0.00000

Regressor	Definition	Coefficient	Standard Error	z	Prob |z|>Z*
B7WWPBLM	"Wastewater is not a problem here"	.49818***	0.1677	2.97	0.003
B8WSSICK	"Sickness caused by poor water is a serious problem"	.38267***	0.08791	4.35	0

Note: ***, **, * → Significance at 1%, 5%, 10% levels.

Table 11 Variables used in WW WTP analyses*

Regressor	Coefficient	Pingjiang County Average	Ganzhou Average*
Constant	-0.2096	1.0	1.0
ENUMR2	0.4754	0.132	***0.0*** [a]
ENUM345	-0.59957	0.338	***0.0*** [a]
TN_SANY	0.35808	0.006	***0.0*** [a]
A18EDU5	0.2519	0.204	***0.1217*** [b]
A18EDU1	-0.15879	0.086	***0.0345*** [b]
A110OC08	-0.29137	0.084	0.084
LN_HHINC	0.31215	11.0347	***10.2771*** [c]
B7GOVRES	-0.65404	0.489	0.4890
B7AFFORD	-0.48708	0.498	0.4980
B7WWPBLM	0.49818	0.356	0.3560
B8WSSICK	0.38267	0.3677	0.3677
Estimated WTP CNY/mo, 2020		18.3603	16.4263

* Variables adjusted to reflect the policy site are italicized. \a assumed; \b CHINA STATISTICAL YEARBOOK, 2020, Table 2-14; \c Ganzhou Statistical Yearbook, 2019.

C. WILLINGNESS-TO-PAY FOR VILLAGE SOLID WASTE MANAGEMENT IMPROVEMENTS

4. A benefits transfer analysis was completed to value solid waste service improvements. One useful CV study dealing with solid waste in the People's Republic of China was located (described below). The results of this study were used to derive an estimate of household WTP for solid waste collection of CNY327 per year. This estimate of the WTP is based on income and household statistics for the project site and is updated to 2020 price levels. Detailed calculations are shown below.

Hua Wang, Jie He, Yoonhee Kim, Takuya Kamata, 2011. Municipal Solid Waste Management in Small Towns, An Economic Analysis Conducted in Yunnan, China. *Policy Research Working Paper*. 5767. The World Bank Development Research Group, Environment and Energy Team.
ABSTRACT (from original): Municipal solid waste management continues to be a major challenge for local governments in both urban and rural areas across the world, and one of the key issues is their financial constraints. Recently, an economic analysis was conducted in Eryuan, a poor county located in the Yunnan Province of the People's Republic of China, where the willingness-to-pay (WTP)

for an improved solid waste collection and treatment service was estimated and compared with the project cost. This study finds that the mean WTP is about 1% of household income and the total WTP can basically cover the total cost of the project. The analysis also shows that the poorest households in Eryuan are not only willing to pay more than the rich households in terms of income percentage in general, but also are willing to pay not less than the rich in absolute terms where solid waste services are not available. The poorest households have stronger demand for public solid waste management services, while the rich have the capability to take private measures when public services are not available.
STUDY AREA: Yunnan Province, People's Republic of China
PERIOD OF ANALYSIS: 2007
SAMPLE SIZE: 221 households, 110 with a solid waste service, 113 in areas to receive a service. 218 valid responses.
MODEL AND ESTIMATOR: multiple bounded discrete choice question, Logit regression to determine each respondent's most probable bid followed by ordinary least squares regression to explore the resulting bid database. With multiple bounded discrete choice questions, response options to each offer are "Definitely No", "Probably No", "Not Sure", "Probably Yes", and "Definitely Yes". Thus, each respondent assigns an implicit probability to every offer. Offers range from CNY3/month to CNY500/month and are not varied across respondents.
COMMENT: Excellent study with a good review of past work in the area. Sample size seems small. Regression results probably could be used in a benefits transfer exercise.

5. The benefits transfer calculation is shown in Table A3-5. Variable statistics for the research site are shown along with assumed values for the policy site. The household WTP for solid waste management is CNY18.35 per month at 2006 price levels or CNY27.3 per month (CNY327.3 per year) at 2020 price levels.

Table 12 Table A3-5: Variables Used in Solid Waste Management WTP Analyses

Variable	Mean	Standard Deviation	Minimum	Max	Policy Site[a]	Model Coefficient[b]	t-Scores[c]
University diploma, yes = 1, no = 0	0.16	0.37	0.00	1	0.16	0.063	(0.35)
Sex: male = 1 female =0	0.60	0.49	0.00	1	0.50	0.112	(0.95)
Respondent Age (years)	37.57	11.39	17.00	78	37.57	-0.002	(0.41)
HH head's profession: farmer = 1, other = 0	0.44	0.50	0.00	1	0.44	-0.013	(0.11)
Married (married = 1, other = 0)	0.88	0.32	0.00	1	0.88	-0.169	(0.85)
Household income (CNY '000) in 2006 (log value used in equation)	22.33	33.75	0.50	200	30.37	0.247	(8.97) ***
Family size (person)	4.59	1.74	1.00	15	3.87	-0.030	(1.02)
Do you expect your household income to decrease in future 5 years? yes = 1, no = 0	0.09	0.29	0.00	1	0.09	-0.428	(2.34) **
Donation for social charity before? (yes = 1, no = 0) past	0.77	0.42	0.00	1	0.77	0.254	(1.96) *
Solid waste considered as one of the three most important environmental problem: yes = 1, no = 0	0.85	0.36	0.00	1	0.85	0.373	(2.63) ***
Do you think environmental problems should only be resolved by government? yes = 1, no = 0	0.13	0.33	0.00	1	0.13	-0.380	(3.04) ***
Estimated household WTP/month,	16.88	20.60	1.49	200	18.35		

Table 12 Table A3-5: Variables Used in Solid Waste Management WTP Analyses

CNY 2006							

( ) = negative value, CNY = Chinese yuan, WTP = willingness-to-pay.
[a] Variables adjusted to reflect the policy site are italicized. Income data for 2018 adjusted back to 2006 price levels using consumer price index.
[b] R-squared = 0.92; F statistic = 213.65.
[c] *** denotes 1% significance level, ** refers 5% significance level, and * indicates 10% significance level.
Source: Asian Development Bank estimates.

D. WILLINGNESS TO PAY FOR WATER SUPPLY IMPROVEMENTS

6. Only one useful CV study dealing with rural water supply in China was located (described below). This study concerns rural WS, and it is on the Yangtze River about 800 km from Ganzhou, so it is considered an appropriate candidate for benefits transfer. WTP for the project area was estimated using income and HH statistics for the project site updated to 2020 price levels. Detailed calculations are shown below. The resulting estimate of household WTP for water supply services is CNY 33.4 per month or CNY 401 per year.

Jin Jianjun, Wang Wenyu, Fan Ying, Wang Xiaomin, 2016. **Measuring the willingness to pay for drinking water quality improvements: Results of a contingent valuation survey in Songzi, China**. Journal of Water and Health · January 2016. doi: 10.2166/wh.2016.247.
ABSTRACT (from original)**:** The aim of this study is to elicit residents' willingness to pay (WTP), by applying the contingent valuation method as a surcharge on their water bill, for a given improvement in the drinking water quality and the supply reliability. The mean WTP for the drinking water quality improvement program was estimated to be 16.71 yuan (0.3% of total household income). The results note that more educated respondents and households with higher income and with fewer household members are, on average, willing to pay more. This study also demonstrates that respondents' concerns regarding drinking water quality and perceptions of the health risk of drinking water quality can have significant positive impacts on people's WTP. The research results can help decision-makers understand the local population's demand for improved drinking water quality and undertake an environmental cost–benefit analysis.
STUDY AREA: Hubei Province
PERIOD OF ANALYSIS: 2011
SAMPLE SIZE: 200 households, 268 valid responses.
MODEL AND ESTIMATOR: single-bound dichotomous choice question, Logit regression to evaluate determinants of respondent bids. Offers range from CNY 2/month to CNY 40/month and are varied randomly across respondents.
COMMENT: Excellent study with a good review of past work in the area. Sample size seems small. Reported regression results support a benefits transfer exercise.

7. The benefits transfer calculation is shown in Table 14. Variable statistics for the research site are shown along with assumed values for the policy site. The HH WTP for SW services is CNY 26.96 per month at 2011 price levels or CNY 33.38 per month (CNY 401 per year) at 2020 price levels.

Table 13 Descriptive statistics

Variable Definition	Mean	Std. Dev.	Min	Max
Gender - Binary variable, 1 if respondent is male; 0 otherwise	0.37	0.48	0	1
Age - Age of the respondent	52	11	20	70
Marriage - Binary variable, 1= married; 0 = otherwise	0.89	0.32	0	1

Education - Education of respondents (1 = No formal schooling, 2= Elementary, 3= Middle school, 4= College, 5= Master's or above)	2.47	0.93	1	5
Hhsize - Number of household members living together	4.61	1.71	1	10
Kids - Number of children less than 5 years old	0.27	0.45	0	1
Hincome - Household income (yuan/month)	3373	2730	500	12000

Table 14 Variables used in WS WTP analyses*

Variable	Model coefficient	t-scores	Research site	Policy site**
Constant	0.01	0	1	1
Bid	0.07***	4.54	na	Na
Gender	0.22	0.57	0.37	***0.5***
Age	0.03	1.33	52	52
Drinking Water important	0.89**	2.23	1	1
Health risk	0.52***	2.56	1	1
Education	0.48*	1.88	2.47	***2.76***
Hhsize	0.22*	1.66	4.61	***3.03***
Hincome	0.19**	2.2	3.373	***5.88***
Estimated WTP, 2011 CNY/mo**			16.08	26.96

* Log Likelihood = -88 (Prob>*chi2* = 0.000), Pseudo R-squared = 0.24; *** denotes 1% significance level. ** refers 5% level and * indicates 10% level
** Variables adjusted to reflect the policy site are italicized. Income data for 2020 adjusted back to 2011 price levels using CPI.
*** Estimated as: =LN (1+EXP (intercept'))/ (-bid coefficient) where intercept' is the sum of the product of non-bid coefficients (including the intercept term) times variable values.

E. HEALTH BENEFITS

8. A health benefits analysis was completed to complement the SW and WW WTP analysis. Considering the possibility of double counting if both approaches to benefits assessment are used, the rationale for this analysis is the likelihood that rural village residents are poorly informed about the health effects of poor sanitation and will underestimate their WTP accordingly.

9. The analysis is based on findings of the report: Economic Assessment of Sanitation Interventions in Yunnan Province, People's Republic of China A six-country study conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines, and Vietnam under the Economics of Sanitation Initiative (ESI) September 2012, THE WORLD BANK Water and Sanitation Program East Asia & the Pacific Regional Office.

10. Results of the analysis are summarized in Table 15. Original values in the referenced report were converted to 2020 CNY values and total benefits were estimated using recent population data. The total per capita benefit, CNY 153/year, implies a HH benefit of CNY 593/year.[24] This measure of benefit double counts WW management benefits which are also

[24] HH size = 3.33, Yueyang Statistical Yearbook, 2019

captured by the estimate of HH WTP documented in Section A of this ANNEX. The HH WTP amount is CNY 16.43 per month or CNY 197 per year; only 33% of the estimated health benefits. This disparity is likely caused by incomplete information on the part of survey respondents. We therefore include only 1/3rd of estimated health benefits in our analysis of WW management benefits.

Table 15 Health Benefits Analysis (CNY 2018 per person)

DISEASE CLASS	Age class			Weighted Average**
	0-4 yrs	5-14 yrs	15+ yrs	
Annual Costs Per Person Attributed to Poor Sanitation and Hygiene				
Diarrheal disease, hepatitis A & E	196.5	140.7	83.6	99.7
Soil-transmitted helminthes	50.1	60.2	38.9	43.0
Hygiene-related	219	108.4	71.4	86.5
BENEFIT*	46.1	33.0	19.6	23.4
Average annual productivity cost/person in field sites, by disease, age group and rural/ urban location				
Diarrheal disease, hepatitis A & E	111.7	70.2	82.9	82.7
Soil-transmitted helminthes	31.5	37.7	48.5	45.7
Hygiene-related	127.2	68.3	93.1	91.3
BENEFIT*	26.2	16.5	19.4	19.4
Average annual mortality cost/person in field sites, by disease, age group and rural/urban location				
Diarrheal disease, hepatitis A & E	553.40	663.7	427.6	472.7
Soil-transmitted helminthes	110.2	110.2	110.2	110.2
Hygiene-related	517	352.8	242.4	277.0
BENEFIT*	129.7	155.6	100.2	110.8
TOTAL BENEFIT	201.9	205.0	139.2	153.5

NOTES:
* Based on estimates of relative risk reductions in disease incidence and prevalence as follows: Improvement from "Unimproved pit latrines (excreta partially isolated) – without hygiene" to "Septic tanks with emptying and treatment or sewerage with full wastewater treatment – without hygiene". Reduction of 31.3% for Diarrheal disease, hepatitis A & E; 60.0% for soil-transmitted helminthes; and 0.0% for hygiene-related diseases.
** Based on the 2018 population age distribution for Ganzhou Municipality (GANZHOU STATISTICAL YEARBOOK, 2019, Table 2-4)

F. WATER QUALITY BENEFITS

11. Pollution control measures for the Gan River system will benefit downstream urban residents in the Ganzhou urban area. Valuation for this project is based on research in Huaping Co. in Northern Yunnan summarized in Table 16. Huaping Co. is a county level city like Ganzhou. Both are more southerly cities, and both are on rivers having impaired water quality. Values from this paper below were used for a benefits transfer calculation.

Table 16 Review of Water Quality Valuation Studies

Hua Wang, Jie He, Yoonhee Kim, Takuya Kamata, 2013. **Willingness-to-pay for water quality improvements in Chinese rivers: An empirical test on the ordering effects of multiple-bounded discrete choices**. Journal of Environmental Management 131 (2013) 256-269

ABSTRACT (from original)**:** This paper presents a study of the willingness-to-pay (WTP) for surface water quality improvement in China. In the Huaping County of Yunnan Province, we found that people are willing to pay 74 Yuan (or US€12.33 in 2012 prices) per household per month (or 5% of household income) continuously for five years to achieve an improvement of water quality in the two major local rivers from the current Grade IV to Grade III, which denotes a level suitable for swimming and fishing and matches the water quality level from 10 years ago. This WTP study is based on an actual investment project that was under serious consideration by the government and is based on the multiple-bounded discrete choice (MBDC) approach, which explicitly recognizes the potential uncertainties involved in the study. The potential ordering effects associated with the MBDC approach are empirically tested, and the results indicate that although the presentation order of the polychotomous likelihood choices may not have a significant impact on the WTP estimation, the presentation order of bid levels may have a significant impact.

STUDY AREA: Yunnan, China
PERIOD OF ANALYSIS: 2007
SAMPLE SIZE: 460
MODEL AND ESTIMATOR: Multi-bounded discrete choice

12. Regression coefficients from the Yunnan study are provided in Table 17 and data averages for the research and policy site are provided in Table 18 along with estimates of HH WTP. Estimated WTP for the policy site is CNY 115/month for 5 years. At 2020 price levels this amounts to CNY171/month. This estimate, once converted to an ongoing payment assuming a 6% discount rate, is CNY 43.2/month.[25] On an annual basis, the WTP is CNY 519/year or 0.54% of HH disposable income.

Table 17 Description and statistics of Regression model variables for the Hua Wang et.al. Paper

Variable	Description	Coefficient	t-score
Sex	Male = 1; female = 0	0.588	0.08
Age	Years of age	-0.245	-0.75
Income	Household income in the year of 2006 (1000 Yuan)	1.383	3.98***
Education	Primary education and above = 1; other = 0	14.653	1.55
Married	Married = 1; otherwise = 0	-7.943	-0.56
Income growth	Did your income increase from 2005 to 2006? Yes = 1; otherwise = 0	12.515	1.68*
Irrigation	Did you use the water for irrigation in 2006? Yes = 1; otherwise = 0	10.444	1.54
Water quality	1 = consider water quality to be one of the three most urgent problems; 0 = otherwise	4.138	0.6
Env. donation	Would you donate for environmental protection? Definitely/probably yes = 1; otherwise = 0	16.566	2.27**
Press	Did you hear press discussion about the water quality in 2006? Yes = 1; no or don't know = 0	17.41	2.94***

[25] Calculated as the NPV of payments over 5 years amortized over 99 years all at 6%. 6% is used because this is an environmental benefit. At 9%, the annual WTP is CNY 736/HH which increases overall EIRR marginally.

Table 17 Description and statistics of Regression model variables for the Hua Wang et.al. Paper

Heard	Did you hear about the project? Yes = 1; no = 0	9.276	1.42
Income increases with water improvement	Would your income increase with the water quality improvement? Yes = 1; no or don't know = 0	15.452	2.30**
Income reduces with project construction	Would the construction of sewers and the wastewater treatment plant decrease your household income? Yes = 1; no or don't know = 0	-19.04	-1.85*
Scope	Target of water quality improvement: Grade II = 1; Grade III = 0	5.432	0.84
High-to-low	Bid price order: 1 = high-to-low; 0 = low-to-high	16.443	-2.60***
Yes-to-no	Likelihood order: 1 = yes-to-no; 0 = no-to-yes	4.155	0.62
One-to-one	1 = one-to-one interview; 0 = group but self-completion with instructions	-5.447	-0.78
Constant		-14.839	-0.58

NOTE: R-squared = 0.18, *** denotes 1% significance level. ** refers 5% level and * indicates 10% level.

Table 18 Data Averages and Estimated WTP

Variable	Research site	Policy site	Comment
Sex	0.71	***0.5***	assumed
Age	41.5	41.5	Original used
Income	15.27	***64.04***	See note
Education	0.97	0.97	Original used
Married	0.94	0.94	Original used
Income growth	0.46	0.46	Original used
Irrigation	0.44	***0***	assumed
Water quality	0.63	0.63	Original used
Env. donation	0.88	0.88	assumed
Press	0.57	0.57	assumed
Heard	0.6	0.6	assumed
Income increases with water improvement	0.4	***0***	assumed
Income reduces with project construction	0.1	0.1	Original used
Scope	0.49	***0***	assumed
High-to-low	0.5	0.5	Original used
Yes-to-no	0.5	0.5	Original used
One-to-one	0.61	***0.5***	assumed
Estimated WTP, CNY/month for 5 years	60.21	114.7	

Table 18 Data Averages and Estimated WTP

Variable	Research site	Policy site	Comment

NOTE: Income estimated using 2019 per capita urban income for Ganzhou adjusted to 2006 with CPI and converted to HH income assuming 3.59 persons per HH (GANZHOU STATISTICAL YEARBOOK, 2019)

G. WETLAND BENEFITS

13. Several published valuation studies were reviewed as a source of information to assign value to wetland benefits (Table 20). Values from the first paper reviewed below were used for evaluation here since this paper considers restoration of a degraded riverine wetland in south China as does the current project. They are summarized in Table 19. The total value of CNY 25,837/ha converts to CNY 38,409 at 2020 price levels.

Table 19 Wetland Values, CNY 2006

2006 prices	CNY/ha	Proportion of Total Benefit	Values Used for this Project	Comment
Material production	7,410	13%	7,410	included
Water Supply	5,695	10%	0	Accounted for under WQ benefit
Environment Purification	23,800	43%	0	
Disturbance regulation	7,627	14%	7,627	included
Gas regulation	7,288	13%	7,288	included
Biodiversity support	3,512	6%	3,512	included
Total	55,332		25,837	

Source: C. Tong, R.A. Feagin, J. Lu, X. Zhang, X. Zhu, W. Wang, W. He, 2007.

Table 20 Review of Wetland and Green Space Valuation Studies

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

ABSTRACT (from original)**:** Over the course of a year, we conducted a study on future restoration work in the Sanyang wetland, a degraded permanent river wetland that is close to the center of Wenzhou city, China. Our main objective was to plan the restoration by using both structural indices and a valuation of the wetland's ecosystem services, thereby linking the science to human welfare. Based on, field surveys and research into the history of the study area, we calculated both the potential and current values of the main ecosystem services. The results showed that the potential value at the Sanyang wetland was 55,332 yuan ha-1 yr-1, while the current value was only 5807 yuan ha-1 yr-1. In other words, 89.5% of the service value needs to be restored for the wetland to reach its potential value. We recommend that the service provided by the wetland's ability to purify the environment needs to be the top priority in restoration. In addition, water and sediment quality should also be greatly improved.

STUDY AREA: Wenzhou, China

PERIOD OF ANALYSIS: 2002

SAMPLE SIZE: na

MODEL AND ESTIMATOR: benefits transfer

COMMENT: The subject wetland is a large (11.41 km^2) degraded natural wetland. Values for ecological services are derived from Costanza and other authors.

Wendy Y. Chen and C.Y. Jim, 2008. **Cost–benefit analysis of the leisure value of urban greening in the new Chinese city of Zhuhai**, Cities 25:298–309 **ABSTRACT** (from original)**:** Nature in cities is increasingly preserved or created to improve urban environmental quality. Green space provision is proceeding apace in many Chinese cities. Cost–benefit analysis of such projects is needed to justify the level of investment and the use of public funds. This paper assessed the use pattern of urban green spaces in the new Zhuhai city in south China and employed the contingent valuation method to estimate the non-market leisure value of an ambitious new urban greening project. A questionnaire survey of 850 randomly chosen households was conducted. Some 65.7% of respondents used public green spaces for leisure frequently and young residents aged 20–30 were less frequent users. The new greening project was strongly supported for its leisure and ecological values. The logit regression model indicated that household income and bid amount would affect individual willingness-to-pay (WTP). The mean WTP was RMB161.84 per household per year, translated into an aggregate leisure value of RMB12.3 million per year. The net present value is projected to be RMB-32.94 million and the discounted benefit–cost ratio is 0.88 when other benefits were not included. The findings confirmed community support and verified the application of cost–benefit analysis in projects related to non-market public goods, and the applicability of contingent valuation method in the Chinese context. The study could serve as the basis to launch other cost–benefits analysis of nature conservation projects which need urgent attention in view of the rapid pace of urbanization in China to contribute to sustainable city goals. **STUDY AREA:** Zhuhai, Guangdong Province **PERIOD OF ANALYSIS:** 2006 **SAMPLE SIZE**: 850 (598 valid) **MODEL AND ESTIMATOR**: double-bounded dichotomous, logistic regression **COMMENT**: May be useful for urban greening. Income was the only variable in the WTP equation.
Wu Yang, Jie Chang, Bin Xub, Changhui Peng, Ying Ge, 2008. **Ecosystem service value assessment for constructed wetlands: A case study in Hangzhou, China**. Ecological Economics 68(2008)116–125 **ABSTRACT** (from original)**:** Based on a comprehensive analysis of various classifications of natural resource values, we summarized an ecological economic value system of constructed wetland (CW) ecosystems for treating eutrophic water. Using the CW located at the Hangzhou Botanical Garden as an example, the contingent valuation method (CVM) and shadow project approach (SPA) were applied to estimate the economic values of CW system ecosystem services. The CVM estimated a value of 800,000 yuan (yuan: Chinese Currency, 7.6 yuan=1 USD as of August 2007) as the total economic value of the CW in a twenty-year period. Meanwhile, the SPA calculated a value of 23.04 million yuan as the total economic value of the CW in a twenty-year period. It is determined that compared to the CVM, the SPA provides a more approximate value of the true monetary value of the Hangzhou Botanical Garden CW. This study could fill the gap of knowledge and provide a benchmark when evaluating constructed ecosystem services and help policy makers to promote the development of constructed wetlands in China. **STUDY AREA:** Hangzhou, China **PERIOD OF ANALYSIS:** 2007 **SAMPLE SIZE**: 300 (294 valid) **MODEL AND ESTIMATOR**: payment card question, OLS estimation **COMMENT**: Final equation includes only income as an independent variable. Study is not relevant due to the context: small (800 m^2) constructed urban wetland used to treat fishpond wastewater, WTP was only for the treatment function.
A. Ghermandi, J.C.J.M. van den Bergh, L.M. Brander, H.L.F. de Groot, P.A.L.D. Nunes, 2009. **The Values of Natural and Constructed Wetlands: A Meta-Analysis**. TI 2009-080/3 Tinbergen Institute Discussion Paper **ABSTRACT** (from original)**:** The values of goods and services provided by natural and constructed wetlands are examined through a meta-analysis of 418 observations of the economic value of 186 wetlands. Water quality improvement, non-consumptive recreation, and provision of natural habitat and biodiversity turn out to be highly valued services. Substitution effects are observed through the negative correlation between values and proximity to other wetlands. Values are found to increase with

anthropogenic pressure. Constructed wetlands are highly valued for biodiversity enhancement, water quality improvement, and flood control. This study provides a substantially new contribution in relation to previous meta-analyses of the wetland valuation literature.
STUDY AREA: na
PERIOD OF ANALYSIS: na
SAMPLE SIZE: 418 primary valuation studies comprising 132 from North America, 106 from Asia, 93 from Europe, 53 from Africa, 22 from South America and 16 from Australasia.
MODEL AND ESTIMATOR: ordinary and weighted least squares
COMMENT: The current interest pertains to passive or recreation values. In this meta-analysis, identified estimates of these values ranged between €101 and €9,144/ha/annum. Applying their basic model (model B in table 3) gives a wetland value for non-consumptive recreation of 2015 RMB 128/ha (2003 €11.43/ha):

Independent Variable	Coefficient	Variable value	Comment
Year of publication	-0.041	21.77	Regression data mean
Marginal	0.713	0.12	Regression data mean
Estuarine	0.27	0	Based on characteristics of the proposed project (setting Lacustrine value at 1 gives the same total value)
Marine	0.754	0	
Riverine	0.38	1	
Palustrine	-0.48	0	
Lacustrine	0.332	0	
Constructed	1.023	1	
Wetland size	-0.234	-1.7148	FSR 06.15 新余景观部分可研(A4).docx -图 3.1-1 本次景观规划总平面
Flood control, storm buffering	0.432	0	Evaluated separately
Surface & groundwater supply	-0.099	0	na
Water quality improvement	0.727	0	Evaluated separately
Commercial fishing & hunting	0.266	0	na
Recreational hunting	-1.007	0	na
Recreational fishing	-0.082	0	na
Harvesting of natural materials	-0.202	0	na
Fuel wood	-0.968	0	na
Non-consumptive recreation	0.67	1	Intended use
Amenity and aesthetics	0.529	0	na
Natural habitat, biodiversity	1.143	0	na
Medium-low human pressure	0.572	0	assumed
Medium-high human pressure	1.243	0	assumed
High human pressure	1.992	1	assumed
GDP per capita	0.358	8.67	Xinyu 2014 per capita GDP in RMB - Jiangxi 2015 yearbook table 1-6 Inflation and exch. rates from ADB Key Indicators for Asia and the Pacific 2015. (log value)
Population in 50km radius	0.399	14.96	Population of Xinyu prefecture (log value)
Wetland area in 50km radius	-0.058	7.17	Interim report, pg 56 (log value)
Constant	-0.681	1	

S. B. Lu, S. G. Xu, and F. Feng, 2012. **Floodwater utilisation values of wetland services – a case study in Northeastern China**. Nat. Hazards Earth Syst. Sci., 12, 341–349, 2012
ABSTRACT (from original)**:** Water plays a significant role in wetlands. Floodwater utilisation in wetlands brings a wide range of wetland services, from goods production and water regulation to animal protection and aesthetics related to water supply in wetlands. In this study, the floodwater utilisation values of wetland services were estimated within the Momoge wetland and Xianghai wetland in western Jilin province of northeastern China. From 2003 to 2008, the floodwater diverted from the Nenjiang and Tao'er River is 381 millionm3, which translates into a monetary value of approximately 1.35 billion RMB in 2008 (RMB: Chinese Currency, RMB 6.80 = US€ 1), and the ratio of economic value, eco-environmental value, and social value is 1:12:2. Besides the monetary value of the water itself, excessive floodwater utilisation may

bring losses to wetlands; the threshold floodwater utilisation volumes in wetlands are discussed. Floodwater utilisation can alleviate water shortages in wetlands, and the evaluation of floodwater utilisation in wetland services in monetary terms is a guide for the effective use of the floodwater resources and for the conservation of wetlands.
STUDY AREA: western Jilin province, China
PERIOD OF ANALYSIS: 2003 to 2008
SAMPLE SIZE: na
MODEL AND ESTIMATOR: na
COMMENT: Valuation of benefits by various means. Recreation benefits are estimated using a travel cost model, but no details are provided.

Zhang Yiran, Zhou Demin, Niu Zhenguo, Xu Fengjiao, 2014. **Valuation of lake and marsh wetlands ecosystem services**. China. Chinese Geographical Science, 24(3): 269–278
ABSTRACT (from original)**:** Wetlands are highly productive natural ecosystems, providing valuable goods and services. There is growing interest in transferring ecosystem service value from the existing wetlands studied to other wetlands ecosystems at a large geographic scale. The benefit transfer method uses the known values from wetlands to predict the value of other wetland sites. This methodology requires only limited time and resources. The present study calculated the value of the ecological services provided by lake and marsh wetlands in China in terms of biodiversity indices, water quality indices and economic indices. Basic data on wetlands were obtained through remote sensing images. The results show that: 1) The total ecosystem service value of the lake and marsh wetlands in 2008 was calculated to be 8.1841 × 1010 United States Dollars (USD), with the marsh and lake wetlands contributing 5.6329 × 1010 and 2.5512 × 1010 USD, respectively. Values of marsh ecosystem service were concentrated in Heilongjiang Province (2.5516 × 1010 USD), Qinghai Province (1.2014 × 1010 USD), and Inner Mongolia Autonomous Region (1.1884 × 1010 USD). The value of the lakes was concentrated in Tibet Autonomous Region (6.223 × 109 USD), Heilongjiang (5.810 × 109 USD), and Qinghai (5.500 × 109 USD). 2) Waste treatment and climate regulation services contributed to 26.29% and 24.74% respectively, of the total ecosystem service value of the marsh wetlands. Hydrological regulation and waste treatment contributed to 41.39% and 32.75%, respectively, of the total ecosystem service value of the lake wetlands. 3) The total ecological service value of the lake and marsh wetlands was 54.64% of the total service value of natural grassland ecosystems and 30.34% of the total service value of forests ecosystems in China.
STUDY AREA: China
PERIOD OF ANALYSIS: Socio-economic data from 2008
SAMPLE SIZE: na
MODEL AND ESTIMATOR: na
COMMENT: Could apply to wetland valuation but must screen benefit categories for relevance.

M. Chaikumbung, C. Doucouliagos and H. Scarborough, 2015. **The economic value of wetlands in developing countries: A meta-regression analysis**. ECONOMICS SERIES SWP 2015/10, Department of Economics, Deakin University, Australia.
ABSTRACT (from original): This paper presents the first comprehensive synthesis of economic valuations of wetlands in developing countries. Meta-regression analysis (MRA) is applied to 1432 estimates of the economic value of 379 distinct wetlands. We find that wetland size has a negative effect on wetland values, marine wetlands are more valuable than estuarine wetlands, and per capita GDP has a positive effect on wetland values. Wetland services for water treatment and biodiversity are valued more highly than recreation. Wetland values estimated by stated preferences are lower than those estimated by market price methods. The MRA benefit transfer function has an average transfer error of 31%, with a median transfer error of 17%. Overall, MRA appears to be useful for deriving the economic value of wetlands at policy sites in developing nations.
STUDY AREA: na
PERIOD OF ANALYSIS: various
SAMPLE SIZE: 342 wetland sites from 50 developing countries in Asia, Africa, Latin America, and the Pacific Islands (37 from China). 1432 observations of values based on different methods.
MODEL AND ESTIMATOR: ordinary and weighted least squares, random effects, panel
COMMENT: Average wetland value is 2002 €1,998 /ha/year. This value includes all benefits.

Applying the coefficients of the general least squares model from Table 2 gives a wetland value for non-consumptive recreation of 2015 RMB 134/ha (2002 €11.56/ha):

Independent Variable	Coefficient	Variable value	Comment
Constant	5.018	1	
Size (ln area)	-0.374	-1.71	FSR 06.15 新余景观部分可研(A4).docx -图 3.1-1 本次景观规划总平面
Riverine	0.481	1	Based on characteristics of the proposed project (setting Lacustrine value at 1 gives the same total value)
Marine	1.137	0	
Constructed	-0.729	1	
Lacustrine	-0.017	0	
Palustrine	-1.471	0	
Other	0.087	0	
Storm or flood protection	0.465	0	Evaluated separately
Water regulation	1.944	0	na
Water supply	-1.07	0	na
Nutrient	1.475	0	na
Erosion	0.433	0	na
Carbon	-1.148	0	na
Water treatment	0.723	0	Evaluated separately
Biodiversity-Habitat	1.474	0	na
Food	-0.698	0	na
Raw materials	0.619	0	na
Culture	-0.028	0	na (recreation is the baseline category and is not included here)
Replacement cost	0.786	0	Regression data mean
Contingent Value	-1.746	1	Assumed
Choice Experiment	-1.182	0	Assumed
Travel Cost method	0.178	0	Assumed
Net factor income and Production function	1.027	0	na
Opportunity Cost	-1.476	0	na
Hedonic Pricing	-2.048	0	na
Avoided damage cost	0.739	0	na
Impact factor	-0.057	0.82	Regression data mean
Published paper	-0.781	0.48	Regression data mean
Thesis	-0.714	0.07	Regression data mean
Year of survey	-0.099	2.5	Regression data mean
Protected area	1.023	0	Assumed
Ramsar	-0.752	0	Assumed
Urban	1.672	1	Assumed
ln (GDP per capita)	0.694	8.67	Xinyu 2014 per capita GDP in RMB - Jiangxi 2015 yearbook table 1-6. Inflation and exch. rates from ADB Key Indicators for Asia and the Pacific 2015. (log value)
Absolute latitude	0.043	27	
ln (population density)	-0.039	5.89	Xinyu data from 2012 Jiangxi statistical yearbook, Table 2-4 人口自然变动情况 Population Natural Change

Middle East & North Africa	-0.321	0	Based on characteristics of the proposed project (east Asia is the baseline category)
South Asia	-0.232	0	
Africa	1.341	0	
Latin America	0.819	0	
Eastern Europe	1.781	0	

H. AFFORESTATION BENEFITS

14. Benefits from the proposed forest areas are associated with carbon fixation, oxygen production, air quality impacts, soil formation, recreation, and biodiversity. Several published valuation studies from the PRC were reviewed as a source of information to assign value to these benefits (Table 22). Values from these are summarized in Table 21. The study by Shixiong et.al. (2019) was selected since it is the most recent work and it distinguishes planted from natural forests. The value for planted forests, CNY 18,346/ha, is used for evaluation.

Table 21 Summary of Forest Values, CNY/ha

Study	Study Area	Reference year	Value in reference year	Value in 2020
Zhongwei G., Xiangming X., Yaling G., Yuejun Z., 2001	Hubei Province	1997	5,450	8,638
Wu Guo-yong, 2009	Guizhou Province	2008	26,022	34,842
Shixiong C., Junze Z., Wei S. 2019	PRC - all forests	2014	29,500	34,039
	PRC - planted forest	2014	15,900	18,346
	PRC - natural forest	2014	36,000	41,539
MA S., WANG J., 2013	Qinghai Province	2013	17,849	20,991
Jing Li, Zhiyuan Ren, Zixiang Zhou, 2006	Shaanxi Province	2005	11,119	16,802
AVERAGE				25,028

Table 22 Review of Forest Valuation Studies

Zhongwei G., Xiangming X., Yaling G., Yuejun Z., 2001. Ecosystem functions, services, and their values a case study in Xingshan County of China. *Ecological Economics*. 38 (2001). 141–154.

ABSTRACT (from original): Forest ecosystem services can provide both direct and indirect economic benefits. In this case study, at county-level, we estimated the annual economic value of some ecosystem services by forest ecosystems in the Xingshan County of Hubei Province of the People's Republic of China (PRC), using both simulation models and geographic information system that helps to analyze the effect of ecological factors (vegetation, soil, and slope) on ecosystem functions. Xingshan County is rich in forest resources, covering 50.64% of total land area in the county. In this study, we referred to ecosystem goods and services together as ecosystem services. The ecosystem goods include timber, other forest products, and forest tour; and produce a direct economic value about Chinese yuan (CNY) 54.23 million in 1997. The ecosystem services assessed relate to three aspects: water conservation, soil conservation, and gas regulation. Water conservation includes hydrological flow regulation and water retention and storage. Soil conservation relates to the reduction of land disuse, prevention of silt accretion, decrease of soil deposit, and protection of soil fertility. Gas regulation is by both carbon fixation and oxygen supply. These services provide an indirect economic value of CNY528.73 million per year based on our estimation. Thus, the total economic value of forest ecosystem services in the Xingshan County is estimated to be CNY582.96 million per year, being a part of actual ecosystem services. In addition, we analyzed the spatial distribution of forest capital stock in the county based on the economic values of forest ecosystem service. Our work can contribute to the conservation of the forest ecosystems and effective use of the ecosystem services.

STUDY AREA: Hubei Province, PRC

PERIOD OF ANALYSIS: 1997 **SAMPLE SIZE**: not applicable (NA) **MODEL AND ESTIMATOR**: various methods, including process-based calculations for soil erosion, water storage, etc. **COMMENT**: Based on data provided, the total value of ecological goods and services is CNY5,450/hectare (ha) at 1997 prices or CNY8,033 at 2018 price levels.
Wu Guo-yong, 2009. Measurement on Monetary Value of Forestry Multi-function: A Case of Danzhai County, Guizhou Province, China. *Asian Agricultural Research*. 2009 1(9). 25-28 **ABSTRACT** (from original): Forestry functions of Danzhai County are introduced from the aspects of physical production value, social service value, and ecological service value. Quantitative research on monetary value of the functions is conducted by using the replacement cost method, classification valuation method, and travel coat method. Result shows that the value of forestry production is CNY19.713 million; and the value of flood control and water conservation is CNY111.000 million, which is 5.63 times of forestry production value. Besides, the value of soil conservation and yield increase is CNY160.102 million, which is 8.12 times of the value of forestry production; the value of carbon fixation and oxygen release and air purification is CNY1,126.624 million, 57.15 times of the value of forestry production; and the value of the employment and income increase, and the landscape and recreation is CNY5,380 million, which is 0.27 times of the value of forestry production. Due to the important external role of the forestry, government should consider the multifunction of forestry when making policies to promote the effective development of forestry and the sustainable development of agriculture. **STUDY AREA:** Guizhou Province, PRC **PERIOD OF ANALYSIS:** 2008 **SAMPLE SIZE**: NA **MODEL AND ESTIMATOR**: various methods **COMMENT**: The total value for ecological goods and services provided by 54,677 ha is CNY1,422,818,000 or CNY26,022/ha at 2008 price levels. (CNY32,399 at 2018 prices).
Shixiong C., Junze Z., Wei S. 2019. Difference in the net value of ecological services between natural and artificial forests in China. *Conservation Biology*. Volume 00, No. 0, 1–8 **ABSTRACT** (from original): Land degradation is a global problem that seriously threatens human society. However, in the PRC and elsewhere, ecological restoration still largely relies on a traditional approach that focuses only on ecological factors and ignores socioeconomic factors. To improve the effectiveness of ecological restoration and maximize its economic and ecological benefits, a more efficient approach is needed that provides support for policy development and land management; and thereby promotes environmental conservation. We devised a framework for assessing the value of ecosystem services that remain after subtracting costs, such as the opportunity costs, costs of forest protection, and costs for the people who are affected by the program; that is, the net value of ecosystem services (NVES). To understand the difference between the value of a resource and the net value of the ecosystem service it provides, we used data on the NVES, timber sales, and afforestation costs from the PRC's massive national afforestation programs to calculate the net value of forest ecosystem services in the PRC. Accounting for the abovementioned costs revealed an NVES of ¥6.1 × 1012 for forests in 2014, which was 35.9% less than the value calculated without accounting for costs. As a result, the NVES associated with afforestation was 55.9% less than the NVES of natural forests. In some regions, the NVES was negative because of the huge costs of human-made plantations; high evapotranspiration rates (thus, high water opportunity costs); and low forest survival rates. To maximize the ecological benefits of conservation, it is necessary to account for as many costs as possible so that management decisions can be based on the NVES, thereby helping managers choose projects that maximize both economic and ecological benefits. **STUDY AREA:** PRC **PERIOD OF ANALYSIS:** 2014 **SAMPLE SIZE**: NA **MODEL AND ESTIMATOR**: benefits transfer **COMMENT**: The NCES was estimated to be CNY15,900/ha for planted forests, CNY36,000/ha for natural forests, and CNY29,500/ha for all forests (2014 prices). At current prices, the value of all forests is CNY31,652/ha.
MA S., WANG J., 2013. Empirical Analysis of Forest Landscape Value Assessment: Huangshui Forest

Park in Xining, Qinghai Province. *Journal of Landscape Research*. 2013, 5(6). 27-28.
ABSTRACT (from original): Questionnaire survey and contingent valuation method were adopted to evaluate economic value of the Huangshui Forest Park in Xining, Qinghai. Value of its forest landscapes was assessed. Multiple linear regression was established to analyze correlation between factors related to willingness-to-pay.
STUDY AREA: Qinghai Province, PRC
PERIOD OF ANALYSIS:
SAMPLE SIZE: NA
MODEL AND ESTIMATOR: benefits transfer
COMMENT: Interesting because of the use of contingent valuation method with park visitors to value this 89-ha forested park. Total park value is CNY21.9 million or CNY245,700/ha. The annualized value at 2018 price levels is CNY19,519/ha (6% discount rate, 30 years).

Jing Li, Zhiyuan Ren, Zixiang Zhou, 2006. Ecosystem services and their values: a case study in the Qinba mountains of China. *Ecological Research*. (2006) 2. 597–604.
ABSTRACT (from original): Terrestrial ecosystem services can provide both direct and indirect economic benefits. In this case study, we estimated the annual economic value of some ecosystem services provided by terrestrial ecosystems in the Qinba mountains of Shaanxi Province in the PRC, using both simulation models and a geographic information system that helps to analyze the effect of ecological factors on ecosystem functions. With respect to differences in vegetation types and their coverage by combining the latest research and using theory and methods for the value of terrestrial ecosystem services, we not only calculated goods produced by different types of vegetation; but also estimated the value of various terrestrial ecosystem services. We also set up a database and an eco-account of a terrestrial ecosystem. The ecosystem services assessed relate to the following aspects: the vegetation's primary productivity, soil and fertility conservation, water conservation, carbon fixation, and oxygen supply. The total economic value of terrestrial ecosystem services in the Qinba mountains was estimated to be CNY968.33 billion per year and represents a part of the actual ecosystem services. In addition, we analyzed the spatial distribution of the vegetation based on the economic values of the terrestrial ecosystem services. Our findings can contribute to the conservation of these terrestrial ecosystems and the effective use of these ecosystem services.
STUDY AREA: Shaanxi Province, PRC
PERIOD OF ANALYSIS: 2005
SAMPLE SIZE: NA
MODEL AND ESTIMATOR: benefits transfer
COMMENT: Total value amounts to CNY11,119/ha (2005 prices) or CNY15,624 at 2018 prices. Non-commercial ecological services account for 80% of this value.