WATER RESOURCES

THAILAND

WASTEWATER MANAGEMENT PROJECT[9]

I. Background of the Project

The present system of domestic, commercial, and industrial wastewater disposal throughout most of Thailand's urban growth centers, and the complete absence of agricultural waste management, means that most of the pollution loads are transferred directly to drains and watercourses. As a result, the pollution of water bodies has reached extreme levels. Statistics of reported waterborne diseases and loss of beneficial uses of water show a rising trend. For example, the incidence of acute diarrhea in the metropolitan area increased by 24 percent from 1992 to 1994, compared to a national increase of 15 percent over the same three-year period. It is estimated that waterborne diseases cause over 1.5 million cases of serious illness per year, and about 6 percent of the deaths in the metropolis.

The Government's objective for wastewater management under the Eighth National Economic and Social Development Plan (October 1996 to September 2001) is to reduce pollution levels in the lower reaches and estuary of the Chao Phraya River; in coastal areas and tourist destinations; and in canals, ponds, and lakes in regional urban centers with critical water-pollution problems. This objective is being met by: (i) implementing programs and projects designed to reduce water pollution generated by communities and industrial and agricultural activities, as well as by relocating pollution-generating industries to designated areas; (ii) enforcing effluent standards for buildings, livestock, and aquaculture farms; (iii) collecting water fees and levying effluent charges to encourage economical use of water; (iv) encouraging the use of cleaner production technologies and wastewater

---

9 *Details referring to the project site have been generalized because project approval and implementation has been postponed.*

recycling; and (v) promoting the use of recycled water. Control measures are also being put in place to prevent additional effluent discharges into watercourses with critical pollution problems.

The Government is also actively supporting investment in construction of wastewater facilities for communities and industrial areas in the metropolitan areas and in regional urban centers; promoting the "polluter-pays-principle" to inform polluters that they will bear the costs of treatment and disposal of pollution; and strengthening the legislation, organization, administration, and management of the agencies responsible for controlling pollution. The Government recognizes that it must provide most of the capital investment to halt the severe environmental degradation. However, long-term strategy is to encourage the private sector to participate in the financing and operation of wastewater management facilities, similar to the current efforts to privatize the electric power, telecommunications, and transport sectors.

ADB's strategy on wastewater management reflects its operational strategy in Thailand, which is to support the Government's strategic priorities and borrowing policies, in tandem with ADB's own strategic thrusts and operational considerations. Within this context, one of the strategic objectives of ADB's program is to assist Thailand in developing the basis for long-term competitiveness to support sustained and more balanced long-term economic growth. To achieve this objective, the operational program's more specific and intermediate objectives are to provide assistance in support of: (i) effective management of the environment and the natural resource base, in terms of both conserving its long-term potential and its appropriate utilization for ongoing economic activities; (ii) development of physical infrastructure, including associated institutional requirements to support the next phase of development; and (iii) development of human resources. In addressing these objectives, proper attention will be given to the continuing transformation of the private sector as a key instrument in the country's long-term development. The approach and areas of emphasis detailed above are expected to help Thailand to increase productivity and efficiency in the economy, and thus to ensure sustainable development.

II. Project Details

The gross provincial product (GPP) across the project area grew by an average of 9.4 percent per annum over the 1980s compared to a national growth rate of 8.2 percent per annum over the same period; that strong growth has continued into the 1990s. The population of the project area has grown by 2.0 percent per annum, and that in the surrounding provinces of the project area by 3.0 percent per annum, over the last 10 years. There is also a sizable tourist population in the project area, with more than 13 million visitor-nights spent in 1995. Rapid growth is evidenced by increases in the amount of manufacturing activity, and extensive urban renewal and urban expansion—particularly residential expansion. Rising land prices in the project area is pushing much of the manufacturing and residential growth out into the surrounding provinces, yet in most of these rapidly growing areas there is minimal environmental infrastructure. This considerable economic and population growth is creating a substantial demand for improved water supply. Most of this water supply is transformed into wastewater, and much of it is discharged into the river, one of the principal raw water sources for the project area water supply. It is estimated that the existing wastewater generation from all point sources within the project area is currently about 4.5 million cubic meters per day (m^3/day) and that this will increase to about 6.0 million m^3/day by the year 2016.

The majority of household, commercial, and industrial water currently flows directly into the stormwater drainage system. Household toilet water is deposited into onsite treatment systems. In many of the higher density areas, onsite household systems are connected into the stormwater drainage system. In the areas of informal housing (slum areas and houses alongside the canals) and lower density formal housing, wastewater seeps into the surrounding soil or is discharged directly into canals. Much of the industrial wastewater in the project area is discharged into the drains and canals with no treatment, or with only minimal pretreatment (removal of floatables, and oil and grease). Surveys indicate that up to one half of all industrial factories have either pretreatment only, or no onsite treatment at all before discharge into the drains or canals. Similarly, the surveys indicate

that around 25 percent of older commercial establishments have some form of pretreatment only, and a further 25 percent have no treatment before discharge.

In addition to domestic, commercial and manufacturing sources of wastewater, the project area contains over 6,500 pig farms containing over two million pigs. About 30 percent of the pig farms in the project area have had urban communities grow around them and, as a result, must now be relocated to rural areas. It is estimated that, on the average, one pig generates the equivalent of 3-4 times the average organic waste generated by a human. Pig farm wastes are generally untreated and therefore it is estimated that such farms in the project area generate wastewater loads equivalent to at least six million human residents—or about 40 percent of the total organic load in the region.

These uncontrolled and untreated wastewater discharges from domestic and industrial sources are adversely affecting all the canals in the project area, and thus the water quality of the canals has deteriorated considerably in recent decades. A dissolved oxygen (DO) level of at least 2.0 milligrams per liter (mg/l) is considered essential for the maintenance of aquatic ecology. To maintain a DO level of 2.0 mg/l requires that the biochemical oxygen demand (BOD) concentrations stay below about 5.0 mg/l. The average BOD concentrations in the canals are in the range of 14-60 mg/l, thus giving rise to anaerobic and malodorous conditions. Water quality in the project area's river has deteriorated significantly especially in the lower portion which receives wastewater discharged from industrial and domestic sources in the project area. The DO level is often as low as 0.2 mg/l in the lower portion of the river, and rarely does it go above 2.0 mg/l. Water quality in the tributary river, especially in the middle and lower portions, has also deteriorated as a result of these wastewater discharges, with the DO level as low as 0.3 mg/l. The exposure and related illnesses caused by environmental pollution is particularly severe for those poorer sections of the community (about 25 percent of the total population) living along the waterways and in proximity to the factories. Impacts include unpleasant odors, illness due to exposure to inadequately treated domestic waste and toxic effluents from inadequately treated factory waste, and the loss of the canals as a source of water, seafood, and scenic beauty.

The goal of the Project is to bring about a sustained improvement in the environment and quality of life for the communities in the project area. This will be achieved through the following objectives: (i) improvement of the water quality of the canals and rivers, and (ii) reduction of human exposure to pathogenic bacteria and other water pollution health hazards. These objectives will be met by the provision of a sustainable centralized wastewater treatment system to the geographic areas designated under the Project (220 square kilometers), together with the introduction of programs to improve environmental monitoring and enforcement, as well as an industrial pollution prevention and cleaner production program (IPP-CPP).

The total estimated project cost is $1,884 million equivalent. The cost of the Collection Component is estimated at $1,518 million. Foreign exchange costs, including indirect foreign exchange costs, amount to $524 million equivalent. The local costs, including duties and taxes, amount to $994 million. The Treatment Component cost, to be undertaken as a public/private venture, is estimated at $366 million.

III. Analytical Methods

The economic analysis of the Project, conducted over a 35-year period, includes: (i) economic least-cost analysis, (ii) identification of incremental economic costs, (iii) identification and valuation of the major economic benefits, (iv) cost-benefit analysis, and (v) sensitivity analysis. The economic benefits and costs were estimated in border prices in domestic currency, derived from financial costs using conversion factors and shadow prices. Land was valued at its opportunity cost. All costs and benefits were estimated on the "with-and-without" Project basis. Both the least-cost analysis and the cost-benefit analysis are consistent with the *Guidelines for the Economic Analysis of Projects*.

A. Benefits

In the absence of the Project, wastewater will continue to be disposed of and treated on-site using methods which are generally expensive and ineffective. Household septic tanks are not regularly desludged, and on-site industrial and institutional wastewater treatment plants are often poorly designed and operated. Implementation of the Project will collect flow from two main catchments: (i) the rapidly growing northern catchment, and (ii) the western catchment (industrial and commercial areas). It is expected that by the year 2003, some 75 percent of wastewater flow in the project area will be collected.

The benefits of collecting and treating this wastewater include: (i) cost savings for residential and nonresidential wastewater generators which are no longer required to operate on-site treatment systems; (ii) reduction of wastewater-related disease productivity losses due to illness and a reduction in medical costs; (iii) minimization of the need for heavy polluters to relocate due to Government and public pressure; (iv) increases in the value of properties served by the Project and properties close to waterways; (v) increases in the productivity of inland fisheries; (vi) improvements in the quality of canal water used for irrigation and for aquaculture and industrial purposes; and (vii) improvements in the aesthetic quality of the waterways which will benefit those living nearby and those using the canals for trade, transport and recreation.

B. Costs

The economic costs of capital works, and system operation and maintenance have been computed from the financial cost estimates by the following procedures: (i) price contingencies are excluded but physical contingencies are included because they represent a real change in costs to society; (ii) import duties and taxes are excluded as these represent transfer payments; (iii) the opportunity cost of unskilled labor is considered to be lower than the wage rate due to the existence of some underemployment within the Thai economy, hence unskilled labor is given a shadow price using 0.8 of the market wage rate; (iv) skilled labor is in demand and therefore considered

to be fully utilized and market wage rates are used; and (v) following the ADB guidelines, tradable costs have been adjusted by the reciprocal of the standard conversion factor (SCF). Thus, all prices are expressed in domestic prices and this allows for the comparison of willingness-to-pay bids and tariffs with the long-run costs of the system (estimated as the average incremental cost of the Project). This method allows easier comparison of project costs with benefits, where a substantial component of benefit is the savings in resources that would be used in the absence of the Project. An SCF of 0.9 has been adopted and it is consistent with other projects in Thailand.

The asset life assumed for the various capital components of the Project are: (i) civil works, sewer rehabilitation - 50 years; (ii) mechanical and engineering equipment - 15 years; (iii) trunk sewers, collectors, and connectors - 80 years; and (iv) operating and monitoring equipment - 10 years. Operating costs for each of the treatment plants, from the year 2003, are estimated on the basis of the amount of wastewater collected and treated to the year 2031. Assets with a life less than 30 years are replaced as required and assets still in use at the end of the 30 years are given a residual value based on their remaining life.

Land is valued in terms of its opportunity cost, that is, what it could earn in the next best alternative use. Alternative uses vary according to location and the following assumptions have been used: (i) the northern and south-western treatment plant sites are in areas with little current residential development but it is likely that in the medium to long term that land would be developed for low density residential use; and (ii) the western plant is a low-lying coastal area subject to regular tidal inundation and the eastern plant is in a flood-prone area. Thus, it is likely that the long-term use for that land will be aquaculture and agriculture, respectively. Returns to land per rai[10] are estimated based on gross margins for the various agricultural and aquaculture activities, and on rent for residential land. It is further assumed that, over time, returns to land will increase in real terms by 1 and 2 percent per annum for the eastern and western sites, and by 6 percent per annum for the northern and south-western sites. Benefits and costs streams are shown in Table 1.

[10] *One rai = 1,600 m²*

Table 1: Integrated Economic and Environmental Analysis *(baht '000)*

	Economic Cost				
Year	Capital Cost	Operating Cost	Total	Industry Relocation	Health Savings
1997	*2,100,561*	*352,000*	*2,452,561*	–	–
1998	*8,173,904*	*988,750*	*9,162,654*	–	–
1999	*6,215,341*	*1,054,000*	*7,269,341*	–	*31,460*
2000	*7,612,259*	*1,034,500*	*8,646,759*	–	*99,389*
2001	*6,952,421*	*931,750*	*7,884,171*	*120,000*	*137,493*
2002	*1,593,514*	*194,250*	*1,787,764*	*122,400*	*165,887*
2003	–	*440,533*	*440,533*	*124,848*	*184,409*
2004	–	*472,844*	*472,844*	*127,345*	*196,421*
2005	–	*507,649*	*507,649*	*129,892*	*209,270*
2006	–	*555,206*	*555,206*	*132,490*	*227,686*
2007	–	*572,658*	*572,658*	*135,139*	*233,843*
2008	–	*591,541*	*591,541*	*137,842*	*240,538*
2009	–	*611,973*	*611,973*	*140,599*	*247,809*
2010	–	*611,973*	*611,973*	*143,411*	*245,356*
2011	–	*650,221*	*650,221*	–	*258,109*
2012	–	*650,221*	*650,221*	–	*255,554*
2013	–	*650,221*	*650,221*	–	*253,024*
2014	–	*650,221*	*650,221*	–	*250,519*
2015	–	*650,221*	*650,221*	–	*248,038*
2016	–	*688,470*	*688,470*	–	*260,028*
2017	–	*688,470*	*688,470*	–	*257,454*
2018	–	*688,470*	*688,470*	–	*254,905*
2019	–	*688,470*	*688,470*	–	*252,381*
2020	–	*688,470*	*688,470*	–	*249,882*
2021	–	*726,718*	*726,718*	–	*261,153*
2022	–	*726,718*	*726,718*	–	*258,567*
2023	–	*726,718*	*726,718*	–	*256,007*
2024	–	*726,718*	*726,718*	–	*253,472*
2025	–	*726,718*	*726,718*	–	*250,963*
2026	–	*726,718*	*726,718*	–	*248,478*
2027	–	*726,718*	*726,718*	–	*246,018*
2028	–	*726,718*	*726,718*	–	*243,582*
2029	–	*726,718*	*726,718*	–	*241,170*
2030	–	*726,718*	*726,718*	–	*238,783*
2031	–	*726,718*	*726,718*	–	*238,783*
Salvage	*(23,441,276)*		*(23,441,276)*		
EIRR (%)					
Contribution to benefits (%)				*0.6*	*3.6*

EIRR = economic internal rate of return.

Increases in rental value rather than increases in land value is now used in economic analysis of ADB projects.

Benefit					Total Net Benefit
On-site Treatment	Increased Land Value	Fisheries Production	Recreation	Total	
–	–	–	–	–	*(2,452,561)*
–	–	–	–	–	*(9,160,654)*
304,072	–	–	*1,616*	*337,148*	*(6,932,193)*
1,059,625	–	–	*1,697*	*1,160,711*	*(7,486,047)*
1,563,752	*10,700,000*	*127,859*	*1,782*	*12,650,886*	*4,766,715*
1,947,096	*11,021,000*	*130,071*	*1,871*	*13,388,325*	*11,600,561*
2,259,565	*11,351,630*	*132,334*	*1,964*	*14,054,750*	*13,614,217*
2,482,862	*11,692,179*	*134,623*	*2,062*	*14,635,492*	*14,162,648*
2,936,067	*12,042,944*	*136,951*	*2,166*	*15,457,290*	*14,949,641*
3,107,014	–	*139,313*	*2,274*	*3,608,777*	*3,053,571*
3,251,434	–	*141,876*	*2,388*	*3,764,680*	*3,192,022*
3,406,643	–	*144,486*	*2,507*	*3,932,016*	*3,340,475*
3,495,987	–	*147,145*	*2,632*	*4,034,172*	*3,422,199*
3,755,623	–	*149,866*	*2,764*	*4,297,020*	*3,685,047*
3,855,589	–	*152,705*	*2,902*	*4,269,305*	*3,619,084*
3,940,629	–	*155,988*	*3,047*	*4,355,218*	*3,704,997*
3,996,409	–	*159,357*	*3,200*	*4,411,990*	*3,761,769*
4,081,291	–	*162,783*	*3,360*	*4,497,953*	*3,847,732*
4,395,503	–	*166,299*	*3,526*	*4,813,366*	*4,163,145*
4,500,846	–	*169,809*	*3,704*	*4,934,387*	*4,245,917*
4,590,452	–	*173,476*	*3,889*	*5,025,271*	*4,336,801*
4,679,971	–	*177,241*	*4,084*	*5,116,201*	*4,427,731*
4,769,405	–	*181,086*	*4,288*	*5,207,160*	*4,518,690*
5,112,236	–	*185,034*	*4,502*	*5,551,654*	*4,863,184*
5,222,914	–	*189,087*	*4,727*	*5,677,881*	*4,951,163*
5,317,054	–	*193,189*	*4,964*	*5,773,774*	*5,047,056*
5,411,112	–	*197,419*	*5,212*	*5,869,750*	*5,143,032*
5,537,468	–	*201,742*	*5,472*	*5,998,154*	*5,271,436*
5,631,341	–	*206,160*	*5,746*	*6,094,210*	*5,367,492*
5,757,480	–	*210,715*	*6,033*	*6,222,706*	*5,495,988*
5,851,177	–	*215,350*	*6,335*	*6,318,880*	*5,592,162*
5,977,105	–	*220,129*	*6,652*	*6,447,468*	*5,720,750*
6,070,630	–	*225,014*	*6,984*	*6,543,798*	*5,817,080*
5,920,508	–	*230,008*	*7,333*	*6,396,632*	*5,669,914*
6,038,300	–	*230,008*	*7,700*	*6,514,791*	*5,788,073*
					(23,441,276)
					23.9
65.7	*27.4*	*2.6*	*0.1*		

IV. Economic Valuation of Environmental Impacts

The economic value of the Project, including major environmental impacts, was estimated using three broad categories—human welfare, human health, and environmental values. Certain benefits have not been valued. These include: (i) improvements in water used for industrial purposes which is of a very minimal usage; (ii) benefits from the use of the waterways for trade and transport (since it is difficult to quantify its link with improvements in water quality); (iii) sale of wastewater sludge as fertilizer or filling material; (iv) reduction of pollution loads (primarily heavy metals) in the coastal zone of the river estuary, thereby reducing heavy metals in seafood and avoiding further damage to coastal fisheries; and (v) higher productivity of fruits in orchards. Further, no attempt was made to value the improvement in the biological environment other than improvements in aquaculture. In the "without-project" scenario, biological resources, freshwater fishery/aquaculture, and coastal fisheries are expected to further decline.

A. Human Welfare

Cost Savings—Households. Domestic flow will be collected by both separate sewers (estimated to collect 40 percent of the flow) and interceptors. For those households which have a connection into a separate sewer, the septic tank will be bypassed, eliminating the need for regular desludging. It is assumed that households will save baht(B)500/year. However, a household survey indicates that desludging is carried out regularly by only 40 percent of households and so a weighted saving of B200 /year/households (40 percent, B500) has been adopted. It is assumed that the 40-percent figure will be increased to 90 percent by the year 2005. Households served by interceptors will still be required to desludge their septic tanks. On-site costs are assumed to increase over time by 5 percent per annum in response to higher environmental standards and improved enforcement over the project period.

Cost Savings—Factories and Institutions. On-site methods of treating wastewater from factories and institutions are considerably higher

than the costs of using a central treatment facility. Cost savings are greatest for the large textile factories with high flows but relatively low loads, and for small- and medium-scale factories with low flows and loads, as confirmed by a factory survey conducted under an ADB-funded technical assistance (TA).

In a survey conducted under the TA, hotels, restaurants, schools and universities reported the highest per m^3 operating cost for treatment. Medium-sized institutions averaged B6/m^3 and large institutions averaged an expenditure of B37/m^3 in cost savings; these may be applied to the institutional/commercial flow treated under the Project. It is assumed that flow from small-scale commercial activities is included in domestic flow due to the prevalence of joint residential/commercial premises for such small-scale activity.

Aquaculture Fish Production. Aquaculture and fish production in the project area accounted for an estimated B32,200 million in 1996 (based on 1994 GDP figures). There are no data available to quantify increases in aquaculture and fish production with improved water quality. However, it is estimated that 5 percent of the productive area of the project area will be affected by improved waterways due to the Project and at the end of the analysis period (2031) the Project will have resulted in a 5 percent increase in productivity.

Commercial Fisheries. No information on catch rates or harvest is available for the upper Gulf of Thailand. The total gross value of fishery to the project area was estimated to be 0.5 percent of total gross provincial product (GPP). The GPP of the project area is estimated at B175,000. It is assumed that 0.5 percent of change in commercial fish catch will be affected by the treated water.

B. Human Health Impacts

In the following section, monetary values (or proxies for values) for the health impacts are presented to obtain benefit estimates for improvements in water quality. Some baseline information on waterborne diseases

is available for the project area through a study conducted by the United States Agency for International Development (USAID). Estimates of total willingness to pay (WTP) of an affected population to avoid adverse health impacts represent one method to measure the total benefits of impacts on human health. However, only limited data are available on valuing morbidity-relevant WTP for the applicable cases. Cost-of-illness (COI) estimates were used to value changes in disease morbidity. The COI approach provides a lower-bound estimate of the value of avoiding an adverse health effect; it reflects the out-of-pocket costs of being sick, not the value of remaining in good health. The COI underestimates an individual's WTP to avoid adverse health impacts, and this should be noted in the valuation.

The COI was used as a proxy for the value of lost work time because of illness. This is assumed to be equal to the wage rate estimated as equal to the per capita GPP. GPP includes returns to all factors of production instead of just to labor and thus may overestimate the value of lost work time. Per capita GPP in the project area was B175,000 in 1996 which, when divided by an assumed 260-day work year, yields a proxy for the daily wage rate of approximately B200, or $8.00. Thus, the indirect cost (work loss) associated with a case of diarrhea and acute diarrhea is approximately $112 and $480, respectively. The indirect cost of typhoid is $480 per case.

According to recent studies on environmental health risks in Thailand, microbiological diseases such as acute diarrhea, dengue fever, and dysentery may affect over 1.5 million urban dwellers a year, and could account for over 6 percent of all deaths. The incidence of acute diarrhea is above the national average for all but two provinces in the project area. The reported incidence in the project area would be approximately 2,000 cases per 100,000 people. It is likely that the reported incidence represents only 10 percent of actual incidence and that the level of mild illness would be higher. Mild illness tends to be self-diagnosed and treated with herbal or pharmaceutical remedies.

The degree to which improved wastewater treatment will reduce the incidence of microbiological disease is impossible to ascertain without a detailed epidemiological study, hence the valuation of health benefits relies on a number of simplifying assumptions. The reduction in illness due

to improved wastewater is assumed to be one case per household per year for domestic households based on an ADB-funded socioeconomic survey.

Table 2: Estimated Cost per Incidence of Microbiological Disease
(weighted average)

Severity	Cost	Probability
Severe	*Hospitalization - B3,000* *Income loss - B2,500*	*5%*
Moderately severe	*Medication - B150* *Income loss - B650*	*35%*
Mild	*Income loss - B200*	*60%*
Weighted cost per case	*B600*	

Further, it is assumed that one day of lost work is equal to B200. Thus, it is assumed that improvements in wastewater collection and treatment will save each household an average of B600/year (see Table 2). However, in the economic analysis only the values estimated under the sample survey were used.

C. Environmental Impacts

Recreation. No information was available on how water quality improvements might affect recreational areas along the Gulf which has many tourist attractions. The river is used for boating and sightseeing, as is the Gulf. It is assumed that if water quality is improved in the river and at the river's mouth in the Gulf, there may be two important impacts: (i) the value of a recreational outing to existing users may increase, and (ii) recreation levels (number of user days) could increase.

It was estimated that 100,000 recreational fishing, boating, and sightseeing trips are taken each year to the upper Gulf. Based on the knowledge of province and baseline water quality problems, it is assumed that an improvement in water quality and dissolved oxygen would lead to a 1 percent increase in annual recreational trips, or an additional 1,000 trips per year.

Using US studies on average outing values ($90)—with adjustments via the proportion of per capita GDP for the province—gives a value of approximately $28.64 per trip. If all 1,000 of the assumed trips were fishing trips, a benefit estimate of $28,640 would result. In a similar manner, if 5 percent of river recreational trips increased due to improvement of water quality, there will be $36,000 worth of annual economic benefits.

Industrial Relocation. In the Samut Prakarn Wastewater Management Project[11] it was assumed that 300 of Samut Prakarn's 3,000 factories would eventually have to relocate due to difficulties in meeting the National Environmental Quality Act (NEQA) requirement with their current factory land area. Thus, it is estimated that 540 factories (excluding Samut Prakarn) are classified as significant wastewater producers. It is estimated that some 300 of these would fall within the project area. A total of 60 factories are assumed to relocate over a 10-year period (2001-2010) if the Project is not pursued, with the cost of relocation estimated at B20 million per factory. Further, a 2 percent cost escalation was assured over the 10-year period.

Increase in Property Value.[12] The benefits of improved wastewater disposal and treatment, and the consequent improvement in the environment, may also be reflected in the amount that people are willing to pay for property either in terms of rent or the purchase price of the house. Conservative estimates have been made of the increase in land value likely to take place.

The Project will be established in a total area of approximately 420 km^2. It is assumed that 20 percent of the area will be affected by the Project. An average land value of B8 million/rai has been adopted and it is assumed that improved wastewater collection will increase the land value by 5 percent (B200,000/rai). Further, 200 ha of piggeries were projected to be cleared due to the Project, and it was assumed that the value of the former piggery areas will increase by B5 million/ha.

---

[11] *Loan No. 1410-THA: Samut Prakarn Wastewater Management Project, approved on 7 December 1995 for $150 million.*

[12] *Increases in rental values rather than increases in land value is now used in economic analysis of ADB Projects.*

V. Notable Aspects

The case embodies several important aspects for urban environmental projects. First, it is an example of rapid urban sprawl encompassing former rural activities such as pig farming. This activity gives rise to odors and to serious water pollution problems in crowded urban areas; the increased incidence of waterborne diseases is the logical outcome. Part of the project entails moving these activities out of the urban area so as to reduce negative environmental externalities. The economical aspect here is that it is clearly cheaper in the long run to separate incompatible uses in this way. Industrial projects are also to be diverted away from the metropolitan area to ease air and water pollution problems.

The Project will involve some regulations but it will also entail the use of various economic incentives to encourage the more economical use of water—including recycling. Storm water and sewage will be separated, and there will be a municipal waste treatment facility constructed.

It is expected that these improvements in environmental quality will enhance somewhat the productivity of inland fisheries and also permit some enhanced opportunities for recreation. Benefits are estimated using the cost-of-illnesses avoided. Recreational benefits are estimated using the benefits-transfer method. Enhanced environmental quality in the form of improved wastewater disposal and treatment are estimated using the changes in property values in the project region.

The economic internal rate of return (EIRR) for the Project is estimated at 24 percent. In terms of contribution to the level of benefit, on-site cost savings to industry and households account for 66 percent; health savings 4 percent; increase in land value 27.4 percent; industry relocation savings 0.63 percent; and fisheries/aquaculture production 2.6 percent. Given the large amount of unquantified environmental benefits and other related social improvements associated with the project, an EIRR of 24 percent is considered a conservative estimate and use of society's resources on wasterwater treatment in the project area is fully justified.

The case study shows that the environmental impacts of a project can be integrated into economic analysis. In this case, various valuation techniques were used to evaluate the economic benefits from environmental improvement.