People's Republic of China

Anhui Environmental Improvement Project for Municipal Wastewater Treatment and for Industrial Pollution Abatement

I. Background of the Project

The industrial and urban sectors in the PRC were undergoing unprecedented growth, especially in the eastern provinces.[17] During the past decade industrial production has more than doubled every five years in many regions, and the urban population is growing at more than 5 percent per year. At the same time, the industry sector is the largest source of air, water, and hazardous waste pollution in the country. In cities, industry typically accounts for more than 70 percent of wastewater generation. The general environment and pollution control infrastructure is under excessive stress from rapid growth; use of obsolete, polluting technology; and weaknesses in the legal, policy and regulatory framework concerning the environment. The deterioration of the environment is particularly acute in Anhui Province, a poor interior province (where GDP is about 58 percent of the national average), where 16 of the 76 counties are designated as poor.

Environmental problems in the PRC's major cities relate to urban air and water quality, wastewater treatment, and industrial solid wastes. In most large urban areas, untreated industrial wastewater is the predominant source of waterborne pollution. Of the 27 billion metric tons of industrial wastewater discharged annually in the PRC, less than 30 percent is treated. After treatment, only about half of industrial wastewater meets national effluent discharge standards, causing severe pollution of rivers and lakes.

---

[17] *This observation was made during project preparation and excludes trends in view of the Asian financial crisis.*

Chao Lake in Anhui Province is one of the five major lakes in PRC. It provides water for about 1.5 million urban residents, 2,600 industries, and 400,000 hectares (ha) of rice, and it supports an extensive fishing industry. With rapid industrialization, the water quality of the lake has deteriorated markedly since the early 1980s. The levels of the key nutrients—nitrogen and phosphorus—in the lake water have tripled over the past 15 years, leading to rapid eutrophication, as evidenced by excessive algae growths; fish kills; and severe color, taste, and odor problems in the water supply for Hefei and Chaohu cities.

Air quality is generally poor in PRC's industrial cities. Airborne concentrations of dust and suspended particulate matter often surpass environmental standards by several hundred percent. Air pollution affects the respiratory and cardiovascular systems of urban populations. Chronic pulmonary diseases linked to exposure to fine suspended particles and dust are a leading cause of death among the country's urban residents. Increased mortality, morbidity, and impaired pulmonary functions have been associated with elevated levels of sulfur dioxide and suspended particulate matters. Nitrogen dioxide and ozone also damage the respiratory system. Lead inhibits the formation of hemoglobin, impairs liver and kidney function, and causes neurological damage. The direct effects of air pollution vary according to both the intensity and duration of exposure and the health of the people exposed. Certain segments of the population (i.e., the young, the elderly, and people suffering from respiratory and cardiopulmonary disease) are more susceptible to air pollution-related health problems.

Increasing environmental problems are constraining sustainable growth. Better environmental quality is essential to improve the quality of life and general state of health, particularly of urban populations, and to achieve sustainable growth and development. Massive investments, together with stricter legal, regulatory, and enforcement frameworks, and the provision of market-based incentives designed to encourage environment friendly production practices, are required to address these problems. Improving environmental protection measures in a financially viable and sustainable fashion is an integral part of both PRC's and ADB's development strategies.

Environmental protection is now clearly established as a national priority in the PRC's development strategy, with all medium- and long-term investment plans incorporating environmental sustainability as a fundamental component. In the provincial and local level, the Ninth Five-Year Plan (NFYP, 1996-2000) serves as the guiding document in the development of local five-year plans, and it places strong emphasis on environmental management and sustainability—requiring that these concerns be incorporated at all levels of the planning and investment process. The Government's continuing emphasis on price and enterprise reforms, aimed at improving industrial efficiency and providing greater autonomy and accountability at the enterprise level for both financial and environmental performance, complements the environmental policies and regulations. Price liberalization will promote environment friendly behavior by encouraging energy efficiency and resource administration of the pollution levy fund to make more investment funds available for waste minimization technology and industrial wastewater treatment facilities. During the 1990s, prices of most key commodities have been liberalized to reflect market conditions and this provides better market-based incentives to conserve industrial inputs.

II. Project Details

The Project was selected for the following reasons: (i) Chao Lake's water quality is deteriorating, and without intervention the Lake will die with serious negative implications on public health and economic development; (ii) programs to protect the other two lakes on the Government's priority list (Dianchi and Tai) are already being carried out through financing from the World Bank; (iii) the Anhui Provincial Government (APG) has prepared comprehensive feasibility studies and initiated environmental protection measures for the Lake; and (iv) the Project presents an opportunity for ADB not only to have a major positive and immediate impact on the environment in the Chao Lake basin, but also to demonstrate that environmental protection can be self-financing and sustainable. This latter point is important, since APG must address environmental management of the remaining 2,600 industries and numerous urban areas in the basin.

The principal objective of the Project is to improve the water quality in Chao Lake and reduce wastewater and air and solid waste pollution in the cities of Hefei and Chaohu (see Map).

The scope of the Project includes: (i) preparing the Integrated Environmental Management Plan for the Chao Lake basin; (ii) providing institutional strengthening for the Anhui Provincial Planning Commission, Anhui Environmental Protection Bureau and the six subproject entities; and (iii) financing six of the most urgently needed physical investments. These are the construction of central wastewater collection and treatment facilities in Hefei and Chaohu (which will be the Municipal Wastewater Treatment component), and the technological restructuring of four major industrial polluters in Chao Lake basin (which will be the industrial Pollution Abatement component).

The Project has six subprojects which were selected based on the following reasons: (i) conventional wastewater collection systems and centralized treatment plants in Hefei and Chaohu provide the most cost-effective way to supply wastewater treatment for 1.3 million urban residents and hundreds of small- to medium-sized industries; (ii) the four industrial enterprises selected have: (a) the highest volume of wastewater generation with the highest strength of pollutants; and (b) the highest air pollution; they will substantially reduce their present pollution emissions through technological restructuring to use cleaner production technology, which will reduce water use, wastewater generation, air pollution and energy consumption, and reuse some wastewater and waste products; and (iii) the four industrial enterprises have: (a) adopted market-based pricing for inputs and outputs; (b) demonstrated that with the enterprise reforms and investments under the Project they will become free of government budgetary support; (c) demonstrated their ability to mobilize the required domestic financial resources for the investment program, and to meet the debt service, amortization payments, and operating costs; and (d) agreed to provide data and information on their subproject to other industries in their respective sectors to encourage the demonstration impact.

Map
Anhui Environmental Improvement Project

III. Analytical Methods

The economic analysis of environmental impact requires comparison of the project viability under the with- and without-Project situation. The Project, which involves the technological restructuring of the four largest industrial polluters in the Chao Lake basin—and the construction of central wastewater collection and treatment infrastructure—will lead to a reduction in air and water emissions, thus improving air and water quality. The analysis is carried out in four stages. In the first stage, major stressors or pollutants are identified and quantified from the EIA. In the second stage, impact screening is carried out for each stressor. If the impacts are major, then in the third stage, there is an attempt to assign monetary values using the benefits-transfer method (BTM). Finally, these flows are integrated with the economic analysis of the project.

The BTM is a procedure for estimating the value of environmental impacts by adapting values reported in other studies, preferably in a similar location under comparable circumstances, through primary research. Although the BTM is a secondary valuation technique, it is practical because it saves budget and time requirements for data gathering and analysis.

In general, there are four basic steps in obtaining BTM values. The first is to select studies that can reveal values and estimates of environmental benefits and damages. These values then must be adjusted to fit the biophysical baseline and socioeconomic and monetary information of the current project. The adjusted economic values are then multiplied by the number of affected individuals to get the total values per unit of time. Finally, the total discounted values of environmental impacts are calculated over the time period during which impacts are expected to occur.

Although the method is straightforward, sound judgment must be used or else the calculated values may be inapplicable to the project being evaluated. If BTM is to be used, it is important to evaluate the appropriateness of the derived values because a wide range may be found in the literature due to the differences in the estimation procedure. It is also important to make necessary modifications in the values to account for differences in the primary study site and the project site. If the values from a developed country are to be extrapolated to a developing country (which is often the case), the major differences in personal income, property rights, land prices, institutions, cultures, climates and resources should be taken into account. In this assessment, such adjustments were made to the extent possible.

IV. Economic Valuation of Environmental Impacts

The EIA indicates that there will be an overall deterioration in the air quality around the location of the four industrial plants, but improvements in water quality for most stressors. The environmental impact of the overall project is largely positive, leading to a reduction of environmental emissions except for TSP, SO_2 and NO_X. One subproject contributes more TSP, NO_X and SO_2, while another contributes more TSP to the atmosphere with the subproject than without the subproject. This is due to the process change involved. It should be noted, however, that the overall Project results in a decrease in other air pollutants such as ammonia (NH_3) and carbon monoxide (CO). There are also significant decreases in solid wastes and water pollutants such as chemical oxygen demand (COD), suspended solids (SS), nitrogen (N), phosphate (PO_4) and various other contaminants.

In the second stage, these stressors are screened for their potential impacts on four major groups: Human Health, Human Welfare, Environmental Resources and Global Systems as shown in Table 1.

Out of the various impacts, the following major impacts are significant and they are described as follows:

A. Human Health Impacts

Increased morbidity and mortality from conventional air emissions. Health studies currently focus on airborne particles that are small enough to be inhaled deeply into the lungs (called PM_{10}). PM_{10} aerosols resulting from the combustion of fossil fuels include sulfate and nitrate aerosols, acid aerosols, and other chemical constituents. Their impacts include both premature mortality and chronic acute respiratory disease.

Table 1. Potential Impacts

	Human Health			Human Welfare		Environmental Resources			Global Systems
Stressor	**Mortality**	**Morbidity**	**Materials**	**Resources**	**Social/ Cultural Use**	**Coastal Marine**	**Ground-water**	**Bio-diversity**	
TSP	x	x	x	x					
CO	x	x							
SO_2	x	x	x	x	x				
NO_x	x	x	x		x				
CO_2									x
Asbestos	x	x				x			
Lead	x	x	x	x		x			
Chlorine			x						
Waste-water flow		x				x	x	x	
Suspended solids		x							
COD							x	x	
Ammonia									
BOD		x					x	x	

TSP = total suspended particulates; CO = carbon monoxide; SO_2 = sulfur dioxide; NO_X = nitrogen oxides; CO_2 = carbon dioxide; COD = chemical oxygen demand; BOD = biochemical oxygen demand

Increased morbidity and mortality from hazardous waste. Polycyclic aromatic hydrocarbons are believed to be carcinogenic and have been cited to cause cardiovascular diseases. Volatile combustible matter such as benzene are known to cause acute myelogenous leukemia, aplastic anaemia and has central nervous system effects in the workplace; other hematological neoplasms are also possible. On the otherhand, cyanide is a poison.

B. Human Welfare Impacts

Visibility impacts from air emissions. Particulate matter (less than 2.5 micrometers in diameter) that is emitted directly from industries or is formed in the presence of SO_2 and NO_X gas emissions can reduce visual range.

Building and materials impacts. Particulate matter and acid deposition from SO_2 emissions can damage materials. Materials damage can include surface soiling, surface erosion, blistering, paint discoloration, corrosion and tarnishing of metals and electronic components, fading, reduction of fabric tensile strength, and spalling of buildings and monuments.

Reduced catch rates. Stress on fisheries from low dissolved oxygen levels in the water sources downstream from the industries might reduce fishery populations. While there may be some change in non-use values associated with reductions in fish stocks, such impacts could not be assessed here due to lack of data.

C. Economic Evaluation of Environmental Impacts

Once the major environmental impacts and their influence on human health, human welfare and socioeconomic activities are properly identified, the next step is to assess the economic value of such impacts. There are various methods available for such valuations and some of the methods require substantial amount of primary data, time and field investigations. However, in this study BTM was used. BTM allows the use of results from similar valuations conducted in the different parts of the world with proper adjustments to any particular project. Tables 2 and 3 summarize the adjusted values for similar environmental impacts for the Yunnan Pulp Mill and Forestry Project in the PRC as given in ADB's *Workbook on Economic Evaluation of Environmental Impacts*. While adjusting the data from the results of original research in the US to the PRC, three major adjustments were carried out: (i) the differential GNP between the US and PRC was computed, (ii) the price level was updated to 1996 prices, and (iii) adjustments were made for medical cost differentials between the US and PRC. The GDP deflator was used for inflation adjustments.

Table 2. Original and Adjusted Unit Values for the Economic Valuation

Impact	Original Unit Value	Adjusted Unit Value
Human health impacts: TSP (PM_{10})	*$2,700-4,500 per ton*	*$45.94-76.57 per ton*
Human health impacts: SO_2	*$563-975 per ton*	*$9.57-16.59 per ton*
Human health impacts: NO_x	*$850-1,700 per ton*	*$14.46-28.93 per ton*
Human health impacts: CO	*N.A.*	*$1.06-1.90 per ton*
Opportunity cost value: CO	*N.A.*	*$7.75-10.26 per ton*
Human welfare impacts: TSP (PM_{10})	*$300-500 per ton*	*$5.10-8.51 per ton*
Human welfare impacts: SO_2	*$188-325 per ton*	*$3.19-5.54 per ton*
Human welfare impacts: NO_x	*$150-300 per ton*	*$2.55-5.10 per ton*
Fishery impacts of BOD and COD discharges	*Y3.94 per kg*	*$1.10 per kg*

PM_{10} = particulate matter less than 10 microns; SO_2 = sulfur dioxide; NO_X = nitrogen oxides; CO = carbon monoxide; TSP = total suspended particulates; CO_2 = carbon dioxide; COD = chemical oxygen demand; BOD = biochemical oxygen demand; N.A. = not available; kg = kilogram

Table 3. Quantification and Economic Valuation of Major Environmental Impacts

Impact	*Change*	*Unit Value*	*Annual Value*
Human health and welfare: TSP (PM_{10})	*5,961 t/yr*	*Human health: $45.94-76.57 per ton Human welfare: $5.10-8.51 per ton This range of values was transferred from US studies of health and welfare values. Several adjustments were made to update the values from the Yunnan Paper Mill Project.*	*Health: $273,848-456,434 Welfare: $30,401-50,728*
Human health and welfare: SO_2	*64 t/yr*	*Human health: $9.57-$16.59 per ton Human welfare: $3.19-5.54 per ton This range of values was transferred from US studies of health and welfare values. Several adjustments were made to update the values from the Yunnan Paper Mill Project; acid deposition impacts on fisheries have been excluded.*	*Health: $612-1,062 Welfare: $204-355*
Human health and welfare: NO_x	*721 t/yr*	*Human health: $14.46-28.93 per ton Human welfare: $2.55-5.10 per ton This range of values was transferred from US studies of health and welfare values. Several adjustments were made to update the values from the Yunnan Paper Mill Project.*	*Health: $10,426-20,859 Welfare: $1,839-3,677*
Human welfare: fishery resource	*not known*	*$1.10 per kg The unit value is based on fish prices in Yunnan province.*	*not estimated*

PM_{10} = particulate matter less than 10 microns; SO_2 = sulfur dioxide; NO_X = nitrogen oxides; TSP = total suspended particulates; kg = kilogram

Both high and low unit values were used for the economic valuation of environmental impacts. Two discount rates were used—10 percent and 12 percent—to compute the with- and without-project NPVs; the results are given in Table 4 (detailed information is found in Table 5). The integrated NPV with environmental impacts is higher than for the NPV without environmental impacts, implying that the project design leads to improvements in the overall environmental conditions in the project location.

Table 4. Summary of Economic Analysis of Environmental Impacts (in Y'000)

	Project Without Environmental Impact	With Environmental Impact		Net Environmental Benefit	
		Low Values	High Values	Low Values	High Values
Net Present Value at 10%	*729,640*	*1,084,866*	*1,211,282*	*355,346*	*481,643*
Net Present Value at 12%	*427,055*	*722,738*	*827,832*	*295,683*	*400,777*

It is important to note that overall environmental benefits are significantly higher than the estimated here. There are many other environmental benefits such as reduction of emission of asbestos, chlorine, lead, tar, and salt which were excluded from the economic valuation due to methodological difficulties or lack of data; only the likely impacts (positive or negative) are indicated in Table 6. Therefore, estimated economic benefits of environmental impacts need to be taken as lower bounds rather than optimistic figures. For example, asbestos is a proven carcinogenic agent and most countries do not want to promote its use. The elimination of asbestos waste is one of the benefits of one subproject which is neither quantified nor assigned monetary values.

Table 5: Integrated Economic and Environmental Analysis *(Y'000)*

Year	Economic Cost	Economic Benefit		Environmental Benefit		Total Net Benefit	
		Benefit	Net Benefit	Low	High	Low	High
1996	(11,290)	–	(11,290)	–	–	(11,290)	(11,290)
1997	(491,012)	–	(491,012)	–	–	(491,012)	(491,012)
1998	(841,286)	–	(841,286)	–	–	(841,286)	(841,286)
1999	(530,858)	–	(530,858)	–	–	(530,858)	(530,858)
2000	(66,698)	290,400	223,702	9,296	12,616	232,998	236,318
2001	(26,859)	361,680	334,821	46,563	63,163	381,384	397,984
2002	–	442,982	442,982	93,209	126,326	536,191	569,308
2003	–	464,521	464,521	93,209	126,326	557,730	590,847
2004	–	464,532	464,532	93,209	126,326	557,741	590,858
2005	–	464,552	464,552	93,209	126,326	557,761	590,878
2006	–	464,443	464,443	93,209	126,326	557,652	590,769
2007	–	464,492	464,492	93,209	126,326	557,701	590,818
2008	–	464,541	464,541	93,209	126,326	557,750	590,867
2009	–	464,591	464,591	93,209	126,326	557,800	590,917
2010	–	464,643	464,643	93,209	126,326	557,852	590,969
2011	394,115	433,248	828,363	93,209	126,326	921,572	954,689
2026	–	88,406	88,406			88,406	88,406

Economic benefit in 2026 refers to salvage values.

	Without Environmental Impact	With Environmental Impact		Net Environmental Benefit	
		Low	High	Low	High
Net present value @10%	729,640	1,084,986	1,211,282	355,346	481,643
Net present value @12%	427,055	722,738	827,832	295,683	400,777
EIRR (%)	16.4	19.1			

EIRR = economic internal rate of return.

Table 6. Analysis of Other Environmental Impacts

Impact Category	Likely Impact on Net Benefits	Comments
Ecosystem impacts of conventional air emissions	+	*Acid deposition impacts are probably small given the low emission rates; should reduce the probability*
Human health impacts of construction dust and noise	–	*Temporary*
Impacts of landfilled waste	–	*This is a potentially important impact category. The effects on net benefits may be very small if waste is properly managed to prevent leachate contamination of groundwater and surrounding soils. If not adequately managed, negative impacts could be large because waste can contain heavy metals.*
Human welfare impacts from aesthetic changes	+	*Reduced emission may have a small impact on visual aesthetics.*
Human health impacts of other hazardous air emissions	+	*These impacts are likely to be small provided the mitigation and safety measures are operating.*
Human welfare impacts of conventional water effluents	+	*Discharge standards minimize water discoloration, smell, and fish. These impacts should be positive.*
Human health impacts of particulate emissions ($>PM_{10}$)	+	*Irritation and reduced visibility caused by large dust particles tend to reduce net benefits. These impacts should be positive.*
Fishery impact	+	*Unknown.*

V. Notable Aspects

The issue here concerns environmental problems in urban areas. Industrial and household wastes account for the major sources of disease. Air pollution problems are often severe. This Project will result in the construction of two municipal wastewater treatment facilities, and the major restructuring of four large industrial polluters in one river basin. These efforts will have an important effect on pollution in the region.

The Project demonstrates that environmental protection, if undertaken in a rational manner, can be financially feasible and sustainable over the long term. It seems reasonable to suggest, in this particular case, that the environmental components strengthens Project feasibility and makes it worth serious consideration by the Government of the PRC.

The case study shows that the economic valuation of environmental impacts of a project can be integrated into economic analysis. BTM was used to estimate the economic value of environmental impacts. The economic analysis of environmental impacts shows that when environmental impacts are factored in, the NPV of the project increases by Y296-482 million. Since not all environmental effects were accounted for in the economic analysis, it may be argued that the assessment is incomplete. However, there can now be a better evaluation of the project since environmental considerations have now been taken into account both quantitatively (through the monetization of environmental impacts) and qualitatively.

Overall environmental benefits are significantly higher than estimates, since there are many other environmental benefits which were excluded from the economic analysis due to resource and time constraints. For example, asbestos is a proven carcinogenic agent and most countries do not want to promote its use. The elimination of asbestos waste is one of the benefits of one subproject which is neither quantified nor assigned monetary values. The reduction of one ton of mercury costed $15 million in Minamata Bay in Japan. Mercury poisoning can cause extensive damages, hence the estimates must be interpreted in the context of the unquantified benefits.

This Project will induce a wide range of policy reforms in the Province. For example, water tariff restructuring, market-based pricing for raw materials, and industrial output pricing will have far greater environmental impacts in the long-run than could be imagined. Enterprise reform including financial autonomy, market-reformed prices and enterprise output, and market-based policies for environmental management are some other notable aspects of this Project. The economic valuation of environmental impacts points clearly to the need for policy re-orientation. For example, valuation is a necessary tool for establishing market-based policies for environmental management.

The Project serves as a pilot case where environmental improvement is expected to have a demonstration effect. The expected project-specific environmental values provide only the lower-bound estimates.

ADB provided TAs worth about $2 million for helping the Government develop an integrated management plan for the Anhui Lake, build capacity for wastewater treatment operations, and strengthen enterprise reform. Human resource development, institutional strengthening, environmental data gathering, monitoring, and training are the major expected benefits.