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Case 2. Control of Water and Coastal Pollution: an Appraisal for Espirito Santo, Brazil

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The State Government is spearheading a multi-million dollar project to build water and sewerage treatment plants in the state of Espirito Santo of Brazil. This ambitious project is a classic example of the challenge facing the public sector in rapidly expanding urban areas where there is a need for public services, despite very scarce public resources. This project is expected to bring significant benefits to the residents of the state by meeting the rapid growth in demand for clean drinking water while reducing pollution and preventing water-borne diseases and other health hazards. Such projects in Brazil have typically required government subsidies and loan guarantees because they have been financially not viable. Many of the benefits to society are either intangible or not directly tied to the operation of the treatment plants. Hence, Government support may be needed to finance the investment.

The project evaluated here includes one water treatment and supply plant and one sewerage collection and disposal plant. Together, the two plants comprise a R$ 30 million investment.[1] The water supply plant is expected to serve new customers by establishing new connections and expanding the capacity of the water supply to meet the concurrent increase in demand. This component of the project accounts for 34% of the total investment costs. The wastewater collection-and-treatment plant is designed to restore the quality of water sources in the region by installing 36,000 new connections for collecting an estimated 11 million cubic meters of sewerage per year. In addition to providing basic water and sewerage services, the

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[1]These projects are to be financed as a part of a larger World Bank loan facility

project aims to establish an effective pricing mechanism to achieve a degree of cost recovery. The water utility company that will operate the plants, CESAN, hopes to achieve financial self-sufficiency over the long run. Evaluation of the two plants will begin with an analysis of the financial and economic costs and benefits expected from the project.

To estimate the non-use values for the environmental and health benefits produced by the project, this study utilized the results of a contingent valuation study that was carried out for another comparable region of Brazil.[2]

This study also addresses the issue of the allocation of costs and benefits amongst the stakeholders of such public sector projects. For example, one objective of the water treatment project is to make drinking water and sewerage services affordable for the poor so that they will utilize the services. Equally important is the project's obligation to sustain a minimum level of financial return in order to reduce the Government's financial burden.

Current State of Environmental Pollution in Brazil

Over the past several decades, Brazil has enjoyed rapid economic growth accompanied by industrialization and urbanization. Accompanying Brazil's rapid economic expansion and urbanization there has been a substantial degradation and pollution of the environment, particularly of the land, air and water of districts located near major urban areas. Brazil's environmental pollution is driven by two factors. First, the rapid pace of environmentally uncontrolled industrialization created a demand for sewerage treatment services, that was not met by the existing treatment systems. Second, Brazil has been unable to expand its urban sanitation and potable water supply infrastructure fast enough in order to keep pace with the increased concentration of its population in the urban areas. The poorest segments of the new urban population have often established residences in vacant areas close to water sources but with no sanitation infrastructure.[3] The deterioration in environmental conditions has led to a noticeable decline in the quality of life in the major metropolitan areas and to a concomitant increase in various health problems, including water-borne diseases and high levels of infant mortality. The

[2]Non-use value refers to the intangible value of a good or service that is not captured by the market price.
[3]The World Bank, "Staff Appraisal Report: Espirito Santo Water and Coastal Pollution Management Project," p. 2.

environmental deterioration also poses a threat to the tourist industry that is commercially important to the country.

The Government of Brazil has identified the contamination of the country's water sources as an urgent environmental problem. Since the establishment of the National Water and Sanitation Program in 1971, the Government has increased urban water supply coverage from 45% of all households in 1970 to 84% in the early 1990s. However, the rate of spending from 1991-1997 has declined. Those people who had access to water connections in 1997 were often rationed to only a few hours of supply each day. Investment in sewerage treatment and solid waste disposal also lagged behind, leading to large-scale dumping of waste materials and the contamination of water sources.[4]

By the late 1990s the Brazilian water systems become increasingly polluted, because wastewater was being discharged by households and industries into rivers and oceans without any form of sewerage treatment to remove pollutants. Currently, only 13% of total wastewater receives some form of treatment.[5] Similarly, insufficient municipal solid waste collection and disposal caused major land, water and air pollution. The situation is further aggravated by the spiraling demand for waste disposal sites that stems from rapid industrialization, which in turn has outstripped the rate of expansion of the existing infrastructure for water treatment in metropolitan areas. In recent years, environmental pollution has reached dangerous levels. Still, the Government has not initiated strong measures in order to regulate waste disposal and to provide environmentally safe alternatives. An accumulation of industrial and residential waste in the environment has contaminated the drinking water, and current water treatment capabilities are not able to cope with this increased level of contamination. Potent chemicals and contaminants have begun to cripple ecosystems in the river basins and coastal regions, killing much of the wildlife and threatening the well being of residents in the area.[6]

Brazilian water systems have become increasingly polluted in recent years, because wastewater is discharged by households and industries into rivers and oceans without any form of

[4] The World Bank Staff Appraisal Report, p. 3.
[5] Ibid., p. 2.
[6] Ibid., p. 13.

sewerage treatment to remove pollutants. Currently, only 13% of total wastewater receives some form of treatment.[7] Similarly, insufficient municipal solid waste collection and disposal has caused major land, water and air pollution. The situation is further aggravated by the spiraling demand for waste disposal sites that stems from rapid industrialization, which in turn has outstripped the rate of expansion of the existing infrastructure for water treatment in metropolitan areas. In recent years, environmental pollution has reached dangerous levels. Still, the Government has not initiated strong measures in order to regulate waste disposal and to provide environmentally safe alternatives. An accumulation of industrial and residential waste in the environment has contaminated the drinking water dangerously, and current water treatment capabilities are not able to cope with this increased level of contamination. Potent chemicals and contaminants have begun to cripple ecosystems in the river basins and coastal regions, killing much of the wildlife and threatening the well being of residents in the area.[8]

Espirito Santo's water supply and waste disposal problems are typical of those in the rest of the country. Despite rapid urbanization and industrialization during the last two decades, only 87% of Espirito Santo has an adequate water supply. Most of those who have connections service water for only a few hours a day. Waste collection and disposal problems are more severe than the problem of water supply coverage. In Grande Vitoria, Espirito Santo's industrial capital, only about 11% of the population is connected to a sewerage network, and only about 9% of the collected wastewater receives some form of treatment prior to its discharge. Most of the collected solid waste is dumped untreated into uncontrolled landfills, streams and the ocean. Water pollution, which has been dramatically worsened by the contamination of land, has become a major cause of water-borne diseases and infant mortality. Enteritis and diarrheal diseases, for example, have become major problems, while infant mortality has reached 6% of live births in many of the State's municipalities.[9]

[7] Ibid., p. 2.
[8] Ibid., p. 13.
[9] For comparison, the infant mortality rate in the US is less than 1%.

Figure 2.1. Map of Brazil

The water sources for Grande Vitoria and Guarapari are still in relatively good condition. However, substantial amounts of untreated waste are being released into rivers, as only 15% of the population in the region is connected to the sewerage collection and disposal network. Safe solid waste disposal is virtually non-existent. Although about 30% of solid waste are actually collected, most of it is thrown into unregulated landfills, dumps, streams and the ocean. There are already signs of rapidly deteriorating conditions in the ecosystem of the coastal lagoons, rivers, and beaches. The assimilation of organic waste has kept the water from reaching poisonous levels in water sources, but coliform levels already exceed standards set by the federal government. The effects of pollution are clearly exhibited by the depletion of oxygen in the water and by the amount of solid waste evident in it. As a result, the quality of the region's water resources has deteriorated markedly.[10] Although a number of large industrial companies have recently begun to dispose of their waste properly, many small and medium industries still do not.

The World Bank has agreed to provide financing to the Government of Brazil, the State Secretary for the Environment (SAEMA), and the State Water Company (CESAN) to improve the country's water and sewerage treatment and disposal systems by upgrading the technical

[10]The World Bank Staff Appraisals Report, p. 2.

capabilities of existing treatment systems and by investing in the construction and operation of new treatment plants.

Financial and Economic Analyses

Methodology

This study evaluates the expected impact of the proposed project in the Guarapari Drainage area which consists of a water supply and treatment system plus a sewerage collection and treatment plant. This evaluation will consider the financial, economic, stakeholder and risk aspects of the project.[11] The four main players in the project - the state of Espirito Santo, the country of Brazil, CESAN and the World Bank - have different interests and stakes in the project. Each stakeholder places varying degrees of emphasis on the different variables. The banker's point-of-view and owner's point-of-view reflect the viewpoints of the World Bank as the financing institution and of CESAN as the operating company, respectively. Although lending institutions and equity holders generally focus on the financial viability of a project, the World Bank and CESAN, as public institutions, should also consider the net economic benefits.

The financial analysis is conducted based on a discounted cash flow analysis. The Net Present Value (NPV) of the project is estimated from the equity point-of-view of CESAN. We also assess the total investment point-of-view by evaluating the project from an unleveraged perspective. Such an analysis helps financial institutions, such as the World Bank, assess the financial robustness of the project and its ability to repay any debt obligations. We conduct this analysis for both the water supply and sewerage collection projects.

Following the financial analysis, we estimate the economic prices for inputs and outputs to construct the statement of net economic benefits. While the financial analysis focuses on the financial benefits and costs accruing to CESAN, the economic analysis considers all the benefits and costs that impact on the entire economy.[12] Furthermore, we calculate the national economic

[11] Jenkins, G., "Evaluation of Stakeholder Impacts in Cost-Benefit Analysis," *Impact Assessment and Project Appraisal*, Vol. 17, number 2, 1999.
[12] Harberger and Jenkins, Cost Benefit Analysis of Investment Decisions, Queen's University, Canada, 2001.

parameters for Brazil, which include the economic cost of foreign exchange and the economic cost of capital. The commodity-specific conversion factors are estimated for the major inputs and outputs of the project. Applying these variables, the financial cash flow statement is converted to reflect the economic resource flows generated by the project.

We further expand the analysis in order to identify the different groups in society who are expected to reap the benefits and to incur the costs of the proposed project. Since the goal of the project is not only to be self-sufficient but also to provide basic water and sanitation services to the inhabitants of the region, the stakeholder analysis becomes an important measure for gauging the success of the project. Since the public sector will bear much of the financial burden and risk of the project in order to enhance people's living standards, it is important to clarify how the benefits will be allocated among the inhabitants of the region.

Risk analysis improves the usefulness of the financial, economic and distributive analyses. It helps with decision making by assessing the likelihood associated with the magnitudes of certain key variables and their expected effects on the project's outcome. Project parameters, such as real exchange rates, input prices, and the rate of inflation are important in determining the future returns of the project. To measure the extent of various risks, a Monte Carlo analysis[13] is used to model a probable distribution of each variable. The risk analysis assesses the impact of changing major microeconomic and macroeconomic conditions on the project's outcome.

Financial Analysis

The financial analysis is the first component of an integrated analysis of an investment project. It is carried out using a financial model built around the projected net cash flows for the project.

Investment and Operating Parameters

- The project is expected to operate for 30 years.

[13]Using Crystal Ball risk analysis software developed by Decisioneering Inc., Denver, Colorado.

- The water treatment and supply plant has a supply capacity of 4.8 million cubic meters of water per annum. The sewerage system will add over 36,000 connections during the project, collecting over 11 million cubic meters of sewerage for treatment and disposal.
- Project financing: The World Bank's variable interest rate is calculated using the real cost of funds, a risk premium for the borrowing country, and the inflation rate of the loan disbursing country. The real rate of interest is estimated to be 7%.
- The real price of the water service is expected to remain constant, but all data are adjusted to reflect the effects of inflation. In the sewerage collection project, CESAN plans to raise the real tariff on service over the life of the project. This is modeled in the analysis.
- Labor is separated into skill categories. The wage rates are considered to be the prevailing government wage rates, which are significantly higher than the market rates for equivalent labor.
- Tertiary labor is taken as a percentage of the total labor.
- It is assumed that there is a 2% rise in real wages during each year of the project's life.
- The total investment in the two projects (water supply and sewerage) is R$34 million. Over two-thirds of this total is attributed to the water supply component. By the end of the project's life, 30 years, it is assumed that all other investments except land are completely depreciated and devoid of any residual value. The residual value of land is assumed to have the same real value as its initial real value. The investment table for the two projects is as follows:

Table 2.1. Investment Profile (*in R$*)

Water Supply Project

	1997	1998	1999
Labor	1,034,000	1,364,880	822,558
Raw Water Intake, Transmission & Pumping	1,687,190	2,136,611	1,275,479
Treatment	898,141	1,148,211	657,948
Treated Water Transmission and Pumping	1,337,692	1,694,383	980,287
Reservoirs & Distribution	1,575,233	1,994,807	1,153,840
Connections	111,765	141,557	43,935
Cost of Land	110,000	-	-
Total Investment Costs	**6,754,021**	**8,480,448**	**4,934,046**

Sewerage Project

	1997	1998	1999
Labor	449,900	867,570	907,742
Connections	131,820	244,650	245,538
Collectors and Interceptors	630,158	1,169,360	1,173,422
Pumping Stations and Raw Sewerage Pressure Pipes	300,667	557,838	559,675
Treatment and Outfall Pipes	594,804	1,103,846	1,107,777
Cost of Land	165,000	-	-
Total Investment Costs	**2,272,350**	**3,943,265**	**3,994,154**

Combined Project Investment

	1997	1998	1999
Total Investment	***9,026,371***	***12,423,713***	***8,928,200***

Source: World Bank Staff Appraisal Report

The equity for the project will be provided by CESAN. The World Bank is expected to provide financial support by means of a loan that covers half of the total investment costs. The loan principal will be repaid in 10 equal installments after a grace period of five years. In addition, CESAN will pay the interest accrued each year at the World Bank's variable interest rate.

Table 2.2. Project Financing

Year	1997	1998	1999
Total Investment	**R$ 9.00 MM**	**R$ 12420 MM**	**R$ 8.90 MM**
Loan Financing (WORLD BANK)	R$ 4.50 MM	R$ 6.20 MM	R$ 4.45 MM
Equity Financing (CESAN)	R$ 4.50 MM	R$ 6.20 MM	R$ 4.45 MM

Analytical Perspectives

The financial viability of the project is appraised from the total investment point-of-view and the equity point-of-view. The total investment point-of-view, (otherwise known as the banker's perspective,) excludes the cost of financing, and is used to assess the financial potential of the project without the loan component. By separating out the effect of loan financing, bankers can more accurately assess the project's ability to meet its debt obligations. The equity point-of-view, alternatively referred to as the owner's perspective, includes the cost of loan financing, and is used to assess the net financial benefits of the project after the loan is received and debt service are made. The initial loan received for investment is treated as a cash inflow, while repayments of interest and principal are treated as cash outflows.[14]

The analyses conducted from the two points of view are converted from nominal terms to real terms using a price index that measures the impact of inflation. The real impacts of inflation are both direct and indirect. Indirect impacts, also known as tax impacts, do not effect this project, because CESAN is not expected to pay corporate income tax.[15] The direct real impacts of inflation on the net income of the project are observed through the changes in the real values of accounts payable and receivable, changes in real cash balances, and the real amount of interest expense.[16]

The total investment point-of-view provides us with estimates of the cash flows produced by the project net of operating costs but before taking into consideration the inflows and outflows caused by the loans used to finance the project. These annual values for the net cash flow allow us to determine CESAN's ability to meet its debt service obligations. From the point of view of CESAN (the owner), the financial net present value is calculated from stream of annual cash

[14] Harberger and Jenkins, Chapter 6: Cost Benefit Analysis of Investment Decisions, Queen's University, Canada, 2001.

[15] Although CESAN is technically liable for taxes, the company has never paid taxes, due to constant financial losses. Even if it were to make a profit in the coming years, it is unlikely that they would be liable for taxes in the near future, due to the large accumulation of losses that are being carried forward for tax purposes.

[16] Harberger and Jenkins, Chapter 6: Cost Benefit Analysis of Investment Decisions, Queen's University, Canada, 2001.

flows that are projected inclusive of the inflow of loan receipts and the outflow of debt service payments. To calculate the net present value, we use a real rate of discount of 10% to reflect the utility's target real rate of return on equity.

Tables 2.3 and 2.4 show the financial analysis from the total investment point of view for the water supply project and the sewerage project, respectively. The real net cash flows from each of these table are carried over to table 2.5 in order to determine annual debt service coverage ratios and the debt service capacity ratios. These ratios are evaluated for the financing package that has been proposed by the World Bank and CESAN for the two components and the combined project.

Table 2.3. Financial Cash Flow Statement for Water Supply Project
(total investment point-of-view, real)

Year	1997	1998	1999	2000	...2005	...2010	...2015	...2020	...2025	...2027
CASH INFLOWS										
Revenue Collected from Water	147,840	323,390	512,431	2,816,410	2,926,424	2,978,219	2,978,219	2,978,219	2,978,219	-
change in A/R	(20,698)	(26,459)	(30,582)	(329,079)	(40,456)	(41,230)	(37,905)	(37,905)	(37,905)	379,046
Residual Value of Land	-	-	-	-	-	-	-	-	-	100,000
Total Inflows	**127,142**	**296,931**	**481,849**	**2,487,331**	**2,885,968**	**2,936,990**	**2,940,315**	**2,940,315**	**2,940,315**	**479,046**
CASH OUTFLOWS										
Investment Costs										
Labor										
Unskilled Labor	552,000	662,000	363,000	-	-	-	-	-	-	-
Semi-skilled Labor	388,000	466,000	255,000	-	-	-	-	-	-	-
Raw Water Intake, Transmission & Pumping				-	-	-	-	-	-	-
Materials	1,281,100	1,479,263	809,876	-	-	-	-	-	-	-
Equipment	252,709	286,531	148,410	-	-	-	-	-	-	-
Treatment										
Materials	681,849	787,362	415,251	-	-	-	-	-	-	-
Equipment	134,644	161,572	79,074	-	-	-	-	-	-	-
Treated Water Transmission and Pumping										
Materials	1,013,916	1,171,092	617,776	-	-	-	-	-	-	-
Equipment	202,168	229,225	118,728	-	-	-	-	-	-	-
Reservoirs & Distribution										
Materials	1,195,696	1,380,642	728,109	-	-	-	-	-	-	-
Equipment	236,334	267,959	138,788	-	-	-	-	-	-	-
Connections										
Materials	84,791	97,925	23,134	-	-	-	-	-	-	-
Equipment	16,814	19,064	9,875	-	-	-	-	-	-	-
Cost of Land	100,000	-	-	-	-	-	-	-	-	-
Operational Costs										
Total Cost of Labor Required by Project	50,051	81,126	113,423	146,980	367,289	617,811	916,502	1,221,110	1,608,258	-
Total Cost of Tertiary Labor Required by Project	25,526	38,129	52,175	63,201	139,570	234,768	348,271	464,022	611,138	-
Total Cost of Chemicals	7,207	14,484	21,808	113,906	114,377	114,377	114,377	114,377	114,377	-
Total Energy Costs	28,185	58,148	86,790	446,958	448,800	448,800	448,800	448,800	448,800	-
Total Other Service Costs	27,742	47,972	68,549	192,761	267,509	353,939	456,988	562,077	695,643	-
Total Maintenance Costs	68,800	68,800	69,800	69,800	71,020	69,800	67,580	64,140	60,700	-
Total Replacement Investments	-	-	-	-	-	-	-	-	-	-
change in A/P	(13,871)	(11,376)	(12,469)	(65,222)	(18,600)	(23,081)	(33,730)	(36,452)	(43,420)	326,430
change in CB	11,097	9,101	9,975	52,178	14,880	18,465	26,984	29,161	34,736	(261,144)
Total Outflows	**6,344,756**	**7,315,019**	**4,117,074**	**1,020,562**	**1,404,846**	**1,834,879**	**2,345,772**	**2,867,237**	**3,530,233**	**65,286**
Net Cash Flow	**(6,217,614)**	**(7,018,088)**	**(3,635,225)**	**1,466,768**	**1,481,122**	**1,102,111**	**594,543**	**73,078**	**(589,918)**	**413,760**

Table 2.4. Financial Cash Flow Statement for Sewerage Collection Project
(total investment point-of-view, real)

Year	1997	1998	1999	2000	2005	2010	2015	2020	2025	2027
CASH INFLOWS										
Revenue Collected from Sewerage Collection	29,493	64,645	113,902	1,938,303	2,584,741	2,689,281	2,736,183	2,773,671	2,803,718	-
change in A/R	(4,129)	(5,297)	(7,719)	(256,866)	(37,444)	(38,581)	(35,913)	(36,173)	(36,383)	357,506
Salvage Value of Land	-	-	-	-	-	-	-	-	-	150,000
Total Inflows	**25,364**	**59,348**	**106,184**	**1,681,437**	**2,547,297**	**2,650,700**	**2,700,271**	**2,737,498**	**2,767,335**	**507,506**
CASH OUTFLOWS										
Investment Costs										
Labor										
Non-Qualified Labor	325,000	570,000	542,000	-	-	-	-	-	-	-
Qualified Labor	84,000	147,000	140,000	-	-	-	-	-	-	-
Connections										
Materials	105,770	178,783	163,438	-	-	-	-	-	-	-
Equipment	14,067	23,407	21,038	-	-	-	-	-	-	-
Collectors & Interceptors										
Materials	504,089	851,990	778,795	-	-	-	-	-	-	-
Equipment	68,783	114,423	102,814	-	-	-	-	-	-	-
Pumping Stations & Raw Sewerage Pressure Pipes										
Materials	240,817	406,928	371,885	-	-	-	-	-	-	-
Equipment	32,517	54,095	48,607	-	-	-	-	-	-	-
Treatment and Outfall Pipes										
Materials	477,558	807,149	737,806	-	-	-	-	-	-	-
Equipment	63,173	105,121	94,483	-	-	-	-	-	-	-
Cost of Land	150,000	-	-	-	-	-	-	-	-	-
Operational Costs										
Total Cost of Labor Required by Project	35,309	36,016	36,736	95,934	110,460	136,013	155,706	195,158	234,387	-
Total Cost of Tertiary Labor Required by Project	18,008	16,927	16,899	41,252	41,975	51,685	59,168	74,160	89,067	-
Total Cost of Chemicals	-	-	-	-	-	-	-	-	-	-
Total Energy Costs	4,038	8,133	13,483	565,442	659,052	750,811	840,608	926,506	1,007,020	-
Total Other Service Costs	13,192	14,047	15,437	161,604	186,642	215,857	242,761	275,040	306,009	-
Total Maintenance Costs	11,800	10,800	10,821	10,842	10,955	11,079	11,217	11,368	11,536	-
Total Replacement Investments	-	-	-	-	-	-	-	-	-	-
change in A/P	(7,055)	(1,099)	(1,426)	(78,918)	(11,519)	(12,947)	(14,252)	(16,765)	(17,333)	151,210
change in CB	5,644	879	1,141	63,135	9,215	10,358	11,402	13,412	13,866	(120,968)
Total Outflows	**2,146,709**	**3,344,600**	**3,093,958**	**859,290**	**1,006,781**	**1,162,857**	**1,306,609**	**1,478,879**	**1,644,553**	**30,242**
Net Cash Flow	**(2,121,345)**	**(3,285,252)**	**(2,987,774)**	**822,147**	**1,540,516**	**1,487,843**	**1,393,662**	**1,258,619**	**1,122,782**	**477,264**

The annual debt service coverage ratios for the water project alone are shown in table 2.5A. Only in one year over the entire ten year loan repayment period is the annual debt service coverage ratio more than one. The water project alone clearly does not generate enough incremental net cash flow to cover the project's debt service obligation.

The situation is somewhat different with respect to the sewerage project (table 2.5B). Here the net cash flow from this component is always larger than its debt service obligations. In the first year, the annual debt service coverage ratio is 1.4 and steadily increase to 3.20 by the final year of the loan.

When both components are combined (table 2.5C), the annual debt service coverage ratio starts out with a value of 0.95, rising to 1.38 in the final year of the loan repayment, 10 years later.

Another measure of the ability of the project to service its debt obligations is the debt service capacity ratio. It is calculated as the ratio of the present value of the net cash flows over the remaining period that the debt is outstanding to the net present value of the amount of debt service obligations. This parameter is calculated for the combined project and reported in table 2.5C. In the first year of operations this ratio is only 1.21 and rises to about 1.5 in the last few years of the life of the loan. These indicate that there is considerable risk that the incremental cash flow generated by the overall project may not be sufficient to service the new loan obligations.

Table 2.5. Annual Debt Service Coverage Ratio and Debt Service Capacity Ratio

A. Water Supply Project

Year	**1996**	**1997**	**1998**	**1999**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Net Cash Flow	**0**	**-6839375**	**-8491886**	**-4838484**	**2940452**	**3095498**	**3279617**	**3492409**	**3267579**	**3812706**	**4016247**	**3995410**	**4185264**	**1969942**
Loan Disbursement by the World Bank (US$)	-	3,162,110	3,717,730	2,025,381	-	-	-	-	-	-	-	-	-	-
Interest and Loan Repayment (R$)	-	-	-	-	3,999,195	4,055,217	4,100,382	4,132,956	4,151,020	4,152,449	4,134,901	4,095,788	4,032,261	3,941,182
Annual Debt Service Coverage Ratio					**0.74**	**0.76**	**0.80**	**0.85**	**0.79**	**0.92**	**0.97**	**0.98**	**1.04**	**0.50**

B. Sewerage Project

Year	**1996**	**1997**	**1998**	**1999**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Net Cash Flow	**0**	**-2333479**	**-3975155**	**-3976727**	**2726730**	**3005651**	**3290009**	**3632456**	**3932417**	**4322783**	**4699439**	**5123053**	**5650083**	**6121955**
Loan Disbursement by the World Bank (US$)	-	1,063,873	1,728,682	1,639,564	-	-	-	-	-	-	-	-	-	-
Interest and Loan Repayment (R$)	-	-	-	-	1,941,484	1,968,680	1,990,607	2,006,420	2,015,190	2,015,883	2,007,364	1,988,376	1,957,536	1,913,320
Annual Debt Service Coverage Ratio					**1.40**	**1.53**	**1.65**	**1.81**	**1.95**	**2.14**	**2.34**	**2.58**	**2.89**	**3.20**

C. Combined Project

Year	**1996**	**1997**	**1998**	**1999**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Net Cash Flow		-9172855	-12467041	-8815212	5667181	6101149	6569627	7124865	7199996	8135489	8715686	9118463	9835347	8091897
Loan Disbursement by the World Bank (US$)		4225983	5446412	3664946										
Interest and Loan Repayment (R$)					5940679	6023897	6090989	6139377	6166209	6168333	6142265	6084164	5989796	5854501
Total Annual Debt Service Coverage Ratio					**0.95**	**1.01**	**1.08**	**1.16**	**1.17**	**1.32**	**1.42**	**1.50**	**1.64**	**1.38**
Total Debt Service Capacity Ratio					**1.21**	**1.25**	**1.30**	**1.34**	**1.39**	**1.44**	**1.48**	**1.51**	**1.52**	**1.38**

Table 2.6. Financial Cash Flow Statement for Water Supply Project
(equity point-of-view, real)

Year	1996	1997	1998	1999	2000	...2005	...2010	...2015	...2020	...2025	...2027
CASH INFLOWS											
Revenue Collected from Water	-	147,840	323,390	512,431	2,816,410	2,926,424	2,978,219	2,978,219	2,978,219	2,978,219	-
change in A/R	-	(20,698)	(26,459)	(30,582)	(329,079)	(40,456)	(41,230)	(37,905)	(37,905)	(37,905)	379,046
Residual Value of Land	-	-	-	-	-	-	-	-	-	-	100,000
Loan Received from World Bank	-	3,070,009	3,504,318	1,853,511	-	-	-	-	-	-	-
Total Inflows	**-**	**3,197,152**	**3,801,249**	**2,335,360**	**2,487,331**	**2,885,968**	**2,936,990**	**2,940,315**	**2,940,315**	**2,940,315**	**479,046**
CASH OUTFLOWS											
Investment Costs											
Labor											
Unskilled Labor	-	552,000	662,000	363,000	-	-	-	-	-	-	-
Semi-skilled Labor	-	388,000	466,000	255,000	-	-	-	-	-	-	-
Raw Water Intake, Transmission & Pumping					-	-	-	-	-	-	-
Materials	-	1,281,100	1,479,263	809,876	-	-	-	-	-	-	-
Equipment	-	252,709	286,531	148,410	-	-	-	-	-	-	-
Treatment											
Materials	-	681,849	787,362	415,251	-	-	-	-	-	-	-
Equipment	-	134,644	161,572	79,074	-	-	-	-	-	-	-
Treated Water Transmission and Pumping											
Materials	-	1,013,916	1,171,092	617,776	-	-	-	-	-	-	-
Equipment	-	202,168	229,225	118,728	-	-	-	-	-	-	-
Reservoirs & Distribution											
Materials	-	1,195,696	1,380,642	728,109	-	-	-	-	-	-	-
Equipment	-	236,334	267,959	138,788	-	-	-	-	-	-	-
Connections											
Materials	-	84,791	97,925	23,134	-	-	-	-	-	-	-
Equipment	-	16,814	19,064	9,875	-	-	-	-	-	-	-
Cost of Land	-	100,000	-	-	-	-	-	-	-	-	-
Loan Repayment to World Bank	-	-	-	-	-	1,752,777	1,061,820	-	-	-	-
Operational Costs											
Total Cost of Labor Required by Project	-	50,051	81,126	113,423	146,980	367,289	617,811	916,502	1,221,110	1,608,258	-
Total Cost of Tertiary Labor Required by Project	-	25,526	38,129	52,175	63,201	139,570	234,768	348,271	464,022	611,138	-
Total Cost of Chemicals	-	7,207	14,484	21,808	113,906	114,377	114,377	114,377	114,377	114,377	-
Total Energy Costs	-	28,185	58,148	86,790	446,958	448,800	448,800	448,800	448,800	448,800	-
Total Other Service Costs	-	27,742	47,972	68,549	192,761	267,509	353,939	456,988	562,077	695,643	-
Total Maintenance Costs	-	68,800	68,800	69,800	69,800	71,020	69,800	67,580	64,140	60,700	-
Total Replacement Investments	-	-	-	-	-	-	-	-	-	-	-
change in A/P	-	(13,871)	(11,376)	(12,469)	(65,222)	(18,600)	(23,081)	(33,730)	(36,452)	(43,420)	326,430
change in CB	-	11,097	9,101	9,975	52,178	14,880	18,465	26,984	29,161	34,736	(261,144
Total Outflows	**-**	**6,344,756**	**7,315,019**	**4,117,074**	**1,020,562**	**3,157,623**	**2,896,699**	**2,345,772**	**2,867,237**	**3,530,233**	**65,286**
Net Cash Flow	**-**	**(3,147,605)**	**(3,513,770)**	**(1,781,714)**	**1,466,768**	**(271,655)**	**40,291**	**594,543**	**73,078**	**(589,918)**	**413,760**
Net Present Value (NPV) @ **10.0%**	**(5,570,846)**										

Table 2.7. Financial Cash Flow Statement for Sewerage Collection Project
(equity point-of-view, real)

Year	1996	1997	1998	1999	2000	...2005	...2010	...2015	...2020	...2025	...2027
CASH INFLOWS											
Revenue Collected from Sewerage Collection	-	29,493	64,645	113,902	1,938,303	2,584,741	2,689,281	2,736,183	2,773,671	2,803,718	-
change in A/R	-	(4,129)	(5,297)	(7,719)	(256,866)	(37,444)	(38,581)	(35,913)	(36,173)	(36,383)	357,5
Residual Value of Land	-	-	-	-	-	-	-	-	-	-	150,0
Loan Received from World Bank	-	1,032,886	1,629,448	1,500,433	-	-	-	-	-	-	-
Total Inflows	**-**	**1,058,251**	**1,688,797**	**1,606,617**	**1,681,437**	**2,547,297**	**2,650,700**	**2,700,271**	**2,737,498**	**2,767,335**	**507,5**
CASH OUTFLOWS											
Investment Costs											
Labor											
Unkilled Labor	-	325,000	570,000	542,000	-	-	-	-	-	-	-
Semi-skilled Labor	-	84,000	147,000	140,000	-	-	-	-	-	-	-
Connections											
Materials	-	105,770	178,783	163,438	-	-	-	-	-	-	-
Equipment	-	14,067	23,407	21,038	-	-	-	-	-	-	-
Collectors & Interceptors											
Materials	-	504,089	851,990	778,795	-	-	-	-	-	-	-
Equipment	-	68,783	114,423	102,814	-	-	-	-	-	-	-
Pumping Stations & Raw Sewerage Pressure Pipes											
Materials	-	240,817	406,928	371,885	-	-	-	-	-	-	-
Equipment	-	32,517	54,095	48,607	-	-	-	-	-	-	-
Treatment and Outfall Pipes											
Materials	-	477,558	807,149	737,806	-	-	-	-	-	-	-
Equipment	-	63,173	105,121	94,483	-	-	-	-	-	-	-
Cost of Land	-	150,000	-	-	-	-	-	-	-	-	-
Loan Repayment to World Bank	-	-	-	-	-	850,918	515,480	-	-	-	-
Operational Costs											
Total Cost of Labor Required by Project	-	35,309	36,016	36,736	95,934	110,460	136,013	155,706	195,158	234,387	-
Total Cost of Tertiary Labor Required by Project	-	18,008	16,927	16,899	41,252	41,975	51,685	59,168	74,160	89,067	-
Total Cost of Chemicals	-	-	-	-	-	-	-	-	-	-	-
Total Energy Costs	-	4,038	8,133	13,483	565,442	659,052	750,811	840,608	926,506	1,007,020	-
Total Other Service Costs	-	13,192	14,047	15,437	161,604	186,642	215,857	242,761	275,040	306,009	-
Total Maintenance Costs	-	11,800	10,800	10,821	10,842	10,955	11,079	11,217	11,368	11,536	-
Total Replacement Investments	-	-	-	-	-	-	-	-	-	-	-
change in A/P	-	(7,055)	(1,099)	(1,426)	(78,918)	(11,519)	(12,947)	(14,252)	(16,765)	(17,333)	151,2
change in CB	-	5,644	879	1,141	63,135	9,215	10,358	11,402	13,412	13,866	(120,9
Total Outflows	**-**	**2,146,709**	**3,344,600**	**3,093,958**	**859,290**	**1,857,699**	**1,678,337**	**1,306,609**	**1,478,879**	**1,644,553**	**30,2**
Net Cash Flow	**-**	**(1,088,459)**	**(1,655,804)**	**(1,487,341)**	**822,147**	**689,598**	**972,363**	**1,393,662**	**1,258,619**	**1,122,782**	**477,2**
Net Present Value (NPV) @ **10.0%**	**3,127,013**										

Results

Table 2.8. Breakdown of Results from Financial Analysis

	Water supply project	Sewerage project
NPV of project* (PV of benefits - PV of costs)	**R$ -5.6 MM**	**R$ 3.1 MM**
PV of benefits*	**R$ 27.6 MM**	**R$ 20.9 MM**
PV of costs*	**R$ 33.2 MM**	**R$ 17.8 MM**

* Discounted sum of values from year 0 to year 30.

Table 2.8 summarizes the results from the financial analysis based on the discounted cash flow analysis. The financial NPV is negative for the water supply plant, but positive for the sewerage disposal plant (R$ -5.6 MM and 3.1 MM, respectively). The high costs that are reflected in the negative NPV of the water supply project are largely due to the high initial investment and to the significant labor costs associated with the operation of the water supply. The sewerage collection project requires only half the investment cost, and also requires notably less labor than the water supply project. Furthermore, the sewerage collection project is able to collect a service surcharge (applied to water consumption) on CESAN's entire supply of water, because the benefits generated by the project accrue to all residents who are connected to the sewerage system. The water revenue attributed to the project, on the other hand, is only for the water services purchased from the new project, exclusive of existing supply. Many of the operational costs of sewerage supply reflect the high levels of energy required to operate the plant. In summary, the large initial fixed cost of building extensive water carriage infrastructure and treatment facilities is one of the main reasons for the poor financial performance of the water project. Conversely, the smaller investment and operational costs render the sewerage project financially more robust.

The biggest cost component of the investments is the purchase of building materials such as bricks, steel and cement, which accounts for over 65% of the total investment in both projects. The remaining costs are made up of equipment and labor for the construction of the two plants.

Sensitivity Analysis

SENSITIVITY OF NPV TO COST OVERRUNS. The financial effects of decreasing or increasing the estimated costs are analyzed in the table below. A 10 percent increase in investment costs would reduce the NPV of the project by more than 20%, since investment costs comprise a significant financial outlay in infrastructure projects of this nature. Conversely, it may be possible to improve the financial performance by managing the investment process better. These investment costs, however, reflect required technical specifications and fair market prices, which do not allow for significant reductions. Regional experience in similar infrastructure projects suggests that costs might actually be expected to surpass forecasts, rather than to fall short of them. Material costs are also sensitive to foreign exchange fluctuations, since over 50% of materials and equipment are imported directly. Therefore, a real devaluation of the Real (R$) during the investment phase could negatively affect the project by increasing the cost of financing the two plants.

Table 2.9. Sensitivity of the Financial NPV to Cost Overruns

Percentage of cost overruns (%)	Water financial NPV	Sewerage financial NPV
-6	(4,763,947)	3,516,980
-4	(5,032,913)	3,386,991
-2	(5,301,879)	3,257,002
0	(5,570,846)	3,127,013
2	(5,839,812)	2,997,024
4	(6,108,778)	2,867,035
6	(6,377,745)	2,737,046
8	(6,646,711)	2,607,057
10	(6,915,677)	2,477,068

SENSITIVITY OF NPV TO CHANGES IN REAL GROWTH IN WAGES: The financial viability of the water project is expected to be affected by increases in the real wage rate, as labor accounts for more than 50% of operating costs. Furthermore, the state of Espirito Santo and CESAN have historically paid their workers wage rates that are 25% to 40% above competitive market rates for similar work. The real wages paid are expected to rise at a rate of 2% per annum, following the current trend in Brazil. However, a single percentage point change in the real growth rate of

wages would alter the projects' financial NPV by as much as R$ 1.2 million. It is difficult to envision a lowering of the existing wage rate structure, reflecting inherent political factors associated with employment by a government utility. Therefore, it will be important that a high rate of productivity growth is realized by effective management practices to offset the growth in real wage rates. The sewerage project's NPV should be less affected by the level of labor productivity, as it utilizes less labor for its operations.

Table 2.10. Sensitivity of the Financial NPV to Growth of Real Wage Rates

Percentage change in growth of real wage rate	Water financial NPV	Sewerage financial NPV
1.00	(4,627,006)	3,317,240
1.20	(4,802,453)	3,281,544
1.40	(4,984,299)	3,244,717
1.60	(5,172,800)	3,206,715
1.80	(5,368,223)	3,167,496
2.00	(5,570,846)	3,127,013
2.20	(5,780,957)	3,085,221
2.40	(5,998,857)	3,042,069
2.60	(6,224,861)	2,997,507
2.80	(6,459,295)	2,951,481
3.00	(6,702,499)	2,903,937
3.20	(6,954,829)	2,854,817

SENSITIVITY OF NPV TO CHANGES IN INVOICING AND COLLECTION EFFICIENCY. Both projects' revenues should be significantly affected by CESAN's current problems in managing the process of invoicing and collecting revenue owed to the utility. These effects are critical in the case of the water project, as this weakness compromises its financial viability. Despite its financial buoyancy, poor management is harmful to the sewerage project as well because of poor invoicing and the revenue collection system.

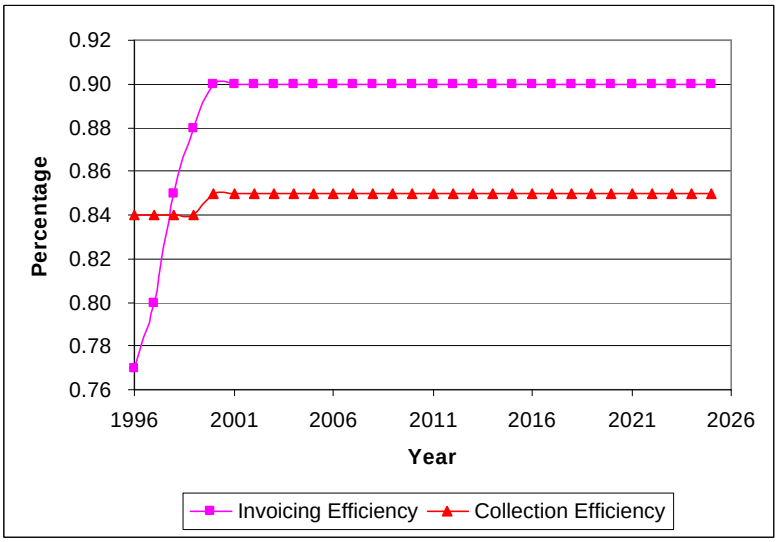
CESAN is unable to invoice many water consumers, since it does not employ an effective system for reading the water meters. The current targets for improvement under this project are not expected to be high enough to make the water project financially feasible. Significant improvements, could vastly improve the financial condition of the project. For example, a 10% increase in invoicing should improve the NPV by over R$2 million.

Table 2.11. Sensitivity of the Financial NPV to Changes in Invoicing and Collection Efficiency

Change in the level of currently expected collection or invoicing efficiency (0%=base case)	Water financial NPV	Sewerage financial NPV
-15	(8,652,783)	506,191
-10	(7,625,470)	1,379,799
-5	(6,598,158)	2,253,406
0	(5,570,846)	3,127,013
5	(4,543,533)	4,000,620
10	(3,516,221)	4,874,228
15	(2,488,909)	5,747,835

CESAN also faces a formidable task with regard to collecting revenues for water service. Improving the current level of collection should lead to a notable influx of additional revenue that would enhance the financial viability of the project. However, the current institutional development strategy of CESAN is formulated to focus on the invoicing efficiency rather than on the collections, as illustrated in the following figure. However, it is clear that improved invoicing alone will not financially revitalize the water project. In other words, invoicing more customers for service, without being able to collect sufficient payments is not likely to result in revenue increases that are adequate. In addition, it would be difficult to sharply improve the already ambitious targets for invoicing set by CESAN. The current target for improving collections of arrears, however, only reaches 85% at its peak. Therefore, it is imperative that CESAN attempt to further improve collection efficiency targets, while attempting modest gains through improvements in the current invoicing targets. In fact, CESAN should consider employing a dual strategy to focus both on improving its invoicing and on expanding the collection of fees for its services.

Figure 2.2: CESAN'S Targets for Improving Invoicing and Collection Efficiency for Water and Sewerage Service



SENSITIVITY OF NPV OF WATER PROJECT TO CHANGES IN INVOICING AND COLLECTION EFFICIENCY. The tables below illustrate that the water supply project is not expected to attain financial self-sufficiency, despite a collective improvement of 10% in invoicing and collections. Any administrative improvement in CESAN, however, would have a positive impact on the sewerage project as well. Therefore, when viewing the combined NPV of the projects, the project is viable with a modest 5% increase in the current targets for invoicing and collections. In fact, CESAN should also be able to maintain its current target for invoicing, while improving collections by 10%, in order to obtain a NPV of R$1.35 MM. It is important to note that CESAN must also consider the additional costs that would likely have to be incurred in the process of increasing its administrative efficiency.

Table 2.12. Sensitivity of the Financial NPV of Water Project to Changes in Invoicing and Collection Efficiency

		Collection efficiency (%)					
		-15	**-10**	**-5**	**0**	**5**	**10**
Invoicing efficiency (%)	**-15**	(11,272,429)	(10,399,214)	(9,525,998)	(8,652,783)	(7,779,567)	(6,906,352)
	-10	(10,399,214)	(9,474,633)	(8,550,052)	(7,625,470)	(6,700,889)	(5,776,308)
	-5	(9,525,998)	(8,550,052)	(7,574,105)	(6,598,158)	(5,622,211)	(4,646,265)
	0	(8,652,783)	(7,625,470)	(6,598,158)	(5,570,846)	(4,543,533)	(3,516,221)

	5	(7,779,567)	(6,700,889)	(5,622,211)	(4,543,533)	(3,464,855)	(2,386,177)
	10	(6,906,352)	(5,776,308)	(4,646,265)	(3,516,221)	(2,386,177)	(1,256,134)

Table 2.13. Sensitivity of the Financial NPV of Combined Project to Changes in Invoicing and Collection Efficiency

		Collection efficiency (%)					
		-15	**-10**	**-5**	**0**	**5**	**10**
Invoicing efficiency (%)	**-15**	(12,993,936)	(11,378,155)	(9,762,373)	(8,146,591)	(6,530,810)	(4,915,028)
	-10	(11,378,155)	(9,667,327)	(7,956,499)	(6,245,672)	(4,534,844)	(2,824,016)
	-5	(9,762,373)	(7,956,499)	(6,150,626)	(4,344,752)	(2,538,879)	(733,005)
	0	(8,146,591)	(6,245,672)	(4,344,752)	(2,443,833)	(542,913)	1,358,007
	5	(6,530,810)	(4,534,844)	(2,538,879)	(542,913)	1,453,053	3,449,018
	10	(4,915,028)	(2,824,016)	(733,005)	1,358,007	3,449,018	5,540,030

SENSITIVITY OF NPV TO CHANGES IN LEAKAGE AND STOLEN WATER. Currently, CESAN does not receive any financial benefit from 28% percent of the water it supplies, due to water leakages and unrecorded connections. The Utility hopes to reduce the percentage of non-revenue water to 13% during the life of the project. Any additional efforts to limit water leakages and to prevent free consumption of water should further enhance the financial viability of the project. However, the gains might be modest, since the benefits from supplying additional water to paying customers will continue to be offset by weak invoicing and collections. For example, CESAN can improve the financial situation by only R$0.4MM through harnessing 15% more of the water that would otherwise escape its water supply system. Reducing the level of non-revenue water also helps the financial position of the sewerage collection plant, as its revenues are directly affected by the quantity of water supplied to paying customers. Despite CESAN's inability to significantly alter its financial situation, a reduction in free and leaked water could turn out to be quite effective when combined with continued improvements in the levels of invoicing and collections.

Table 2.14. Sensitivity of the Financial NPV to Change in Leakage and Stolen Water

Change in the level of currently expected level for leakage and free water (0%=base case)	**Water financial NPV**	**Sewerage financial NPV**
-15	(5,290,330)	3,436,103
-10	(5,366,911)	3,338,073
-5	(5,469,433)	3,231,851
0	(5,570,846)	3,127,013

5	(5,701,237)	3,014,940
10	(5,835,597)	2,902,706
15	(5,968,169)	2,791,934

* lower percentage = less leakage, base case assumes current target for level of leakage and stolen water

SENSITIVITY OF NPV TO CHANGES IN WATER TARIFF. On the revenue side, CESAN cannot raise prices further for two reasons. First, one objective of the project is to provide affordable basic services to all residents in the region. Second, the projected price is already close to revenue maximizing rates. The sensitivity analysis illustrates that an initial rise in the real water tariff to R$1.05 would raise the financial NPV of the water project by R$ 1.4 MM. Any cutback in consumption should be more than offset by the increase in revenue per cubic meter of water consumed. Further increases in the water tariff beyond this point would induce cutbacks by consumers, which would cause revenue to fall. Therefore, the NPV of the water project would be decreased by increases in the water tariff beyond R$ 1.05.

A reduction in the water tariff would increase the quantity of sales by CESAN. The utility, however, is unable to supply the additional water demanded by consumers at the lower tariff. This is due to the fixed capacity of CESAN's water supply. The financial outcome of the project would be considerably weakened, since revenues decrease rapidly when the price per unit is reduced.

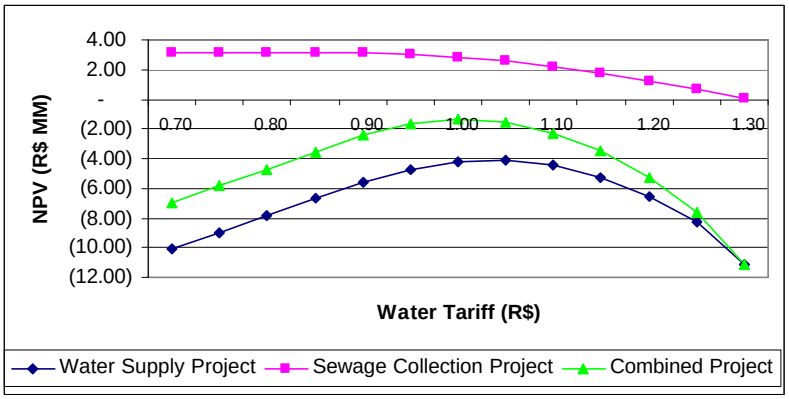
The sewerage revenue is affected directly by the quantity of water supplied to paying customers. A lower water tariff does not alter the financial viability of the sewerage project, since the fixed supply of water prevents CESAN from increasing its supply, and the sewerage surcharge remains unchanged. Increases in the water tariff gradually begin to reduce the quantity of water consumed, which, in turn, leads to a reduction in revenue collected through the sewerage surcharge. Therefore, it is important to be aware of this implication for both projects when designing the tariff structure for the water supply project.

Table 2.15. Sensitivity of the Financial NPV to Changes in Water Tariffs

Water tariffs (R$)	Water financial NPV	Sewerage financial NPV
0.70	(10,132,609)	3,128,664
0.75	(8,990,720)	3,128,664
0.80	(7,848,831)	3,128,664
0.85	(6,706,941)	3,128,664
0.90	(5,570,846)	3,127,013
0.95	(4,712,758)	3,044,716
1.00	(4,236,003)	2,855,485
1.05	(4,153,497)	2,574,130
1.10	(4,477,210)	2,212,343
1.15	(5,261,592)	1,767,930
1.20	(6,507,181)	1,252,834
1.25	(8,295,303)	678,823
1.30	(11,155,806)	43,540

A financially optimal water tariff, which would maximize revenues under the present circumstances, is estimated in the following graph. A tariff of R$ 1.05 per cubic meter of water provides the most promising financial prospect for the combined project. Such a tariff should provide a substantial amount of additional water revenue, despite a small drop in revenue from the sewerage surcharge. It is important to note, however, that a higher tariff level would negatively affect one objective of the project, namely the provision of water to the poorer residents of the area, at a price that will improve their standard of living.

Figure 2.3. Optimal Water Pricing for Maximizing Financial NPV



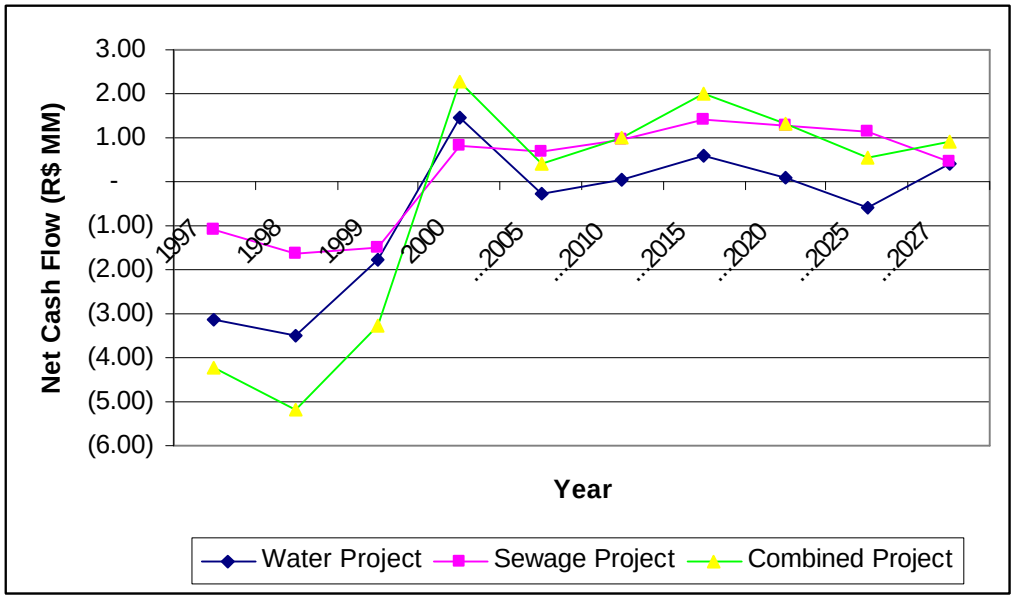
SENSITIVITY OF NPV TO CHANGES IN SEWERAGE SURCHARGE. Consumers react to a rise in the sewerage charge in the same way as they respond to a rise in the price of water. This is due to the fact that sewerage fees are applied as a surcharge on water, rather than as separate charges for sewerage collection. The NPVs (following a 0.05 rise in water or sewerage, for example) differ, however, because the change in revenue due to changes in the sewerage surcharge is attributed only to the sewerage project. The effect on the water project is due to the corresponding cutback in water consumption as the price of water services is perceived to be rising. Alternatively, lowering the sewerage fee (by between R$ 0.14 and R$ 0.17) has no effect on the NPV of the water project, as the existing network cannot supply the increase in demand for water service. However, small reductions in the sewerage surcharge have a significant impact on the NPV of the sewerage project. In fact, the project would not be financially viable if the surcharge were lowered to R$ 0.14.

Table 2.16. Sensitivity of the Financial NPV to Changes in Sewerage Charges

Sewerage charges (R$)	Water financial NPV	Sewerage financial NPV
0.14	(5,565,052)	(754,401)
0.15	(5,565,052)	216,365
0.16	(5,565,052)	1,187,132
0.17	(5,565,052)	2,157,898
0.18	(5,570,846)	3,127,013
0.19	(5,603,999)	4,087,714
0.20	(5,637,152)	5,047,366
0.21	(5,692,579)	5,996,676
0.22	(5,756,771)	6,940,221
0.23	(5,834,609)	7,875,229

Figure 2.4. Net Financial Cash Flow Profile of Project Equity Point-of-View

Water NPV	Sewerage NPV	Combined NPV
R$ -5.6 MM	R$ 3.1 MM	R$ -2.4 MM



The above graph illustrates the cash flow profiles of the water supply plant, the sewerage disposal plant, and the combined project. The graph shows that the cash flow for the sewerage disposal project is greater and more consistent than for the water supply project. It also illustrates the effect if the two plants were treated as one project. For the combined project, the financial outcome is more promising. In fact, the total project is able to meet all its financial obligations during the years of operation, despite its inability to earn a normal rate of return on its equity. The financial rate of return that it does earn from its operations, however, may be sufficient, in light of the public sector nature of the project. Combining the two projects effectively causes the sewerage project to subsidize part of the water project's losses. It is important to realize, however, that the sewerage revenues and amount of sewerage collected (which will determine the operational costs) are functions of the water supply. This relationship between the two components of the project makes it reasonable to ultimately evaluate the two plants as one project.

Economic Analysis

The economic analysis is the second component of an integrated investment appraisal. Its perspective is to evaluate the investment from the point of view of the entire country.

General Approach

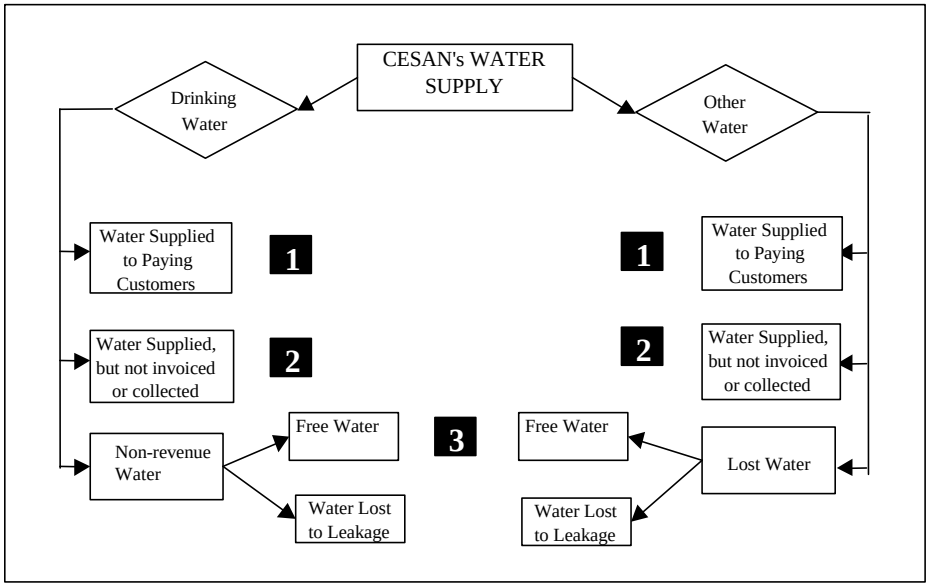
The economic analysis changes all major cash flow items from financial terms to economic terms by estimating economic prices for all inputs and outputs.[17] The net economic value of a project is defined as the sum of all economic benefits from the project minus all resource costs, applied to all residents in Brazil. We use the price level in domestic currency as the numeraire for measuring both financial and economic values. To conduct the economic analysis, we first estimate the national economic parameters, including the economic cost of foreign exchange and the economic cost of capital. We then proceed with the estimation of the economic benefit of the clean water service and the sewerage collection and disposal services. Finally, we estimate the economic value of all inputs of the project. We then utilize all derived economic values to transform the statement of net financial cash flows into a statement of net economic benefits.

Conversion from Net Financial Benefits to Net Economic Benefits

The economic rate of foreign exchange deviates from the financial rate of foreign exchange due to distortions created by tariffs, quotas and indirect taxes.[18] The economic premium on foreign exchange in Brazil is estimated to be 12.06% above the current market exchange rate.[19] The economic cost of capital (EOCK), which is the discount rate used for the economic analysis, measures the real opportunity cost of resources in Brazil. The effects of the returns from domestic savings, returns on investment in different sectors and the costs of foreign borrowing are brought into the calculation of the economic cost of capital. The current economic cost of capital in Brazil is calculated at 12.17%.[20]

[17] Harberger and Jenkins, Manual 2001, Chapters 7,8,9,10, and 11.
[18]Harberger, A.C. and Jenkins, G.P. "Introduction", *Cost-Benefit Analysis*, Edward Elgar Publisher, 2002.
[19]Table 12.2 in Spreadsheet Tables – Water Supply Project.
[20]Table 12.1 in Spreadsheet Tables – Water Supply Project.

Figure 2.5. Breakdown of Economic Valuation of Water

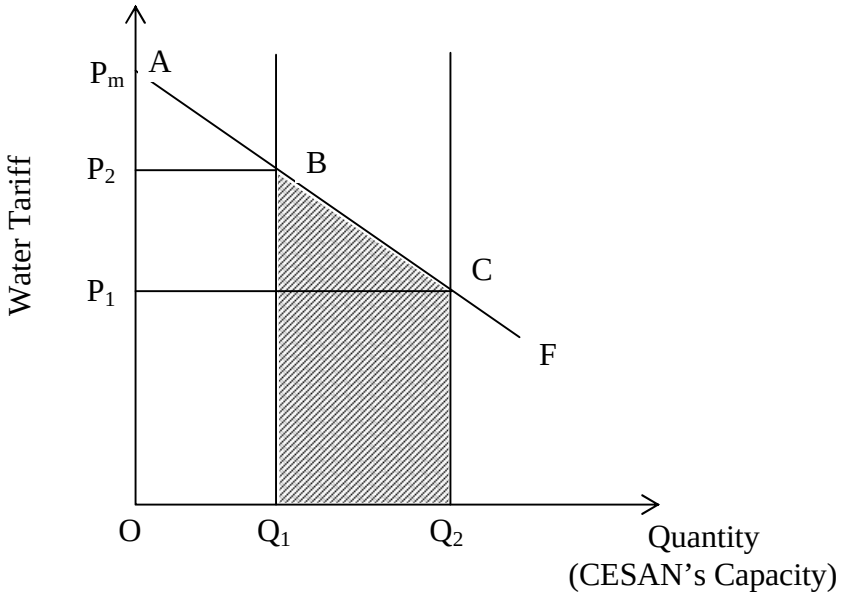


The economic value of water is assessed in the following manner: First, we separate drinking water and water used for other purposes. The economic values for the two separate uses of water are significantly different, unlike the financial prices which are identical. Furthermore, if the water tariff were to change, the customers' reaction to the modified price would be based on their specific use of the water. The elasticity of demand for drinking water with respect to its price is significantly less than for water used for other purposes. The consumers of water are divided into three distinct groups. The first group consists of customers who pay for CESAN's water supply (#1 in figure 2.5). For this group, the economic value of consumption is an adjustment to the financial revenue from water. The second group is made up of the customers serviced by CESAN, who do not pay, due to the lack of invoicing and collection (#2 in figure 2.5). Finally, we separate non-revenue water (#3 in figure 2.5), which is further divided into unauthorized consumption water and water lost as a result of leakage in the water supply network. The former has some economic value because it is consumed, despite the lack of any financial benefit. The latter is a loss in both economic and financial terms. Thus, we estimate the economic value associated with water used for drinking and other purposes by paying customers, by non-paying (i.e. non-invoiced) customers, and for water that is distributed free.

Valuation of Additional Water and Improved Service to Paying Customers who are now Rationed

Figure 2.6 illustrates the economic valuation of water for paying users. The demand for water service in the Guarapari region is reflected by the demand curve AF, and the price for water service is established by CESAN at P_1. Thus, there exists a shortage of water service, as the demand for water at a price of P_1 is Q_2, yet CESAN's capacity allows it to supply only Q_1 cubic meters of water. If water prices were not fixed, but determined by market forces, the equilibrium price for the quantity supplied would be P_2. Suppose that rather than allowing the price of water to rise so that demand equals supply, the utility maintains the price at P_1 and rations the water to all its users. Under this scenario, the consumers will store the water and use to it for their highest value uses. However, the stored water that is provided on an intermittent basis will not be fit for drinking without boiling or some other further treatment.

Figure 2.6. Economic Valuation of Water for Paying Customers



The economic value of the rationed water currently purchased by paying users at the controlled price of P_1 is the area $OABQ_1$ in figure 2.6. P_m will likely be set by the consumer's maximum willingness to pay for the drinking and cooking water.

The proposed project will expand the supply of water from Q_1 to Q_2 and also improve its quality to the level where it can be used directly for drinking and cooking. After the project the shortage of water will be eliminated at the price charged by IDAAN, i.e. P_1. If the consumer's current marginal valuation of water under rationed conditions is P_2, then the economic value of the additional water supplied by the project to these consumers can be illustrated as the area Q_1BCQ_2 in figure 2.6.

The problem now is how to place the appropriate value on the higher quality of water that CESAN will provide because it is able to give 24 hour service of high quality water.[21]

It is estimated that 25 percent of the total new water supplied will be delivered to the paying customers who currently being rationed. Of this amount it is assumed that 5 percent of the quantity will be used for drinking and cooking.[22]

From a contingent valuation study it was found that the consumer's marginal valuation of additional water provided by a higher quality of service is $3.90 per cubic meter. Hence 5 percent of the water provided to this group of customers is given an economic value of $3.90 per cubic meter.

This leaves the remaining 95 percent of the incremental water they receive to be valued as water that will be used primarily for washing and other purposes. The marginal value of this quality of water is expected to be substantially lower than the value placed on clean water for drinking and cooking. The estimate we use for the maximum willingness to pay for additional washing water as 50 percent of what the consumer's have indicated they would be willing to pay for a high quality water service. This gives us a maximum marginal valuation of $1.95 per cubic meter.

If the total quantity supplied by the project is sufficient to meet the quantity demanded at the price of $0.90 per cubic meter, then the average economic value per cubic meter will be the

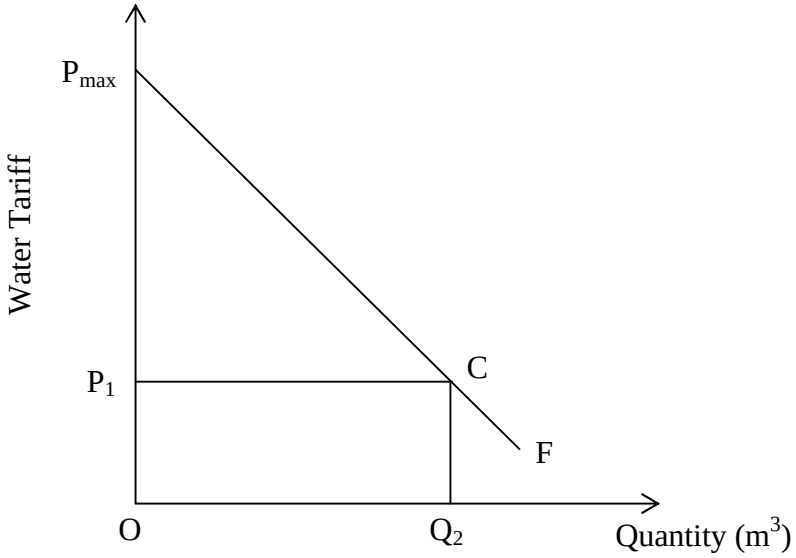
[21]When water is provided on an intermittent basis with pipes that leak the back pressure in the soil until force polluted water to enter the pipes when the system is not pumping water. This polluted water is then delivered to the households when the system begins to supply water again.

simple average of (1.95 + 0.90) or $1.43 per cubic meter. For the additional water supplied of (Q_2–Q_1) as show in Figure 2.6, we value 5 percent of the quantity at $3.80 because it is used as drinking and cooking and consumers are willing to pay a premium for such quantities. For the remaining 95 percent of the quantity a valuation of $1.43 per cubic meter is used.

Valuation of Additional Water and Improved Service to Paying Customers who are now Rationed

Consumer's who obtain new connections via the project will ultimately be responsible for the consumption of 75 percent of the additional supply of water by this project. In the case of new connections, the economic valuation of the water is considerably higher on average, because they are now not receiving any water directly from CESAN. This is shown in figure 2.7. The curve $P_{max}F$ reflects the willingness to pay of these consumers for high quality water services.

Figure 2.7. Economic Valuation of Water for New Connections



[22] For an empirical estimation of this variable see Korman, V., "An Application of Contingent Valuation and Averting Expenditure Methods: Estimating Willingness to Pay for Improvements in Water Services in Famagusta-Cyprus", Ph.D Dissertation, Northeastern University, Boston, USA, 2002.

At the present time they are obtaining water from various sources (and of various qualities) and have indicated that they would be writing to pay P_{max} for high quality water services. The project will provide a service that will allow them to purchase all they want at CESAN's selling price of P_1. Hence, the economic value of Q_2 cubic meters of water per period is $OP_{max}CQ_2$. From the contingent valuation study P_{max} is equal to approximately $3.90 per cubic meter. We assume that the valuation of $\$3.90/m^3$ comes from the consumer's demand for drinking and cooking water who obtain via these new connections. It is this value that we place on the 5% of the water that used for drinking. The remainder will be used for other uses, where we expect the marginal willingness to pay will be declining as the volume of water consumed increases. Hence, the remaining in 95 percent of the water to be consumed by households that receive new connections is valued at the average of the maximum willingness to pay of 3.90 per cubic meter and the price they pay to CESAN of 0.90 per cubic meter, for an average value of $2.45 per cubic meter.

Evaluation of Water that is Supplied Free of Charge

Individuals who obtain the water service free of charge also derive an economic benefit, although CESAN is unable to recover any financial remuneration from such consumers. Thus, an adjustment has to be made in order to estimate the true economic impact of the project. It would be incorrect to assume that the economic value of water which generates no revenue is equal to the market price of water for all units of water consumed, because many of the non-paying consumers may value the service below the current price of water. Some consumers may actually value their water at a level higher than that of CESAN's water tariff, but pay nothing due to the method of acquisition. This project will both reduce the quantity of free water that is now received by some consumers and will increase free water to others as the overall system's supply of water is increased. The maximum value for the willingness to pay for water which generates no revenue is set half way between the maximum willingness-to-pay as measured by the contingent valuation studies and the price that CESAN charges them for water. Most of the people who will get the free water will be from the lower income groups. We expect their willingness to pay will be lower than the average of all consumers. Since the price of non-revenue water is zero, the economic value is simply 50 percent of the maximum willingness-to-

pay[23], or $1.95. Of course, water that is lost through leakage is devoid of any economic value. With these adjustments, the total economic value of water more closely reflects the true sum of all the benefits which it offers to society.

Evaluation of Health Externalities

The economic value can include an additional element that is not measured by the individual consumer's willingness-to-pay for the service. This element is associated with water used for drinking and cooking purposes that reflects the value of the social externalities that clean water is responsible for creating. For example, treated water can reduce waterborne contagious diseases that will spread if someone in the community gets sick from it. Yet an individual consumer will not consider the full value of preventing this disease, as he will not realize the total benefit from the eradication of the spread of the disease. As a consequence the private market demand function measuring the private willingness-to-pay will undervalue the service.

The value of this externality associated with non-drinking water is expected to be small. Research done by the World Bank indicates that the incidence of illnesses in Guarapari due to water-borne diseases is very low.[24] Nevertheless, the total economic value of water in our analysis is noticeably greater than the total financial value because of the shortage of supply and the value placed on unpaid-for and illegally acquired water.

The external benefits from sewerage collection and disposal, however, are significant. The non-use value can be classified into two main categories. The first category includes the externalities generated through sewerage disposal to the entire society, including the benefits that arise from living in a cleaner environment. The second category includes the benefits to consumers that are not typically attributed to the service. For example, many people are not aware that the sewerage service will help to maintain the purity of water sources from which drinking water is drawn. The resulting cleaner aquifers lead to a reduction in waterborne diseases, for which many consumers would be willing to spend financial resources, if they realized that this decrease in illness was a direct result of the sewerage service. The unrealized

[23](P_{max} + P1)/2, but P1 is 0 for non-paying users. Thus, P_{max}/2 is the economic value of non-revenue water.
[24]Frannie Humplick, The World Bank, Washington D.C.

nature of the benefits is not reflected in the consumer's willingness-to-pay for the project's services.

This study utilizes a contingent valuation (CV) survey in order to assess the consumer's valuation. The CV analysis is based on an extensive survey conducted by the World Bank. It was designed to measure people's willingness-to-pay for water supply and sewerage disposal services, and for any recreational and environmental benefits that could be attributed to the project.[25] Unlike the financial price in the water supply component, the financial price for the sewerage disposal does not give us a basis for calculation of the consumers' valuation of the sewerage service because it is part of the price charged for water. Sewerage is a by product or externality created by additional water consumption and its cost is not completely internalized in the market for water. Therefore, our economic valuation of the sewerage service must be based on the results of a household survey that focuses peoples attention on the services they receive.

The study indicates that the residents in Guarapari were willing to pay approximately R$0.49 per cubic meter for the proper disposal of sewerage, when all the benefits of the service are considered. They place an additional value of R$0.35 per cubic meter on the environmental recuperation benefits derived from properly discarded sewerage. The total environmental externality comprises a larger benefit to society, since the benefits are derived by the populace of the entire region, while the direct benefits of the sewerage service are only enjoyed by the paying consumers.

Economic Valuation of Inputs

In order to obtain the economic resource costs of all the inputs of the project, we calculated an economic price for each input item. Economic prices eliminate the various market distortions created by taxes and subsidies that are reflected in the financial prices and add the premium on foreign exchange to the list of tradable components of an item.[26] Furthermore, economic prices account for any changes in the domestic prices of non-traded goods that may occur as a result of

[25]Conducted by Frannie Humplick, the survey encompasses 54 questions, and included 900 observations.
[26] See the Harberger and Jenkins, Cost-Benefit Analysis, Queen's University, 2001 for the methods by which these economic values were calculated.

the project. These economic prices are then expressed as a ratio of their financial price. We refer to this ratio as an economic conversion factor. Table 2.17 lists the economic conversion factors for all the major inputs. As illustrated in the table, the economic resource costs of inputs are all lower than their financial costs, due to high taxes and tariffs in Brazil, which offset any increase in economic burden by subsidies and the foreign exchange premium. Since taxes and tariffs are merely transfer payments from consumers to the government, they are not treated as a resource cost to society. Electricity, as a case in point, bears the dual economic burdens of a large foreign exchange premium on its major input item, petroleum, and the government subsidy provided to stimulate production. Therefore, the resource cost of consuming electricity is slightly higher than the financial cost, despite high taxes and tariffs that partially offset the foreign exchange premium and subsidy [27].

Table 2.17. Economic Conversion Factors for Project Inputs

Cement	0.873
Steel	0.798
Wood	0.873
Bricks	0.952
Sand	0.945
600mm Pipes	0.820
Pvc Pipes	0.941
Motor Pumps	0.767
Pump Controller	0.767
Transformers	0.771
Labor	0.462
Chemicals	0.825
Electricity	1.051
Other Services	0.700

Results of Economic Analysis

In the case of labor, the extent to which the project is affected is evident. Labor has a low conversion factor of 0.462, not only because of high income tax rates, but also because of the protected-sector wage received by Government workers. Labor's resource cost to society is much less than the financial cost incurred by the projects, since the market value of wages paid to similar labor is much lower than the wages paid by CESAN.

[27] 17% and 10%, respectively.

All other conversion factors reflect slightly smaller economic resource costs versus financial costs, largely due to market distortions caused by taxes and tariffs.

The results of the economic analysis indicate that this project generates considerable net economic benefits for the country as a whole – as illustrated in Table 2.18, 2.19, and 2.20. The sewerage project proves to be a potentially attractive investment for the economy, as the value of the service, coupled with the environmental benefits, far exceeds the resource costs of building and operating the project. The NPV of the project is equal to almost 350 percent of the present value of the economic value of investment and operation costs.

The economic analysis indicates that, for the country as a whole, the water project also is very attractive. It has a substantial NPV that is approximately 125 percent of the present value of all of the economic costs incurred to build and operate the project.

Table 2.18. Results of the Economic Analysis

(in million R$)	Water supply project	Sewerage project
NPV of project* (PV of benefits - PV of costs)	**R$ 15.82 MM**	**R$ 35.1 MM**
PV of benefits*	***R$ 34.12 MM***	**R$ 45.8MM**
PV of costs*	**R$ 18.30 MM**	**R$ 10.7MM**

* Sum of values from 1997 to 2027

Table 2.19. Economic Net Benefit Flow Statement for Water Supply Project

(1996 Price Level)

Year	Conversion Factors	1996	1997	1998	1999	2000	2005	...2010	...2020	...2025	...2027
ECONOMIC BENEFIT FLOW											
Value of Water for Paying Customers		-	231,847	507,149	803,609	2,816,410	4,589,304	4,670,531	4,670,531	4,670,531	-
Valuation of Stolen Water		-	125,806	231,955	328,058	1,592,829	1,521,896	1,481,078	1,481,078	1,481,078	-
change in A/R		-	(26,109)	(33,376)	(38,577)	(250,923)	(51,034)	(52,009)	(47,815)	(47,815)	-
Residual Value of Land	**1.000**	-	-	-	-	-	-	-	-	-	100,0
Total Inflows		**-**	**331,544**	**705,728**	**1,093,090**	**4,158,316**	**6,060,166**	**6,099,599**	**6,103,793**	**6,103,793**	**100,0**
ECONOMIC COST FLOW											
Investment Costs											
Labor											
Unskilled Labor	**0.462**	-	254,776	305,547	167,543	-	-	-	-	-	-
Semi-skilled Labor	**0.462**	-	179,082	215,083	117,696	-	-	-	-	-	-
Raw Water Intake, Transmission & Pumping											
Materials	**0.892**	-	1,142,931	1,319,722	722,530	-	-	-	-	-	-
Equipment	**0.795**	-	200,806	227,681	117,928	-	-	-	-	-	-
Treatment											
Materials	**0.895**	-	610,020	704,418	371,507	-	-	-	-	-	-
Equipment	**0.794**	-	106,963	128,356	62,818	-	-	-	-	-	-
Treated Water Transmission and Pumping											
Materials	**0.906**	-	918,656	1,061,065	559,734	-	-	-	-	-	-
Equipment	**0.795**	-	160,644	182,144	94,343	-	-	-	-	-	-
Reservoirs & Distribution											
Materials	**0.892**	-	1,066,738	1,231,737	649,581	-	-	-	-	-	-
Equipment	**0.783**	-	185,030	209,790	108,660	-	-	-	-	-	-
Connections											
Materials	**0.905**	-	76,717	88,601	20,932	-	-	-	-	-	-
Equipment	**0.873**	-	14,675	16,639	8,619	-	-	-	-	-	-
Cost of Land	**1.000**	-	100,000	-	-	-	-	-	-	-	-
Operational Costs											
Total Cost of Labor Required by Project	**0.462**	-	23,101	37,444	52,351	67,839	169,523	285,151	563,605	742,293	-
Total Cost of Tertiary Labor Required by Project	**0.462**	-	11,782	17,599	24,081	29,171	64,419	108,357	214,170	282,071	-
Total Cost of Chemicals	**0.825**	-	5,945	11,948	17,989	93,957	94,345	94,345	94,345	94,345	-
Total Energy Costs	**1.051**	-	29,623	61,115	91,218	469,759	471,695	471,695	471,695	471,695	-
Total Other Service Costs	**0.700**	-	19,413	33,568	47,967	134,884	187,188	247,667	393,310	486,772	-
Total Maintenance Costs	**1.000**	-	68,800	68,800	69,800	69,800	71,020	69,800	64,140	60,700	-
Total Replacement Investments	**1.000**	-	-	-	-	-	-	-	-	-	-
change in A/P	**0.653**	-	(9,054)	(7,425)	(8,139)	(42,571)	(12,140)	(15,065)	(23,792)	(28,340)	213,0
change in CB	**1.000**	-	11,097	9,101	9,975	52,178	14,880	18,465	29,161	34,736	(261,1
Total Outflows		-	5,177,745	5,922,932	3,307,132	875,015	1,060,930	1,280,416	1,806,635	2,144,273	(48,0
Net Economic Benefit Flow		**-**	***(4,846,202)***	***(5,217,204)***	***(2,214,043)***	***3,283,301***	***4,999,237***	***4,819,183***	***4,297,159***	***3,959,520***	***148,0*
ECONOMIC NPV @	**12.17%**	***15,822,912***									

Table 2.20. Economic Net Benefit Flow Statement for Sewerage Collection Project (1996 Price Level)

Year	CF	1996	1997	1998	1999	2000	...2005	...2010	...2015	...2020	...2025	...2027
ECONOMIC BENEFIT FLOWS												
Sewerage Collection Benefits		-	21,536	43,370	65,354	3,008,843	3,508,049	3,997,384	4,476,251	4,934,330	5,363,694	-
Environmental Recuperation Benefits		-	-	-	-	4,395,640	4,554,347	4,634,955	4,634,955	4,634,955	4,634,955	-
Residual Value of Land	**1.000**	-	-	-	-	-	-	-	-	-	-	150,000
Total Inflows		**-**	**21,536**	**43,370**	**65,354**	**7,404,484**	**8,062,396**	**8,632,339**	**9,111,206**	**9,569,284**	**9,998,649**	**150,000**
ECONOMIC COSTS												
Investment Costs												
Labor												
Unskilled Labor	**0.462**	-	150,004	263,084	250,161	-	-	-	-	-	-	-
Semi-skilled Labor	**0.462**	-	38,770	67,848	64,617	-	-	-	-	-	-	-
Connections												
Materials	**0.912**	-	96,443	163,019	149,027	-	-	-	-	-	-	-
Equipment	**0.828**	-	11,653	19,390	17,428	-	-	-	-	-	-	-
Collectors & Interceptors												
Materials	**0.908**	-	457,821	773,791	707,314	-	-	-	-	-	-	-
Equipment	**0.777**	-	53,454	88,924	79,902	-	-	-	-	-	-	-
Pumping Stations & Raw Sewerage Pressure Pipes												
Materials	**0.904**	-	217,646	367,774	336,103	-	-	-	-	-	-	-
Equipment	**0.777**	-	25,258	42,019	37,756	-	-	-	-	-	-	-
Treatment and Outfall Pipes												
Materials	**0.908**	-	433,399	732,514	669,583	-	-	-	-	-	-	-
Equipment	**0.819**	-	51,734	86,086	77,375	-	-	-	-	-	-	-
Cost of Land	**1.000**	-	150,000	-	-	-	-	-	-	-	-	-
Operational Costs												
Total Cost of Labor Required by Project	**0.462**	-	16,297	16,623	16,956	44,278	50,983	62,777	71,866	90,075	108,182	-
Total Cost of Tertiary Labor Required by Project	**0.462**	-	8,312	7,813	7,800	19,040	19,374	23,855	27,309	34,229	41,109	-
Total Cost of Chemicals	**0.825**	-	-	-	-	-	-	-	-	-	-	-
Total Energy Costs	**1.051**	-	4,244	8,548	14,171	594,287	692,673	789,113	883,491	973,771	1,058,392	-
Total Other Service Costs	**0.700**	-	9,231	9,830	10,802	113,082	130,602	151,045	169,870	192,457	214,128	-
Total Maintenance Costs	**1.000**	-	11,800	10,800	10,821	10,842	10,955	11,079	11,217	11,368	11,536	-
Total Replacement Investments	**1.000**	-	-	-	-	-	-	-	-	-	-	-
change in A/P	**0.881**	-	(6,218)	(969)	(1,257)	(69,554)	(10,152)	(11,411)	(12,561)	(14,776)	(15,276)	133,269
change in CB	1.000	-	5,644	879	1,141	63,135	9,215	10,358	11,402	13,412	13,866	(120,968
Total Outflows		**-**	**1,735,493**	**2,657,973**	**2,449,698**	**775,109**	**903,650**	**1,036,817**	**1,162,594**	**1,300,537**	**1,431,937**	**12,301**
Net Cash Flow		**-**	***(1,713,958)***	***(2,614,603)***	***(2,384,344)***	***6,629,374***	***7,158,746***	***7,595,522***	***7,948,612***	***8,268,748***	***8,566,712***	***137,699***
Net Present Value (NPV) @	**12.17%**	**35,103,958**										

Sensitivity Analysis

SENSITIVITY OF ECONOMIC NPV TO CHANGES IN WATER TARIFF. The economic valuation of the water project increases as the water tariff[28] is varied from R$0.70 to R$0.85. The increase in price induces consumers who are willing to pay for water below the new tariff level to reduce the quantity that they consume. However, other consumers who are now rationed will be willing to pay the higher tariff and will happily consume the released water. Since the new consumers of the released water value the service more than the previous consumers, the value of the total benefits generated by the water project will increase. Further price increases, however, should begin to reduce the economic NPV of the project, once the current shortage is completely relieved. Once the water tariff is raised to a level that relieves the shortage, further price increases will induce consumers to curtail their use of CESAN's water service. The economic value of water will be lower, since less water is consumed. The lower consumption of water from the project causes the economic NPV to diminish. If the tariff is raised as high as R$ 1.30, the reduction in water consumption would reduce the economic benefits to such an extent that the project would have a negative economic NPV.

Upon completion of the investment and the commencement of its full-scale operation, the project should be able to satisfy the total demand for water supply in the region for a short period. The growth in demand for water, however, should eventually reintroduce the shortage.

The economic NPV of the sewerage service remains unchanged in the initial price range of R$0.70 to $0.85, because the quantity of water supplied remains unchanged. The lower price of water does increase the demand for the service, yet CESAN is unable to provide additional water, due to its fixed capacity. The economic value, therefore, remains unchanged, since the amount of water provided by the project remains the same. Once water consumption is reduced due to price increases, the economic value of the sewerage service diminishes, as there is less sewerage requiring proper disposal.

[28]Real Water Tariff

Table 2.21. Sensitivity of Economic NPV to Changes in Water Tariffs

Water tariffs (R$)	Water economic NPV	Sewerage economic NPV
0.70	14,674,521	35,107,507
0.75	15,191,813	35,107,507
0.80	15,709,106	35,107,507
0.85	16,226,399	35,107,507
0.90	15,822,912	35,103,958
0.95	14,112,810	34,943,907
1.00	11,561,142	34,609,673
1.05	9,352,218	34,133,156
1.10	6,408,995	33,538,606
1.15	3,187,305	32,828,999
1.20	(1,120,375)	32,026,404

SENSITIVITY OF NPV TO CHANGES IN SEWERAGE SURCHARGE. Changing the sewerage surcharge has a similar effect to altering the price of water, since the charge is added to the water tariff. Therefore, an increase in price that induces cutbacks in consumption of water will reduce the economic benefits of the project. For example, as the surcharge is increased beyond R$ 0.17, the resulting rise in the price consumers pay for water will cause the economic NPV to decrease. This is a consequence of the cutback in the amount of water acquired from the project. Sewerage surcharges that cause water usage to be transferred to consumers with a higher willingness-to-pay enhance the water project's economic NPV, due to the alleviation of shortages.

Table 2.22. Sensitivity of Economic NPV to Changes in Sewerage Surcharge

Sewerage surcharge (R$)	Water economic NPV	Sewerage economic NPV
0.14	16,743,692	35,107,507
0.15	16,743,692	35,107,507
0.16	16,743,692	35,107,507
0.17	16,743,692	35,107,507
0.18	15,822,912	35,103,958
0.19	15,752,612	35,083,651
0.20	14,778,742	35,063,344
0.21	14,647,437	35,029,695
0.22	13,694,449	34,990,797
0.23	13,507,769	34,943,907

SENSITIVITY OF NPV TO CHANGES IN MAXIMUM WILLINGNESS-TO-PAY FOR WATER. The economic valuation of the water project would be significantly different if the maximum willingness-to-pay for water service in Guarapari (with rationing) were different from the survey

estimate. Since there is a rationing of water due to the shortage, the willingness to pay, along with the water tariff, determines the economic value of the water service[29]. A higher willingness-to-pay would result in a higher valuation of the service by water consumers. Nevertheless, the economic NPV of the water project remains robust even if the assessments are as low as $2.00 for drinking water and $1.00 for the other uses of water. In fact, the consumer's valuation of water must be lower than R$ 1.12 and R$ 0.56 for drinking and other water, respectively, in order to render the project economically unfeasible.

Table 2.23. Sensitivity of NPV to Changes in Maximum Willingness-to-Pay for Water

Other water (R$)	Drinking water (R$)	Water economic NPV
1.05	2.10	(870,727)
1.20	2.40	984,122
1.35	2.70	2,838,970
1.50	3.00	4,693,819
1.65	3.30	6,548,668
1.80	3.60	8,403,517
1.95	3.90	10,258,366
2.10	4.20	12,113,214
2.25	4.50	13,968,063
2.40	4.80	15,822,912
2.00	4.00	17,677,761
2.05	4.10	19,532,610
2.10	4.20	21,387,459

SENSITIVITY OF NPV TO CHANGES IN PROPORTION OF DRINKING WATER TO OTHER WATER. The base case analysis assumes that 5% of the water supplied by CESAN is consumed as drinking and cooking water, while the remaining 95% is used for other purposes. Consumers place a substantially higher valuation on drinking and cooking water than on water used for other purposes, due to its basic-needs nature. Therefore, if consumers were to use a larger percentage of water for drinking purposes, then the total economic value of the project would be greater. For example, the base case estimates the economic value of drinking water to be R$ 3.90, while the value placed on other uses of water is R$ 1.43 for consumers now obtained water from CESAN but are rationed. 2.40 per cubic meter for households obtaining a new connection and 1.95 per cubic meter for those who will obtain water free with the expansion of the standpipes in the system. Conversely, a reduction in the percentage of water used for drinking, which will increase

[29]Economic value = $(P_{max} + P1)/2$, where P_{max} is the maximum willingness-to-pay.

the amount of water used for other purposes, will reduce the economic benefits of the project. Despite the significant impact this may have on the project, we found the project to be remarkably robust.

Table 2.24. Sensitivity of NPV to Changes in Proportion of Drinking Water to Other Water

Proportion of drinking water (%)	Water economic NPV
1	14,794,260
2	15,051,423
3	15,308,586
4	15,565,749
5	15,822,912
6	16,080,075
7	16,337,238
8	16,594,401

SENSITIVITY OF ECONOMIC NPV TO CHANGES IN THE VALUATION OF NON-REVENUE WATER. The economic value of non-revenue water is estimated to be the average between the maximum that people are willing to pay for drinking and other uses of water and zero, which is the price these people pay for the service. Therefore, the economic NPV can be significantly affected if the actual consumer valuation of stolen, un-invoiced, or unpaid water is different than the initial estimate. For example, if the economic value of non-revenue water were reduced to 70% of the estimate (R$ 1.37 for drinking water and R$ 0.68 for other uses) in the base case, the net economic gain to society could be reduced by almost 15%. Alternatively, the project's economic NPV would receive a significant boost, if the valuation were to rise.

Table 2.25. Sensitivity of Economic NPV to Changes in Valuation of Non-Revenue Water

Percentage of original estimate (%)	WTP for drinking water	WTP for other water	Water economic NPV
70	1.37	0.68	19,567,015
80	1.56	0.78	20,684,695
90	1.76	0.88	21,802,375
100	1.95	0.98	22,920,055
110	2.15	1.07	24,037,735
120	2.34	1.17	25,155,415
130	2.54	1.27	26,273,095
140	2.73	1.37	27,390,775

SENSITIVITY OF NPV TO CHANGES IN REAL WAGE INCREASE. The effect of an increase in the cost of labor is less significant in the economic analysis than in the financial analysis. The reason for the smaller effect is that the economic cost of labor is substantially less than the financial expenditure on workers' salaries.

Table 2.26. Sensitivity of NPV to Changes in Real Wage Increase

Changes in real wage (%)	Water economic NPV	Sewerage economic NPV
1.00	16,162,479	35,175,939
1.20	16,099,088	35,162,375
1.40	16,033,522	35,148,409
1.60	15,965,695	35,134,028
1.80	15,895,522	35,119,216
2.00	15,822,912	35,103,958
2.20	15,747,771	35,088,239
2.40	15,670,001	35,072,042
2.60	15,589,501	35,055,351
2.80	15,506,164	35,038,147
3.00	15,419,881	35,020,411
3.20	15,330,535	35,002,127

SENSITIVITY OF NPV TO CHANGES IN CONTINGENT VALUATION ASSESSMENT. The valuation of the sewerage service and the gain in environmental benefits forecast by the survey conducted in Guarapari is an important factor, which contributes to the high economic return on the investment in the sewerage project. One can also see from the sensitivity analysis that the NPV would change substantially if the estimates of the willingness to pay are altered. Nevertheless, if the estimate of the benefits of the service and the corresponding environmental recuperation

benefits were lowered by R$ 0.25 and R$ 0.20 per cubic meter respectively, the sewerage component of the project would still be economically feasible.

Table 2.27. Sensitivity of NPV to Changes in Contingent Valuation Assessment

		Contingent valuation of sewerage service (R$ per M^3)						
		0.25	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**
Contingent valuation of environmental recuperation benefits (R$ per M^3)	**0.20**	14,413,945	16,524,800	18,635,654	20,746,509	22,857,363	24,968,217	27,079,072
	0.25	18,058,584	20,169,439	22,280,293	24,391,148	26,502,002	28,612,856	30,723,711
	0.30	21,703,223	23,814,078	25,924,932	28,035,787	30,146,641	32,257,496	34,368,350
	0.35	25,347,862	27,458,717	29,569,571	31,680,426	33,791,280	35,902,135	38,012,989
	0.40	28,992,501	31,103,356	33,214,210	35,325,065	37,435,919	39,546,774	41,657,628
	0.45	32,637,140	34,747,995	36,858,849	38,969,704	41,080,558	43,191,413	45,302,267
	0.50	36,281,779	38,392,634	40,503,488	42,614,343	44,725,197	46,836,052	48,946,906
	0.55	39,926,418	42,037,273	44,148,127	46,258,982	48,369,836	50,480,691	52,591,545

Table 2.28 compares the results of the financial and economic analysis of the two project components. The economic value of the benefits of water is greater than the financial benefits accruing from the project, due to the higher economic value placed on water service by consumers. Moreover, the economic valuation of costs is also significantly different from their financial assessment. The economic resource costs are almost half those of the financial costs associated with the project, mainly due to the lower economic valuation of labor. Furthermore, many other input costs also have a lower economic valuation, due to distortions created by taxes and tariffs.

Table 2.28. Comparing Results from Financial Analysis and Economic Analysis

(in million R$)	**Economic analysis**		**Financial analysis**	
	Water	**Sewerage**	**Water**	**Sewerage**
NPV of project* (PV of benefits - PV of costs)	**R$ 15.82MM**	**R$ 35.1 MM**	**R$ -5.6 MM**	**R$ 3.1 MM**
PV of benefits*	***R$ 34.12MM***	**R$ 45.8MM**	**R$ 27.6 MM**	**R$ 20.9 MM**
PV of costs*	**R$ 18.30MM**	**R$ 10.7MM**	**R$ 33.2 MM**	**R$ 17.8 MM**

The sewerage project shows an even greater divergence between the economic and the financial analysis. Much of this discrepancy is due to all the environmental benefits and unrealized values associated with sewerage service that the financial markets are unable to

capture. A less significant reason for the difference is that the economic costs are also approximately 40% less than the financial costs of the project.

The economic benefits of water are estimated to be higher than the financial values, by approximately 100.6 percent[30]. The economic price of labor and the lower economic valuation of other inputs also combine to lower the total economic cost and render a positive NPV. This is in contrast to the financial analysis, which yields a negative NPV.

Stakeholder Analysis

The stakeholder analysis is the third component of integrated project analysis. The distribution of positive externalities - the difference between net economic benefits and net financial benefits, both discounted at the economic discount rate, tells us which stakeholders obtain benefits without bearing equivalent costs and vice versa.[31] In table 2.29, we find that the values of the total externalities produced by the sewerage disposal plant (R$ 35.1 MM) and for the water supply plant (R$ 29.9 MM) are very substantial.

Table 2.29. Distribution of Externalities

	Total externalities	**Government**	**Water consumers**	**Workers**	**Society**[32]
Water Supply Plant	R$ 22.81 MM	R$ 2.9 MM	R$ 17.62 MM	R$ 2.25 MM	R$ 0.0
Sewerage Disposal Plant	R$ 35.1 MM	R$1.0 MM	R$ 6.3 MM	R$1.0 MM	R$25.2 MM
Combined Project	R$ 65.0 MM	R$ 3.9 MM	R$ 31.0 MM	R$ 3.3 MM	R$ 25.2 MM

In both projects, the Government reaps direct financial benefits (R$ 3.9MM) through the collection of taxes and tariffs that are imposed on the inputs of the projects. It also collects taxes on the additional workers that are employed. Water consumers realize significant benefits(R$

[30]Based on an average between drinking and other uses of water.
[31]Refer to Table 15 in Spreadsheet Tables – Water Supply Project, Sewerage Collections Project.
[32]Society includes water consumers as well as all other inhabitants of Guarapari who receive the benefits of improved sewerage treatment.

24.7 MM) since the project alleviates much of the burden caused by the pre-project water shortage and the resulting rationing of service. Additional external benefits are obtained by those who steal water, since they do not pay for the services they acquire. The benefits to workers come mostly in the form of a wage premium that the Government pays over the supply price for equivalent labor. Since the water supply project is more labor intensive, the benefits to the workers are greater in this project than in the sewerage disposal project (R$ 2.3 MM and R$ 1.0 MM, respectively). Nevertheless, consumers of the sewerage service also obtain a consumer surplus of R$ 3.6 MM. The positive externalities captured by society at large from the operation of the sewerage disposal plant reaches R$ 25.2 MM, which is much greater than the total financial cost of the project (R$ 17.8 MM). This positive externality is due to the large amount of benefit obtained through environmental improvement that the project is unable to capture financially.

In the final analysis, consumers are the biggest gainers in the water supply project, but the government and workers also realize a good share of the benefits from the positive externalities. In the case of the sewerage disposal project, most of the benefits accrue to all of the residents of the region of Guarapari, while the direct consumers, workers and the government also realize some gains. Finally, in both projects, there are no net negative externalities inflicted on any stakeholder.

Risk Analysis

The risk analysis is the fourth and often the most difficult component of an integrated investment appraisal to carry out. The cash flow projections in the static model of the financial and economic analyses do not account for the uncertainties and fluctuations in the real world. Monte Carlo simulations, a form of risk analysis, provides one of the most practical methods to approximate the dynamics and uncertainties of the real world. The risk analysis repeats the financial and economic analyses many times using distributions for the values of the most sensitive variables that affect the project. In preparation for these simulations, we conducted sensitivity analyses to identify the variables that significantly affect the outcomes of the projects. After identifying the

sensitive variables, we distinguished from among them those that are within limited or full control of management and those that fall outside the control of CESAN. For example, the invoicing efficiency is a variable that clearly has an impact on the projects' financial viability. It also happens to be under CESAN's control. On the other hand, inflation can affect the outcome of the project, but CESAN cannot influence the inflation rate in Brazil. Furthermore, the contingent valuation estimates could be uncertain due to errors of estimation. All these variables contribute to the uncertainty of future project outcomes. Thus, they qualify as risk variables.

Table 2.30. Risk Variables and their Impact and Risk Significance

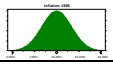
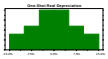
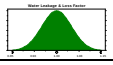
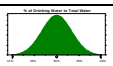
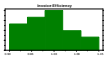
Risk variables	Impact and risk significance
Inflation	Large effects on working capital and interest rate on loans. Beyond management control; based on economic factors and policies.
Devaluation of real exchange rate	Large effects on the costs of tradable inputs, particularly on initial investment costs. Beyond management control.
Level of lost water	Effects financial as well as economic analysis. Larger amounts of lost water reduces financial revenue. Also effects economic benefits since stolen water is valued differently from bought water.
Valuation of non-revenue water	Value placed by consumers on water stolen from CESAN's network. No financial revenue is realized, but has economic value.
Ratio of Drinking Water to Total Water	Effects economic valuation of water project since consumers place a different economic value on drinking water than other uses of water
Real increase in wages	Large effects on the costs of labor. Influenced by government policies and market conditions; beyond management control.
Collection efficiency	Direct effect on revenues and profitability. The management controls the efficiency to a large extent.
Invoicing efficiency	Direct effect on revenues and profitability. The management controls the efficiency to a large extent.
Investment cost overruns	Direct increase of investment costs. Management can control it to a large extent.
Maximum willingness-to-pay for water	Determines economic value of water when there is rationing. Uncertainty is related to inaccuracy in estimate.
Valuation of sewerage service	Value derived from contingent valuation survey. Uncertainty is related to survey bias that may exist. Effects economic valuation of sewerage.
Environmental recuperation benefits	Large effect on the economic valuation of environmental protection. Beyond management control; based on people's preferences.

The objective of the risk analysis is to assess the impact of the variables in Table 2.30 on the project's outcome. Thereafter, the project managers can make their best efforts to optimize

variables within their control and to reduce the risks faced by the project. An analyst can also determine the project's ability to withstand the impacts of variables such as inflation that are beyond the control of project managers. To evaluate the impact of the risk variables on the project outcomes under various circumstances, we used a computer software package to generate random values for the variables, whose behavior was assessed through research and analysis.[33] We simulated 2,500 trials in our analysis. These simulations approximate the range of possible scenarios in real life, thereby giving us a probability distribution of financial and economic NPV of the two projects.

Once identified, we also estimate a distribution and a range for each risk variable. Table 2.31 summarizes the specification we estimated for the variables.

Table 2.31. Risk Variables and their Impact and Risk Significance

Variable	Distribution	Range (%)
Inflation Rate	Normal 	Mean 10.00 Standard Dev. 2.00
Devaluation of real exchange rate (average over life of project)	Custom/ Step 	-15.0 to –10.0 0.10 -10.0 to -5.0 0.15 -5.0 to 0.0 0.25 0.0 to 5.0 0.25 5.0 to 10.0 0.15 10.0 to 15.0 0.10
Level of lost water (as ratio of target level)	Normal 	Mean 1.00 Standard Dev. 0.05
Valuation of non-revenue water (as percentage of maximum willingness-to –pay)	Normal 	Mean 50 Standard Dev. 5
Ratio of Drinking Water to Total Water	Normal 	Mean 5 Standard Dev. 1
Real increase in wages	Custom/ Step 	1 to 2 0.20 2 to 3 0.50 3 to 4 0.20 4 to 5 0.10
Invoicing efficiency	Custom/ Step 	0.90 to 0.95 0.20 0.95 to 1.00 0.25 1.00 to 1.05 0.30 1.05 to 1.10 0.15
Investment cost overruns	Custom/ Step 	-15 to –10 0.05 -10 to –5 0.15 -5 to 0 0.25 0 to 5 0.30 5 to 10 0.15 10 to 15 0.10

[33] The computer software package we used is Crystal Ball produced by Decioneering Corporation, Denver, CO.

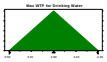
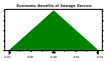
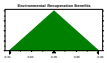
Maximum willingness-to-pay for water	Triangular		Minimum Likeliest Maximum	3.50 3.90 4.30
Valuation of sewerage service	Triangular		Minimum Likeliest Maximum	0.44 0.49 0.54
Environmental recuperation benefits	Triangular		Minimum Likeliest Maximum	0.31 0.35 0.38

Table 2.32 summarizes the results of our risk analysis. The expected NPV of the financial analysis of the water project alone is a negative R$ 5.8 MM, with almost no probability of the outcome being positive. The opposite is true for the Sewerage Disposal plant, where the expected financial NPV is slightly positive. The expected NPV is significantly above zero, in the economic analysis of both the water and sewerage disposal project. The probability of a negative return is also zero, given the assumptions surrounding the specification of the variables. Similarly, the expected economic value of the sewerage project is high enough so that there is no probability of a negative outcome, given the assumptions used in the risk analysis. In other words, both projects are quite certain to provide a significant return to the economy of Espirito Santo. It is important to note, however, that much of the economic variability in the project stems from the uncertainty that may exist in the contingent valuation study.[34]

Table 2.32. Economic and Financial NPV based on Risk Analysis[35]

	Water supply financial	**Water supply economic**	**Sewerage financial**	**Sewerage economic**
Expected NPV	R$ -5.8 MM	R$ 15.8MM	R$ 3.28 MM	R$ 35.0 MM
Standard Deviation	R$ 2.4 MM	R$ 2.4 MM	R$ 1.7 MM	R$ 1.4 MM
Probability of NPV > 0	0.87%	100%	98.7%	100%

Since the expected NPVs for both projects are quite different from a break-even situation, changes in each of the projects NPV's may alter the viability of the combined project.

[34]There are many biases that may exist in a contingent valuation that may lead to overvalued or undervalued results. For a more detailed explanation, refer to the following: Asian Development Bank, Economic Evaluation of Environmental Impacts, Manila, Philippines, 1996.

[35] Based on 2500 simulation trials. For further information, refer to reference readings or Appendix D.

Table 2.33. Risk Analysis of the Combined (Water & Sewerage) Project Financial NPV

Expected NPV	R$ -2.6 MM
Standard Deviation (σ)	R$ 4.0 MM
Probability of NPV > 0	26.33%

The expected value of the combined financial NPV is R$ -2.6 MM. There is, however, significant volatility in this estimate, as indicated by the high standard deviation. Furthermore, the probability of obtaining a positive NPV is only 26 percent. In fact, the results indicate that the possible NPVs can range from R$ –13.9 MM to R$10.3 MM.

The financial NPV and its' standard deviation is not a sufficient indicator of the risks associated with this project, due to its public sector nature. A policy maker's likely objective in undertaking this project is to have it earn the minimum financial rate of return that would allow it to be sustainable, while generating the large economic benefits. Therefore, evaluating the risks associated with the yearly financial cash flows is more useful.

The investment stage risks are critical, since any changes in the estimated expenses will alter the required amounts of debt and equity. The highest investment costs occur in 1998, where the volatility in the expected costs is also large. The final year of investment (1999), however, may be more critical to the success of the project. The relative variability with respect to the expected NCF, indicated by the coefficient of variation, is at its highest in the third year of investment. Moreover, the expected financing may not be available in 1999, since resources may have already been utilized to finance shortfalls during the previous two years.

The expected net cash flows show that during the operational period, the combined project is able to financially sustain itself. There is still a certain amount of uncertainty regarding the project's ability to meet its financial obligations, especially during the phases of reinvestment. Volatility during the period surrounding year 2005 can have a significant impact, since the project cash flows are not robust because of repayment of the loan. The project's financial condition also begins to deteriorate after the year 2020, as the financial revenues are

unable to cover the real increase in the cost of labor. Therefore, volatility in the projects' estimated variables could have a significant impact on financial self-sufficiency.

Table 2.34. Risk Analysis of the Yearly Real Net Cash Flows for Combined (Water & Sewerage) Project from the Equity Point-of-View

	Investment Stage			Operational Stage						
Year	**1997**	**1998**	**1999**	**2000**	**…2005**	**…2010**	**…2015**	**…2020**	**…2025**	**…2027**
Expected NCF (R$ MM)	-4.28	-5.22	-3.29	2.31	0.42	1.01	1.94	1.20	0.27	0.89
Standard Deviation (R$ MM)	0.35	0.44	0.29	0.38	0.57	0.56	0.60	0.74	0.99	0.07
Coefficient of Variation	0.08	0.08	0.09	0.16	1.35	0.56	0.31	0.61	3.62	0.08
Probability of NCF>0	0.0%	0.0%	0.0%	100.0%	75.4%	97.5%	100.0%	93.5%	65.9%	100.0%

The variability of the stakeholder impact estimations is also important in determining the success of a public sector project. The largest volatility is associated with the externalities obtained by consumers and society. Much of the variability in the surplus obtained by water consumers is due to some uncertainty in the estimation of their valuation of water. For example, the uncertainty in the estimate of maximum willingness-to-pay for water, which is a key determinant of the consumers' economic valuation of water, will cause far greater uncertainty than the original stakeholder estimate. The variability of the sewerage project's impact on consumers and society is based on any biases pertaining to the contingent valuation study. Consumers and society still stand to gain significantly despite the large volatility, due to the magnitude of the original assessment. The gains to government and labor are more constant, since they are based on more certain estimates of investment and of the labor required to operate the two plants.

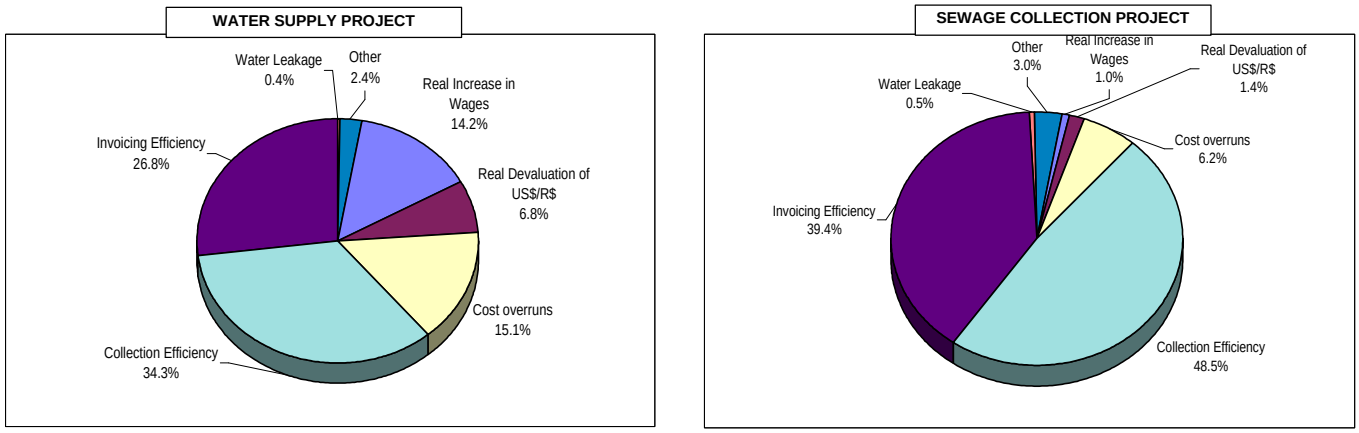
Table 2.35. Risk Analysis of the Stakeholder Impacts

	Government	Consumers	Labor	Society*
WATER PROJECT				
Expected Externality	2.99	25.22	2.33	
Standard Deviation	0.19	2.13	0.21	
SEWERAGE PROJECT				
Expected Externality	1.02	6.17	1.02	25.20
Standard Deviation	0.06	1.55	0.06	1.04

* Consumers are also part of the society

The variables that have the largest impact on the economic NPV can be easily identified. The largest impacts in both projects reflect possible variability in the level of invoicing and collection efficiency. Additionally, the water project is significantly affected by changes in the real exchange rate and cost overruns, due to the larger investment required. It is affected by variability in wages due to its large requirement of labor as well.

Figure 2.8: Estimate of Breakdown of Variance[36] in the Financial Analysis



Conclusions

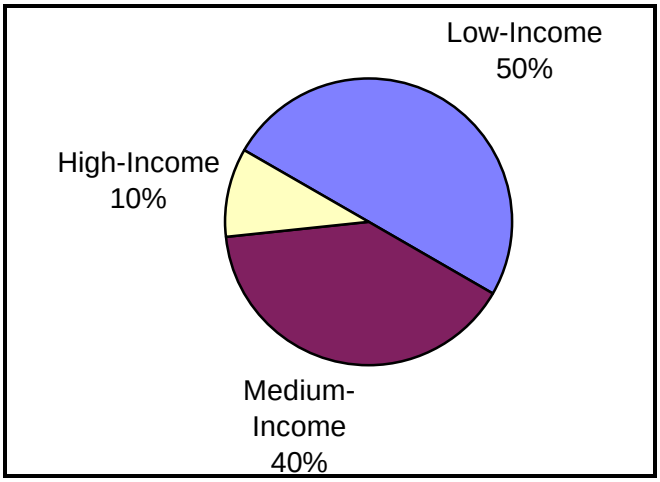
Evaluation of the Project

The State of Espirito Santo's objectives for undertaking the water supply project and the sewerage disposal project in the Guarapari region are five-fold: 1) to increase the supply of clean

water for the residents in the region in order to alleviate current shortages; 2) to enhance sanitation services in the region by increasing sewerage collection and treatment rates; 3) to improve environmental protection by treating sewerage prior to discharge into regional water systems; 4) to improve financial self-sufficiency and management efficiency of CESAN; and 5) to make the water supply and sewerage disposal services affordable for low income residents.

The water supply project effectively eliminates the shortage of clean water in the region by increasing the number of connections between residences and public water utilities and by expanding the supply made available to the existing connections. By implementing the project, CESAN is expected to achieve connections to over 98% of the residential areas and to increase the quantity of water supplied by 68%, which will eliminate much of the need for water rationing. Figure 2.9 identifies the breakdown of new connections. The biggest beneficiaries from the new connections should be the low-income families, who make up 50% of the new connections. CESAN expects to provide 52 cubic meters of water per person per year, falling only slightly below the current demand of 54 cubic meters.

Figure 2.9. Breakdown of New Water Supply Connections by Income Level



Assessment of efficiency and profitability of the two projects should be focused on four key issues: invoicing efficiency, collection efficiency, water leakage and losses, and its high cost of labor. In our static financial analysis, the water project has a negative financial NPV. Despite

[36] The analysis is an approximation of the breakdown in variance, not an exact decomposition of variance. For more information, refer to the Crystal Ball User's Manual.

the positive financial NPV, the sewerage project can also be further improved by effectively changing the above mentioned factors. To raise the revenues, CESAN has to increase the rate at which it invoices and collects bills for the services that it renders. Currently, CESAN expects to improve its invoicing efficiency from 77% to 90% and its collection efficiency from 84% to 85% over the life of the project. Clearly, this rate of increase in efficiency is not sufficient to make the water project financially profitable. By having one flat rate for services[37], CESAN neither harness possible revenues from customers on the upper end of the demand curve nor attracts potential consumers on the lower end of the demand curve. An improved pricing policy could enhance the profitability of the projects directly.

On the expense side, the high cost of labor is the main reason for generating inadequate financial net benefits from the projects. The cost of labor is higher in public sector projects than in private sector operations because CESAN is paying a significant premium above-market rates to its workers. The premium is not justified on any market principle, yet it is maintained for political reasons. Since labor costs make up over 33% of total costs in the water supply project and 12% of the sewerage disposal project, paying the workers at 25% to 40% above the market rate can turn a profitable venture into a financial failure.

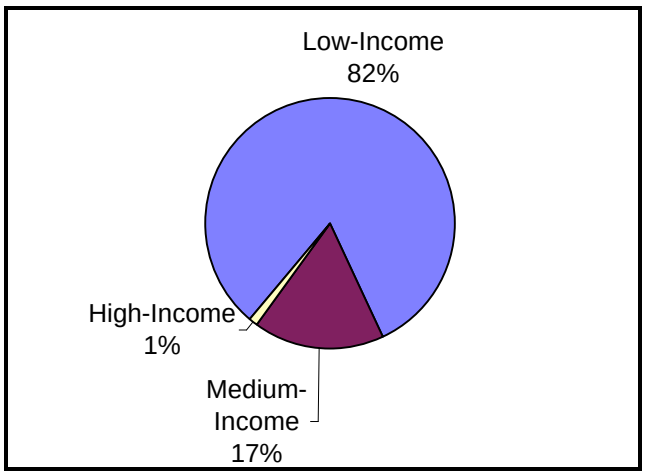
The risk analysis and the deterministic model, both indicate that the water supply project should produce net economic benefits for society. The consumers of CESAN's water service reap most of the external benefits(R$ 24.7MM) produced by the project. The remaining externalities are shared between the government (R$ 2.9MM) and workers (R$2.3).

There may be some non-use value of clean water that will become more evident in the future. Clean water supply prevents water-borne diseases, particularly as water sources become more contaminated by discharge of untreated waste. At present, health officials do not record a noticeable increase in water-borne diseases, because the water system in the project area has yet to reach the hazardous conditions found in the rest of the region. Nevertheless, even with the new

[37]At present, CESAN has charges a flat rate for everyone regardless of how much people use the service, because they do not have water meters. This promotes inefficiency and waster, because people who cannot pay for the rate will not become connected and people who are already connected will use as much as they can because they pay the same rate. The poor pricing policy thus contributes to shortages. The project proposes to put in water meters and

sewerage disposal project in full operation, more than 40% of the waste will still not be treated before it is discharged. Hence, the economic value of water may be undervalued in our analyses, since externalities from supplying clean water might increase significantly in the near future. This possible undervaluation strengthens the case for the water supply project, despite its poor financial performance.

Figure 2.10. Breakdown of New Sewerage Connections by Income Group



The sewerage disposal project is expected to significantly improve the conditions of the water systems in the region by reducing the volume of untreated waste discharged into rivers and into the ocean by 6 million cubic meters per year. The project plans to expand the collection capacity to over 11 million cubic meters over the life of the plant. The project increases the share of the population connected to sewerage service from 13% to 46%. Figure 2.10 shows that the low-income families are expected to reap most of the benefits from the expansion of sewerage services; they represent 82% of the new connections.

The strongest case for undertaking the sewerage disposal project is the large economic benefits it is expected to generate for society by preventing environmental degradation. While the financial NPV for the project is marginal, the economic NPV is robust. The positive externalities alone are greater than the total costs of investment and operations.

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charge a flat rate of R$ .9 per cubic meter of water. Again, although this fixed rate eliminates the problem of abuse, it does not capture the demand effectively at the lower and upper ends.

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