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Cost Benefit Analysis of Private Sector Environmental Investments

A Case Study of the Kunda Cement Factory

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Contents

Abbreviations

CIF	Cost, insurance, freight
COI	Cost of illness
CVM	Contingent valuation method
EEK	Estonian kroon
ERR	Economic rate of return
ESP	Electrostatic precipitator
FIM	Finnish mark
FOB	Free on board
IFC	International Finance Corporation
IRR	Internal rate of return
KNC	Kunda Nordic Cement Corporation
NEFCO	Nordic Environment Finance Corporation
NO_x	Nitrogen Oxides; mainly NO_2
NPV	Net present value
PM10	Particulate matter below 10 microns in diameter
PV	Present value
SO_2	Sulfur dioxide
TSP	Total suspended particles (concentration in ambient air)
US$	United States dollars
WTP	Willingness to pay

Note: Exchange rates used in this study (prevailing in 1993): US$1=FIM5,2= EEK13

Foreword

This Discussion Paper breaks new ground for IFC. It considers the case of a cement plant in Estonia and tries to answer the question: how do the (private) costs of curbing pollution compare to the (social) benefits to the population? While it is often easy to estimate costs, it is exceedingly difficult to capture the benefits, especially in developing and transition countries. This pioneering empirical study concludes that in the case of Kunda Cement, the social benefits exceed private costs by a margin wide enough to justify the environmental investment in economic terms.

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Yannis Karmokolias of IFC developed the conceptual framework for the study and managed its implementation. Field work and preliminary analysis were carried out by Soil and Water Ltd., under Fjalar Kommonen, while work pertaining to the health impact was performed by Pekka Roto of the Tampere Regional Institute of Occupational Health. The support and participation of Harro Pitkanen of NEFCO is gratefully acknowledged.

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The project team obtained important data and comments from KNC; the Nature Protection Office of West-Viru county; the Ministry of Environment in Estonia; and the Ministry of Environment in Finland.

I. Executive Summary

Project economic analysis is based on estimating and comparing costs and benefits during the economic life of the project. Analysis is usually limited to those costs and benefits internal to the project. Occasionally, external costs and benefits of public sector projects dealing with natural resources have been valuated and included in the analysis but this is rarely the case for private sector projects.

An increase in environmental awareness in recent years, has led IFC, and other institutions, to ensure that projects it finances are environmentally sound. This means that, when necessary, borrowers must undertake capital and operating costs to ensure compliance with World Bank/IFC's environmental guidelines. In practice, these "environmental" investment costs are included in a project's economic analysis but corresponding benefits, generally, are not. As a result, the economic analysis is incomplete and its findings can be misleading.

Inclusion of environmental benefits and costs would improve significantly the reliability of the economic analysis and its value to private sector managers and public policy makers. More comprehensive environmental cost-benefit analysis would: Improve the estimate of a project's development impact; provide information to managers on the benefits associated with specific environmental investments; and enlarge the information base available to public policy makers by estimating the benefit and identifying the beneficiaries of environmental investments.

This study entails an environmental cost-benefit analysis of a private sector project, using the Kunda cement factory in Estonia as a case study. Kunda was chosen because the existing factory, which had been recently privatized, was a heavy polluter. The Kunda Nordic Cement Corp. (KNC) had embarked on a US$31 million renovation, including US$8.7 million of environmental investments to meet World Bank/IFC environmental guidelines. Thus, it was possible to compare the "before and after" situation in pollution and related impacts. Kunda was the only source of pollution in the area so that there was no risk of mixing up pollution sources and impacts. Together with the advantages, Kunda also entailed some difficulties for the analysis. Data was generally scarce, particularly on market prices, as the transition from a communist to a market economy had just gotten underway. It was, therefore, necessary to complement data collected in Estonia with findings of studies conducted elsewhere.

The study identified all impacts related to Kunda's air pollution but valuated only those which had economic significance and for which data was available. These impacts included: Soiling and material damage; real estate values; health; forestry and agriculture; tourism; raw materials and personnel turnover at the cement company; and global effects of SO_2 and NO_x emissions. The rate of return for the environmental investments was estimated at about 25 percent over fifteen years. Sensitivity analysis showed that even if benefits are drastically reduced, the rate of return remains acceptable at over 16 percent.

Most benefits take place in the vicinity of the factory. Significantly, important benefits also accrue to residents throughout Estonia and of nearby countries. This clearly demonstrates that environmental policies should be approached from a broad international perspective.

II. Introduction

Major changes have taken place in recent years in the way the environment is regarded by policy makers and implementing agencies in governments, multilateral institutions and private companies. Multilateral institutions understand that environmental protection is an integral part of the development process and have adopted measures to put this into practice. IFC has taken concrete steps to ensure that environmental issues are addressed when potential IFC investments are appraised. Specifically, IFC has sought to arrest environmental damage by on-going projects in which IFC invests and to minimize any such damage in new projects.

Statement of the Problem

Projects are eligible for IFC financing if they meet four criteria. Appraisal of the project must conclude that it: is in the private sector and financially profitable; makes a positive contribution to the country's national economy; is technically feasible; and is environmentally sound.

Under current IFC practice, environmental analysis consists of ensuring that the project's construction and operation, including that of existing facilities, do not violate the respective country's and World Bank/IFC's environmental policies and guidelines. Otherwise, IFC will not invest in the project. It is important to highlight that IFC's environmental analysis, as practiced currently, is based on technical considerations. For example, in the case of an air polluting project, the analysis ascertains whether maximum emissions permitted under the guidelines are exceeded, and if they are, what must be done to lower emissions below the maximum limit. Compliance invariably requires additional investment outlays by the sponsors. The environmental analysis does not address the economic aspects of environmental impacts such as their respective values, whether they are costs or benefits, and who bears the costs or enjoys the benefits.

Correspondingly, economic analysis of projects does not, as a matter of course, quantify environmental factors. In general terms, economic analysis estimates incremental costs and benefits directly related to the investment during the economic life of the project and calculates the economic rate of return (ERR). The analysis includes only costs and benefits internal to the project, adjusted, if necessary, for distortions because of, for example, subsidies, tariffs, or exchange rate discrepancies. Ordinarily, environmental externalities are not included in the economic analysis.

Omission of substantial environmental impacts from a project's economic analysis may result in a significantly distorted picture of its effect on the national economy. Often, their omission also distorts the estimate of a project's profitability. For example, pollution could affect workers' health and productivity, health related company expenses, or corporate product marketability.

There are good reasons for estimating the costs and benefits of major environmental impacts and including them in a project's economic analysis. Such analysis would result in:

- More accurate estimates of a project's development impact;

- Broader information base for investment decision making;
- Development of a management tool for company executives;
- Better information for environmental policy makers.

There are, as may be expected, valid reasons why this is not being done:

- It requires additional expenses;
- Relevant data is scarce;
- Findings may support claims for retroactive compensation.

Objectives of the Study

The main objective of the study was to investigate the feasibility of developing a practical method to calculate, in economic terms, the major impacts of environmental investment undertaken by the private sector. The Kunda cement factory in Estonia was selected as a case study. The study also aimed to answer the following:

- What are the major environmental impacts of the investment?
- Which of these impacts can be quantified? Why are other impacts not quantifiable?
- Which are the investment costs and benefits, both internal and external to the project, associated with the Kunda investment?
- What is the ERR of these investments?
- Who bears the costs and who are the beneficiaries of the environmental investments and related impacts?

Methodology

Cost-benefit analysis, including externalities, has been used to evaluate some public sector investment projects since the 1930s, although the practice became more prevalent in the 1960s (Marglin, 1967; McKean, 1967). This has rarely been the case for private sector projects, where cost-benefit analysis has been confined to direct, or internal, costs and benefits. This was due, in part, to scarcity of relevant data and to the limited time and other resources available but also due to the comparatively little emphasis placed on external effects, particularly the environment.

External effects of a project are usually defined as income or income-equivalent welfare changes for individuals or groups not directly affiliated with the project. A project generating external effects neither receives nor makes a full financial payment to these individuals or groups. In economic analysis, all environmental effects, both costs and benefits, should be identified and, where possible, quantified. Environmental effects can be quantified by measuring the change in output that these effects cause in the economy. It is recognized, however, that some environmental effects, because of their nature, do not readily lend themselves to quantification.

The Kunda cement plant in Kunda, Estonia was selected as the case study. KNC used to be fully-owned by the Government. At the time of the study, it had been partially privatized, a substantial share had been bought by a consortium of private companies, and management had been taken over by one of the Finnish sponsors. The new owners planned major renovation of the factory, including pollution control. Part of the financing for the renovation was provided by IFC, the Nordic Environmental Finance Company (NEFCO), FinnFund, and EBRD.

The factory was the only major source of pollution in the area, which facilitated the identification of impacts. The pollution was of major concern to all those involved in financing and operating the plant, to the Government and, most of all, to the area residents who had expressed their concerns quite clearly and forcefully. The environmental impacts identified in the study were measured as the differences between the following two scenarios:

Scenario A: The Kunda cement factory continues to operate without making investments for environmental improvements.

Scenario B: Environmental investments are implemented as planned and cement production continues accordingly.

Differences in the environmental impacts projected in the "with" and "without" scenarios represent incremental costs and benefits quantified and monetized in this study. Costs were defined as the investment and operating costs of new equipment to reduce pollution to the level prescribed by World Bank/IFC guidelines. In project economic analysis, inputs and outputs should be valued at their contribution to the national economy; i.e. the alternative production foregone or the cost of alternative supplies. Because domestic market prices do not always represent these opportunity cost values, alternative methods of valuation have been developed. The most common methods are briefly described in Box 1.

Of these methods, the market-valued direct cost approach was used whenever possible in this study, as well as damage cost valuation and, to a lesser degree, hedonic pricing. The resources available did not allow for generation of data that would have required a long time, e.g. data for health and tourism related benefits. In these cases, findings of other relevant studies were used to complement or compare data collected in the course of this study. Willingness to pay (WTP) field work to establish social cost valuations was not undertaken. WTP reliability, questionable in many situations, would have had especially limited value in Estonia, where a centrally planned economic system could have made responses devoid of a market price context. A consequence of this approach is that the benefits are probably underestimated, because non-quantifiable positive impacts have been omitted from the calculations. Tradable goods were priced at border parity prices but because of data limitations in Estonia, parity prices were, at times, substituted with those of nearby Finland (Curry and Weiss, 1993; Pagoulatos, 1992).

Box 1 Social Cost Valuation Methods

For welfare losses that cannot be directly calculated from market prices, several techniques have been developed to approximate social welfare losses from pollution. Commonly used valuation techniques are briefly presented below.

Damage Cost Valuation
Reduction in income based on product market prices, increase of medical costs and indirect costs from illness. Dose-response functions relate the responses to pollutant concentrations, and the concentrations are calculated from emission amounts and dispersion studies. Example: SO_2 and NO_x particle emissions which affect health, crop yield, forest growth, material damage and others.

Replacement Cost Valuation
Costs of emission reduction or costs of shadow projects (shadow projects are alternative measures to reduce emissions to the same recipient). Example: National or regional evaluations of total and marginal costs to meet internationally agreed pollution reduction goals.

Avertive Expenditures
Expenditures for substitutes or complements to compensate for effects of pollution on “victims" of pollution. Example: Noise abatement using insulation, cost to farmers of more land or extra fertilizer to compensate for reduced crop yield.

Travel Cost Method
Travel expenditures to reach a recreational site indicate its value to society.

Hedonic Pricing Methods
Prices of marketed goods, e.g. housing, influenced by the presence of non-marketed goods, e.g. pollution. In such cases, valuation can be based on the effect of the state of the environment on property prices.

Experimental Methods
Field studies of society's willingness to pay (WTP) for environmental improvement, or willingness to accept (WTA) compensation for environmental damage. Examples: WTP to avoid chronic or acute illness, WTP to preserve endangered species.

Legal Liability
Damage penalties paid according to law enforcement can give indications of the value to society of environmental quality.

Costs and benefits were compared using standard cost-benefit analysis, including conversion of money flows to net present value (NPV) at a real discount rate of 10 percent. The "profitability" was assessed in terms of the rate of return on the environmental investments (Little and Mirrlees, 1974; Ray, 1984) by calculating the corresponding ERR. Local prices were converted to US$ at the 1993 exchange rate of 13 Estonian Kroon (EEK) per US$. For the time series involved in NPV and IRR calculations, all values are expressed in 1993 constant prices.

The analysis followed the phases described below:

1. Identification of all impacts caused by pollution generated by the Kunda cement plant;
2. Selection of impacts to be quantified and valuated, on the basis of economic significance and availability of data;
3. Description of non-quantifiable impacts;
4. Valuation of selected impacts;
5. Evaluation of the profitability of the proposed environmental investment on the basis of NPVs and ERRs.

III. Description of the Region and of the Kunda Cement Plant

Characteristics of the Region

The KNC cement plant is situated in the town of Kunda, West-Viru county, about 100 km east of Tallinn, Estonia's capital. Kunda has a population of about 5,000. The plant was located there because of the proximity to raw materials. Limestone and clay deposits are available in Kunda and oil shale in Kivioli, about 45 km southeast.

The surrounding area is mostly covered with forest. There are also a number of farms for crop production and dairying. The town has a small scenic fishing harbor that was recently expanded for bulk shipping cement. At a distance of 3 to 7 km from the factory are beaches and other recreational areas, where about 2,000 persons spend summer vacations. There are also some archaeological sites dating to medieval times.

Plant Description and Process

KNC is the main employer in the Kunda area where the factory has been producing cement for several decades. The four kilns operating at present are quite old, having been installed between 1961 and 1972. While Estonia was part of the Soviet Union, most cement was marketed within the Union, mainly in the St. Petersburg area. When Estonia became independent, former markets in the former Soviet Union were no longer available. The resulting drop in demand caused production to decline from nearly full capacity of 900,000 tons in 1991 to 500,000 tons in 1994. Since privatization, the objective has been to modernize the plant, restore production to 900,000 tons by 1998, and develop new export markets, mainly in northern Europe.

Kunda cement is produced using the standard wet process. Oil shale is used instead of coal or fuel oil because it is locally available, its oil content is high and the oil shale ash is used as raw material in cement production.

Pollution from the Kunda Plant

Prior to the environmental investment program, the Kunda plant generated air and water pollution from its production processes and from solid waste mismanagement. Most significant , by far, was air pollution, predominantly in the form of flue gases from the cement kilns. At full production of 900,000 tons of cement, dust emissions amounted to a staggering 129,000 tons per year. In addition, there were substantial SO_2 and NO_x emissions, as well as dust emissions from oil shale preparation and grinding, transport of raw materials, and cement bagging operations.

Water pollution, although minuscule in comparison to the air pollution problem, related to inefficient use of water and to possible contamination of water supplies from occasional spills in the fuel and lubricating oil storage areas. Waste from the plant was dumped at a landfill which did not meet Estonian and World Bank/IFC guidelines.

Air pollution has earned Kunda the dubious distinction of “The Gray Town of Estonia.” Area residents have been actively protesting the pollution problem. They have taken their case to the national and local government authorities, to the media, and to KNC. They have organized petitions, seminars, demonstrations and have had frequent meetings with KNC. They managed to get the Kunda Town Council to discuss the possibility of closing the plant until pollution controls were in place. The motion was not approved, in view of the plant’s importance to the regional and national economy, but the pollution issue remains very much alive for Kunda’s residents.

To establish the spatial extent of the problem, a dispersion survey was carried out as part of this study, to find out where the dust settled. The survey estimated particle concentrations and depositions in an area of 100 km^2 around the plant. Dust dispersion measurements were made at 356 receptors, placed at distances of 250 m to 1 km between receptor points. The survey results, presented in Table 1, show that particulate emissions from the unrenovated factory caused very high levels of one-day dust concentrations.

Table 1

One-Day Dust Concentration Around Kunda Cement Factory

Distance From Plant (km)	Dust concentrations ($\mu g/m^3$)
1-2	1800
3-5	500
6-10	300

Note: One-day concentration value is a daily value exceeded less than 2 percent of the time.

The annual concentration maximum was also extremely high at 263 $\mu g/m^3$, compared to 60 $\mu g/m^3$ allowed in nearby Finland and 80 $\mu g/m^3$ under World Bank/IFC guidelines. The Finnish standard was exceeded throughout an area of 28 km^2 around the plant.

The dispersion of PM10 (particulate matter below 10 microns in diameter) was also estimated. PM10 makes up 25 percent of cement dust emissions and is considered more harmful to humans than larger particles. The survey showed that PM10 dispersion patterns are similar to those of total suspended particles in the air (TSP) and that when TSP emissions are reduced, those of PM10 are reduced proportionally.

If the calculated particle concentrations are compared to Finnish and recently established Estonian air quality guidelines, one-day values exceeded the limit by 1,200 percent in the vicinity of the plant and by more than 100 percent in the total dispersion area. Maximum annual average concentrations were 3.3 times higher than the World Bank guideline and 4.4 times the Finnish guideline. After the modernization, the highest daily values would be dramatically reduced to about 10 percent of the air quality guidelines and the highest annual average concentrations would be about 4 percent of the guideline.

IV. Investment Program

New Company Environmental Policy

After privatization, the new management adopted a new environmental policy with the following objectives:

1. To meet Estonian environmental requirements as soon as possible;
2. to meet all World Bank/IFC requirements within 3 years; and
3. to be the best environmentally managed industrial company in Estonia within 5 years.

To meet these objectives, management embarked on a three-part strategy: First, it assigned responsibility for environmental matters to the general manager; second, it gave top priority to investing in new equipment and modifying the production process, aiming to meet World Bank guidelines by end-1997; third, to give all KNC personnel basic environmental training to increase their awareness and responsibility in environmental matters.

Environmental Investment Program

KNC gave priority to reducing dust emissions by installing new ESP flue gas filters and modifying the kilns. By end-1996, all operating kilns would have an emission level of 50 mg/m^3 according to World Bank/IFC guidelines. Total annual dust emissions, at full production of 900,000 tons, would be reduced from almost 130,000 tons to below 10,000 tons.

Oil shale preparation, mainly grinding, would be improved by replacing existing equipment to reduce emissions from 4,000 mg/m^3 to about 50 mg/m^3.

Mills would be equipped with new ventilation and cooling systems, including new bag filters. Emissions would be reduced from 4,200 mg/m^3 to below 20 mg/m^3. The fly ash receiving silo would be equipped with a fabric cassette filter, bringing emissions down to 20 mg/m^3.

Fabric filters would be installed at the cement bulk loading, where at present no de-dusting takes place. The cement packing plant and its silo would be renovated and the existing bag filters would be made operational.

Additional investments would be made to safeguard against water pollution and improve waste management.

The total investment for the plant’s modernization was estimated at US$30.9 million, of which US$8.7 million would be allocated for environmental improvements.

KNC’s investment program is summarized in Table 2.

Table 2

KNC Investment Program, 1993-1996

	Environmental	Other	Total
	(Thousands/US$)		
Basic engineering	50	140	190
Engineering of new cement plant		150	150
Storage hall cranes	--	170	170
Slurry preparation	--	125	125
Oil shale preparation improvements	2135	670	2805
Kiln improvements	4810	4035	8845
Clinker conveying	310	90	400
Grinding improvements	534	1850	2384
Bulk loading and storage improvements	300	450	750
Electrification	35	130	165
Process control and instrumentation	210	835	1045
Laboratory equipment	--	525	525
Buildings and infrastructure restoration	--	800	800
Finish grinding in closed circuit	150	2510	2660
Palletizing line for cement bags	--	700	700
Cement bag storage	--	350	350
Port facilities		8000	8000
Contingency	165	661	826
Total	8699	22191	30890
Percent of Total Investment	28.2	71.8	100

Source: KNC

V. Impacts of the Environmental Investments

Description of Impacts

Actions taken by KNC, their effects on pollution and the corresponding impacts on the environment are summarized in Table 3.

Table 3

Environmental Impacts of KNC Actions to Reduce Pollution

KNC Action	Effect on Plant Pollution	Environmental Impact
Improve kilns; install ESPs; improve oil shale and cement grinding, bagging and transport operations	Dramatic reduction in dust emissions	Workers' and residents' health; tree and plant growth; livestock health and productivity; soiling of buildings, streets and households; town image; real estate values; tourism; factory operating costs
Energy saving in slurry preparation	Lower SO_2 /NO_x emissions	Health; corrosion; plant and tree growth; soiling
Oil spill prevention or containment; sewer renovation; new waste landfill site	Less water contamination under ground and in Kunda river	Health; fish population; salmon spawning

Some of the environmental impacts are confined locally but others occur over a much larger area. For example, the survey of dust dispersion showed that its effects are felt at the local and regional level but SO_2 and NO_x emissions, which are airborne over very long distances, affect the environment beyond Estonia's borders. A geographical classification of Kunda's environmental impacts is shown in Table 4.

Table 4

Geographical Significance of the Environmental Impacts

Type of Pollution Control and Related Impact	Geographical Area Affected: Local	Regional	National	International
Dust emission				
- tree growth	x	x		
- crop production	x	x		
- tourism	x	x		
- health	x			
- soiling	x			
- real estate	x			
- operating costs	x			
- livestock	x			
- fish population	x			
- salmon spawning	x	x	x	x
- town image	x	x	x	
So2 and NOx emission				
- tree growth	x	x	x	x
- crop production	x	x	x	x
- health	x	x	x	x
Ground water	x	x		
River pollution	x		x	

Quantifiable and Non-Quantifiable Impacts

Environmental impacts were classified, with respect to economic valuation, into quantifiable and non-quantifiable. Among the former are: Health; forestry; agriculture; soiling; tourism and recreation; real estate value; SO_2 and NO_x impacts; and operating costs.

Non-quantifiable impacts, for the purposes of this study, are those for which value judgments would be required, e.g. regarding Kunda's image, or for which data is unavailable or their economic significance is minor or are practically the same in both scenarios. Non-quantifiable impacts are briefly described in the following paragraphs.

There are indications that water pollution decreases fish catches and reduces the quality of fish in the Kunda river. However, there has been no scientific work to verify that pollution from the factory actually impacts on the fish and to what degree. The river is used only by recreational fishermen, and even if there is an impact from reduced pollution, the incremental catch would be very small (Raukas and others, 1993). A more significant impact could occur on the population of salmon in the Gulf of Finland, given that the Kunda river is one of the few remaining spawning sites in the area.

Changing the image of Kunda from "the gray town of Estonia" into a clean and prosperous place to live is very important. Part of this has been quantified in other impacts such as real estate values and the cost to KNC of personnel turnover. It is certainly important to those who have organized protests against Kunda pollution, as well as to the passive members of the community. No attempt was made in this study to valuate these sentiments.

There have been reports of cement dust affecting the milk production and fertility of dairy cows. Reliable studies establishing a cause and effect relationship between Kunda pollution and livestock health or dairy production have not been carried out. Also, there are complaints that cement dust has reduced the supply of berries, mushrooms and other horticultural produce in the forests. However, the affected forest area is limited and so is the market value of the goods involved. The study did not attempt to calculate the WTP for these products by affected individuals.

In some areas, a negative effect of reduced dust deposition may be the result of decreased neutralization of acid rain. This effect, however, is not so important in Estonia because of the relatively high buffer capacity of the soil.

VI. Economic Quantification of Environmental Impacts

Raw Materials and Operating Benefits and Costs

The plant's operating costs would be affected by the environmental investments in several ways. It would be possible to return about 2/3 of the dust collected from ESPs to the production process, thus saving limestone raw material. However, remaining dust would be disposed in the new industrial waste dump at an annual cost of EEK600,000 at the current production level of 600,000 tons/year or EEK900,000 at full capacity. The change in benefits and costs associated with ESPs is shown in Table 5.

Table 5

Impact of ESP Operation on Kunda's Operating Costs

Savings	EEK/year	US$/year
Raw material savings	8,351,850	642,450
Costs		
ESP Operating costs	5,204,550	400,350
Dust removal	900,000	69,231
Net savings	2,247,000	172,846

Source: KNC

At full production of 900,000 t/year, net benefits from ESPs on operating costs would be US$173,000/year. Full benefits would be gradually realized over a period of six years with US$120,000 in year 1 and US$173,000 in year 6.

Pollution abatement would affect recruitment costs as more qualified people would be willing to work at Kunda, while fewer would be leaving. KNC's 20 percent yearly personnel turnover, at present, is double that at the Rakvere meat packing plant yearly. The cost of recruitment and training of a new employee averages EEK4,000 per person. If the turnover is reduced to 10 percent or 60 employees annually, the corresponding savings would be EEK240,000/year or US$18,500/year.

With respect to compensation, the company did not anticipate that salaries and wages would be reduced as more persons sought to work at KNC.

Soiling and Material Effects

Soiling of the town of Kunda from the thousands of tons of cement dust that have been falling on the town impose a dual burden on its residents. First, surfaces become dirty more quickly than they would in the absence of dust, so that streets, sidewalks, and floors have to be swept or dusted more frequently, and clothing must also be washed more frequently. Secondly, the dust, which is alkaline, damages painted surfaces such as walls, doors and automobiles. No damage has been reported to stone and brick surfaces.

Most studies of the impact of air pollution on buildings and materials have been concerned with acid pollutants like SO_2 and NO_x, and acid corrosion. In Kunda, the main pollutant is alkaline cement dust, not known to cause corrosion but, in combination with moisture, is damaging to painted surfaces. The cost of surface cleaning and painting in Kunda was estimated at about EEK250/m^2. There are 160 individual houses in Kunda and the wooden painted surface of an average house is estimated at 70 m^2. (The remaining population live in cinder-block apartment buildings). Interviews with Kunda residents revealed that the average period between house painting of 8 years has been shortened by half because of the cement dust. Savings from less frequent painting were estimated at EEK750,000/year or US$577,000/year. Cars also needed more frequent repainting because of the dust. There were about 250 cars in Kunda, half of which were not kept in garages. On an annual basis, the incremental cost of car painting in Kunda because of the cement dust was estimated at EEK330/car for a total of about EEK58,000/year or about $4,800/year. These estimates do not include the cost of sweeping dust from the streets or buildings nor the cost of washing clothes.

Earlier studies have pointed out that actual expenses for cleaning, repair and maintenance, do not reflect the total value of household cleanliness (Watson and Jaksch, 1982; Freeman, 1982). Findings from these studies indicate that households do not always increase the frequency and cost of cleaning as the level of pollution rises. Nevertheless, total welfare loss is greater, because households experience reduced utility from having to live in a dirty environment. Also, if repairs and maintenance are not kept up, the result would be more costly repairs later or reduced property values. Comprehensive studies of the cost of soiling in the US have found that the benefit of reduced soiling from lower TSP corresponded to US$1.0 – US$1.5 per inhabitant for 1.0 $\mu g/m^3$ reduction. Partial findings in Kunda pointed to a slightly greater benefit but the data was too limited to be sufficiently reliable. Applying the more conservative findings of earlier studies to the 50 $\mu g/m^3$ TSP decrease in Kunda results in a total economic benefit from reduced soiling of: 4,700 inhabitants * 50 $\mu g/m^3$ * US$1.5 = US$350,000/year. About 20 percent of this amount represented the cost of unskilled labor, a non-tradable, and the remaining 80 percent the cost of paint, brushes, brooms and other supplies, all tradable. Unskilled labor in Kunda was valued at the local wage level for a total of US$7,000. Costs for tradable items were valued at import parity prices for a total of US$280,000 (Soil and Water Ltd., 1995). Thus, the total economic benefit from reduced soiling at Kunda was estimated at US$287,000 per year.

Real Estate

In January 1994 the Government assigned property values for the purpose of determining taxes and fees for use of state-owned land. The values were EEK12/m^2 (US$0.9/$m^2$) inside Kunda town limits and EEK6,200/ha (US$0.05/$m^2$) beyond town limits (Teedunae, 1994). No other data exist and, in the absence of a real estate market in Estonia, it is not known whether these assigned prices represent actual values. These prices were about 1/20 to 1/10 of those for similar land in Finland.

Earlier studies have used hedonic pricing techniques to assess the impact of pollution on property values. They have concluded that, a one percent increase in TSP decreases property values by 0.05 percent to 0.14 percent (Pearce and Markandya, 1989). Typically, this relationship is not linear, especially when pollution levels increase substantially. Based on this information, it could conservatively be assumed that in Kunda, where TSP reduction would be close to 80 percent, real estate values would increase by at least 5 percent.

The total town area of Kunda is 1,001 ha (Raukas and others, 1993) of which about 66 percent is buildings and the remaining vacant lots and fields. In economic valuation, land and unskilled labor, as non-tradable, should be shadow-priced, while construction materials and skilled labor should be valued at the appropriate border price. In the absence of data for Estonia, the average value of US$19.2/$m^2$ for buildings in Finnish towns similar to Kunda was applied as a border parity price (Finnish National Board of Survey, 1994).

Thus the increase in economic value of buildings in Kunda from the reduction in pollution was estimated at 1,001 ha x 0.66 x 0.005 x US$192,000 = US$6.3 million. The value of undeveloped land is about 10 percent that of buildings and the corresponding economic impact from reduced pollution would be 1,001 ha x 0.34 x 0.10 x 0.05 x $US192,000 = US$0.33 million, for a total real estate benefit of US$6.6 million. In view of the time it will take for pollution to be reduced and for the realization of a cleaner Kunda to be reflected in real estate values, the real estate benefit was spread over five years, starting with the second year of the project.

Health

During the planning stages of the study, discussions with Estonian government officials and with Viru County and KNC health personnel indicated that the plant's pollution caused significant health problems, related primarily to respiratory and dermatological illnesses. In view of the apparent importance of the health issues involved, the Finnish Institute of Occupational Health joined the study team to assess the health impact of Kunda's air pollution. It became evident very quickly that this would be a complex and time consuming task. Possible impacts related to both chronic and acute respiratory problems that could best be studied with a time-series methodology spanning many years. This approach was not possible in this study because of time and budget limitations. Furthermore, many of the plant's long-time workers were ethnic

Russians who had left the company, and possibly Estonia, after the country gained its independence from the Soviet Union.

Faced with these constraints, the study team decided to tackle the issue as follows: First, regarding chronic health problems, to rely on an on-going study by Orebro Medical Center Hospital of Sweden and the Estonian Institute of Experimental and Clinical Medicine which was scheduled to be completed prior to this study. Secondly, regarding acute health problems, to carry out a cross-section investigation comparing Kunda workers and Kunda residents to a control group of workers in a meat packing plant in Rakvere, about 30 km from Kunda. Rakvere has no heavy industry and the meat packing plant had been constructed recently according to Finnish environmental and occupational safety standards.

The results of the epidemiological cross-section study did not indicate statistically significant differences in relevant symptoms or diseases between the groups tested (Roto and others, 1995). This contradicted the perception of the participants in the health study, with Kunda workers and town residents reporting significantly more air pollution related health problems than the Rakvere workers. Furthermore, three peer reviewers of the health investigation gave differing opinions on the validity of the results but all suggested a time-series approach which would require a number of years to complete. In the meantime, the completion of the Swedish-Estonian study of chronic effects had been delayed. It was, therefore, decided to rely on existing studies that had dealt with the health impact of construction materials dust, including cement (Ostro, 1994). Dose-response relationships established on this basis are shown in Table 6.

Table 6

Morbidity Effects from a 10 μg/m^3 Change in PM10 Concentration

Morbidity	Low Estimate	Central Estimate	High Estimate
RHA/100,000	6.57	12.0	15.6
ERV/100,000	128.3	235.4	342.5
RAD/person	0.404	0.575	0.903
LRI/child	0.008	0.0169	0.0238
Asthma attacks/asthmatic	0.163	0.326	2.73
Respiratory symptoms/person	0.91	1.83	2.74
Chronic Bronchitis/100,000	30.6	61.2	91.8

Notes: PM10 concentration is the annual average concentration in ambient air TSP below 10 microns in diameter; RHA is Respiratory Hospital Admissions; ERV is Emergency Room Visits; RAD is Restricted Activity Days; LRI is Lower Respiratory Illness of children.

These general morbidity coefficients were monetized applying the findings of recently completed studies (US Department of Energy, 1994) to the average change in PM10 concentration in Kunda of 20 μg/m^3. The change in PM10 had been established by the dust dispersion survey undertaken in the course of this study. The results are shown in Table 7.

Table 7

Kunda Town: Benefits from a 20 μg/m^3 Reduction in PM10 Annual Concentration

	Number of Affected Persons	Annual Morbidity (# of Incidents)	Average Morbidity Cost (US$/Incident)	Total Annual Morbidity Cost (US$)
Hospital Admittance	4700	1.13	6306	7126
Emergency room visits	4700	22.13	178	3939
Symptom days	4400	16104.00	6	96624
Restricted activity days	4400	5060.00	51	258060
Children's LRI	300	10.14	132	1338
Asthma incidents*	235	153.22	30	4597
Total				371684

* The number of asthmatic persons is assumed to be 5 percent of the population.

Thus the total health benefit from reduced pollution at Kunda, including the cost of treatment (medical facilities, medical personnel, medicine) as well as the cost of days lost from work, was estimated at US$372,000/year. This estimate does not include WTP measurements for being healthy. Nor does it include the effect on the productivity of employees normally working with the person absent nor the effect on productivity of employees who work even though they are sick.

Forestry

About 46 percent of the affected area is covered by commercially exploited forest. The total volume of the forest stands was estimated at nearly 700,000 m^3, comprised of deciduous trees (51 percent), pine (38 percent) and spruce (11 percent). It has been established that cement dust from the plant retarded tree growth by obstructing photosynthesis or by negatively affecting soil composition. Preliminary findings showed that 70 percent of the yield reduction was caused by inadequate photosynthesis of leaves and needles and 30 percent from changes in the soil. However, the latter effect occurred very slowly, so the impact on tree growth would not be significant during the 15-year time period covered by this study (Mandre, 1994). The average growth deficit in the affected area (up to 5 km west and 10 km east of the plant) compared to non-affected areas is 12 percent for pine and 20 percent for spruce. These percentages correspond to volumes of 1,000 m^3 for pine and 420 m^3 for spruce each year.

The fob-Tallinn price for pine and spruce timber averaged \$50/m^3. Processing and transport costs from Kunda to Tallinn were estimated at \$15/m^3, which was subtracted from the fob price, giving an export parity price of $35/m^3$. Thus, the benefits from increased timber production once the pollution decreases were estimated at $34,790 per year.

Agriculture

Cement dust fallout affects about 1,850 ha of agricultural land. Crops mainly consist of barley, wheat, oats and potatoes. Earlier research had found that, depending on the species, growth is 23 percent to 33 percent lower in heavily polluted areas within one km from the factory, compared to a control area. The impact is lower, as dust fallout decreases, averaging a yield reduction of 10 percent over the affected area of 1,850 ha of farmland (Mandre, 1994). The reduction in rate of growth is strongly dependent upon climatic factors. Dust effects are smallest in cold and rainy seasons and largest when the growing season has been warm and sunny. Crop quality is also affected by dust downfall, based on experiments which show that crops exposed to cement dust have lower contents of beta-carotene and essential amino acids (Mandre, 1994).

The average price of crops in the affected area was estimated at US$780/ha cif-Tallinn equivalent. Handling and transport costs from Kunda were added, making the farm gate value at import parity prices US$830/ha. With the reduction of dust fallout, yields would increase by 10 percent. The impact on quality is not quantified because of lack of data. Because the quantity affected by the plant's pollution is small, prices of the various crops will not be affected from the increase in supply. Thus, the total agricultural benefit from increased crop production in the affected area after pollution has been reduced, would be 1,850 ha x 0.1x US$830/ha = US$101,000/year.

Tourism and Recreation

The area around Kunda is very scenic, especially along the coast. Yet, recreational and tourism activity is noticeably less than just beyond the dust dispersion area. Even where there is no dust deposition, the visible dust cloud rising from the factory and Kunda's bad reputation also act as deterrents to would-be visitors. It is obvious that should air pollution be substantially reduced, tourism activity would rise. The question remains, however, how much tourism and how much related spending would take place in the absence of pollution. To answer this question would required extensive field research which was not possible within the constraints of this study. Consequently, this part of the analysis relies on secondary information about tourist activity and spending in other parts of Estonia and neighboring countries.

Most tourists in Viru County are Estonian nationals. An estimated 2,000 Estonians and 300 foreigners spend their summer vacations at the fringe of the dust dispersion area. Practically all are Viru County natives who now live in Tallinn or in neighboring countries. It is assumed that with the reduction of pollution, the number of vacationers in this area would increase by 1,000 Estonians and by 150 foreigners, (Case A). If the pollution continues unabated, the numbers would decrease by 1,000 and 150 persons, respectively, (Case B). Thus, the difference in tourism volume between the two scenarios after 15 years would be 2,000 domestic tourists and 300 foreign tourists.

Based on 1992 data, expenditures by foreign tourists amounted to EEK207/day with an average stay of 2.5 days. Domestic tourists spent EEK36/day, averaging 14 days per stay (Estonian Statistical Yearbook, 1993). In 1993 prices, total annual tourist expenditures would be:

Domestic tourists	2000 x 14 x 79	= EEK2212000
Foreign tourists	300 x 2.5 x 449	= EEK336750
Total		= EEK2548750 or US$196,000 per year

Because of the difficulty in calculating border prices for goods and services consumed by tourists, tourist expenditures in Finland were used as a proxy. In 1993 they averaged US$ 96/day for foreigners (Finnish Tourist Board, 1994a), and US$ 46/ day for local tourists (Finnish Tourist Board, 1994b; Finnish Tourist Board, 1994c) or 5.5 times higher than in Estonia. It was estimated that 50 percent of tourist expenditures related to tradable, e.g. food, drinks, supplies, which should be valued at border parity prices and 50 percent to non-tradable, such as labor and utilities.

Accordingly, the annual tourism benefit for tradable would be US$0.5 * 196 * 5.5 = US$539,000 and for non-tradable US$0.5 * US$196,000 = US$98,000, or a total of US$637,000. Since independence, tourism has been increasing rapidly in Estonia. Tallinn is the main destination but the coast has also been attracting visitors leading to the construction of two new hotels in Viru county. It is difficult to project how tourism will develop over time. Adopting a conservative approach, it was assumed that tourism benefits would increase linearly over 15 years, from about US$43,000 in year 1 to US$637,000 in year 15 of the project. Although these estimates are based on plausible assumptions, they are probably conservative because in the absence of pollution the average stay would probably be greater. Also, recent tourism activity in the area, particularly of visitors from Germany and Sweden, suggests that tourism receipts would rise faster than assumed in this study.

SO_2 and NO_x Reduction Impacts

Energy savings achieved through process improvements in the factory have been calculated by KNC to be 20 percent of existing energy consumption. This would, in turn, result in lowering SO_2 emissions by 1,200 tons/year and NO_x emissions by 200 tons/year. Because SO_2 and NO_x are transported over long distances, those originating in Kunda would affect areas far beyond Estonia's boundaries. A recent study found that 71 percent of SO_2 and 87 percent of NO_x emissions originating in Finland were deposited several hundred kilometers from the source of emission, mostly in other countries (Tuovinen, 1994; Otterstrom and Koski, 1994). Other studies have reached similar findings (Markandya and Rhodes, 1992; Pearce, Bann, and Georgiou, 1992; Finnish Ministry of the Environment, 1989). The Finnish study is especially relevant to Kunda because it analyzed emissions originating in an area 50 km to 200 km from Kunda, a short distance in comparison to the transboundary character of SO_2/NO_x impacts. It concluded that the most significant impacts from SO_2 and NO_x emissions are:

Morbidity: A dose-response function was established between SO_2 concentration in the air and cough-days for children and of chest discomfort for adults. Values based on WTP to avoid these symptoms were estimated. NO_x also caused morbidity, directly and via ozone formation, but its significance was small.
Material impact: Dose-response functions were established between the SO_2 concentration in air and deterioration of structural materials like zinc-plated steel, painted steel, aluminum, concrete and wood. Damages were valued for structures in Finnish urban areas.
Forest growth: Forest damages due to acidification have been estimated in several studies of critical acidification loads in Finland. SO_2 deposition was found responsible for 60 percent of the total acidification, NO_x for 30 percent and ammonia for the rest. The potentially important damages on forests (mainly due to NO_x concentration) have not been reliably valuated.
Crop production: The combination of NO_x and volatile organic substances in the air produce ozone, part of which is from pollution imported from other countries. Results from several published dose-response functions were applied to estimate relevant damage to crops.
Water pollution: Water pollution damages were estimated from acidification of ground water, which causes corrosion in water pipes and from the reduction in fish populations.

The findings of the Finnish study regarding SO_2/NO_x emissions are summarized in Table 8.

Table 8

Costs of SO_2 and NO_X Emissions from Energy Production in Finland

Impact	Costs: Cost per kg of SO_2 emitted (US$)	Cost per kg of No_x emitted (US$)
Morbidity	0.77	-
Material Damage	2.43	-
Tree Growth	0.21	0.16
Crop Production	-	0.61
Water Pollution	0.03	0.05
Total	0.56	0.69

Source: Otterstrom and Koski 1994.

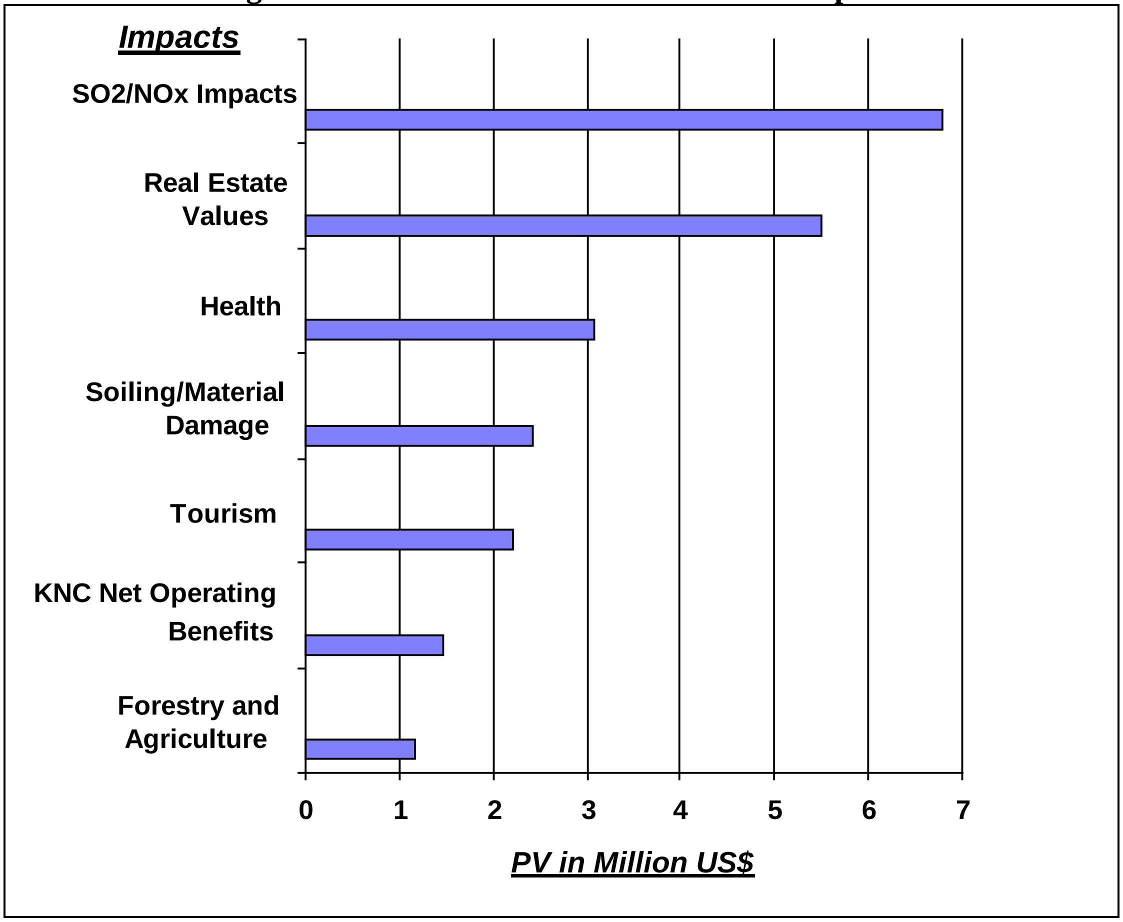
The values shown in Table 8 are lower than those estimated in the other studies but are more relevant to Kunda because of Southern Finland's proximity to the plant. These estimates were, therefore, adopted in this study, giving annual benefits of US $672,000 for a 1,200 ton reduction of SO_2 and US$138,000 for a 200 ton reduction in NO_x.

VII. Cost-Benefit Analysis

Return on Investment

The cost of the environmental investments to reduce air pollution below the maximum allowed under World Bank/IFC guidelines consists of the capital and operating costs of the pollution control equipment and of other improvements in the factory. Benefits consist of less raw material and personnel recruitment costs, less soiling, higher real estate values, lower health costs, increased forestry and agricultural production, higher tourism receipts and lower SO_2/NO_x impacts (Figure 1).

Figure 1 Present Value of Environmental Impacts



Quantified incremental costs and benefits related to the environmental investments are presented in Table 9. The table does not include benefits that were not quantified.

Table 9

Total Discounted Incremental Costs and Benefits

Costs/Benefits	Present Value* (US$ million)
Costs	
Capital	8.00
Operating	3.55
Total Costs	11.55
Benefits	
Raw Materials	4.86
Personnel Turnover	0.17
Soiling Reduction	2.42
Real Estate Values	5.50
Health Improvement	3.09
Agriculture and Forestry	1.17
Tourism Receipts	2.22
SO_2/NO_x Reduction	6.78
Total Benefits	26.21
Economic Rate of Return (ERR)	24.7%

* 10 percent rate of interest

The reduction of dust concentration gives benefits that are more than twice the capital and operating costs. The largest benefit is derived from the reduction of SO_2/NO_x emissions, the impact of which extends over an area substantially larger than Estonia. The second largest benefit relates to increased real estate values in the town of Kunda. However, given the still uncertain situation with respect to transfer of ownership and the real estate market, the increased values may not fully translate into tangible benefits for their owners. Cost savings in raw materials and energy are substantial and more than offset the operating and maintenance costs of the pollution control equipment. Health benefits are also substantial, and may be underestimated because intangible factors such as the value of well-being were not included. Tourism receipts are not as sizable as most other benefits but are also the least reliable, both with respect to magnitude and as to the year in which they might materialize. There are plans for the construction of the Baltic Highway to connect Finland and the Baltic countries to Central Europe and to develop Kunda's port into a marina for Finnish yachts. Should these plans materialize benefits from tourism would be much larger than estimated in this study.

The economic rate of return has been calculated at 24.7 percent which certainly justifies the investment. Estimates of the benefits tended to be on the conservative side and the return on investment could well be higher. At the same time, it is recognized that scarcity of data and the absence of market transactions for some factors, necessitated the use of relevant findings from other studies which may not be fully applicable to Kunda, even though pollution in Kunda was many times higher than that in most parts of the world. There is no doubt that the environmental investment has significantly high returns. Even if the three most uncertain benefits are reduced by 50 percent (tourism, health, and real estate) the ERR would still be 19.7 percent, and with the additional halving of SO_2/NO_x related benefits the ERR would be over 16 percent, which demonstrates that the investment in air pollution control results in significant benefits.

Beneficiaries

An important aspect of the cost-benefit assessment was to identify the groups of persons benefitting from the environmental investments at Kunda. Beneficiaries include residents of Estonia and of other countries in the region, as shown in Table 10.

Table 10

Present Value and Beneficiaries of Environmental Investments (US$ million)

Impact	PV	Beneficiaries
Forestry and agriculture	1.17	Forest owners and farmers within 5 km radius
Raw materials/ Employee turnover*	1.48	KNC
Increased tourism	2.22	Enterprises and employees in Kunda region
Reduced soiling and material damages	2.42	Kunda residents
Reduced health care costs	3.09	KNC workers and Kunda residents
Real estate values	5.50	Real estate owners in Kunda
Less damage from SO_2, NO_x emissions	6.78	Inhabitants of European countries near Estonia

Of the total benefits of US$22.66 million (discounted to year 1 of the project and having subtracted ESP operating costs) about US$16 million accrue to residents of the Kunda region and nearly US$7 million to residents of a wide area encompassing all of Estonia, Latvia and Lithuania and parts of Finland, Sweden, Norway, Russia, Belarus and Poland. If non-quantified benefits are considered, e.g. water pollution and salmon spawning, welfare increases in Estonia and neighboring countries would be even greater. Some of the environmental impacts which affect the Kunda area directly, also affect the whole country indirectly. For example, improved health or increased tourism activity in the Kunda region generates national benefits in the form of foreign exchange or in terms of budget allocations for public health. It is significant that an investment concentrated in a single factory has substantial environmental and socioeconomic impacts not only for the local community but also for Estonia and for neighboring countries.

VIII. Major Findings

Investments to reduce air pollution at Kunda cement factory would, once fully implemented, result in significant net economic benefits. The ERR has been calculated at 24.7 percent and sensitivity analysis confirmed that even if benefits are significantly reduced, the ERR is over 16 percent.

The most important environmental benefits identified are: Reduced global effects of SO_2 and NO_x emissions, better health and less health-related costs, reduced soiling and material damage, increased tourism income, greater real estate values, and increased forestry and agricultural yields. Additional benefits were identified but were not valuated because of limited data.

It is important to highlight that benefits occur over a wide geographical area. Although most would take place in the vicinity of the factory, important benefits also accrue to Baltic countries and to parts of Russia, Belarus, Finland, Sweden, Norway and Poland.

This type of research requires an inter-disciplinary team approach. In this study, environmental impacts ranged across several disciplines including agriculture, forestry, fisheries, livestock, chemistry, real estate, health, engineering, business and economics.

Data limitations, of both technical and economic data, made the study period longer than had been anticipated and necessitated the use of findings from other parts of the world, which may have resulted in underestimating some impacts and overestimating others. The sensitivity analysis indicated that, for this study, these over/under-estimates do not materially affect the conclusions of the study.

Findings of this type of study have many applications in the private sector, including:

- Improved project investment analysis;
- Clearer demonstration of the development impact of environmental investments;
- Help in developing investment plans, by estimating the returns to specific environmental investments;
- Improved corporate image and public relations;
- Higher environmental awareness.

Environmental cost-benefit analysis can also help public policy makers with respect to:

- Funding investments;
- Providing incentives;
- Justifying environmental regulations;
- Establishing penalties for non-compliance of regulations.

The research initiated in this study should be continued through subsequent case studies to establish the degree of validity and replicability of the findings in other locations and across different economic activities.

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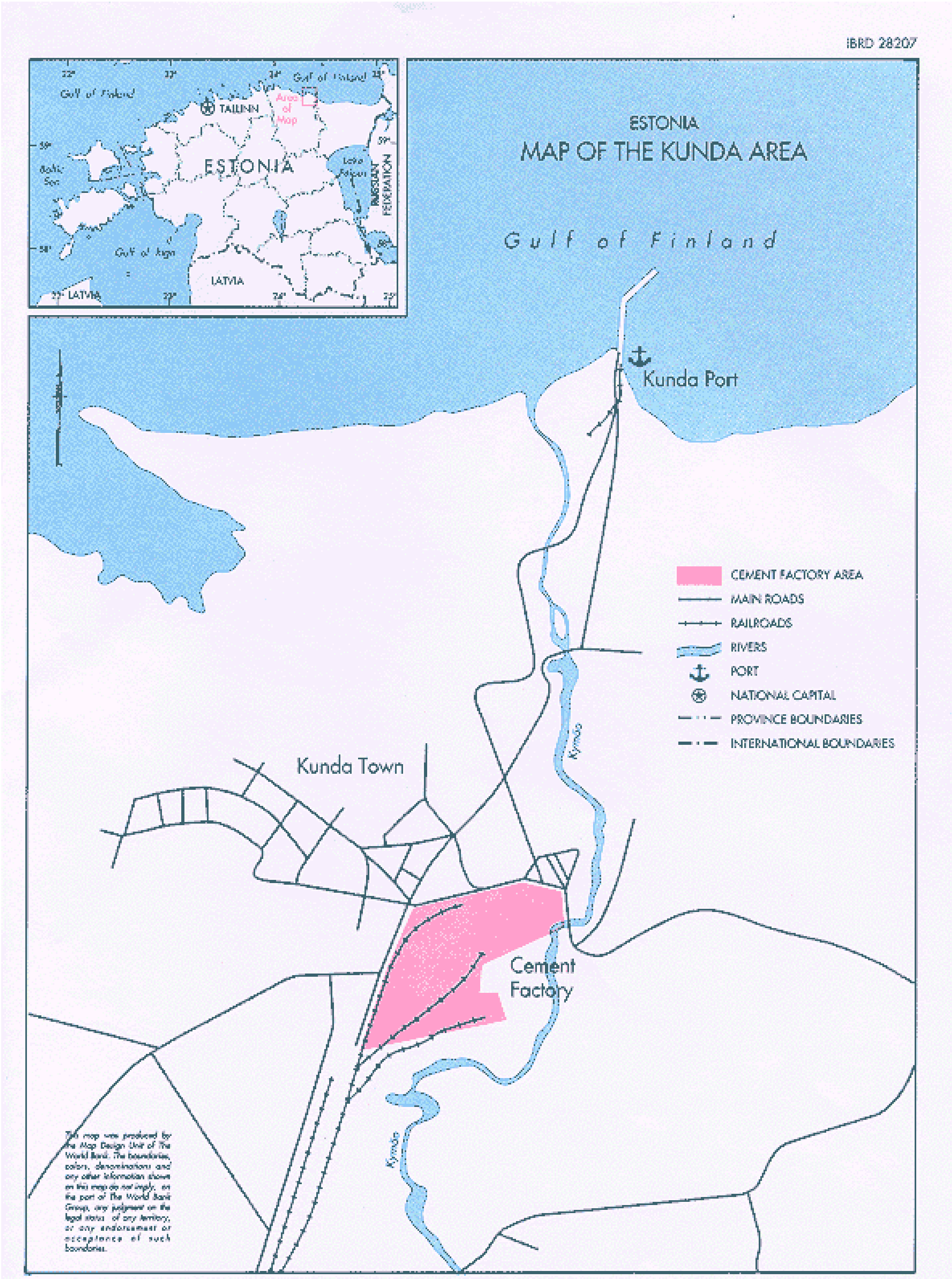
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ESTONIA
MAP OF THE KUNDA AREA
Gulf of Finland
Kunda Port
Kunda Town
Cement Factory
Kunda
CEMENT FACTORY AREA
MAIN ROADS
RAILROADS
RIVERS
PORT
NATIONAL CAPITAL
PROVINCE BOUNDARIES
INTERNATIONAL BOUNDARIES
TALLINN
Area of Map
ESTONIA
LATVIA
RUSSIAN FEDERATION