Report No. 16635-BR

Brazil
Managing Pollution Problems
The Brown Environmental Agenda

(In Two Volumes) Volume II: Annexes

February 27, 1998

Brazil Country Management Unit
ESSD Sector Management Unit
Latin America and the Caribbean Region

Document of the World Bank

CURRENCY EQUIVALENTS
Currency Unit - Real (R$)
US$1 = R$1.10 (October 1997)

WEIGHTS AND MEASURES
The Metric System is used throughout the report.

FISCAL YEAR
January 1 to December 31

Vice President LAC:	Shahid Javed Burki
Director LCC5C:	Gobind T. Nankani
Director ESSD:	Maritta Koch-Weser
Lead Economist:	Suman Bery
Task Manager:	Joachim von Amsberg

CONTENTS

ABBREVIATIONS

ABEMA	Association of State Environmental Agencies *[Associação Brasileira de Entidades do Meio Ambiente]*
ABNT	Brazilian Association for Technical Norms *[Associacao Brasileira de Normas Tecnicas]*
ABRELP	Association of Public Waste Management Companies *[Associacao Brasileira de Empresas de Limpeza Publica]*
BANESPA	State Bank of the State of São Paulo *[Banco de Estado de São Paulo]*
BAPEDAL	Environmental Protection Agency of Indonesia
BHMA	Belo Horizonte Metropolitan Area
BNDES	Social and Economic Development Bank *[Banco Nacional de Desenvolvimento Economico e Social]*
BOD	Biological Oxygen Demand
BOT	Build-operate-transfer
CAGECE	Ceará State Water and Sanitation Company *[Companhia de Agua e Esgoto do Ceará]*
CBA	Cost-Benefit Analysis
CECA	Rio State Commission for Environmental Control [*Comissão Estadual de Controle Ambiental]*
CEDAE	Rio State Water Company *[Companhia Estadual de Agua e Esgotos]*
CEMPRE	Industrial Recycling Association *[Compromiso Empresarial para Reciclagem]*
CETESB	São Paulo State Environmental Agency *[Companhia de Tecnologia de Saneamento Ambiental]*
CGRSS	*Comissao de Gerenciamento do Residios Solidos de Saude*
CIBAPAR	Intermunicipal Consortium for the Praopeba Bain, Minas Gerais *[Consórcio Intermunicipal da Bacia Hidrográfica do Rio Paraopeba]*
COD	Chemical Oxygen Demand
CODEVASF	São Francisco Valley Development Commission *[Companhia de Desenvolvimento do Vale do São Francisco]*
COGERH	Ceará State Water Resources Management Agency
COMEC	*Coordenacao da Regiao Metropolitana de Curitiba*
COMPESA	State Water and Sanitation Company of Pernambuco *[Companhia Pernambucana de Saneamento]*
CONAMA	National Environment Council *[Conselho Nacional de Meio Ambiente]*
COPAM	Council of Environmental Policy (Minas Gerais) *[Conselho de Politica Ambiental]*
CPLS	Cost Per Life Saved
CPRH	Pernambuco State Environmental Agency *[Controle da Poluciao Ambiental e da Administracau dos Recursos Hidricos]*

CVRD	*Companhia Vale de Rio Doce*
DALY	Disability-adjusted Life Years
DNAEE	National Department of Waters and Electric Energy *[Departamento Nacional de Agua e Enegria Elétrica]*
DRH	Water Resources Agency of Minas Gerais *[Departamento de Recursos Hidricos]*
EIA	Environmental Impact Assessment
EMPLASA	*Empresa Metropolitana de Planejamento de Grande Sao Paulo S.P.*
FEAM	State Environmental Control Agency of Minas Gerais *[Fundação Estadual do Meio Ambinte]*
FEEMA	State Environmental Control Agency of Rio de Janeiro *[Fundacão Estadual de Engenharia do Meio Ambiente]*
FEHIDRO	State Water Resources Fund
FESB	Basic Sanitation State Fund
GHG	Greenhouse Gases
GIS	Geographic Information System
GSPMA	Greater Sao Paulo Metropolitan Area
IBAMA	Brazilian Institute of the Environment and Renewable Natural Resources *[Instituto Brasileiro de Meio Ambiente e dos Recursos Renováveis]*
IBGE	Brazilian National Statistical Agency *[Instituto Brasileiro de Geografia e Estatistica]*
ICMS	Value Added Tax *[Imposto Sobre Operações Relativos a Circulação de Mercadorias]*
IPEA	Institute for Applied Economic Research *[Instituto de Pesquisa Economica Aplicada]*
IPPS	Industrial Pollution Project System
LFG	Landfill Gas
M&E	Monitoring and Enforcement
MERCOSUL	South American Common Market *[Mercado Comun do Sul]*
MMA	Ministry of Environment, Water Resources and Legal Amazon *[Ministério de Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal]*
MSMW	Municipal Solid Waste Management
NIMBY	Not-In-My Backyard
NIPCP	National Industrial Pollution Control Project
ODS	Ozone Depleting Substances
OEMA	State Environmental Control Agencies *[Orgãos Estuduais de Meio Ambiente]*
PM-10	Particulate Matter less than ten microns in diameter
PNMA	National Environmental Plan *[Plano Nacional de Meio Ambiente]*
PPA	Public Performance Audit
PROALCOOL	National Ethanol Program *[Programa Nacional de Alcool]*

PROCONVE	National Program for Vehicle Emission Control *[Programa Nacional de Controle da Poluicao do Ar por Veiculos Automores]*
PROCOP	Sao Paulo Industrial Pollution Control Program *[Programa de Controle á Poluicão]*
PROKASIH	Clean River Program (Indonesia)
PROPER	Program for Pollution Control, Evaluation and Rating (Indonesia)
PROSAM	Minas Gerais Water Quality Project
SABESP	State Water and Sanitation Company of São Paulo *[Companhia de Sanemento Basico de Estado de Sao Paulo]*
SANEGRAN	Sao Paulo Sewage Collection and Treatment Master Plan
SEMA	Rio de Janeiro State Secretary of the Environment *[SecretariEstadual de Meio Ambiente]*
SEMAD	Minas Gerais State Environemnt Secretary [*Secretaria de Estadol de Meio Ambiente e Desenvolvimento Sustentável]*
SEPA	State Environmental Protection Agencies
SEPURB	Secretariat of Urban Policy in the Planning Ministry *[Secretaria de Política Urbana, Ministério do Planejamento e Orçamento]*
SISNAMA	National Environmental System *[Sistema Nacional de Meio Ambient]*
SLAP	National Licensing System *[Sistema de Licenciamento de Atividades Poluidoras]*
SLU	Urban Cleaning Service *[Servicio de Limpeza Urbana]*
SO_2	Sulfurdioxide
SOMMA	Minas Gerais Municipal Develoment Project
SWC	State Water Companies
TA	Technical Assistance
TLV	Threshhold Limit Values
TPD	Tons Per Day
TPLS	Tons Per Life Saved
TSP	Total Suspended Particles
UNCED	United Nations Conference on Environment and Development
WHO	World Health Organization

FOREWORD

For many years, the World Bank has supported the efforts of the Brazilian Government to address a large range of environmental problems. Over the years, the World Bank has financed a large number of projects that support natural resource management and conservation, environmental institutions strengthening, industrial pollution control, basic sanitation and water pollution management, and urban environmental improvements. As administrator of the Rain Forest Trust Fund, the World Bank helps Brazil address problems related to the threats to the Amazon ecosystem. Finally, the World Bank supports Brazil's effort to address global environmental challenges through projects financed by the Multilateral Fund of the Montreal Protocol and the Global Environment Facility.

Recently, the Brazilian Government and several Brazilian States requested the World Bank's assistance in pulling together the lessons of experience of past efforts to address environmental pollution problems in Brazil and developing a more proactive strategy for addressing the increasingly important "brown environmental agenda." The present policy report is part of the response to this request. It follows a policy study on pollution problems in the State of Rio de Janeiro (Brazil: Managing Environmental Pollution in the State of Rio de Janeiro, World Bank Report No. 15488-BR, August 1996) and focuses on environmental pollution problems whose costs are predominantly domestic. The report does not address questions related to natural resource management and conservation (see Brazil: The Management of Agriculture, Rural Development and Natural Resources, World Bank Report No. 11783-BR, July 1994) and contributions to international environmental problems (such as emissions of ozone depleting substances and greenhouse gases). International environmental issues involve a number of important concerns and choices for Brazil. The World Bank is assisting the Government in these concerns through its operations under the Montreal Protocol and the Global Environment Facility. Issues of industrial and occupational safety as well as problems strictly confined to the household level (such as indoor air pollution) are also outside the scope of this report.

This report is based on the findings of visits to Brazil in September 1996 and March 1997. The report was prepared by a World Bank team comprised of Messrs./Mmes. Joachim von Amsberg (Task Manager), Carl Bartone, Gordon Hughes, Karin Kemper, Sergio Margulis, John Redwood III, Laura Tlaiye, and David Wheeler. Susmita Dasgupta, David Gray, Kseniya Lvovsky, and Muthukumara Mani contributed background analysis for different parts of the report. Andrew Hurd assisted in editing of the report. Furthermore, the report draws freely from a large number of previous studies and documents prepared by other Bank staff. The report was produced under the supervision of Mr. Gobind T. Nankani, Director, Ms. Constance Bernard, Division Chief, Natural Resources, Environment, and Rural Poverty Division, and Mr. Homi Kharas, Lead Economist and Country Unit Chief, Country Department I, Latin America and the Caribbean Region. The peer reviewers for this task were Sudhir Shetty and John Redwood III (who later also contributed an Annex for this report).

This report was produced in close collaboration with various institutions and individuals in Brazil whose cooperation is gratefully acknowledged. The following institutions contributed, in particular: *Ministério de Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal* (MMA); *Secretaria de Política Urbana, Ministério do Planejamento e Orçamento* (SEPURB); *Fundação Instituto Brasileiro de Geografia e Estatistica* (IBGE); *Instituto de Pesquisa Econômica Aplicada* (IPEA); F*undação Estadual de Meio Ambiente, Minas Gerais* (FEAM), and *Companhia*

Pernambucana de Controle da Poluição Ambiental e da Administração dos Recursos Hídricos (CPRH).

This report consists of two volumes. Volume I is the Policy Report which is directed at policy makers and a general audience interested in environmental management. The Policy Report contains a summary of the most important policy recommendations without providing full analytical support. Volume II is the Technical Report which provides the analytical backup to the Policy Report. The Technical Report is directed at policy makers working specifically on environmental issues and anyone interested in the more detailed background analysis.

1. NATIONAL POLLUTION MANAGEMENT PRIORITIES[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
Data on emissions, environmental quality and impact of pollution are limited but decisions about priorities have to be made.
A comprehensive municipal-level database is used to illustrate the use of cost-benefit analysis for the prioritization of pollution problems across locations, sources, and media. Even though the analysis is tentative given limited data, some clear priorities emerge for reducing health and ecosystem damage.

STRATEGY AND RECOMMENDATIONS
The costs per life saved through the reduction of PM10 emissions and investments in water and sanitation services varies widely between interventions and locations. The overall priorities should include the following: • Extension of water supply networks with highest benefits in the North-East followed roughly by the North, the Center-West, the South-West and the South • Extension of sewerage networks with highest benefits in the North-East followed roughly by the North, the Center-West, the South-West and the South • Control of industrial PM10 sources with highest benefits in the larger cities of the South-East and Northeast • Control of PM10 from diesel vehicles with highest benefits in the larger cities of the South-East and Northeast.
Regulation of industrial heavy metal emissions to water should be focused on a relatively small number of municipios which have heavy emissions and relatively low ratios of abatement costs to abatement benefits.
The priorities for protecting aquatic ecosystems would include control of medium and large industrial BOD sources in areas with heavy BOD loads and phosphorous control through removal from sewage and improved agricultural practices.

INTRODUCTION

Brazil's Brown And Green Agendas

1.1 Environmental priorities differ widely across Brazil due to its vast size and varied geography. It houses such diversified ecosystems as the Amazon region, the Pantanal and the Mata Atlântica, along with the extremely urbanized and industrialized Rio-São Paulo corridor, where severe pollution problems are encountered. Both brown and green environmental problems are aggravated by the country's extreme income inequality, both in individual and regional terms. Figures 1.1 and 1.2 (at end of report) illustrate the country's regional disparity, using census data from 1991. A large region of extreme poverty dominates the Northeast and extends well into Minas Gerais. There is also a striking division

[1] This paper was prepared by Sergio Margulis and David Wheeler with support from Susmita Dasgupta and Muthukumara Mani.

between middle and high-income areas, particularly in Sao Paulo State. As this report will show, regional income disparity has important implications for brown-sector priorities in Brazil.

1.2 Brazil has responded in different ways to its environmental problems over time, depending on their severity, the political and institutional systems in place, and public pressure. Major steps have included the creation of IBAMA in 1989, the decentralization following the 1988 Constitution, and the incorporation of the Ministry of Amazonian Affairs into the Ministry of Environment in 1994. The federal government has focused almost exclusively on the green agenda, with a major emphasis on the Amazon region. While this has been well-received by the international community, the fact remains that over 80% of the Brazilian population lives in urban areas. For the vast majority of Brazilians, the critical environmental problems are brown.

1.3 Although measures of pollution damage in Brazil are scarce, it is possible to estimate aggregate costs by combining data on environmental quality with estimates of health impacts, the cost of treatment, and willingness to pay to avoid premature mortality. Available estimates of pollution costs show that Brazil's brown problems are serious, and warrant the attention of national policymakers.

Priority Problems And Priority Interventions

1.4 Because resources are scarce, all levels of government have to restrict the range of problems to be addressed. The Bank's experience suggests that environmental policies frequently fail in developing countries because governments do not identify the most serious problems and set clear priorities for intervention. This problem is less serious in industrialized countries because resources are more plentiful.

1.5 In principle, only the identification of priority actions is relevant for governments, which then have to allocate resources so that the net social returns to investments are maximized. However, identification of priority problems is the essential first step in determining what actions (investments) are likely to produce the greatest returns. In a country as large and diverse as Brazil, different levels of government will typically have different perspectives on the costs and benefits of the same investment. Decisions deemed optimal by the federal government may not necessarily be deemed optimal by local communities, municipalities or even States.

1.6 An additional complication concerns the classification of environmental problems. For instance, environmental issues can be defined geographically (industrial districts, urban areas), sectorally (industries, households, governments), and by medium (air, water, soils). Each approach will require different institutional arrangements. Thus, deciding on priority problems and actions is ultimately a political process, in which a consensus should be reached by affected communities, major polluters, environmental experts, NGO's and government agencies. Governments play a critical role in assuring broad participation in the decision process.

Priorities In Brazil: A Sensible Idea?

1.7 Establishing national priorities is difficult in a nation of continental dimensions like Brazil. Inhabitants of the Amazon region may have little interest in the pollution problems of São Paulo or Rio de Janeiro; *Gaúchos* in Rio Grande do Sul may know little about the environmental problems of the Northeast or Center-West. However, the federal government is charged with assuring that environmental quality is at reasonable levels for all Brazilians. If regional problems differ greatly in severity, federal environmental policy may help re-

store the balance with appropriate regional cross-subsidies.

1.8 Brazil's regional income disparity requires the federal government to balance income distribution and environmental objectives. In the richer Southeast, greater willingness to pay for environmental quality suggests greater economic benefits from improvements than in poorer regions. On strict 'valuation' grounds, this could justify assigning high federal priority to the solution of environmental problems in the Southeast. However, it would clearly be undesirable from an income distribution perspective. Without some compensatory weighting scheme, the monetized returns to air pollution control in São Paulo could be much higher than providing sanitation services in the Northeast. Although environmental policy is a poor channel for income redistribution, such decisions are beyond the sole domain of the Ministry of Environment. They must also involve agencies such as the Ministries of Finance and Planning, which have to consider the distributional impacts of policies.

Criteria For Establishing Priorities

1.9 The political consensus-building process must be supported by sound technical and economic analyses. Access to adequate and reliable information is essential for setting priorities. Commonly used criteria for ranking are: (1) ecological (physical impacts and irreversibility or recurrence of problems); (2) social (the number of people affected, health effects, and incidence among the poor); and (3) economic (effects on economic productivity and growth, and factors such as risk and uncertainty). In Brazil, relevant data are often missing or inaccurate, but this should not prevent all levels of governments from setting priorities with the best available information.

1.10 Economic analyses have been gaining increasing attention since critical environmental problems can, in theory, be evaluated by assessing the incremental benefits and costs associated with different levels of remediation. In practice, however, the economic approach can be difficult because links between environmental problems and damages are not easy to establish. For instance, what health improvement will follow the reduction of air pollution by 10% in a particular city, and how much will 10% abatement cost? Even when impacts can be predicted with a reasonable degree of confidence, it may be difficult to value them in monetary terms. Recent advances in economic analysis are reducing some of these difficulties, but significant controversy remains.

Main Objectives Of The Report

1.11 This report provides an economic analysis of brown environmental problems in Brazil, with the objective of assisting the identification of environmental priorities by federal and State government officials and other stakeholders. It also provides a benchmark document for the Bank's dialogue with the Brazilian government on environmental policy issues. Critical questions to be addressed include:

- Which brown environmental problems impose the heaviest costs?
- What actions would be most effective in addressing the critical problems? What are the remediation costs?
- How do the benefits of investment in pollution control compare to the benefits from other social investments (e.g., in education, health or infrastructure)?

ASSESSMENT OF POLICY ALTERNATIVES

An Ideal Framework: Benefit-Cost And Cost-Effectiveness Analyses

1.12 Many stakeholders should participate in setting environmental priorities; the economic perspective provided by this report can be only one input to the decision-making process. However, setting priorities always involves critical trade-offs – in allocating budgets, subsidizing specific groups or regions, and setting pollution reduction targets. Under ideal conditions, decisions should focus on control measures that maximize net social benefits. For an economic analysis, this requires estimating the marginal benefits from emissions reduction and the marginal costs of control (i.e., installation of filters, substitution of fuels, proper operation and maintenance of equipment, dissemination of information). Benefits calculation is the more complex exercise, involving estimation of physical damage reduction from control (effects on health, economic productivity, or ecosystem functioning) and assignment of monetary values to the results.

1.13 Assignment of monetary value to damage reduction is often assumed to be the most difficult part of benefit-cost analysis. Indeed, the available methods have technical limitations and require data which are frequently unavailable. However, this approach can provide valuable insights without assigning monetary values. For instance, two alternative pollution control strategies can be evaluated by comparing their 'cost per life saved,' or more generally, their costs relative to their estimated impacts on morbidity or mortality. In fact, the more serious problem for benefit-cost analysis is frequently the absence of technical information on links between pollution, changes in environmental quality, and physical impacts on health, productivity and ecosystems. Some (certainly not all) of the important links have been quantified for industrialized countries. However, most have not been re-calibrated for developing countries, where both environmental and socio-economic conditions are typically quite different.

1.14 When benefit estimation proves too difficult, a modification of the same approach involves establishing a performance target (typically an environmental quality standard), and determining the cheapest way of reaching it. This is termed cost-effectiveness (CE) analysis. While it imposes fewer demands for data and estimation, CE cannot judge the relative value of alternative targets. In practice, this can be a serious weakness. For instance, a 50 percent violation of ozone standards may impose much lower health costs on an urban population than a similar violation for particulate or lead standards.[2]

Application To Brazil

1.15 For a benefit-cost assessment of possible interventions at the national level, some aggregation of problems and simplifying assumptions are necessary. The first step is to classify the problems into four broad sectoral categories: industry, agriculture, household and transport.

Data

1.16 For the analysis of problems in each sector, a large database has been constructed with information from IBGE and other Brazilian agencies. This section provides a brief summary of the information resources available.

---

[2] In Mexico, the estimated health costs from particulate air pollution are at least 8 times higher than from ozone, even though ozone levels violate existing standards to a greater degree than particulates. It took some time for the government to realize that, despite the greater 'severity' of ozone pollution in terms of standard violation, particulates pose a far more critical problem for society.

1.17 **Industry:** Emissions of all major pollutants are estimated using an IBGE database of approximately 156,000 Brazilian factories, categorized by 266 4-digit CNAE codes, employment size, and location (for over 5,000 municipios). Emissions have been estimated using international parameters established in previous work with FEEMA (Rio) and FEMA (Minas Gerais). This large database has enabled the assessment of the distribution and severity of Brazil's industrial pollution problems at an unprecedented level of detail. For the benefit-cost assessment, the emissions estimates have been combined with data on abatement costs by pollutant and sector.

1.18 **Agriculture:** The critical brown issue for agriculture is runoff of fertilizer and pesticides. Data on pesticides were not available for this analysis, but detailed estimates for fertilizer have been developed. Phosphorus runoff is of particular interest, since excessive phosphorus loads contribute significantly to eutrophication of receiving waters. Using data provided by Brazilian research institutes, measures of phosphorus intensity (average phosphorus fertilizer application per hectare) for over twenty major crops have been developed. These have been combined with IBGE agricultural census data on acreage by crop for all municipios in Brazil to produce crop-specific estimates of phosphorus loading. The summation of these estimates produces total loadings by municipio, and recorded information on state-level loadings was used for proportional adjustment of municipio-level estimates within each state.

1.19 **Households:** Domestic waste water is a source of Brazil's three most serious water pollution problems: Coliform bacteria, organic pollution (BOD), and phosphorus. Although production of coliforms and BOD is roughly constant per person, household production of phosphorus differs significantly between rural and urban areas because urban households make greater use of phosphorus in detergents. Data on urban and rural population by municipio have been combined with standard parameters to estimate total loads of BOD and phosphorus. Estimations of the impact of sewerage and clean water connections on health utilize the results of a statistical model fitted to Brazilian data. In addition, data on the cost of sewerage and clean water connections were used to provide a benefit-cost perspective on water and sanitation investments.

1.20 **Transport:** Combustion of motor fuels is an important source of air pollution in large urban areas. This report has used several types of data to estimate the contribution of transport to air pollution in each Brazilian municipio: measures of pollution-intensity (pollution per unit consumed) for each major fuel and pollutant; state-level fuel consumption data; and a statistical equation which distributes state-level fuel consumption to municipios in proportion to their urban and rural populations. The latter distinction is important, because urban fuel consumption per capita is much higher than rural consumption.

Benefit-cost analysis

1.21 To perform a benefit-cost analysis of intervention alternatives, the following estimates are necessary:

- Emissions of air, water and toxic pollutants by the various sectors (households, industries, agriculture and transport). The estimation methods have been described above.

- Impact of emissions on environmental quality. Actual data are only available for a few urban areas and priority ecosystems. This report has relied mostly on proxy estimates of the impacts. It is clear that environmental quality data are the most important 'missing link' for analyzing Brazil's brown problems, and high priority should be given to in-

creasing the stock of information in this area.

- Impacts of environmental degradation. Where supporting data are available, health effects are estimated using 'dose-response' functions, relating different levels of environmental quality to the incidence and severity of diseases. They have been developed for industrialized countries and, with some caution, they can be applied to developing countries as well.[3] In principle, it would be possible to extend dose-response functions to estimation of losses in economic productivity, ecosystem functions and environmental amenity. However, no reliable techniques are available at present.

- Marginal benefits of damage reduction from abating different pollutants. Whether or not monetary values are assigned to such benefits, a benefit-cost assessment requires that they be compared with the costs of control.

- Marginal costs of abating pollution (per source and type of pollutant). This is one of the areas where international experience is most useful, and where application to Brazil is probably subject to the least error.

- The relative cost of monitoring and enforcement (M&E) for different pollution sources. International experience shows that the impact of regulation on environmental performance is principally due to M&E, not legal statutes. The cost of M&E per unit of induced abatement depends on the scale, mobility and dispersion of pollution sources, as well as pollutant characteristics. In general, regulatory cost per unit of induced abatement varies inversely with size of the source and directly with its mobility and dispersion. In the case of household sewage, wide dispersal of emissions may necessitate collection into sewage transport networks before treatment is economically feasible.[4] Deployment of M&E resources is less costly in urban areas, where activities are more concentrated.

1.22 After all these steps are completed, it is possible to assess the relative benefits and costs of alternative approaches to controlling pollution. Theoretically, it is optimal to target different levels of abatement for different problems (or the same problem in two different areas) because so many factors determine benefits and costs.[5] However, regulation is 'lumpy' (regulatory agents must operate from offices in central locations; travel times are critical for inspectors; laboratories are needed to test samples; etc.). Thus, in practice, it is not possible to distribute M&E resources continuously at the margin. Cost-effective regulation generally requires focusing resources on large problems which have high benefit-cost ratios at intermediate/high levels of abatement.

---

[3] A few dose-response curves have been estimated in developing countries, including Brazil, and the results are not significantly different from those observed in industrialized countries.

[4] Septic tanks can be used, of course. Their effectiveness will depend on the quality of construction and maintenance.

[5] It is important to clarify the distinction between net benefits (benefits - costs) and benefit/cost ratios in this context. The objective of social policy should be to choose activities so that aggregate net benefits (benefits - costs) are maximized while staying within the budget constraint. A standard result in economic theory shows that this is achieved by allocating resources to each activity so that marginal benefit/cost ratios are equalized and the budget is completely absorbed.

Limitations and feasible analyses

1.23 As noted above, estimation of pollution impacts requires four analytical steps: (1) Measuring emissions; (2) Measuring the effect of emissions on ambient quality in a specific control region; (3) Measuring the effect of ambient quality on health, productivity, amenity and ecosystem functions; and (4) Valuing these effects. For a Brazilian analysis, existing modeling and estimation techniques can provide reasonable approximations for steps (1), (3) and (4). The key 'missing link' is step (2). For instance, air quality models which relate emissions to atmospheric concentrations require data on local temperature, winds, precipitation, topography, etc., while water pollution models require data on water temperature, volume and flow rates. Development of an inventory of this information for each critical environmental region in Brazil should be a high priority. At present, however, the basis for estimating such models in complete form do not exist. It is therefore unrealistic to attempt a full four-step analysis of the type described above.

1.24 However, it is possible to make considerable progress with the information available. In the case of air pollution, for example, a simple dispersion model uses total emissions, physical area, and typical wind patterns to predict atmospheric concentrations by municipio. Estimated concentrations can be combined with dose-response functions and area populations to generate estimates of mortality. Reductions in emissions can then be linked directly to reductions in mortality; abatement costs in each area (which depend on sectoral composition) can then be used to calculate the 'cost per life saved' for air pollution control. Given data limitations, the results are mostly illustrative and should not be misinterpreted as direct calls for specific regulatory action. However, this type of analysis establishes order of magnitude estimates of costs and priorities and highlights those areas that deserve more detailed analysis. The analysis also permits comparison of air pollution control with other important life-saving measures – provision of clean water and sewerage – to determine the most cost-effective approaches to safeguarding health.

1.25 Because the relationship between air pollution concentrations and respiratory diseases is strongly established in the literature, the use of air pollution dose-response curves is clearly justified. However, dose-response curves for water pollution are far more problematic. While most air emissions are eventually breathed by the population, municipalities usually treat water prior to public consumption. Households also have options such as independent filtration, boiling, and purchasing bottled water from safe sources. Thus, the relationship between water pollution concentrations and health effects is not straightforward. The same reasoning applies to sanitation services, such as sewerage and solid waste collection. Nevertheless, sewage contamination in poorly-served areas is inevitable, and a vast literature documents the increase in waterborne diseases associated with lack of sanitation. We will use dose-response curves for water pollution which are estimated in Annex 2.

Comparing the severity of environmental problems

1.26 Large metropolitan areas exposed to high levels of pollution seem like the most plausible candidates for high brown environmental priority. Air pollution is clearly serious in some parts of the São Paulo and Rio de Janeiro metropolitan regions, and lack of access to sanitation services seems likely to cause significant problems in large cities with poor infrastructure such as Belem, Recife and Fortaleza. However, different areas within these regions have very different conditions, and there are undoubtedly other urban areas in Brazil which suffer from high exposure. Decisions become more complex when comparing the pollu-

tion problems of large cities exposed to moderate pollution levels with smaller cities exposed to more extreme levels of pollution.

1.27 A convenient metric for comparison in this context is 'tons abated per life saved,' since this allows policy to focus directly on pollution problems with the ultimate objective – health improvement – in mind. It also allows for the introduction of economic analysis, since abatement costs vary widely across sources and pollutants. With a life saved as the common metric (this is sufficient, since existing morbidity estimates are directly tied to mortality estimates),[6] it is possible to develop an estimate of the 'cost per life saved' (CPLS) which can be used to evaluate alternatives across regions, pollutants and media. This report will make extensive use of CPLS measures for comparison of pollution control alternatives.

[6] Definition of an equivalence between mortality and morbidity cases permits combination of mortality and morbidity into a single indicator. Equivalence is defined by the rate at which society is willing to "trade" one mortality case (i.e., a statistical life) for a certain number of morbidity cases (involving days of work lost, incidence of sickness and disability, costs of medication and/or hospitalization). For the sake of illustration, it is assumed that the equivalence is 10,000 morbidity cases for each statistical life (reflecting an expected productive lifespan of 20 years, if time discounting is not applied). Ostro (1994) estimates the following problems are avoided through reduction of PM10 by 10 $\mu g/m^3$: 6.72 deaths per 100,000 inhabitants, 37,000 restricted activity days (RDA), 80 asthma attacks, 9 cases of bronchitis, 35 hospital emergency room visits, etc. These results imply that about 5,750 morbidity cases are directly associated with the loss of one statistical life. Using the 10,000 assumption, each reduction of 10 $\mu g/m^3$ of PM10 leads to 6.72*15,750, or approximately 100,000 'morbidity-equivalent' cases. Valuation of one morbidity unit permits assessment against abatement costs; the same exercise could be made for other air and water pollutants, enabling comparisons of alternative pollution reduction strategies.

CRITICAL POLLUTANTS

1.28 The critical first step in priority-setting must be selection of the most damaging pollutants. In Brazil, three seem particularly harmful to human health: (1) Emissions of small particles from industry and transport; the most harmful are 2.5 microns or less in diameter, but available information only permits an assessment for particles of 10 microns or less (PM10); (2) Coliform bacteria in sewage; and (3) Heavy metals in industrial water emissions. For aquatic ecosystems, the most serious threats are posed by two pollutants: (1) organic water pollution (indexed by Biological Oxygen Demand (BOD)) from industrial emissions and household wastes; and (2) dissolved phosphorus from household wastes and agricultural runoff.

1.29 Table 1.1 summarizes the pollutant-specific information relevant for this analysis. In general (as shown in a later section), BOD and phosphorus from sewage are the most expensive to control, followed by heavy metals, PM10 and BOD from industry. The cost of phosphorus reduction in agriculture is uncertain because reliable information on crop losses from fertilizer reduction and on the cost of runoff prevention do not exist.

1.30 The characteristics of primary source activities are also important for specific control strategies. In general, point sources are easier to regulate than dispersed sources. Deployment of monitoring and enforcement resources is also less costly in urban areas, where activities are more concentrated. Finally, as previously noted, certain industrial, transport and agricultural activities may have widely-differing costs of abatement.

Table 1.1: Critical Pollutants

Pollutant	Main Damage	Medium	Source Activity	Source Characteristic	Source Location
PM10	Health, aesthetics and materials	Air	Industry (by sector)	Point (Small, Large)	Urban
			Transport (by fuel)	Mobile	Urban
Coliform Bacteria	Health	Water	Households	Dispersed	Urban
Heavy Metals	Health	Water	Industry (by sector)	Point (Small, Large)	Urban
BOD	Ecosystems	Water	Industry (by sector)	Point (Small, Large)	Urban
			Households	Dispersed	Urban
Phosphorus	Ecosystems	Water	Households (by location)	Dispersed	Urban
			Agriculture (by crop)	Dispersed	Rural

1.31 This analysis focuses on the parts of Table 1.1 for which data are available. Particular attention is paid to the two most immediate threats to human health: PM10 and coliform bacteria in sewage.

THREATS TO HUMAN HEALTH

PM10

1.32 This analysis of harmful air pollution focuses on PM10 emissions from industry and motor vehicles. To develop priorities for PM10 control, the following estimates for every municipio in Brazil have been produced:[7]

- PM10 emissions from four sources: small plants (50 employees or less); large plants (more than 50 employees); gasoline-powered vehicles; and diesel-powered vehicles.
- Tons of abatement required to reduce atmospheric concentration by .1 ug/m^3.
- Lives saved by this reduction; tons abated/life saved.
- Cost/life saved (from cost/ton x tons abated/life saved).

1.33 The results provide several insights into the economics of pollution control in Brazil. To illustrate the computations and their implications, several versions are presented in Tables 1.2 - 1.5. Table 1.2 provides a 'conventional' priority ranking for PM10 control: the top 15 municipios in Brazil by total PM10 emissions (industrial and vehicular).

1.34 Each column of Table 1.2 summarizes a large body of information. The estimates of transport emissions are developed from state fuel consumption data, fuel-specific emissions parameters, and a statistical equation for allocating fuel consumption to municipios based on their populations and urban/rural proportions. The estimates of PM10 emissions from industry are from information on over 155,000 industrial facilities (municipio location, 4-digit CNAE sector, employment) and average PM10 emissions intensity per employee by CNAE sector. Since data are available at the plant level, it is also possible to categorize industrial PM10 emissions by the scale of emitting factories. This is tabulated in two col-

[7] Missing data produced some limitations, but most of these estimates include at least 3,000 municipios. Most of the missing data are for lightly-populated areas in northwest Brazil.

Table 1.2: Top 15 Municipios By Total PM10 Emissions

Municipio (State)	Pop ('000)	Total PM10 (tons)	Ind. PM10 (tons)	Transp % of Total	Small Ind. % of Total	Large Ind. % of Total
Sao Paulo (SP)	9,646	41,204	17,123	58	1	41
Rio de Janeiro (RJ)	5,481	16,684	6,957	58	1	41
Belo Horizonte (MG)	2,020	10,140	5,206	49	1	50
Curitiba (PR)	1,315	9,759	3,706	62	2	36
Porto Alegre (RS)	1,263	6,107	1,413	77	2	21
Salvador (BA)	2,075	6,104	1,308	79	2	19
Brasilia (DF)	1,601	6,089	2,461	60	1	39
Volta Redonda (RJ)	220	5,833	5,443	6	1	93
Manaus (AM)	1,012	5,480	1,800	67	1	32
Campo Grande (MS)	526	4,603	639	86	1	13
Recife (PE)	1,298	4,542	2,494	45	3	52
Itapeva (SP)	82	4,515	4,403	2	1	97
Cubatao (SP)	91	4,406	4,168	6	4	90
Sete Lagoas (MG)	144	4,316	3,982	8	1	92
Guarulhos (SP)	788	4,228	2,208	48	2	50

umns, which portray the percentage of total PM10 emissions from small industry (50 or fewer employees) and large plants (more than 50). Estimates of industrial emissions are adjusted from the US to the Brazilian conditions by a factor which is proportional to the number of employees. The results can be modified as local data is eventually provided.

1.35 The relative importance of PM10 sources is of particular interest from a regulatory cost perspective. In the four most populous cities which head the list, transport emits a major share of PM10 – from 49% in Belo Horizonte to 62% in Curitiba. For municipios with a population of less than 250,000, the situation is obviously very different: in no cases are transport emissions responsible for more than 8% of total PM10. It must be noted, however, that the effects of emissions from transport and industry are different. For a city like Belo Horizonte, for instance, 1 ton of PM10 emitted by large industries increases the average concentration of the pollutant in the air by 0.25 ug/m^3; the effect of the same ton emitted by the transport sector is an increase of 4.2 ug/m^3.

1.36 Thus, even among Brazil's top 15 PM10 emitters, the regulatory environment is entirely different. Reduction beyond 50% in the large cities would require a vehicle control strategy, but large reductions in some smaller cities would require tight control in only a few plants.

CPLS for Industrial Sources

1.37 From the perspective of benefit-cost analysis, total emissions of PM10 do not provide a reliable guide for setting priorities. This requires estimating the cost per life saved (CPLS) as explained earlier. For this study, the CPLS for four sources have been computed in each area: small factories (50 employees or less), large factories (greater than 50), gasoline-powered motor vehicles, and diesel-powered vehicles. As shown in Table 1.4, municípios differ greatly in CPLS because their emissions, populations, areas and distributions of PM10 sources are quite different.

1.38 CPLS for small and large plants is estimated separately because the average difference in stack height makes a great difference for atmospheric concentration of PM10. An atmospheric dispersion model

Table 1.3: The Cost Of Controlling Vehicular PM10 Emissions

Vehicle Type	Km/Year Per Vehicle	PM10 Emissions (g/km)	PM10/Vehicle Per Year (grams)	Vehicles/Ton of PM10 Per Year	Control Cost/Ton (@$300/year per Vehicle; 80% Eff.)
Gasoline	11,858	0.21	2,490	402	150,592
Diesel	80,000	0.81	64,800	15	5,787

which uses information on municipio area and atmospheric conditions (stability, wind speed) is employed to estimate the contributions of small- and large-facility emissions to atmospheric concentration of PM10.[8] In the dispersion model, percent changes in emissions and atmospheric concentration are equal (although different across transport, small and large industries). Therefore, a PM10 dose-response result from Ostro (1994) is used to estimate required tons of abatement per life saved (TPLS). Ostro reports that a .1 ug/m^3 reduction in concentration induces a fall of .067 per 100,000 in the mortality rate. Dividing .1 by the estimated concentration components (in ug/m^3) for small and large sources in each area produces the percentage reduction in concentration (and emissions) associated with a fall of .067 per 100,000 in mortality. Multiplication of the latter by area population yields expected lives saved; division of tons abated by expected lives saved yields estimated TPLS. Multiplication of this number by the estimated marginal cost of abatement at 70% abatement yields cost per life saved for small and large industry sources (SI CPLS and LI CPLS in Table 1.4).[9]

1.39 Note that Ostro's result is expressed in terms of elasticities, his model assuming constant elasticity, i.e., that the relation between changes in pollution concentrations and mortality rates are the same irrespective of the level of air pollution. This is an assumption perhaps valid for certain ranges of air pollution levels. It is reasonable to assume, however, that for pollution levels below the WHO recommended concentration standards such effects will eventually disappear, i.e., further reductions in pollution will bring no additional reductions in mortality rates. Since only few metropolitan areas in Brazil have PM10 concentration levels above the WHO standards, the results below should be considered only for the most polluted metropolitan areas.

1.40 To estimate comparative costs per life saved for motor vehicle emissions control, Sao Paulo data on average annual driving distance for gasoline and diesel vehicles (alcohol-powered vehicles emit negligible PM10), and PM10 emissions factors in grams/kilometer are used (Table 1.3). Using these factors, it is estimated that one ton of PM10 is emitted annually by 402 gasoline vehicles and 15 diesel vehicles. Assuming that the annual cost of PM10 control at 80% efficiency is $300, vehicular PM10 control

8 This study applied one representative set of atmospheric parameters to emissions from all municipios because local atmospheric data were not available. Better information on atmospheric conditions would undoubtedly increase the accuracy of the estimates.

9 International parameters have been used to estimate marginal abatement costs. The minimum MC for large sources is $100/ton. A model of PM10 abatement cost which adjusts for plant size has been used to estimate a small-plant multiplier of 7.9 for the marginal cost of abatement (that is, small plant MC is assumed to be 7.9 times large plant MC in the same sector; international parameters are for large plants). Note also from Table 1.4 that CPLS in smaller industries is smaller than for large ones. This is because even though the unit control costs are higher, the effects on air pollution by smaller industries are greater than those caused by large industries.

Table 1.4: Lifesaving Through Emissions Control In Least-cost Municipios

Municipio	POP ('000)	Area (km²)	PM10 ('000 tons)	SI % PM10	LI % PM10	Gas % PM10	Dies % PM10	SI TPLS	LI TPLS	SI CPLS $000	LI CPLS $000	Dies CPLS $000	Gas CPLS $000
Sao Paulo (SP)	9,646	1514	24.9	.2	3.4	36.9	35.3	9	132	7	13	52	1,378
Rio de Janeiro (RJ)	5,481	1272	10.6	.5	7.4	35.6	36.4	14	212	11	21	84	2,198
Belo Horizonte (MG)	2,020	331	5.4	.4	7.7	48.7	27.7	18	309	14	31	103	2,688
Fortaleza (CE)	1,769	311	2.9	.8	14.2	27.5	41.0	20	344	16	34	113	2,957
Recife (PE)	1,298	212	2.4	.8	14.3	27.4	36.8	20	398	17	40	121	3,170
Salvador (BA)	2,075	705	5.4	.7	10.8	22.8	53.4	27	422	22	42	158	4,122
Tocantins (TO)	919	169	1.2	1.3	26.4	38.4	21.8	26	512	20	52	149	3,882
Curitiba (RN)	1,315	443	6.6	.4	7.2	27.2	51.2	33	539	26	54	189	4,930
Sao Joao de Meriti (RJ)	426	29	.9	.5	17.4	31.7	32.4	217	563	14	56	101	2,648
Osasco (SP)	568	70	1.7	.5	12.8	33.2	31.8	23	583	19	58	135	3,531
Porto Alegre (RJ)	1,263	519	5.2	.6	9.7	32.1	45.6	37	603	30	60	216	5,649
Sao Goncalo (RJ)	779	248	1.8	1.1	20.8	30.1	30.8	38	708	31	71	223	5,835
Nova Iguacu (RJ)	1,297	810	3.0	1.4	21.1	30.0	30.6	47	721	38	72	274	7,152
Santo Andre (SP)	616	166	2.0	.8	16.0	31.8	30.5	38	758	31	76	219	5,723
Natal (RN)	606	163	1.0	1.6	32.7	20.9	26.2	38	765	30	76	220	5,751
Olinda (PE)	341	37	.7	.8	24.3	24.1	32.5	26	768	21	77	149	3,888
Diadema (SP)	305	28	1.0	.5	16.3	31.8	30.5	24	770	19	77	137	3,568
Guarulhos (SP)	788	313	2.5	1.0	16.7	31.5	30.2	44	773	35	77	255	6,659
Carapicuiba (SP)	284	30	.9	.5	17.7	31.3	30.0	27	854	21	85	155	4,060
Niteroi (RJ)	436	132	1.0	1.3	26.6	27.9	28.5	47	976	37	98	267	6,982
Goiania (GO)	922	798	3.7	1.1	16.7	21.3	48.5	66	1007	53	101	382	9,980
Joao Pessoa (PB)	497	210	.6	3.1	60.0	22.2	2.2	54	1036	43	104	315	8,242
Duque de Caxias (RJ)	667	471	1.7	1.8	29.0	26.8	27.4	66	1092	53	109	386	10,081
Nilopolis (RJ)	158	12	.4	.7	29.0	27.1	27.7	26	1100	21	110	150	3,920
Contagem (MG)	449	191	1.3	1.3	25.5	38.8	22.1	57	1101	45	110	328	8,574
For comparison, examples of high-cost municipios:													
Cuiaba (MT)	402	4029	3.8	2.5	37.4	12.2	41.2	373	5344	2,985	5,344	2,163	56,546
Campo Grande (MS)	526	8139	6.4	2.3	34.2	9.1	48.1	414	6214	3,311	6,213	2,401	62,762

Note: POP: Population
S/LI: Small/Large Industry
CPLS: Cost per life saved
TPLS: Ton per life saved

costs per ton are as follows: $151,600 for gasoline vehicles and $5,800 for diesel vehicles.

1.41 These figures are multiplied by TPLS for small sources to estimate cost per life saved (CPLS) for vehicles in each fuel class.

1.42 Table 1.4 summarizes the results for Brazil's top 25 municipios by Large Industry CPLS. The last six columns of the table combine data on population, area, emissions by source and marginal control costs to produce composite estimates of TPLS and CPLS for small plants, large plants and motor vehicles (gasoline, diesel). Two

Table 1.5: Cost Per Life Saved For Urban Sewerage Investments In Brazilian States

State	Total Households	Households Connected to Sewerage	Connection %	10% Incr.: Households Connected	Infant Lives Saved	Cost/Life Saved ($)
Alagoas	528,150	325,581	61.6	32,558	157.6	20,661
Paraíba	695,355	442,031	63.6	44,203	206.9	21,361
Pernambuco	1,591,230	1,091,070	68.6	109,107	493.6	22,106
Amazonas	391,460	294,100	75.1	29,410	100.7	29,195
Roraima	44,567	29,926	67.1	2,993	9.2	32,553
Amapá	53,530	42,662	79.7	4,266	12.9	33,063
Rondônia	256,053	178,818	69.8	17,882	53.7	33,313
Bahia	2,523,134	1,440,449	57.1	144,045	372.1	38,714
Pará	986,474	715,170	72.5	71,517	156.1	45,809
Acre	88,755	55,237	62.2	5,524	11.3	48,910
Ceará	1,349,815	759,714	56.3	75,971	151.6	50,105
Tocantins	192,934	94,165	48.8	9,417	18.3	51,497
Distrito Federal	379,865	332,676	87.6	33,268	63.8	52,144
Espírito Santo	620,705	530,301	85.4	53,030	95.2	55,694
Minas Gerais	3,720,563	3,111,247	83.6	311,125	554.5	56,104
Sergipe	329,944	226,372	68.6	22,637	38.5	58,783
Mato Grosso do Sul	462,264	379,331	82.1	37,933	63.2	60,044
Paraná	2,093,050	1,814,654	86.7	181,465	296.8	61,149
Mato Grosso	433,638	359,261	82.8	35,926	53.8	66,824
Rio Grande do Norte	521,672	376,844	72.2	37,684	50.6	74,548
Goiás	994,490	774,266	77.9	77,427	94.3	82,084
Rio de Janeiro	3,463,292	3,169,148	91.5	316,915	333.7	94,975
São Paulo	8,062,075	7,442,293	92.3	744,229	783.5	94,989
Santa Catarina	1,126,860	1,018,378	90.4	101,838	105.9	96,201
Rio Grande do Sul	2,497,757	2,212,961	88.6	221,296	204.0	108,465

patterns are particularly noteworthy in these results. First, for any emissions source, there are large differences in CPLS *across municipios*. For example, even among Brazil's top 25 municipios ranked by large-source CPLS, this cost varies from around $13,000 in São Paulo to $110,000 in Contagem. CPLS for large sources in lower-ranked municipios are much higher.

1.43 Secondly, there are very large differences in typical CPLS *across sources*. In Rio de Janeiro, for example, CPLS are $11,000, $21,000, $84,000, and $2,198,000 for small plants, large plants, diesel vehicles and gasoline vehicles, respectively. The ordering of relative CPLS is consistent across all top-ranking municipalities: CPLS for large plants is generally at least twice the CPLS for small plants; CPLS for diesel vehicles is at least twice the CPLS for large plants; and CPLS for gasoline vehicles is at least twenty times the level for diesel vehicles.

1.44 These results imply some clear strategic priorities for allocating regulatory resources to tighter PM10 control in Brazil. Small industry emissions should be addressed first in areas where these emissions are a significant source of pollution, if tighter regulation of these sources is feasible. This will depend on two factors: the public cost of regulating small, dispersed plants, which will be much higher than the cost of regulating large plants (per ton of abatement); and the potential loss of output and employment associated with tighter control of small sources whose marginal abatement costs are high. If these factors do not compensate for the CPLS advantage of small plants, then an initial strategy focused on small industry looks promising for several cities.

Table 1.6: Cost Per Life Saved For Urban Water Investments In Brazilian States

State	Total Households	Households w. Water	Connection %	10% Incr.: Households Connected	Infant Lives Saved	Cost/Life Saved ($)
Alagoas	528,150	252,631	47.8	25,263	216.3	17,516
Paraíba	695,355	362,123	52.1	36,212	284.1	19,120
Pernambuco	1,591,230	909,904	57.2	90,990	677.6	20,143
Rondônia	256,053	108,541	42.4	10,854	73.7	22,093
Amazonas	391,460	208,760	53.3	20,876	138.3	22,642
Amapá	53,530	29,627	55.3	2,963	17.7	25,087
Roraima	44,567	21,455	48.1	2,146	12.6	25,500
Pará	986,474	366,948	37.2	36,695	214.3	25,681
Acre	88,755	27,542	31.0	2,754	15.5	26,645
Bahia	2,523,134	1,170,254	46.4	117,025	510.8	34,364
Tocantins	192,934	58,054	30.1	5,805	25.1	34,688
Ceará	1,349,815	544,285	40.3	54,429	208.2	39,221
Mato Grosso	433,638	270,489	62.4	27,049	73.8	54,971
Rio Grande Do Norte	521,672	257,209	49.3	25,721	69.4	55,593
Sergipe	329,944	196,915	59.7	19,692	52.9	55,868
Distrito Federal	379,865	328,168	86.4	32,817	87.6	56,200
Mato Grosso Do Sul	462,264	327,536	70.9	32,754	86.7	56,646
Minas Gerais	3,720,563	2,921,732	78.5	292,173	761.3	57,565
Espírito Santo	620,705	502,078	80.9	50,208	130.7	57,612
Paraná	2,093,050	1,738,862	83.1	173,886	407.4	64,020
Goiás	994,490	703,891	70.8	70,389	129.5	81,533
São Paulo	8,062,075	7,703,706	95.6	342,439	622.0	82,588
Rio De Janeiro	3,463,292	3,162,821	91.3	274,403	468.0	87,957
Santa Catarina	1,126,860	1,017,203	90.3	98,986	146.9	101,071
Rio Grande Do Sul	2,497,757	2,165,731	86.7	216,573	280.1	115,979

1.45 Large plants are generally a significant source of PM10 emissions, and the CPLS criterion suggests that they also be given high priority in most areas. The results suggest that a very high level of large-plant emissions control is warranted before addressing emissions from diesel vehicles. And the control of PM10 emissions from gasoline vehicles is enormously costly and should have far lower priority for PM10 reduction.[10]

1.46 Finally, as noted previously, our results are based on Ostro's constant elasticity assumption: the results are likely to be overestimated for municípios with lower pollution levels.

[10] Gasoline vehicles may well be a cost-effective target for the reduction of other air pollutants.

Contaminated Water

1.47 The second pollutant which threatens human health comes from households themselves. Coliform bacteria and other pathogens in sewage are a major source of mortality and morbidity, particularly in young children. Exposure comes from numerous sources, including direct contact and contaminated drinking water. For reduction of this primary threat to health, the most important action is to collect and transport sewage away from residential areas, either through sewerage systems or periodic removal from well-maintained septic tanks. There is little evidence of additional health benefits from treatment of sewage before it is deposited in waterways and removed from urban residential areas. The primary reason for this is the self-cleaning capability of rivers; coliform bacteria do not live for long

periods once they are expelled from the body.[11]

1.48 By reducing exposure to pathogens, clean water and sewage collection systems can significantly reduce the incidence of mortality and morbidity. The study presented in Annex 2 quantifies the reduction in infant mortality associated with increases in urban household water and sewerage connections. In Tables 1.5 and 1.6, these results are used to estimate the benefits of clean water and sewerage for Brazilian states. For each state, the reduction in the infant mortality rate associated with providing water and sewerage to an additional 10% of urban households (or the remaining urban households, in cases where connection rates are already above 90%) is estimated. The change in the infant mortality rate is multiplied by the state's infant population to produce estimates of infant lives saved. In Brazil, the annualized cost of connection per household is approximately $106 for sewerage and $127 for water. Multiplication of these numbers by the household connections required for a 10% increase (or an increase to 100% in states with connection rates over 90%) yields an estimate of the increase in annual costs for clean water and sewerage. Division of this cost by infant lives saved yields an estimate of the cost per urban life saved for each state in Brazil. These are presented in Tables 1.5 and 1.6.

1.49 The water and sewerage results clearly reflect the great disparities in income, access to sanitation, and infant mortality across Brazilian States. For sewerage and water connections, the CPLS varies fivefold and tenfold, respectively, from the North-East and North to the more prosperous states of Brazil's South-East and South.

Heavy Metals

1.50 As in the case of PM10 emissions, heavy metals from industry are highly concentrated in a few municipios. Table 1.7 lists the top 25 Brazilian municipios in estimated emissions of toxic metals to water. Heavy metals differ greatly from PM10 in their pattern of sectoral intensity. As a result, the metals ranking for municipios is quite different from the PM10 ranking. Only Rio de Janeiro, Belo Horizonte and Sao Paulo are near the top in both sets due to their sheer scale. The metal products industries are the source of most heavy metals emissions, and the regional clustering of the top 25 reflects the concentration of the industry in Sao Paulo and Minas Gerais States: 10 are in Sao Paulo State; 7 in Minas Gerais; 3 in Rio State; 2 in Rio Grande do Sul; and the remaining 3 in Bahia, Santa Catarina and Espirito Santo. For sheer volume of metals output, Sao Paulo and Minas Gerais are clearly the focus of concern for Brazil.

1.51 From the perspective of monitoring and enforcement, the data in Table 1.7 suggest a relatively easy situation for regulation. For 24 of 25 municipios, large plants account for at least two-thirds of all heavy metals emissions; in 11 cases they account for over 90%.

1.52 For benefit-cost analysis, information on emissions volume must be combined with data on the area of each region, its population, and the cost of abatement. And, as in the case of PM10, introduction of these factors makes a big difference for rank-

[11] Of course, downstream settlements which are too close to outfalls for untreated sewage can suffer severe impacts if they use untreated water for drinking and recreation. Such cases seem to be relatively rare, because coliform counts decline rapidly downstream and because relatively few people use untreated water which is obviously contaminated.

Table 1.7: Brazil's Top 25 Municipios For Heavy Metal Emissions To Water

Municipio	Metals (tons)	Pop. ('000)	Area	Sm Ind Shr	Med Ind Shr	Lg Ind Shr	Rank: Tot. Metals	Rank: Cost/ Benefit
Sao Paulo (SP)	61.1	9,646	1,514	7	37	57	1	8
Volta Redonda (RJ)	29.6	220	168	0	2	98	2	18
Rio de Janeiro (RJ)	26.2	5,480	318	5	26	69	3	3
Cubatao (SP)	24.1	91	140	0	2	98	4	30
Ipatinga (MG)	20.2	180	163	0	2	98	5	23
Camacari (BA)	19.7	113	742	1	11	88	6	147
Belo Horizonte (MG)	17.1	2,020	331	3	20	77	7	7
Guarulhos (MG)	15.7	787	313	2	31	67	8	17
Joinville (SC)	12.5	347	1,056	1	8	91	9	118
Timoteo (MG)	11.3	58	154	0	3	97	10	55
Santo Andre (SP)	9.3	616	167	2	11	87	11	16
Contagem (MG)	8.5	449	191	3	22	75	12	21
Serra (ES)	8.5	222	270	1	2	97	13	48
Diadema (SP)	8.4	305	29	4	38	58	14	2
Ouro Branco (MG)	8.0	4	275	0	2	98	15	364
Sao Bernardo do Campo (SP)	7.9	566	428	3	17	80	16	46
Porto Alegre (RS)	7.6	1,263	520	6	28	66	17	28
Divinopolis (MG)	7.6	151	726	2	20	79	18	139
Sao Caetano do Sul (SP)	7.6	149	13	2	16	82	19	1
Barra Mansa (RJ)	7.2	172	860	2	1	97	20	146
Sete Lagoas (MG)	7.1	144	534	0	7	93	21	122
Maua (SP)	6.2	294	77	1	13	86	22	14
Piracicaba (SP)	6.1	283	1,497	3	23	74	23	159
Triunfo (RS)	5.8	17	825	0	5	95	24	469
Pindamonhan-Gaba (SP)	5.7	102	746	0	5	95	25	161

ordering. The last column of Table 1.7 provides rankings for the same municipios, but on the basis of a cost/benefit index explained below. When area, population and cost are considered, only 9 of the municipios remain in the top 25; nine rank lower than 100 for Brazil as a whole.

1.53 Table 1.8 shows Brazil's 25 highest-ranked municipios according to a cost/benefit index for toxic metals control. Once again, Sao Paulo State leads the list with 12 entries. However, the distribution of other areas is broader than for total emissions: Minas Gerais has only 3 entries; Rio State has 4; Pernambuco and Rio Grande do Sul have 2; Espirito Santo and Ceara have one each. Furthermore, the list of top municipios in Sao Paulo State changes considerably: only 6 are common to the two lists.

Table 1.8: Brazil's 25 Municipios With The Highest Cost/Benefit Index For Control Of Toxic Metals

Municipio	Cost/ Ben Rank	Metals Rank	Pop. ('000)	Metal (tons)	Area	Shr. Of Lgst Sector	Ben. Index [B]	Abate Cost [C]	C/B	Sm Ind Shr	Med Ind Shr	Lg Ind Shr
Sao Caetano do Sul (SP)	1	19	150	7.6	12.7	45	9,051	611	0.07	2	16	82
Diadema (SP)	2	14	305	8.4	28.5	18	5,804	611	0.11	4	38	58
Rio de Janeiro (RJ)	3	3	5,481	26.2	318.0	18	4,948	611	0.12	5	26	69
Osasco (SP)	4	34	568	4.0	70.0	43	1,948	611	0.31	2	18	81
Sao Joao de Meriti (RJ)	5	124	426	0.9	30.0	62	2,431	843	0.35	19	16	66
Ferraz de Vasconcelos (SP)	6	189	96	0.5	27.4	25	487	206	0.42	3	39	58
Belo Horizonte (MG)	7	7	2,020	17.1	331.4	68	1,385	611	0.44	3	20	77
Sao Paulo (SP)	8	1	9,646	61.1	1,514	21	1,280	611	0.48	7	37	57
Jandira (SP)	9	63	63	2.2	17.4	39	1,267	611	0.48	1	60	38
Carapicuiba (SP)	10	248	284	0.3	30.9	28	936	611	0.65	12	48	41
Olinda (PE)	11	234	341	0.4	38.0	59	902	611	0.68	13	26	60
Poa (SP)	12	264	76	0.3	13.0	57	860	611	0.71	7	76	17
Vitoria (ES)	13	151	259	0.7	40.6	48	832	611	0.73	3	11	86
Maua (SP)	14	22	295	6.2	77.2	52	1,084	843	0.78	1	13	86
Recife (PE)	15	46	1,298	3.1	212.1	49	739	611	0.83	7	22	71
Santo Andre (SP)	16	11	617	9.3	166.6	45	876	843	0.96	2	11	87
Guarulhos (SP)	17	8	788	15.7	313.2	22	564	611	1.08	2	31	67
Volta Redonda (RJ)	18	2	220	29.6	167.5	92	553	611	1.10	0	2	98
Nilopolis (RJ)	19	626	158	0.1	12.8	35	763	843	1.10	76	14	10
Fortaleza (CE)	20	50	1,769	2.9	311.6	24	549	611	1.11	9	29	62
Contagem (MG)	21	12	450	8.5	191.3	33	496	611	1.23	3	22	75
Sapucaia do Sul (RS)	22	35	105	3.9	63.7	76	410	611	1.49	1	4	95
Ipatinga (MG)	23	5	180	20.2	163.1	98	388	611	1.57	0	2	98
Barueri (SP)	24	36	131	3.9	68.9	21	452	843	1.87	2	27	71
Esteio (RS)	25	193	71	0.5	23.9	44	433	843	1.95	8	80	12

1.54 To derive the cost/benefit index in Table 1.8, it is assumed that damage per person in an area is a function of emissions density (or emissions per unit area); this is multiplied by population to obtain an index of total damage. Lacking the parameter which relates emissions density to physical damage, an index is used in this case. The associated index of marginal benefit to abatement (termed the 'Ben. Index' in Table 1.8) is the product of population density and a function of emissions density. The square root of emissions density represents the latter; the heavy metal abatement cost for the

Table 1.9: Household And Industrial BOD: Top 25 Municipios

Municipio	Household Rank	Industry Rank	Household BOD ('000 tons)	Industry BOD ('000 tons)	Total BOD ('000 tons)	Household Share
Sao Paulo (SP)	1	1	217,810	19,875	237,685	92
Rio de Janeiro (RJ)	2	2	124,962	8,309	133,270	94
Salvador (BA)	3	76	47,300	735	48,035	98
Belo Horizonte (MG)	4	7	45,997	2,021	48,018	96
Fortaleza (CE)	5	18	40,325	1,540	41,865	96
Brasilia (DF)	6	155	35,730	360	36,089	99
Curitiba (PR)	7	49	29,983	957	30,940	97
Recife (PE)	8	35	29,600	1,129	30,728	96
Nova Iguacu (RJ)	9	132	29,557	403	29,961	99
Porto Alegre (RS)	10	25	28,661	1,328	29,989	96
Belem (PB)	11	3118	24,780	0	24,780	100
Manaus (AM)	12	118	23,017	490	23,508	98
Goiania (GO)	13	53	20,947	923	21,870	96
Campinas (SP)	14	31	19,119	1,187	20,305	94
Guarulhos (SP)	15	14	17,873	1,604	19,477	92
Sao Goncalo (RJ)	16	64	17,780	817	18,597	96
Tocantins (MG)	17	1269	17,431	11	17,442	100
Duque de Caxia (RJ)	18	56	15,193	891	16,083	94
Santo Andre (SP)	19	6	14,067	2,041	16,108	87
Maceio (AL)	20	8	13,926	1,898	15,825	88
Natal (RN)	21	396	13,837	99	13,936	99
Natal (RN)	22	397	13,837	99	13,936	99
Teresina (PI)	23	265	13,278	180	13,458	99
Osasco (SP)	24	148	12,956	375	13,331	97
Sao Bernardo do Campo (SP)	25	19	12,821	1,538	14,359	89

sector with the largest local share of emissions represents the marginal cost of abatement (Abate. Cost in Table 1.8). Division of estimated marginal abatement cost by marginal benefit yields the estimated C/B ratio.

1.55 This introduction of population size, area and marginal abatement cost changes the picture considerably from Table 1.7: many large-emissions municipios drop far down in the rankings, and many municipios with considerably lower total emissions rise sharply. From an economic perspective, the 25 municipios in Table 1.8 seem to offer the most attractive returns to increased control of toxic metals. However, this illustrative cost/benefit index model needs to be refined before being useful as a practical guide for regulatory action.

1.56 One factor complicating this analysis is the distribution of industrial sources for these municipios: in Table 1.8,[12] only 14 of 25 municipios have large-plant shares of two-thirds or more, and only 3 have large-plant shares over 90%. One municipio (Nilopolis) has most of it heavy metal emissions from small plants (those with 10 or fewer employees); 2 have over two-thirds of their emissions from medium plants, and 13 have over 30% of their emissions from small and medium plants.

[12] For these estimates, industry size is classified as follows: Small (less than 10 employees); Medium (10-100 employees); Large (more than 100 employees).

Table 1.10: Industrial BOD Sources By Plant Size, Top 25 Municipios[13]

Municipio (State)	Household BOD ('000 tons)	Ind BOD ('000 tons)	Total BOD ('000 tons)	HH Shr	Ind Abate Cost ($)	Sm. Ind Shr	Med Ind Shr	Lg Ind Share
Sao Paulo (SP)	217,810	19,875	237,685	92	112	6	26	67
Rio de Janeiro (RJ)	124,962	8,309	133,270	94	112	4	26	70
Santo Andre (SP)	14,067	2,041	16,108	87	220	4	8	88
Belo Horizonte (MG)	45,997	2,021	48,018	96	112	6	23	71
Maceio (AL)	13,926	1,898	15,825	88	7	2	15	83
Guarulhos (SP)	17,873	1,604	19,477	92	220	6	52	42
Fortaleza (CE)	40,325	1,540	41,865	96	112	10	27	63
Sao Bernardo do Campo (SP)	12,821	1,538	14,359	89	112	5	11	84
Porto Alegre (RS)	28,661	1,328	29,989	96	112	8	49	43
Sao Luis (MA)	11,781	1,285	13,066	90	112	1	7	92
Campinas (SP)	19,119	1,187	20,305	94	112	8	21	72
Recife (PE)	29,600	1,129	30,728	96	112	13	38	49
Curitiba (PR)	29,983	957	30,940	97	112	14	55	31
Goiania (GO)	20,947	923	21,870	96	112	9	38	53
Duque de Caxias (RJ)	15,193	891	16,083	94	112	6	20	74
Sao Goncalo (RJ)	17,780	817	18,597	96	112	3	9	88
Salvador (BA)	47,300	735	48,035	98	112	22	38	40
Manaus (AM)	23,017	490	23,508	98	293	8	52	40
Nova Iguacu (RJ)	29,557	403	29,961	99	230	1	57	41
Osasco (SP)	12,956	375	13,331	97	220	15	19	66
Brasilia (DF)	35,730	360	36,089	99	112	12	15	73
Teresina (PI)	13,278	180	13,458	99	112	25	66	9
Natal (RN)	13,837	99	13,936	99	112	40	45	15
Tocantins (MG)	17,431	11	17,442	100	112	99	1	0
Belem (PB)	24,780	1	24,781	100	206	12	88	0

1.57 To summarize, Brazil's heavy metal emissions are more highly concentrated than PM10 emissions, particularly in Sao Paulo State. Table 1.8 provides valuable information on three factors which should be taken into account when determining priorities for stricter regulation: total emissions, a cost/benefit index for regulation, and the size distribution of sources. In practice, it would probably be best to focus on areas in the top 25 by the cost/benefit criterion which have relatively high emissions and a concentration of emissions in large plants. If

[13] For these estimates, industry size is classified as follows: Small (less than 10 employees); Medium (10-100 employees); Large (more than 100 employees).

the choice is restricted to areas with 4 tons of emissions or greater, thirteen municipios remain on the list. All have large plant shares of approximately 60% or greater. Seven are in Sao Paulo State (Sao Caetano do Sul, Diadema, Osasco, Sao Paulo, Maua, Santo Andre, Garulhos); 3 are in Minas Gerais (Belo Horizonte, Contagem, Ipatinga); 2 are in Rio State (Rio de Janeiro, Volta Redonda); and one is in Rio Grande do Sul (Sapucaia do Sul).

CRITICAL POLLUTANTS FOR ECOSYSTEMS

1.58 Since we are primarily concerned with man-caused emissions, we do not focus on siltation of water bodies even though this is largely due to agricultural erosion and erosion caused by deforestation. The information on such problems is essentially nonexistent for the level of analysis developed here.

Biological Oxygen Demand (BOD)

1.59 Organic water pollution (BOD) has two major sources: industrial emissions and household sewage. Knowledge of relative emissions volumes and abatement costs for these two sources is critical for regulatory strategy. If BOD pollution from large plants is the main problem, careful targeting of monitoring and enforcement activity can significantly reduce emissions in a short period of time. A large share for household sewage, on the other hand, will imply the need to construct sewerage and treatment systems for large areas.

1.60 Household BOD is directly proportional to population, while industrial BOD depends on the distribution and scale of activity in BOD-intensive industry sectors. Significant threats to aquatic ecosystems are only likely in areas with heavy emissions volumes. Table 1.9 provides evidence on the distribution of BOD emissions by source; the 25 municipios listed have the highest estimated BOD emissions in Brazil. The top-ranked municipios are, in effect, a list of the largest cities in Brazil which are scattered all over the country. It is clear that households are the dominant source of BOD, since their share is above 85% in all cases and above 95% in 17 of 25 cases.

1.61 Clearly, organic water pollution in Brazil will not be controlled until household sewage is treated. However, relative abatement costs are so skewed in favor of industrial BOD abatement that it makes sense to begin a program of organic pollution control with targeted regulation of emissions from large factories. For Brazilian households, the incremental cost of BOD removed through sewerage is approximately $1775/ton. For industry as a whole, by contrast, marginal cost at 50% abatement ranges from approximately $10 to $400/ton. Even the highest figure is less than 25% of the cost of BOD control through sewerage.

1.62 Where should a targeted regulation program begin? A complete answer would depend on knowledge of receiving waterways (volume, flow rate, etc.) which is not available for this analysis. However, good candidates are factories in municipios where total BOD loads are high (indexing the potential threat to ecosystems); industrial loads are also significant (providing scale economies for regulation); industrial BOD emissions are concentrated in a few large plants (lowering the cost of monitoring and enforcement); and industry's abatement costs are low. Municipios in Table 1.10 which rank high in the first three categories are, in order of abatement cost, Maceio (Alagoas), Sao Bernardo do Campo (SP), Sao Luis (Maranhao), Santo Andre (SP), and Sao Goncalo (Rio). Within this set, marginal abatement costs range from $7/ton to $220/ton. These criteria can be used for further investigation of municipios where BOD-related damage may be relatively severe.

Table 1.11: Brazil's Top 25 Municipios: Phosphorus Loadings

Municipio	Total Phosphorus	Household Phosphorus	Agricultural Phosphorus	Household Share
Sao Paulo (SP)	10,508	10,508	0	100
Dourados (MT)	7,295	144	7,151	2
Rio de Janeiro (RJ)	6,031	6,029	3	100
Rio Verde (GO)	2,488	101	2,387	4
Campo Novo do Parecis (MS)	2,474	5	2,468	0
Sorriso (MS)	2,452	16	2,437	1
Salvador (BA)	2,287	2,282	5	100
Brasilia (DF)	2,281	1,724	557	76
Ponta Pora (MT)	2,108	57	2,051	3
Sao Gabriel do Oeste (MT)	2,102	12	2,090	1
Piracicaba (SP)	2,001	306	1,695	15
Fortaleza (CE)	1,946	1,946	0	100
Maracaju (MT)	1,870	23	1,847	1
Londrina (PR)	1,732	419	1,313	24
Ituverava (SP)	1,638	35	1,603	2
Guarapuava (PR)	1,622	156	1,466	10
Unai (MG)	1,572	65	1,507	4
Sidrolandia (MT)	1,544	16	1,529	1
Costa Rica (MT)	1,535	13	1,522	1
Cascavel (PR)	1,466	206	1,261	14
Curitiba (PR)	1,456	1,447	10	99
Nova Iguacu (RJ)	1,427	1,426	1	100
Toledo (PR)	1,422	94	1,328	7
Porto Alegre (RS)	1,389	1,383	6	100
Candido Mota (SP)	1,368	26	1,342	2

1.63 Phosphorus is another threat to aquatic ecosystems because excessive loadings are a major cause of eutrophication. The two major sources of phosphorus are household waste water and runoff from agriculture. As in the case of BOD, appropriate targeting of regulation depends on three factors: the scale of phosphorus loading relative to the absorptive capacity of local waterways; the relative magnitude of phosphorus loading in different municipios; and the shares attributable to households and agriculture.

1.64 Since evidence on the incidence of eutrophication problems by waterway is currently unavailable, this analysis will be limited to identifying areas which may pose problems, and tracing potential phosphorus loading problems back to household and agricultural sources.

Phosphorus

1.65 Table 1.11 provides information on the geographic and sectoral distribution of estimated phosphorus loads. For agriculture, the estimate is based on the assumption that 20% of total phosphorus fertilizer applications find their way into waterways through runoff.[14] Potential problems from agriculture appear to be concentrated in the agricultural hinterlands of the Brazilian South, and this is confirmed by Table 1.11. Large potential loadings are identified in agricultural municipios of Mato Grosso (6), Mato Grosso do Sul (2), Sao Paulo (3), Parana (4), Goias (1) and Minas Gerais (1).

[14] Qualitative results are not changed by variation of the runoff percentage from 10% to 30%.

The largest loadings from households are found in the major urban centers: Sao Paulo, Rio de Janeiro, Salvador, Brasilia, Fortaleza, Curitiba, Nova Iguacu and Porto Alegre.

CONCLUSIONS

1.66 This report utilized a large new database for a comprehensive analysis of brown environmental problems in Brazil. The analysis has included all four sectors which are major sources of pollution: households, industry, transport and agriculture. Because regulatory resources are limited, attention has focused on intervention priorities for the few pollution problems identified as most serious. For public health, these are PM10 air pollution, sewage-contaminated water, and industrial heavy metal emissions to water. For aquatic ecosystems, the two major problems are emissions of BOD by households and industry, and emissions of phosphorus by households and agriculture.

Human Health

1.67 Although some missing links remain, it has been possible to use the wealth of available information to identify those areas where the three critical health-related pollution problems seem to be greatest. Furthermore, available data on abatement costs have been sufficient to provide an indication of relative benefits and costs in most cases. For PM10 control and sanitation investments, intervention priority rankings were based on estimated costs per life saved. In the case of heavy metals, a comparative cost/benefit index was developed.

1.68 These results provide a relatively clear sense of priorities. To combat threats to human health, immediate actions should focus on the countrywide expansion of urban water connections. Second priority should be given to sewerage in the North/Northeast and industrial PM10 emissions control in the South/Southeast. In most areas, PM10 pollution can be reduced significantly by stricter regulation of a few large industrial facilities.

1.69 Additional reduction of PM10 in Brazil's large urban areas will require stricter control of motor vehicle emissions. However, this option is generally about twice as expensive as industrial PM10 control, and should be deferred until large industrial sources have been brought under control. Such conclusions perhaps call for some careful consideration by Brazilian policymakers at a time when inspection and maintenance programs are becoming mandatory, and also when some large metropolitan cities are considering the (very) costly strategies of banning the circulation of vehicles during certain periods of the year.

1.70 Focusing on cost-effectiveness for lifesaving leads to the following order of priorities for regulatory intervention. For heavy metal emissions, regulatory attention should be focused on the small number of municipios which have large metals loads and low abatement costs relative to abatement benefits:

- Countrywide: Extension of water networks, primarily in urban areas.
- North/Northeast: Extension of sewerage networks, primarily in urban areas.
- South/Southeast: Control of industrial PM10 sources (in sectors with low marginal abatement costs) in heavily-polluted, densely-inhabited cities with large populations.
- South/Southeast: Extension of sewerage networks, particularly in urban areas.
- North/Northeast: Control of industrial PM10 sources (in sectors with low marginal abatement costs) in heavily-

polluted, densely-inhabited cities with large populations.

- South/Southeast: Control of PM10 from diesel vehicles.
- North/Northeast: Control of PM10 from diesel vehicles.
- (A very distant last) Nationwide control of PM10 from gasoline vehicles.

Aquatic Ecosystems

1.71 Priority interventions to protect aquatic ecosystems are subject to much greater uncertainty than measures to protect human health. The carrying capacity of receiving waters is subject to high variation, and data on ambient water quality near large emissions sources are generally unavailable. Therefore, this analysis has focused on the identification of areas where emissions are large enough to pose a potential risk. Again, an assessment of relative costs has enabled some conclusions about relative priorities for intervention to be made. In all cases, ambient quality should be checked prior to action. The ranking in terms of cost-effectiveness is as follows:

- Control of medium and large industrial BOD sources (in sectors with low marginal abatement costs) in areas with large total BOD loads.
- Evaluation of the potential for low-cost changes in agricultural practice which will reduce phosphorus runoff in agricultural areas where receiving waters have serious eutrophication.
- Installation of sewage treatment in cities with large total BOD and phosphorus loads.

Reference

Ostro, Bart. 1994. "Estimating the Health Effects of Air Pollutants." World Bank Policy Research Working Paper 1301, Washington D.C.

Figure 1.1: Municipio Incomes in Brazil (1991 Currency Units)

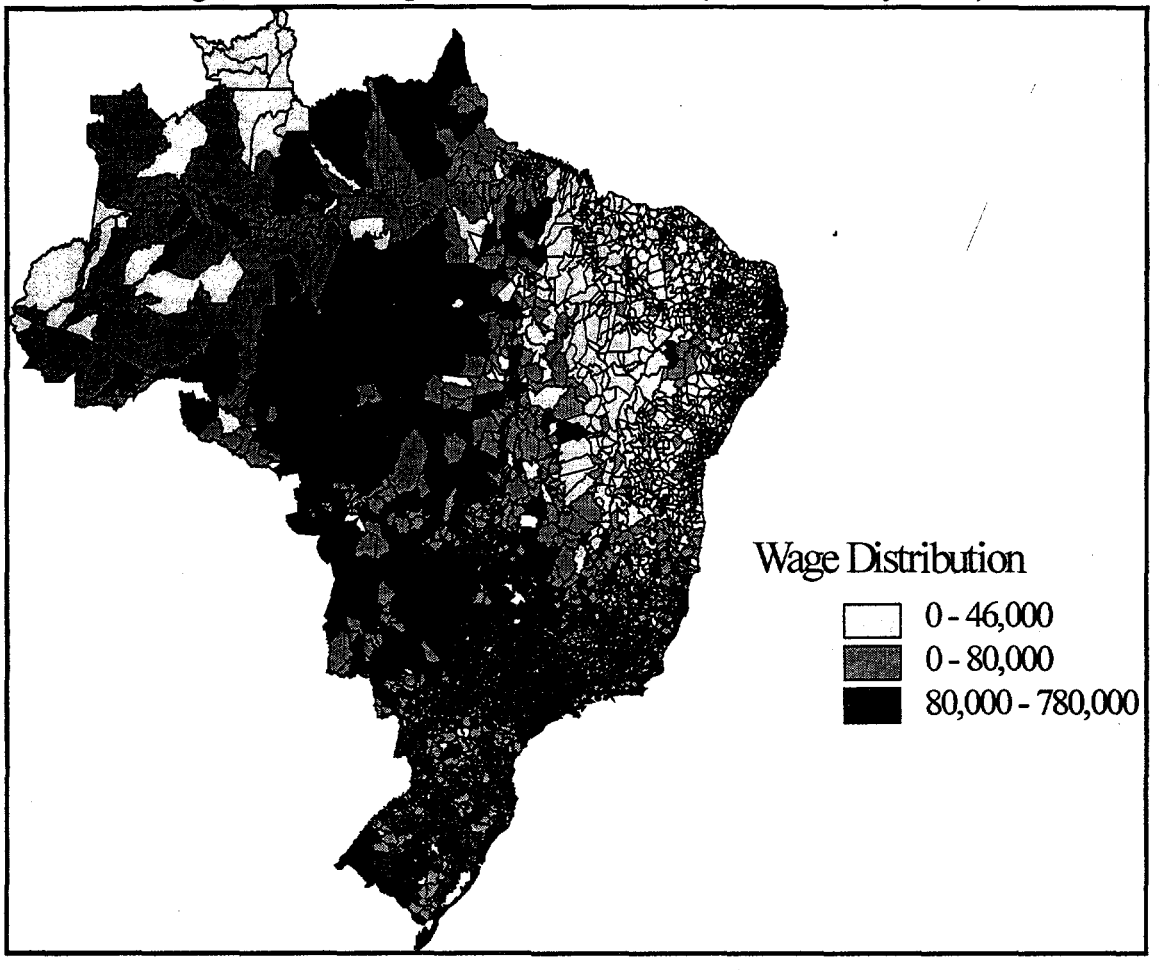
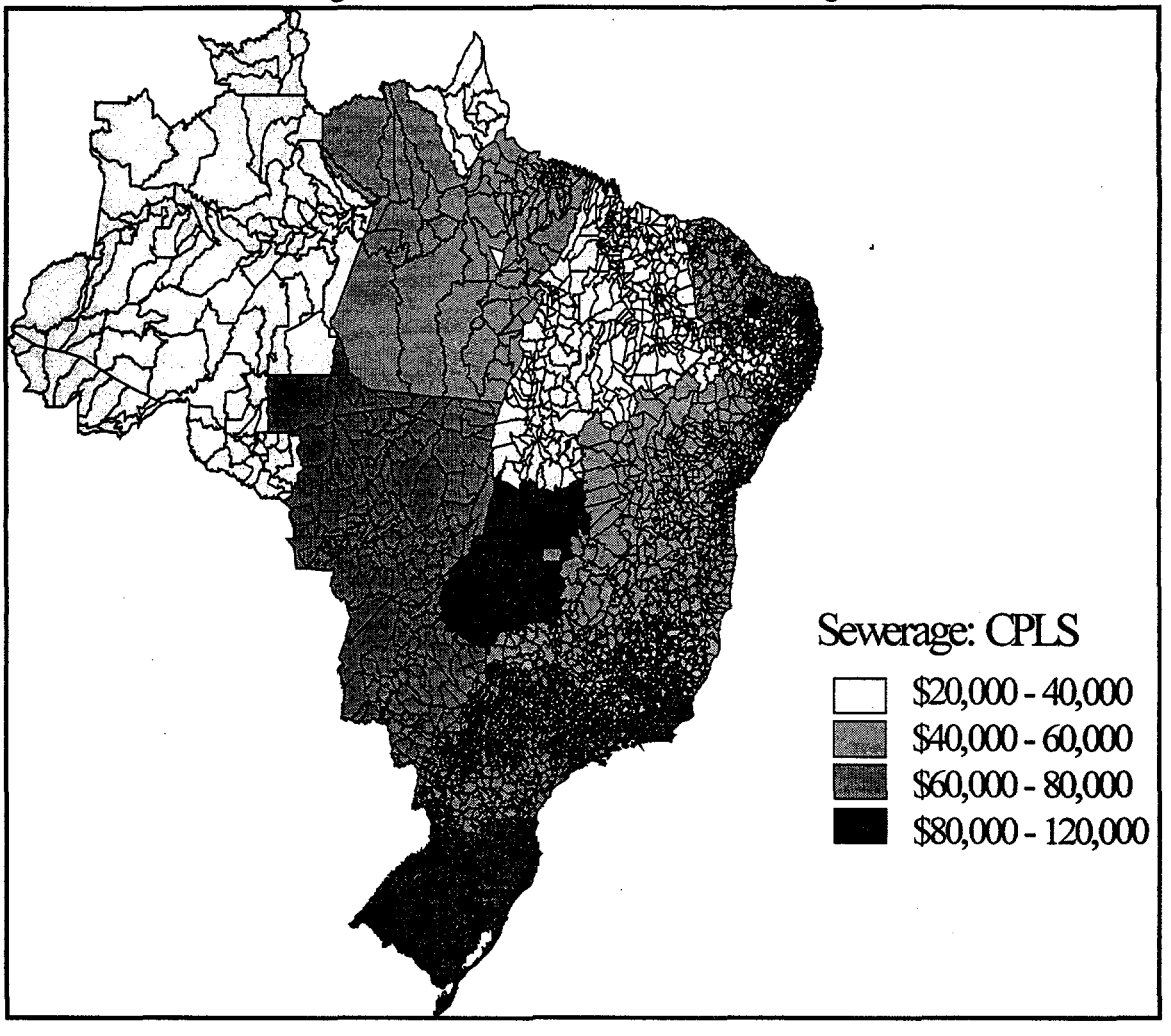


Figure 1.2: Cost Per Life Saved: Sewerage



2. BENEFITS OF WATER AND SANITATION SERVICES[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
Urban access to piped water and sanitation has a significant effect in reducing infant and child mortality; however, water supply and sanitation are not equally important as influences on the incidence of different diseases.
A ten percentage point rise in urban access to piped water reduces the average mortality rates for both infants and children under 5 by almost 3%.
A ten percentage point rise in urban access to sewers reduces the average mortality rates for both infants and children under 5 by almost 2%.
For Minas Gerais, Pernambuco, Rio de Janeiro, and Sao Paulo, it is possible to avoid nearly 3,000 deaths of babies and young children each year and to reduce the burden of disease by over 220,000 DALYs through investments in water and sanitation. Under-5 deaths account for 70-75% of the total burden of disease affected by water and sanitation.
The case for expanding piped water and sewer services to urban residents rests on the general community benefits of reducing the burden of ill-health and infant mortality as well as on the willingness to pay of the households receiving increased coverage.
Household willingness to pay for piped water and sewage removal exceeds the costs of supplying piped water if household income is greater than $4,000 per year; for sewers, the threshold is higher at $5,000 per year.

STRATEGY AND RECOMMENDATIONS
The largest impact at the lowest cost can be achieved by concentrating on ensuring that the entire urban population has access to piped water at a cost of $1,560 per DALY. Providing every urban resident with access to piped water should be the first priority for reducing the burden of disease and ill-health via investments in water and sanitation.
The average cost per DALY saved by expanding urban sewers is higher at $2,440, but is still well below reasonable estimates of willingness to pay to save a DALY. When the substantial non-health benefits from expanded sewer coverage are taken into account, the benefits are likely to outweigh the costs.

2.1 There is ample evidence from intervention and cross-community studies to establish that access to improved water supply and sanitation can have a significant impact in reducing the incidence of both morbidity and mortality associated with diarrhea, intestinal nematodes, and other tropical diseases. However, few studies have attempted to use these epidemiological results as the basis for (a) estimating the net social benefits of expenditures on water and sanitation, and (b) identifying which urban areas or rural communities should receive priority in expanding water and sanitation services.[2]

[1] This paper was prepared by Gordon Hughes.

[2] The original report on the study undertaken by Esrey *et al* included an analysis of the expected net benefits from water and

This section will draw upon a detailed cross-sectional epidemiological study of the impact of water and sanitation on infant and under-5 mortality in Brazil to estimate and rank the net benefits of improvements in water and sanitation.

2.2 The primary indicators of the health impacts of water supply and sanitation that were used are (i) the infant mortality rate, defined as the number of deaths of babies less than 12 months old per 1,000 live births, and (ii) the under-5 mortality rate, defined as the number of deaths of babies and young children under 5 years old per 1,000 children under 5. In Brazil, infant mortality accounts for over 80% of under-5 mortality. The under-5 mortality rate was used in the analysis as the link between the cross-section analysis of mortality and data on the overall burden of disease in Latin America which was then used to calculate the total impact of improvements in water and sanitation on health.

2.3 Casual observation supported by detailed community studies show that income and education are both critical factors in understanding the impact of water supply and sanitation on health. Income matters both as a determinant of, and possible proxy for, nutritional status and as an indicator of the resources available for avoidance or mitigation expenditures. Infants who are well-nourished are less likely to die during episodes of diarrhea. A higher average income means that parents are more likely to be able to buy either bottled water or other clean water, thus reducing the frequency of such episodes, or to pay for medical attention to mitigate their severity. Education, especially of women, plays a critical role in disseminating the importance of personal and domestic hygiene in reducing the frequency and severity of waterborne disease. Thus, the influence of these factors must be taken into account when estimating the impact of water and sanitation improvements.

2.4 Diarrhea diseases are a major cause of mortality among young children in Africa, Asia (except China), and Latin America, typically accounting for 20-25% of deaths of children from 0 to 4 years old as well as about 8% of the total loss of DALYs in the developing world as a whole (just behind lower respiratory infections).[3] Other water-borne diseases impose substantial costs as a result of disability and loss of productivity by those who suffer them. The magnitude of such costs seems to be strongly correlated with levels of mortality for infants and young children. Thus, it is reasonable to use changes in these mortality variables in response to access to water supply and sanitation as a general indicator of the impact of water and sanitation on the overall burden of water-borne diseases.

2.5 Small scale studies have shown that water supply and sanitation are not equally important as influences on the incidence of different diseases. Water supply seems to be the critical variable for guinea worm (*dracunculiasis*), schistosomiasis, and trachoma in the sense that access to ample water of reasonable quality for drinking and

sanitation interventions for six diseases for Africa, Asia, and Latin America. This analysis takes account of the costs of both mortality and morbidity, but the figures are inevitably very broad-brush since the authors had to rely upon continent-scale data.

[3] DALY is the acronym for 'disability-adjusted life years' and is a standard measure of the burden of disease. DALYs are calculated as the present value of the future years of disability-free life that are lost as the result of the premature deaths or cases of disability occurring in a particular year. A full discussion of the definition and calculation of the burden of disease in terms of DALYs may be found in Murray & Lopez.

hygiene substantially reduces the transmission of these diseases. For hookworm infection (*ancylostomiasis* and *necatoriasis*) it is sanitation that is critical in breaking the cycle of transmission, though its impact on incidence as opposed to severity of the disease is uncertain. The incidence and severity of diarrhea diseases and ascariasis seem to be influenced by both water supply and sanitation, though it is not possible to conclude which of the two is more important.

2.6 Since important questions of priorities may arise in allocating resources to the development of water and sanitation services in poor communities, the study was designed to identify the separate influences of water and sanitation on mortality and, by inference, on morbidity. No attempt has been made to examine the impact of quality variables -- in particular, the quality of water supplies and the extent and nature of sewage treatment.

2.7 The overall burden of ill-health associated with transmission through contact with untreated sewage outside the local neighborhood is relatively small. Children and adults may develop diarrhea, cholera, typhoid, or hepatitis as a result of bathing in contaminated waters or eating contaminated shellfish, but both mortality and the overall loss of DALYs from such causes is usually small. Moreover, conventional sewage treatment on its own yields minimal or zero health benefits. Unless the treatment plant chlorinates its effluent -- an unusual measure -- or includes maturation ponds, land treatment or other measures for bacterial removal, sewage treatment has little impact on the bacteriological quality of wastewater. In most cases, the collection of sewage and the discharge of wastewater to more distant or less harmful locations is more effective in achieving a reduction in *e-coli* or fecal coliform counts of, for example, bathing or shellfish waters.

EPIDEMIOLOGICAL ANALYSIS

2.8 The analysis was carried out using a sample of 1533 municipalities from 4 states -- Minas Gerais, Pernambuco, Rio de Janeiro, and Sao Paulo -- which span the full range of incomes and living conditions found in Brazil today. The data was extracted from individual state reports from the 1991 Census plus a dataset containing full death registration information compiled by the Fundacao Nacional de Saude, an institute affiliated with the Federal Ministry of Health. Deaths are recorded by municipality where the deceased person resided, but it was not possible to separate deaths of urban and rural residents, so that infant and under-5 mortality rates could only be calculated at the municipal level. Analysis of mortality rates for urban and rural populations was only possible for those municipalities which are predominantly either urban or rural.

2.9 The main independent variables used in the analysis were :

- average head of household income, expressed originally as a multiple of the minimum wage but converted to US$ at the average exchange rate for 1991;
- percentage of population living in urban areas;
- percentage of females aged 5 or greater who are illiterate;
- percentage of total population served by piped drinking water; and
- percentage of total population served by sewers and/or septic tanks.

Since mortality rates cannot be less than zero, a logit specification was estimated by a maximum likelihood procedure using the number of deaths of infants or of children

under 5 years old in 1991 together with the total number of infants under 1 year or 5 years old in the population census. Dummy variables for three states were included in the equations in order to allow for state differences in variables that could not be included in the analysis.

2.10 *A priori* one would expect that infant mortality (or under-5 mortality) will decline with increasing values of (a) income per person, (b) the level of female education, and (c) access to piped water and sanitation. The coefficients for the relevant variables are all highly significant and negative. The expected effect of urbanization on mortality is uncertain. Infants and children in urban areas may be more exposed to the diseases associated with squalid living conditions, but equally their parents may have better access to information and services which reduce the chances of contracting these diseases or mitigate their effect. In all of the models estimated it turns out that the coefficient on the level of urbanization is very significant and positive so that infant and under-5 mortality rates are higher in urban than in rural areas if other factors are held constant.

2.11 It is possible that water supply and sanitation have different effects for urban and rural households, so various alternative specifications were estimated to examine whether this is case. The initial approach was to decompose the influence of the water variable by including (a) access to piped water in urban areas multiplied by the urban share of the population, and (b) access to piped water in rural areas multiplied by the rural share of the population plus a similar decomposition of the sanitation variable. Unfortunately, this yielded significant positive coefficients for both rural water and sanitation, which is entirely counter-intuitive. It is probable that the rural variables are acting as a proxy for some unobserved characteristic(s) affecting mortality among rural populations. Attempts to identify what these might be -- such as rural-urban income differentials, income inequality among the rural population -- were not successful.

2.12 Better results were obtained by dropping the rural component of the water and sanitation variables altogether. Measures of goodness of fit for this specification were much better that those for the model using access to piped water and sanitation for the whole population and only slightly worse than those for the model in which both rural and urban components were included. Thus, the working hypothesis is that urban access to piped water and sanitation has a significant effect in reducing infant and child mortality, whereas rural access may have little or no such effect -- in Brazil at least.

2.13 Another question concerns the relative importance of sewers and other types of sanitation in contributing to lower mortality rates. Households with septic tanks comprise about 10% of urban households and 15% of rural households, while the equivalent shares for sewers are 61% and 13%. To compare the effects of different types of sanitation separate equations were estimated for sewers and septic tanks combined, sewers alone, and sewers and septic tanks separately. In all cases, the model with sewers and septic tanks separately was no better than the one with sewers and septic tanks combined, since the coefficients for sewers and septic tanks were effectively identical. This confirms that, in terms of the impact on human health, it does not matter whether urban sanitation takes the form of sewers or septic tanks.

2.14 The relative importance of water and sanitation as influences on infant and under-5 mortality may be inferred from the equations by calculating the impact on mortality rates of a 10 percentage point increases in the water and sanitation variables. These are shown in Table 2.1.

Table 2.1: Impact Of Water And Sanitation On Mortality Rates

	Infant Mortality	Under-5 Mortality
Average Mortality Rate	39.4	8.8
Change due to a 10 percentage point rise in:		
Urban access to piped water	0.8	0.25
Urban access to sewers	0.6	0.15

2.15 Clearly, expanding access to piped water has a larger impact on mortality rates per person or household affected than does expansion of sewers. However, over 91% of all urban households in the 4 states had access to piped water in 1991 and the proportion is likely to be nearly 95% now, so that the scope for reducing mortality by further investments in water supplies is rather limited. Building sewers or septic tanks has a much less powerful impact on mortality rates but may, nonetheless, have a large impact in aggregate because of the much more limited coverage in most urban areas.

2.16 As a working hypothesis, it will be assumed that morbidity and mortality of those aged 5 or above will decline as a result of increased coverage of urban piped water and sewers in proportion to the reduction in mortality rates. The scale of the reduction in the overall burden of disease has been estimated from the data compiled for the Global Burden of Disease study sponsored by the World Health Organization and the World Bank (see Murray and Lopez (1996), and footnote 3 above). This gives estimates of the total burden of various diseases linked to water and sanitation in terms of DALYs for Latin America as a whole.

2.17 To scale changes in mortality, the total number of DALYs lost each year to (a) diarrhea diseases, (b) hepatitis B & C, (c) tropical cluster diseases excluding trypanosomiasis and Chagas disease, and (d) intestinal nematode infections were summed to provide an aggregate estimate of the burden of water- and sanitation-related diseases for the region.[4] This was normalized by the total number of deaths of children under 5 years old each year from the same group of diseases.[5] Thus, the scaling factor represents the average number of DALYs lost as a result of water- and sanitation-related diseases per under-5 death associated with the same group of diseases. Applying it to the estimated reduction in under-5 mortality as a result of improvements in water and sanitation yields an estimate of the total number of DALYs that may be saved by such measures.

2.18 There are alternative ways of computing DALYs which vary in their assumptions about the discount factor and age weights that are used. The results reported here are based on the standard parameters used in the Global Burden of Disease study. Alternative calculations using a zero discount rate and uniform age weights have also been prepared. The broad conclusions are little affected though the average cost per DALY saved is much lower because the death of a child under 5 years old means the loss of 34 DALYs for the standard parameters but about 78 DALYs under the alternative assumptions. The aggregate scaling factor is 47.9 DALYs per under-5 death from water- and sanitation-related diseases for the standard assumptions and 102.2

[4] Trachoma might also have been included but it is of negligible importance in Latin America and the evidence for the impact of water and sanitation on its incidence is rather mixed. The survey by Esrey *et al* suggests that it may be personal hygiene practices rather than the availability of water that is the critical factor.

[5] Diarrheal diseases accounted for 99% of the total deaths and 85% of total DALYs lost as a result of this group of diseases.

DALYs for the alternative. Thus, under-5 deaths account for 70-75% of the total burden of disease affected by water and sanitation.

2.19 It would have been possible to have used mortality from infectious and parasitic diseases rather than total mortality as the base for the analysis. However, this category represents barely 10% of both infant and under-5 mortality, whereas it accounts for 36% of under-5 deaths in Latin America in the Global Burden of Disease estimates. This suggests that many under-5 death from many water- and sanitation-related diseases may have been classified under the general 'Unspecified' category. For this reason it was better to make use of the total mortality statistics rather than relying on an possibly erratic classification by cause of death.

COST-EFFECTIVENESS OF INVESTMENTS IN WATER AND SANITATION

2.20 These results were used to estimate the reduction in the burden of disease that would follow an extension of water supply and sewers to all urban households in each of the municipalities in the four states. Since this would be a non-marginal change, the full logit equation was used rather than the slope coefficients shown above. Note, also, that the shape of the logit model means that the sum of the reductions in mortality associated with the extension of water supply or sewers alone exceeds that due to the full extension of both water supply and sewers.[6]

2.21 The estimated reductions in under-5 mortality and DALYs lost to water- and sanitation-related diseases following an extension of urban water supply and sewers are shown in Table 2.3 (at end of report). The total number of avoided under-5 deaths for the 4 states would be just under 22,000 per year, with the biggest proportional impact in Pernambuco, which had an under-5 mortality rate double that of Minas Gerais and 40% or more higher than those for Rio de Janeiro and Sao Paulo.

2.22 The estimates suggest that over 700,000 DALYs per year could be saved by expanding the coverage of urban water supplies to the 4.2 million people who were not served in 1991. The average health benefit amounts to 0.17 DALYs per year per additional urban resident supplied with water, with a range from 0.12 for Minas Gerais to 0.26 for Pernambuco. If all of the urban population has access to piped water supply, the additional impact of expanding sewers would be much smaller. The total saving would amount to about 340,000 DALYs per year for an additional 19.6 million people served. Thus, for sewers, the average health benefit is only 0.018 DALYs per year per additional urban resident covered, or one-tenth of the equivalent figure for water supply. The range is from 0.014 for Minas Gerais to 0.023 for Pernambuco.

2.23 The cost of expanding urban water supply and sewers will, of course, depend upon the specific circumstances of municipalities. However, it is possible to compute a broad index of the cost effectiveness of expenditures across services and municipalities by using average costs based on re-

[6] In essence, this is a question of which comes first. The calculation of reductions in mortality for urban water supply or sewers alone assume that each change is made from the current level of coverage and, thus, are based on current mortality rates. If, instead, it were assumed that 100% urban water supply is achieved first, then the reduction in mortality resulting from a subsequent move to 100% urban sewers would start from a lower mortality rate and would be equal to the difference between the figure for 100% urban water and sewers combined and that for 100% urban water alone.

Table 2.2: Average Costs for Water Supply and Sewers

	Water supply	Sewers
Investment costs ($ per additional urban resident served)	150	220
Annualized total cost ($ per year per additional urban resident served)	30	25

cent projects in Brazil. Table 2.2 gives the average costs that have been assumed.

2.24 Note that the cost of sewers does not include any allowance for sewage treatment, since this is not strictly required in order to achieve the health benefits examined here.

2.25 The total investment cost required to provide piped water supply to all urban residents who did not have it in 1991 would be about $630 million, while that for extending sewers to all of the urban population without sanitation would be about $3 billion. The total annualized costs would be $126 million and $340 million per year respectively. The largest shares of both water and sewer investments would arise in Sao Paulo because of its size, but scaling by total urban population the investment per person would be much larger in Pernambuco than in the other states -- see Table 2.3 (at end of report).

2.26 It is possible to rank states and municipalities by the cost per DALY saved as a result of expanding access to water supply and sewers -- see Table 2.4 (at end of report). The average investment per DALY per year saved is $7,810 for urban water supply and $21,460 for urban sewers. Converting investment costs to annualized costs and allowing for operating cost narrows the relative difference somewhat with average costs of $1,560 and $2,440 per DALY on an annual basis, which will be used for the remainder of the analysis. Average costs per DALY saved vary substantially across states with Pernambuco having the lowest costs and Minas Gerais the highest costs for both urban water supply and sewers. Even so, the average costs per DALY saved for urban water supply are low relative to other practical interventions that might have a significant impact on the total burden of disease in these states.

2.27 There are large differences across municipalities within each state in the cost per DALY saved. The second half of Table 2.4 shows a simple distribution of costs per DALY saved across municipalities aggregated in terms of (a) the populations that would be covered by expanding urban water supplies and sewers, and (b) the numbers of municipalities in each category. The lowest class limit of $2,000 was chosen as a level that few, if any, would challenge as an acceptable cost per DALY saved per year. The upper class limit of $6,000 is slightly greater than twice the minimum wage and GDP per person in 1991, which fell in the range $2,700-2,900 per year at the average exchange rate for the year. It is reasonable to assume that the minimum willingness to pay for a DALY saved will fall in this range.

2.28 About 64% of all urban residents without piped water live in municipalities for which the annualized cost per DALY saved is less than $2,000. Thus, it is easy to conclude that providing most urban residents with access to piped water should be the first priority for reducing the burden of disease and ill-health via investments in water and sanitation. The slightly lower share of municipalities for which the average cost per DALY saved was less than $2,000 indicates that it is the municipalities with the largest number of people without urban water supplies which have the lowest average costs per DALY saved.

2.29 The picture is more mixed for expenditures on sewers. The average cost is higher than for water supply, but there are a significant number of municipalities for

which the annualized cost per DALY is less than $2,000. This is particularly the case for Pernambuco and Rio de Janeiro where 40% and 55% respectively of urban residents without sanitation. Most urban residents without sanitation live in municipalities for which the annualized cost falls in the range $2,000 to $6,000 per DALY. Since the overall size of the population without sanitation is much higher than that without piped water, the number of people who would be covered by giving priority to municipalities in the lowest category (< $2,000 per DALY) would be large -- over 3.4 million in total with over 1.5 million in Rio de Janeiro, over 1.3 million in Pernambuco, and over 0.4 million in Sao Paulo.

2.30 At the other end of the scale there are only 9% of urban residents without sanitation living in municipalities for which the average cost per DALY saved exceeds $6,000. This proportion varies from 0.1% in Rio de Janeiro to 24% in Minas Gerais. The median cost per DALY saved is just under $3,000 and even the state median values for the highest cost state -- Minas Gerais -- is under $4,000.

2.31 Table 2.5 shows the cost per DALY saved by expenditures on urban water supply and sewers for a sample of 17 large urban municipalities in the 4 states. The sample was constructed by taking all municipalities with a population greater than 200,000 which had *either* at least 25,000 urban residents without piped water in the 1991 Census *or* at least 100,000 urban residents without sanitation. The 17 municipalities account for about 30% of urban residents without piped water and/or sanitation. The annualized cost per DALY saved by expanding urban water supplies ranges from $910 for Campos in Rio de Janeiro to $2840 for Campinas in Sao Paulo. The same two cities also have the lowest and highest costs per DALY saved by expanding urban sewers at $1,350 for Campos and $4,010 for Campinas. For most of these municipalities, the cost per DALY saved for sewers falls in the range from $2,200 to $3,200.

WILLINGNESS TO PAY FOR URBAN WATER AND SEWERS

2.32 There are two, partially overlapping, aspects of the benefits generated by expenditures on water supply and sewers that must be weighed against the costs involved. The first is the general community's willingness to pay for infrastructure improvements that generate health benefits in the form of a lower burden of disease and infant mortality. The second is the willingness of individual households or neighborhood groups of households to pay for the convenience and better quality of life that is associated with access to piped water and sewers. There is an overlap between the two to the extent that households or groups of households allow for a reduction in the risks of ill-health or infant mortality that they face in evaluating their willingness to pay for water or sewer services. The extent of the overlap is uncertain, but it is clearly not complete. The risks of some kinds of epidemics or of exposure to water-borne disease via the consumption of contaminated food or water extend far beyond the immediate neighborhood effects that may be taken into account by individual households.

2.33 Classic studies of willingness to pay for a reduction in the risk of premature mortality tend to generate estimates for the US that are equivalent to $3-7 million per so-called statistical life -- i.e. the product of the change in the probability of death times the number of people at risk. Converting this into DALYs depends on the age of those at risk. Most studies are based on risks that are faced by people in an age range from 30 to 60 years old. The average number of DALYs lost per death will fall in the range from 28 (for the youngest) to 12 (for the oldest), so that it is reasonable to use

a mid-point value of 20 DALYs per statistical death. On this basis, the value of a statistical life would be at least 6 times US GDP per person per DALY saved. This is much higher than one would expect from a model of willingness-to-pay based on a simple model of individual behavior, but is not so far out of line with the results of a model that takes account of life cycle and intergenerational transfers.[7]

2.34 Even if the value of a statistical life were set at only $1 million for the US (equivalent to twice the level of GDP per person per DALY saved), this would imply an average willingness to pay per DALY saved for Brazil of about $5,500 in 1991. This is well above the annualized costs per DALY saved by expanding urban water supplies and sewers for all but a small number of municipalities.

2.35 Surveys of household willingness to pay for piped water and sewage removal consistently suggest that people are willing to pay in the range of 2-3% of household income for each service. Typically, willingness to pay for piped water is somewhat higher than that for sewage removal. With a median household size of about 4 for urban households, the annualized cost of piped water is $120 per year and of sewers is $100 per year. It is reasonable to assume that willingness to pay for piped water is 3% of household income and for sewers is 2%. On this basis, household willingness to pay exceeds the costs of supplying piped water if household income is greater than $4,000 per year or 3.2 times the minimum wage in 1995, while the similar threshold for sewers is $5,000 per year or 4 times the 1995 minimum wage.

2.36 The 1995 National Survey of Household Expenditures reports the number of households by income group expressed as multiples of the monthly minimum wage. Interpolating these income groups and excluding households which did not reply to the income question, about 38% of households had incomes less than 3.2 minimum wages and 44% had incomes less than 4 minimum wages. The shares will be higher -- perhaps much higher -- for those which did not have piped water or sewers in 1991. Hence, the case for expanding piped water and sewer services to the large number of urban residents without them must rest as much on the general community benefits of reducing the burden of ill-health and infant mortality as on the willingness to pay of the households which would be covered by the expansion of services. This has important implications for the ways in which basic sanitation services might or should be financed.

SUMMARY

2.37 The health benefits that would be generated by expanding urban water and sewer services are large. For 4 states, the analysis shows that it should be possible to avoid over 3,000 deaths of babies and young children each year and to reduce the burden of disease by nearly 220,000 DALYs (disability-adjusted life years) each year. The largest impact at lowest cost would be achieved by concentrating on ensuring that the entire urban population has access to piped water at average cost of $1,560 per DALY.

2.38 Whether this expenditure can be justified on health grounds alone is open to

[7] See pp. 56-57 of Murray and Lopez (1996). Note that Murray focuses on the issue of whether non-uniform age weights should be used in constructing the DALY calculations. These are already implicit in the results reported above. However, his calculations also show that the social willingness to pay model generates estimates of willingness to pay to avoid a death at specific ages that may 3-4 times the product of DALYs lost as a result of that death time consumption per person.

debate. The cost per DALY saved is high by comparison with most health interventions examined in the 1993 *World Development Report* on health, because it is cheaper to give oral rehydration therapy to babies suffering from diarrhea than to reduce the incidence of such episodes by expensive investments in infrastructure. On the other hand, it may reasonably be argued that the ranking of other health interventions should be adjusted to take account of the (usually) low shares of episodes to which the relevant intervention is actually applied. In that case, investments in water infrastructure may be seen as a justifiable and practicable use of resources to improve public health.

2.39 The average cost per DALY saved by expanding urban sewers is higher at $2,440, but is still well below a reasonable estimate of willingness to pay to save a DALY in Brazil. In addition, investments in both urban water supplies and sewers generate substantial non-health benefits as reflected in the willingness of households to pay for these services. When these are taken in account, the benefits of extending urban sewers to cover almost all of the urban population are likely to substantially outweigh the costs involved. Thus, the question to be addressed next is how such an expansion in services can be financed.

References

Esrey, S.A. et al - "The health and economic benefits following improvements in water and sanitation" (Arlington, Va : WASH Report, US-AID; July 1989).

Esrey, S.A., J.B. Potash, L. Roberts, and C. Shiff - "Effects of improved water supply and sanitation on ascariasis, diarrhea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma," *Bulletin of the World Heath Organization*, Vol 69 (5), 1991, pp. 609-621.

Murray, C.J. and A.D. Lopez (eds) - *The Global Burden of Disease* (Cambridge, Mass : Harvard University Press, 1996).

VanDerslice, J. and J. Briscoe - "All coliforms are not created equal : a comparison of the effects of water source and in-house water contamination on infantile diarrheal disease," *Water Resources Research*, Vol 29 (7), 1993, pp. 1983-1995.

Table 2.3: Impact Of Urban Water Supply And Sewers On Health By State

	Total	Minas Gerais	Pernambuco	Rio de Janeiro	Sao Paulo
Total population 1991 ('000s)	66,732	15,631	7,097	12,720	31,284
Urban population 1991 ('000s)	57,895	11,704	5,028	12,117	29,046
No of children under-5 1991 ('000s)	6,823	1,710	850	1,151	3,113
No of under-5 deaths in 1991 ('000s)	63.9	10.9	10.8	14.9	27.3
Reduction in under-5 mortality ('000s per year) due to :					
100% urban water supply	1.68	0.17	0.37	0.77	0.37
100% urban sanitation	3.01	0.45	0.99	0.83	0.74
100% urban water supply & sanitation	4.57	0.61	1.32	1.54	1.10
Reduction in total DALYs ('000s per year) due to :					
100% urban water supply	80	8	18	37	18
100% urban sanitation	144	22	47	40	36
100% urban water supply & sanitation	219	29	63	74	53
Increase in urban population served ('000s) by water supply and/or sewers for :					
100% urban water supply	4,186	723	695	1,679	1,088
100% urban sanitation	13,529	3,252	3,391	3,026	3,860

Table 2.4: Cost Per DALY Saved By Expanding Urban Water Supply And Sewers

	Total	Minas Gerais	Pernambuco	Rio de Janeiro	Sao Paulo
Average investment per DALY per year saved ($)					
Urban water supply	7,810	13,570	5,880	6,840	9,120
Urban sewers	21,460	33,620	16,320	17,990	24,470
Average annualized cost per DALY saved ($)					
Urban water supply	1,560	2,710	1,180	1,370	1,820
Urban sewers	2,440	3,820	1,850	2,040	2,780
% of urban population without water supply in municipalities with annualized cost per DALY for urban water supply in range :					
< $2,000 per DALY	64	19	80	84	55
$2,000 - $6,000 per DALY	31	64	14	16	44
> $6,000 per DALY	5	17	6	0	1
% of urban population without sanitation in municipalities with annualized cost per DALY for urban sewers in range :					
< $2,000 per DALY	25	3	40	51	12
$2,000 - $6,000 per DALY	66	73	52	49	84
> $6,000 per DALY	9	24	8	0	4
% of municipalities with annualized cost per DALY for urban water supply in range :					
< $2,000 per DALY	30	17	69	73	29
$2,000 - $6,000 per DALY	46	54	14	26	49
> $6,000 per DALY	24	29	17	1	22
% of municipalities with annualized cost per DALY for urban sewers in range :					
< $2,000 per DALY	15	6	55	39	11
$2,000 - $6,000 per DALY	57	56	25	60	68
> $6,000 per DALY	28	38	20	1	21

Table 2.5: Cost Per DALY Saved For Large Urban Areas

Municipality	State	Urban population ('000s) without:		Annualized cost per DALY saved ($) by:	
		Piped water	Sanitation	Piped water	Sanitation
Belo Horizonte	MG	41	262	2,310	3,270
Contagem	MG	13	145	2,070	2,990
Jaboatao	PE	44	310	1,810	2,720
Olinda	PE	27	156	1,850	2,730
Recife	PE	69	621	1,950	2,860
Campos	RJ	74	158	910	1,350
Duque de Caxias	RJ	132	264	1,170	1,750
Niteroi	RJ	101	62	2,260	3,320
Petropolis	RJ	134	221	1,370	2,260
Rio de Janeiro	RJ	132	430	2,270	3,170
Sao Goncalo	RJ	165	263	1,880	2,800
Campinas	SP	25	92	2,840	4,010
Carapicuiba	SP	11	114	1,970	2,870
Guaralhos	SP	104	195	1,600	2,330
Moji des Cruzes	SP	30	41	1,820	2,720
Sao Paulo	SP	96	779	2,250	3,160
Sumare	SP	16	136	2,170	3,250

3. MOBILIZING PRIVATE FINANCE FOR WATER AND SANITATION SERVICES[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

SUMMARY OF ISSUES AND RECOMMENDATIONS
Providing safe water to the currently unserved urban population should be straightforward. Also, ensuring adequate rural water supplies is more an institutional than a financial problem.
The major challenge is to provide access to reasonable sanitation for up to 40 million urban residents -- over 35% of the urban population -- who have neither sewer connections nor septic tanks. Also, in the long term, it is desirable to replace septic tanks by sewer connections because many septic tanks are overloaded and discharge a substantial pollution load to groundwater or, indirectly, local streams.
Both states and companies rely primarily upon the availability of subsidized investment funds either from the federal government or from multilateral lenders to finance new investments. This creates perverse incentives, which encourage a 'boom and bust' pattern of investment spending.
There is little likelihood that state water companies or state finances will permit the scale of investments in urban sanitation required over the next two decades to fill existing deficits in sewer coverage and to meet the expansion in demand due to the growth in urban populations.
Attention has been turning increasingly to the role that might be played by the private sector in both improving the operational efficiency of water and sanitation companies and in providing the finance required to meet current and future demands.
Concession arrangements are likely to be the best mechanism for mobilizing private finance to expand the coverage and improve the quality of water and sanitation services in Brazil.
Access to financial resources is less important than operational skills and managerial competence in determining the likelihood that a concession operator will meet its service obligations, so that pre-qualification and selection criteria should not rely too heavily on the financial resources of potential bidders.
Contracts must be carefully designed to minimize the chances of later renegotiation and proper arrangements for monitoring contract performance and regulating operators must be established.
In most cases, the preferred option should be the creation and award of concessions to private operators on the basis of clear service and environmental targets (after a competitive bidding process in terms of the lease payment for the use of existing assets).

THE PROBLEM

3.1 The analysis in Annex 2 has demonstrated that expenditures on expanding access to water and sanitation services rank among the most cost-effective options for reducing the burden of ill-health and disease in Brazil. The primary focus was on urban water and sanitation, as this is the largest problem in terms of the number of people affected and the total investment required. Still, rural water supplies should not be neglected, since there is ample evidence that ensuring the availability of piped water sup-

[1] This paper was prepared by Gordon Hughes.

plies can contribute much to reducing infant mortality and improving the quality of life for rural communities. Lack of rural water supplies is closely linked to poverty problems and is primarily concentrated in the North-East.

3.2 Providing water supplies for poor rural populations is more an institutional than a financial problem. In aggregate terms, the costs involved are modest -- IPEA estimated an investment cost of US $2.8 billion over the 20 years 1992-2011 -- but it is difficult to get the incentives right. State water companies with cumbersome organizations and high costs have mostly not been interested in devoting much effort to rural water supplies, while municipal and communal authorities may find it difficult to maintain the organizational and technical capacity to operate such services. There may, therefore, be a case for establishing specialized rural water agencies (or cooperatives) -- along the lines of rural electrification utilities in many countries -- at either state or meso-region level.

3.3 It is frequently assumed that heavy subsidies are required for the provision of rural water supplies in Brazil. This runs counter to the results of detailed studies in various parts of the world, though the size of the populations to be served can be a significant factor. However, if subsidies are necessary they can be provided through mechanisms which provide better incentives to lower costs, improve quality of service, and expand coverage than under present arrangements.

3.4 Ensuring access to piped water supplies for almost all of the urban population should be more straightforward. For the country as a whole, the number of urban residents without piped water was about 15.2 million in 1991. The total investment required to expand urban piped water supplies to cover these people would be about $2.3 billion, though additional investment will be required to maintain 100% coverage as the urban population grows over the next 15 years. Further, as noted above, most urban households are willing to pay sufficient amounts to cover the marginal costs of urban water supplies. Given an appropriate set of prices and incentives, a set of competently managed and efficient urban water utilities should have no difficulty in reaching a target of 98% or 99% access to piped water supplies for all households in their service area within a period of 5 years at most. No special financial mechanisms should be required, since the investment is substantially less than the cash flow available under any reasonable financial structure.

3.5 The scale of the urban sanitation problem is altogether different. IPEA's estimates of investment needs for 1992-2011 amount to US $23.5 billion, which covers both sewers and sewage treatment. However, it is important to distinguish the various categories within this overall total, since the urgency of the problem and options for financing the investments required are very different.

3.6 Reducing mortality rates and improving the general health of the urban population depends on ensuring that fecal material is sufficiently removed from the immediate environment to provide reasonable protection from exposure to pathogens and parasites. For this, septic tanks can be a satisfactory substitute for sewers if they are properly installed in medium or low density urban areas. Thus, the first priority should be to provide access to reasonable sanitation for up to 40 million urban residents -- over 35% of the urban population -- who have neither sewer connections nor septic tanks.

3.7 In the longer term, it is desirable to replace septic tanks by sewer connections because many septic tanks are overloaded and discharge a substantial pollution load to groundwater or, indirectly, local streams. At

present, about 20% of the urban population is estimated to rely upon septic tanks.

3.8 There is a substantial deficit of sewage treatment relative to sewage collection, so that most sewage is discharged to receiving waters with little or no treatment. The extent to which this is a serious problem varies from place to place. The health costs associated with the discharge of untreated sewage are small and easily avoided -- though this implies some loss of amenity and economic output from, for example, fisheries. The amenity costs may be larger but depend upon the population's willingness to pay to protect bathing beaches and to avoid exposure to the offensive smells and other consequences of using drainage canals and rivers as open sewers.

3.9 Finally, there is the need to invest in water and sanitation systems in order to keep up with the growth of the urban population. The sanitation component of this item accounts for nearly US $10 billion for 1992-2011.

3.10 The financial position of many state water companies is dire. Typically they have relied upon inflationary accounting practices to preserve their balance sheets, so that the balance between current operational revenues and expenditures allows limited resources for debt service, let alone for financing new investments. Neither are the states which own them any more creditworthy. As a result, both states and companies rely primarily upon the availability of subsidized investment funds either from the federal government or from multilateral lenders to finance new investments. This creates perverse incentives, which encourage investment in new areas rather than the maintenance and improvement of existing assets, as well as a 'boom and bust' pattern of investment spending.

3.11 There is little likelihood that state water company or state finances will permit the scale of investments in urban sanitation required over the next two decades to fill existing deficits in sewer coverage and to meet the expansion in demand due to the growth in urban populations. Thus, attention has been turning increasingly to the role that might be played by the private sector in both improving the operational efficiency of water and sanitation companies and in providing the finance required to meet current and future demands.

OPTIONS FOR PRIVATE SECTOR FINANCE

3.12 There are a variety of arrangements under which responsibility for operating an existing system and managing investments in expanding services is transferred to private operators. In some cases, the private operator may be required or choose to finance certain categories of investment which have short payback periods. Contract terms may extend from 5 to 10 years with the payment to the operator being linked to improvements in indicators of operating performance such as unaccounted for water, costs per connection or per cubic meter of water, etc. The French system of 'affermage' is, in practice, equivalent to a *performance contract*, since the concedent retains a decisive role in medium and longer term investment plans together with the responsibility for raising the necessary finance, perhaps via issuing municipal bonds.

3.13 In general, performance contracts are most appropriate when the primary concern is to ensure efficient management of a water and sanitation system which does not require significant investments in expanding its facilities or the population served. The experience of performance contracts in developing countries where large investments are usually required has not always been satisfactory, often because of divergent expectations and incentives between the authorities which grant the contract and the contractor. For example, it can be very dif-

ficult to settle disputes over responsibility for cost over-runs in large investment projects, since it will usually not be clear how much is due to changes in specification and how much to deficiencies in construction management. Such difficulties are particularly likely to arise when contracts are taken on by consortia whose members have divergent interests. Experience shows that consortia that bring together companies whose primary interest is construction with others interested in supplying goods and services and with operators may be especially prone to conflicts of this nature.

3.14 Contracts for the construction and operation of production facilities - *Build-operate-transfer (BOT) contracts* -- are a standard feature of the energy sector and are becoming more widespread in transport and water. A common variant is one under which projects are financed on the basis of long terms purchase agreements for 80-90% of the capacity of the facility. The development of power plants and, even more, gas transmission pipelines by independent operators, i.e. those which are not part of vertically-integrated utilities, rely heavily upon such arrangements. For the water and sanitation sector this implies that BOT contracts are most suitable for large water supply systems such as reservoirs, transmission pipelines, and water treatment plants or for sewage treatment. However, it is difficult and unusual to rely upon BOT-type contracts for distribution services including both household water distribution and sewage collection. Typically, these account for the major share of the total costs of providing water and sanitation services, so BOT arrangements are, at best, only a partial solution to the financial and operating problems facing the sector in Brazil.

3.15 Since BOT-type contracts are relatively familiar to both operators and financial institutions, it is often assumed that large investments can be financed more easily via BOT contracts than by other arrangements. In fact, the reverse is closer to the truth. There are two great problems which face those raising finance for BOT projects.

3.16 The debt will usually be secured against the value of the contract to supply water or sewage treatment services, not against the assets of the contractor. Thus, the appraisal of the project's credit risk will depend primarily on whether the ultimate purchaser is creditworthy and contractual arrangements for guaranteeing payment. A variety of arrangements to mitigate this risk have been used -- for example, escrow accounts for a portion of revenues for water or sanitation services. None of these can get around the difficulties of dealing with a nearly insolvent utility whose tariffs are too low or which is dramatically inefficient. In such cases, it is the government which owns that company that will be seen the ultimate borrower -- via guarantee or other provisions -- in which case the BOT contract is no more than a combination of a government-guaranteed loan with a performance contract. This will not solve the problems faced by governments which are uncreditworthy and unable to finance investments in extending water and sanitation services.

3.17 Currently, most financial institutions view the risks associated with water and sanitation projects as being high. Thus, the cost of capital for these projects will be high -- at least 18-20% p.a. in real terms -- though this will fall if experience over the next 5-10 years is positive.

3.18 A full *concession contract* represents a combination of the characteristics of performance and BOT contracts. In effect, the concessionaire leases the existing assets of the system being concessioned and is then expected to invest in expanding services to meet specific targets. The length of concessions may run from 20 years if the investment commitment is relatively small

to 50 or even 100 years if very large capital expenditures are needed.

3.19 Care in designing the concession contract is critical to the success of a concession arrangement. Too often this has been neglected. One approach is to spell out general objectives and procedures, while leaving the details to be worked out between the concessionaire and the concedent as specific issues arise. In practice, there will be frequent renegotiations of the terms of the concession, so that the outcome will be close to what might be expected under an 'affermage' type of performance contract. This approach can be satisfactory if the main concern is to improve the operation of an existing system rather than financing the expansion of services. There are a number of examples of concession contracts of this kind in Brazil. Experience has been mixed, but there have been some notable failures arising out of different expectations on the part of the concedent and the concessionaire or difficulties in raising finance for investment where the obligations and rights of the concessionaire are unclear and open to reinterpretation.

3.20 At the other end of the spectrum is a contract which specifies service targets, financial obligations, and other requirements in considerable detail together with procedures for the intermittent review and revision of certain provisions of the contract to take account of changing circumstances. In defining the terms of the contract, the following issues need detailed consideration :

A. What should be investment obligations of the concessionaire or, equivalently, what should be the target for expanding the coverage and level of services?

B. What environmental targets should the concession meet? In particular, how should the utility deal with the sewage that is collected by its sewage collection network, and what water quality standards should apply to the water which it supplies?

C. What should be the arrangements for reviewing and, if appropriate, modifying the provisions of the contract? How frequently should such review occur and what rules should govern the adjustment of tariffs or other financial provisions of the contract if service targets and other obligations are varied?

D. What penalties should apply if the concessionaire fails to comply with the terms of the contract? Under what circumstances can a concession be terminated early and what compensation, if any, should be paid if the concession is abrogated?

E. What happens at the end of the concession period? Can the concession be extended without a rebidding process and, if so, what criteria will apply in deciding whether to extend the concession? If the concession terminates, what provisions should there be to compensate the concessionaire for a part of the costs of investments made in the later years of the concession? Without such compensation the concessionaire will seek to minimize investments and, possibly, maintenance expenditures in the final 10 or even 15 years of the concession.

3.21 All of these issues impinge upon the financial viability of the concession and on the prospects of attracting bidders for the concession with the financial capacity to fund the necessary investment program. Thus, there are close links between defining the regulatory and legal framework that will govern the operation of the concession and assessing the financial implications of service and environmental obligations. Whether explicitly or not, trade-offs will have to be made between what can be achieved in different areas. Is it more important to expand the water supply or sewage collection networks rather than to upgrade the quality of

water supplied or the level of sewage treatment? How far can tariffs be raised in order to finance better services? Relying upon private sector finance may improve the efficiency of water and sanitation utilities, but it does not avoid the necessity of making difficult choices about priorities and the affordability of different goals. Indeed, involvement of the private sector may appear to exacerbate the conflicts that have to be resolved -- at least temporarily -- because the scope for fudging the options is limited by the necessity of providing clear guidelines as the basis for financial planning by bidders and the ultimate concessionaire.

3.22 A variety of mechanisms for awarding concessions have been tried. In general, the ease and transparency of the process is a direct function of the amount of work that has gone into preparing the concession contract. Vague and poorly-prepared concessions result in a beauty contest, since the obligations of the concessionaire are ill-defined and there will be a great deal of scope for differences in evaluating the proposals submitted by different bidders. A better approach is to rely on a two step process involving an initial technical pre-qualification stage followed by the submission of financial proposals that are evaluated on the basis of a single criterion variable.

3.23 However, even this can go wrong if those responsible for the design and award of a concession try to impose inappropriate technical or other requirements on the technical proposals or financial bids. A concession contract is not a contract for carrying out public works, rather it is a contract for the delivery of certain services to the population according to specific service standards and other obligations. Thus, the technical pre-qualification stage should not require that bidders provide full technical plans for how they intend to fulfill the service obligations of the contract. In any case, such plans cannot possibly be binding because the circumstances under which concessions are awarded mean that neither the bidders nor, indeed, the concedent will have the information about the existing system required to develop detailed plans. Similarly, the evaluation of the financial bids should, as far as possible, avoid any attempt to judge the commercial basis for each bid. In other concession or franchise competitions major disputes have been prompted by the disqualification of bids that did not correspond to the technical or financial expectations or preconceptions of those responsible for evaluating proposals.

3.24 There is a genuine problem that must be acknowledged. It is usually difficult, expensive, and slow to terminate a concession contract when the concessionaire is failing to honor its requirements. The consequences of a concessionaire going bankrupt as a result of a misjudged concession bid may even worse. Thus, the cost of making a mistake when awarding a concession contract can be high. Politically, the concedent will be less willing to take risks that might be regarded as commercially acceptable, so that the process is bound to err on the side of caution and conservative technical or financial proposals. On the other hand, it is important to encourage competition, new approaches, and some degree of risk-taking so long as the rewards to innovation are high enough.

3.25 Probably the best way of dealing with this is to transfer much of the burden of assessing the technical and financial feasibility of proposals to those better placed to bear the cost of risks involved. This may be achieved by devising an appropriate structure of non-performance penalties. Too little thought has been given to the incentives implied by different types of performance bonds and penalties in water and sanitation concessions, perhaps because of a reluctance to invoke them in practice. Minor or temporary infractions should not be heavily penalized, but a concessionaire which ex-

hibits a consistent pattern of failing to meet its contractual obligations should be subject to increasingly heavy penalties. Similarly, contracts should require substantial performance bonds and should contain clear provisions about the circumstances under which the bonds will be called upon. This will ensure that the financial guarantors who stand behind bids have a strong incentive to undertake an independent evaluation of proposals.

3.26 The choice of the financial criterion for awarding the contract will also have an important impact on the bidders' incentives. Two main alternatives have been used:

- an annual lease payment (or, perhaps, the capitalized value of the stream of such payments) for a fixed level of tariffs; or
- a base tariff level to which the whole tariff structure is linked for a fixed (usually zero) lease payment.

3.27 The core issue is how the implicit lease value of the assets that the concessionaire takes over is to be allocated. In both cases a part of this value may be used to finance the expansion of services while charging a uniform level of tariffs to all consumers. Under the tariff bidding process, the concedent foregoes most or all of this implicit value in order to hold down the level of tariffs required to expand services. As a result, the level of tariffs paid by new users may often be less than the marginal costs of expanding the network and supplying the water which they consume or dealing with the sewage that they discharge. Thus, the concessionaire has an incentive to delay the expansion of the network or to focus their investments on serving areas which are expected to generate the highest levels of net revenue per connection.

3.28 Under the lease payment bidding process, the concessionaire will be encouraged to accelerate the expansion of the network, as its lease payment is fixed so that its incentive is to maximize revenue provided that the tariff covers the marginal cost of serving new connections. However, this arrangement can also mean that the concession is regarded as a riskier financial proposition, which may affect the concessionaire's required rate of return on capital and the viability of the project. In most cases, the lease payment process is the better option because its incentive structure can be more closely linked to the priority goals established for the concession and the performance bond can be tied to a pre-payment of some portion of the lease payments into an escrow account.

3.29 A final option for the involvement of the private sector is *privatization*, similar to the structure adopted in England and Wales. In the case of Brazil, this would involve the grant of a very long – e.g. 999 years – but non-exclusive concession to operate water and sanitation services in a defined area to a private company created by transferring some or all of the assets of the existing state or municipal water company. Shares in the new company could be offered for sale, either via a stock exchange flotation or/and by a tender open to trade purchasers. The original state or municipal owners might choose to retain shares in the privatized company for later sale.

3.30 The practical differences between awarding a full concession and privatization are limited, since the basic regulatory structure and obligations imposed on the operator would be very similar. Privatization enables the current owners to put an immediate market valuation on the assets of state or municipal water companies. This may be important if the initial ownership structure is complex and there is pressure to transfer some of these assets from, for example, a state water company to municipalities. Tariffs for the services supplied by the privatized company should be based on the mar-

ginal and average costs of providing these services, since the option of using the lease value of existing assets to cross-subsidize tariffs for new customers would be neither efficient nor sustainable.

3.31 When evaluating alternative mechanisms for mobilizing private finance for investment in expanding water and sewer networks or in building treatment plants, it is important to understand the reasons why external finance is required at all. The basic fact is that an established and well-run water utility should not need large amounts of external finance, unless either (a) it is being expected to meet a new set of goals – perhaps as a result of stricter environmental standards – or (b) there has been a radical shift in the external financial environment that affects its balance sheet. Without such changes, water and sanitation companies are usually able to finance the expansion of their networks and treatment plants out of their operational cash flow after an initial period of relying upon external finance to develop a core distribution network.

3.32 As will be seen, most Brazilian water companies are not well-managed, but equally the public expects them to deliver a higher quality of service to many more people at a time when macroeconomic stabilization has eliminated the inflationary mechanisms which underpinned their balance sheets in the past. Thus, a period of reliance upon substantial external finance should accompany a temporary phase of correcting the mistakes of the past, equivalent to that when the companies were first established. Indeed, some companies may not require external finance at all if they can rapidly bring their ratios of operating costs to revenues down to a level more typical of the more efficient water utilities in the rest of the world.

3.33 BOT investments rely upon project financing and are, thus, primarily suitable for circumstances where large lumpy investments are required for the construction of new sewage or water treatment plants. Even then, a BOT contract may only be attractive if the operator is able to hold down construction and/or operating costs sufficiently to outweigh the additional expense of relying upon project rather than cash flow financing. In contrast to the power sector, there are almost no cases where an efficient water and sanitation concession has chosen to contract out the construction and operation of a large treatment plant under a BOT-type contract in preference to financing and operating it itself.

3.34 Two important conclusions may be drawn from this analysis:

- concession arrangements are likely to be the best mechanism for mobilizing private finance to expand the coverage and improve the quality of water and sanitation services in Brazil; and

- access to financial resources is (much) less important than operational skills and managerial competence in determining the likelihood that a concession operator will meet its service obligations, so that pre-qualification and selection criteria should not rely too heavily on the financial resources of potential bidders.

Example 1 : Rio de Janeiro

3.35 CEDAE, the state water company of Rio de Janeiro, is the second largest water company in the country (after SABESP), but its performance in terms of physical and financial indicators is typical of the sector as a whole. By international standards it is inefficient – with about 420 households served per employee, about 50% unaccounted for water, and nearly 20% of water and sewerage bills not being collected – and its financial position is very precarious. Despite high tariffs the company is barely able to service its debts and it is not generating

anything like the level of cash flow that should be available to finance the expansion in services that is required. Further, like other water companies in Brazil, it relies in part on a structure of tariffs that allows it to charge for sewerage services which it often does not supply. Thus, any large expansion in its sewer network will worsen its financial situation by increasing its operating costs and debt service obligations without any commensurate increase in revenues.

3.36 The main operations of CEDAE are concentrated in the metropolitan region of Rio de Janeiro and lie within the water basin of Guanabara Bay. Water quality in the bay has been deteriorating and, despite a large program of investment in basic sanitation with sewage treatment, is not likely to improve in the immediate future. Millions of people live in the poorer suburban areas of Rio de Janeiro located in a flood plain on the north-west side of the bay – the Baixada Fluminense – without access to piped water or sewers. Investments in water supply and sewer network plus limited sewage treatment in this area will produce large health and environmental benefits for these communities as well as the whole metropolitan region.

3.37 In the recent past, the company has relied primarily on federal and multilateral loans to finance its investment programs. The fiscal positions of the federal and state governments will not allow a continued expansion in this kind of debt, especially if the company's performance means that they are obliged to take on some or all of the associated debt service. Thus, the state government has decided that the company must be restructured in order to (a) establish the framework for expanding water and sanitation services to areas of the state that have been neglected until now, (b) improve the operational and environmental performance of the sector, and (c) provide a secure financial base for water and sanitation utilities in the state.

3.38 In legal terms, CEDAE operates on the basis of concessions to provide water and sanitation services granted either by municipalities or by the state government (or its predecessors). Many of these concessions have expired or will shortly expire, so that the approach being suggested to the state government is to create a small number (4 or 5) of large concessions in the metropolitan area and to 'municipalize' the sector outside the metropolitan area. About 80% of the population of the metropolitan area receive water from one very large water treatment plant – the Guandu plant – that serves 10 municipalities, while the remaining 20% of the population rely upon another integrated water supply system that covers 4 municipalities. Thus, decisions about the structure of water and sanitation services in the metropolitan region must take account of essential common interests, which provides the legal basis for concessions to be awarded by the state rather than municipalities. Outside the metropolitan area, the formal responsibility for awarding concessions lies with the municipalities. A number of large towns/cities already have municipal water companies independent of CEDAE. For reasons of operational efficiency and financial stability, it would be desirable that municipalities within water basins or sub-basins join together to award concessions with a minimum size of 100,000-200,000 people. To encourage competition between concessionaires no operator or major investor in a consortium would be allowed to hold more than one concession in the metropolitan area or (probably) more than 2-3 concessions in the state.

3.39 For each concession, service targets and other goals would be developed on the basis of detailed financial and environmental models. In the metropolitan region, the service targets would be designed to ensure that :

- 98% of households have access to piped water connections within 5 years;

- 90% of households have access to sewer connections within 10-15 years; and
- all sewage collected receives advanced primary treatment with phosphorus removal within 5 years, but secondary treatment will not be required prior to 2015 except, perhaps, in one or two special cases.

3.40 Currently, the tariffs – an increasing block structure with very high prices for commercial and other large users -- operated by CEDAE provides industrial plants with a strong incentive to rely upon groundwater drawn from their own boreholes. This is inefficient and poses long term dangers to the quality of groundwater due to the risks of salt water intrusion as a consequence of over-abstraction. Thus, the new concessions will be given the freedom to negotiate water and sewage tariffs for large consumers, though these consumers can opt to take supplies on the basis of the regulated tariff structure which will put a cap on the negotiated rates.

3.41 The basic tariff structure for the metropolitan region is being reviewed in order to encourage the expansion of water metering -- many households do not have meters and pay according to a schedule based on housing area – and to provide incentives for improvements in operational efficiency. The new concessions will not be permitted to charge for sewerage services unless they are supplied, but property owners may be required to connect to sewers passing within 10 or 20 meters of their property. Preliminary financial analysis suggests that each of the metropolitan concessions should be able to meet its service targets and pay a positive lease payment if the overall level of tariffs is reduced by 10-20%. At least initially, a uniform tariff structure will apply to all of the concessions in the metropolitan region, though this may change as a result of regulatory reviews during the life of the concessions.

3.42 One problem concerns the future of the Guandu treatment plant which will continue to provide bulk water supplies to 3 or 4 of the metropolitan concessions. The current proposal is that the plant should be vested in a new company owned by the state government as a minority shareholder – but with certain blocking rights – and the concessionaires for the concessions served by the plant. Since little investment is required at the plant, it would be operated under a performance contract that would awarded by the new company on the basis that none of the concessionaires could have an interest in the company that operates the plant. The plant would then supply bulk water to the concessions at a regulated price ex-treatment plant. In addition, transmission fees would be payable to the concession(s) responsible for maintaining and operating the main water transmission pipelines.

3.43 The state government will have to bear the costs of restructuring CEDAE and shedding excess workers, so that funds will be required to finance severance and early retirement payments. For this reason, the successful bidders for some of the concessions may be required to make lump sum payments at the beginning of their concessions. Once these have been determined, concessions will be awarded on the basis of the annual lease payment offered for the concession.

3.44 Water quality models for Guanabara Bay and Sepetiba Bay – the primary water basins affected by water pollution in the metropolitan region – are being used as the basis for establishing wastewater treatment goals for the concessions. This builds upon earlier work on the cost-effectiveness of measures to improve Guanabara Bay undertaken by the Bank and others. The working assumption is that it should be possible to achieve an 80% reduction in the damage-weighted load of pollution flowing in each bay within 10-15 years and a 90% reduction by 2020 without imposing exces-

sive costs on the concessions and their customers. The specific targets for each concession will be designed to improve the quality of receiving waters – including the rivers which flow into the bays – in a manner that is consistent with the primary goal of expanding the coverage of water supply and sewers at tariffs which ensure that efficient concessions can operate profitably and are affordable for households.

3.45 Based on the earlier analyses, it is already clear that it would not be appropriate to impose a uniform standard of secondary wastewater treatment for all of the concessions. It is possible that some level of BOD or nitrogen removal beyond that achieved by advanced primary treatment may be necessary in order to deal with specific environmental problems. Thus, the environmental goals for the concessions will be based on a flexible and gradual implementation of treatment standards with provision for review and, if necessary, revision of the goals at 5 or 10 year intervals in the light of additional information and analyses.

Example 2 : Piripama, Recife

3.46 The metropolitan region of Recife, Pernambuco, faces a rapidly growing imbalance between water demand and water supplies. The performance of the state water company, COMPESA, is little different from that of CEDAE, so that it is unable to finance the development of new water supply projects. As a result, it has been exploring the option of relying upon private finance to complete the development of a new reservoir, water treatment plant, and associated transmission system drawing upon the Piripama river to the south of the region. The company's water losses in 1995 were 54%. Its demand projections assume that these can be reduced to less than 30% within 7 years, though it is not clear how this is to be achieved under the present system of incentives and management. Even so, the water supply available from the current system and one other project nearing completion will only cover 60-70% of projected demand at that time. Hence, the state has invited proposals for a BOT-style contract to supply water from the Piripama reservoir to COMPESA over a period of 20 years.

3.47 The investment required is about $200 million for the reservoir, treatment station with a capacity of 5.6 m^3/s, and transmission pipes. Construction will require 2-3 years, but the projections assume that water supplied by the project will only reach 80% of full capacity after nearly 8 years of operation. The slow build-up of revenue from water supply means that the net cash flow from the project is unlikely to cover the full costs of debt service for several years, even though the bulk water price is 57.5 US cents per m^3 which is very high for such contracts.

3.48 A very preliminary project analysis suggests that the project might just be viable on current projections with an average cost of capital of 20%. However, the risks are high. Cost overruns or delays in completing the reservoir would greatly reduce the return on capital. On the other hand, if COMPESA fails to meet its targets for reducing water losses, then revenues in the early years will be higher than projected and the return will be significantly higher. In effect, any firm that undertakes the project is betting that it can control its development costs and that COMPESA will not be successful in reducing its losses.

3.49 Many features of the project suggest that neither COMPESA nor the state government appreciate the conditions required to develop a successful BOT project. The marginal cost of water under this scheme will be very high, yet the project will only be viable if less costly measures to meet some of the supply deficit have not been implemented. Indeed, this deficit will in-

crease rapidly after the project reaches full capacity, so it will be no more than a temporary stopgap. Further, large changes are required in the financial and operation management of water and sanitation services in the metropolitan area in order to achieve something close to 100% coverage of piped water and sewers.

3.50 In these circumstances it would be much more appropriate to follow the example of Rio de Janeiro by splitting the existing system into two or three separate subsystems and awarding concessions to private operators who will take complete responsibility for improving or expanding services. The Piripama project might then be completed – after review and, perhaps, redesign – by the concessionaires acting jointly or by one concessionaire that would have exclusive access to the water that it supplies. Financing the project as one part of a much larger investment program covering both treatment and distribution would be much easier and more satisfactory than relying upon a stand-alone BOT contract.

MEETING THE NEEDS OF THE POOR

3.51 In thinking about the problems of ensuring that the poor have access to water and sanitation services it is important to distinguish between the problems of (a) poor households and neighborhoods in medium and large urban areas, and (b) small towns and rural communities where most of the population are poor. In both cases, some form of implicit or explicit transfer from either higher income consumers or the government will be required, but this is usually easier to arrange within a single concession and tariff structure than between concessions.

3.52 The basic difficulty in devising tariff structures is that the bulk of the costs of providing water and sanitation services are fixed. Thus, an efficient pricing schedule would have a relatively large fixed element (monthly connection fee) plus a volume charge which reflects the marginal cost of supplying water or treating sewage. This means, of course, that low volume consumers -- who are assumed, not always correctly, to be poorer than medium or high volume consumers – pay a higher average price. The typical response is to create 'lifeline' tariffs for low volume under which the fixed cost is kept down by cross-subsidies from larger consumers.

3.53 In fact, the marginal cost of serving additional households is more complicated than this description suggests. A distinction can be drawn between the fixed costs of (a) extending a local distribution network and servicing each additional customer, and (b) building and maintaining the utility's trunk network and other basic infrastructure. The former will be referred to as the 'customer fixed cost' and the latter as the 'network fixed cost'. It is important that even the basic lifeline tariff should cover the customer fixed cost as well as the marginal cost of water consumed or sewage discharged. If this is not the case, then the operator will have no incentive to expand service coverage in areas where it expects that most customers will pay the lifeline tariff. Even if it does expand coverage in order to comply with its service obligations, it is likely to delay compliance as long as possible or may offer a minimal quality of service if this reduces costs.

3.54 The issue, then, is how the network fixed cost should be allocated across consumers. The tariff structure can be designed so that the smallest consumers make no contribution to this element of total fixed costs, while large consumers pay a substantial contribution. The allocation should not be loaded too heavily towards the largest consumers, since perverse incentives may be created if the average and marginal prices charged rise too steeply or are discontinuous -- particularly if water consumption is not

metered so that some proxy such living space is used instead.

3.55 For poor communities this approach may still result in tariffs that exceed willingness to pay. Then, external assistance will be required. Under a concession this could take the form of a negative lease payment, so that the government provides a subsidy to hold down the level of tariffs. Care is needed in structuring the lease payment, in order to create the right incentives for the operator, especially to serve the poorest or more remote communities. Probably the best approach is to start from an efficient tariff structure without subsidies. The actual tariff charged will be this base tariff less a subsidy calculated from a formula defined in terms of standard subsidy units, i.e. referring to the discount applied to the tariff for some specific tariff category. In the simplest case this would be the same for all tariff categories, so it would be equivalent to a uniform reduction in the network fixed cost that is charged. For more complex cases, such as concessions that cover dispersed rural communities as well as urban areas, the subsidy formula might give greater weight to rural inhabitants or to towns/communities whose average income falls below some threshold.

3.56 The advantage of basing the subsidies on a standardized unit is that bids for the right to operate a concession can be specified in terms of the required subsidy per unit without imposing the assumption that the subsidy is uniformly distributed over all consumers. The structure of subsidies should not be too elaborate, so as to avoid the danger that neither those who design the system nor the potential operators can really appreciate its consequences. On the other hand, a lump sum negative lease payment or a uniform subsidy for all consumers are unlikely to be consistent with appropriate incentives for the operator to serve the whole community.

CONCLUSIONS

3.57 Private sector investment is not a panacea for the problems of expanding water and sanitation services. Contracts must be carefully designed to minimize the chances of later renegotiation. Proper arrangements for monitoring contract performance and regulating operators must be established. All of this means that a large amount of preparatory work is required to establish targets, financial viability, tariffs, and regulatory structures. The aphorism 'more haste, less speed' applies very strongly to attempts to mobilize private finance for ill-designed projects or concessions.

3.58 Still, the general performance of state and municipal water companies in Brazil over the past 20-30 years has been lamentable. If the future is to be any better, each state government or municipality ought to be examining what role the private sector can play in operating and expanding water and sanitation services. In most cases the preferred option should be the creation and award of concessions to private operators on the basis of clear service and environmental targets after a competitive bidding process in terms of the lease payment for the use of existing assets.

4. INSTITUTIONS FOR WATER RESOURCE MANAGEMENT[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
In the past, stakeholders, such as industries and water and sanitation companies or civil society, have had no say in how to manage their water resources and render their use more sustainable.
Relatively broad consensus has emerged in Brazil on the principles of integrated water resource management at the lowest appropriate (typically river basin) level and treating water as an economic good.
Due to the erosion of state finances, state environmental agencies have suffered from a prolonged lack of funding which has substantially reduced their capacity to monitor compliance with regulations. Also, command-and-control mechanisms are too rigid and difficult to enforce.
While some states have passed laws to introduce the new water resource management strategy, practical implementation has been lagging behind.

STRATEGY AND RECOMMENDATIONS
The concept of a *social catchment* permits the interests of local stakeholders to be taken into account and relates their interests and incentives to the natural environment.
State agencies will continue to play a role in water resources management and will have to be involved with the implementation process of the new system from the beginning.
An agency provided with initial funding - preferably through stable multi-year budgets - can become financially independent once it has its own revenues through service provision and pricing.
Laws and implementation procedures should be simplified to minimize time and financial costs.
Since resources, both in terms of finances and in terms of qualified expertise, are scarce, management efforts should concentrate on areas where the benefits of management will be highest and where clear targets can be achieved. This includes determining pollution 'hotspots' in basins (and sub-basins) and making them a high priority.

INTRODUCTION

4.1 This chapter discusses institutional arrangements for water pollution control. The chapter begins by describing state of the art water resources management as it relates to pollution issues and places the current Brazilian framework into this context. Subsequently, a number of specific issues are discussed, such as basin vs. sub-basin management and the incentive structure for institutional change. The incentive structure is analyzed from two points of view. First, an attempt is made to identify the existing incentives for change. Second, once change has been decided upon, how can sustainable institutional arrangements be designed, taking into account, inter alia, stakeholder participation and financing. The chapter makes the point that although on paper Brazil is very advanced in basin and pollution management issues, in practice not much has happened to date largely due to the fact that the incentives to implement institutional change are very weak for some of the prin-

[1] This paper was prepared by Karin Kemper.

cipal actors. The chapter concludes with recommendations for further development of the institutional arrangements for water resources management in Brazil.

WATER RESOURCES MANAGEMENT AND POLLUTION CONTROL

4.2 Water pollution has two major impacts. First, it deteriorates water quality with detrimental effects on health, productivity and recreational value. Second, it decreases the availability of water since a polluted water source may not be suitable for certain uses. This is the case in the southeast of Brazil where increasing demand for water due to population growth and economic development has reduced the quantity of usable water.

4.3 To control pollution, adequate institutional arrangements must be in place. It is now widely recognized that a fragmented sectoral approach to water resources management is not successful. For example, in Agenda 21, elaborated under the auspices of the United Nations in 1992, a number of factors were stressed to improve water resources management worldwide. Three of the principles that evolved are as follows:

- Water resources management should take place in an integrated manner.
- Water resources management should take place at the lowest appropriate levels.
- Water should be treated as an economic resource that has an opportunity cost.

Brazil not only subscribes to the above principles, but was, in fact, a forerunner. In the 1980s, the Brazilian Association of Water Resources pushed for these principles which led to three practical implications, namely integration through management at the riverbasin level, taking into account the different uses and users of water; decentralization of decision making structures to appropriate levels, e.g. from the state to municipalities and other stakeholders within a riverbasin; and third, the pricing of water as a resource in order to provide incentives for more efficient water use, allocation and pollution control.

4.4 In addition, prior to UNCED, two Brazilian states, São Paulo and Ceará, had passed State Water Resources laws that were based on these principles. Other states[2] have since followed suit, and recently, a federal water resources law was passed confirming the standards set in the state laws and providing guidance for water resources management of federal rivers. Box 4.1 provides a summary of the key principles found in five Brazilian Water Resources Laws. Thus, conceptually Brazil might be considered a leader in terms of water resources management. In practice, however, the country has not advanced as much as could be expected.

4.5 To understand the causes of this gap between the conceptual and practical frameworks, one can begin by regarding the above principles as *instruments* used to achieve better water resources management, including pollution control. These principles, however, are very broad in scope and therefore are difficult to disagree with. The key issue is how to make them operational and to identify the obstacles that impede effective water resources management.

4.6 One obstacle is the need for a comprehensive institutional framework consisting of, on the one hand, institutional arrangements such as laws, legal norms, and regulations and, on the other hand, water

---

2 As of March 1997, the following states have water resources laws: Rio Grande do Sul, Santa Catarina, São Paulo, Minas Gerais, Distrito Federal, Bahia, Sergipe, Rio Grande do Norte and Ceará. The states of Rio de Janeiro, Goiás and Pernambuco are preparing laws.

Box 4.1: Principles Contained in Most Brazilian Water Resources Laws

- Federal/State Water Resources Council with representation of government, municipalities and other interested parties (water users, civil society)
- river basin as entity for integrated management and planning
- water as a public good with an economic value
- water pricing
- basin committees with representation of the state, municipalities and other interested parties (water users, civil society)
- basin agencies with executive functions

users as well as entities such as state agencies and organizations, NGOs, research institutes etc. The former can be regarded as the arrangements that provide guidance and incentives to the latter, who are the actors. In traditional systems, water users have had no say in determining the framework. They have merely been dependents. In the new evolving frameworks, however, water users are recognized as stakeholders and interact officially with rule-making entities, and consequently, can have an influence on norms and regulations as well as facilitate institutional change (see Fig 4.1).

4.7 In the following section, Brazil's current institutional framework for water pollution control is briefly examined, followed by a brief description of the country's goals as exemplified by the laws that have already been passed, and an analysis of obstacles - and successes - concerning the operationalization of these laws.

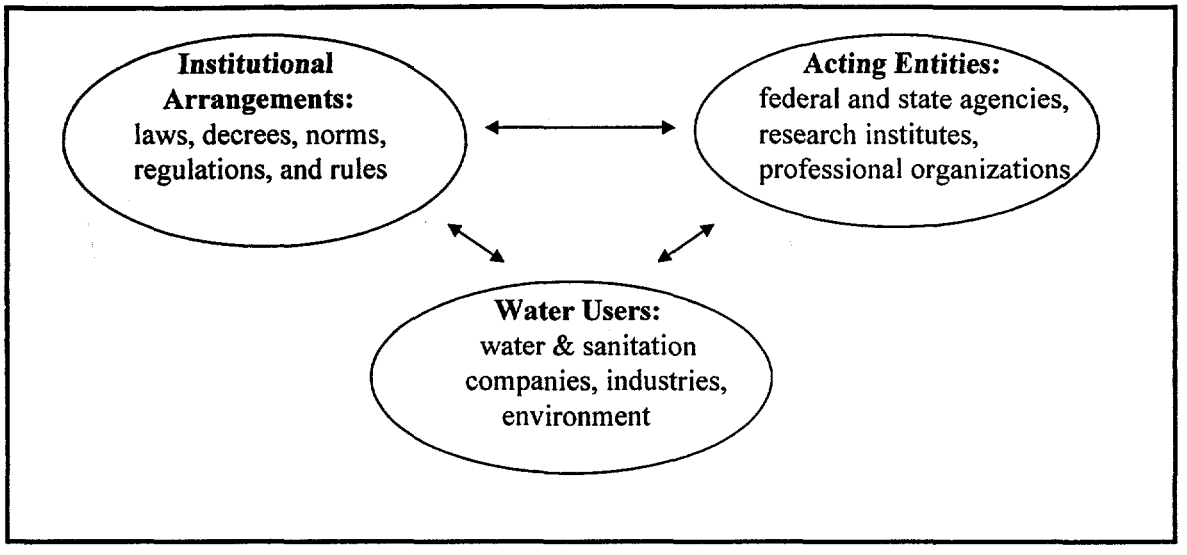
BRAZIL'S CURRENT INSTITUTIONAL FRAMEWORK

4.8 Brazil has three types of rivers; state, federal and international. State rivers are confined to one state only and are under state jurisdiction. Federal rivers flow between at least two states, and international rivers flow between Brazil and at least one more country. Federal and international rivers are under federal jurisdiction. Thus, in Brazil, the legal framework for river basin management has to exist at least at two levels, the state and the federal level.

4.9 Pollution control has traditionally been practiced at the state level by state environmental agencies. These are usually tied to the Environment Secretariat (e.g. FEEMA in Rio de Janeiro). At the federal level IBAMA has been responsible for pollution issues, but the agency has primarily concentrated on natural resources management. The instruments that have been used to achieve pollution control are of the command-and-control nature, i.e. zoning regulations and licensing.

4.10 Due to the erosion of state finances, the agencies have suffered from a prolonged lack of funding which has substantially reduced their capacity to monitor compliance with regulations. Thus, on the one hand, pollution policy has been quite rigid due to the inflexible command-and-control mechanisms. On the other hand, the lack of enforcement has not provided incentives for polluters to comply with the regulations so that, in reality, the institutional framework has been very lax - with obvious effects on pollution loads. Ironically, the main polluters, such as water and sanitation companies, often have not been subject to any formal or informal rules to reduce their pollution output. In their case, an institutional framework to reduce pollution simply has not existed. This may explain in part why sewerage coverage levels in Brazil are so low and why new water supply systems are implemented without taking into account the necessity to treat the increasing sewage volume.

Figure 4.1: Institutional Framework Of The Water Resources Sector



4.11 In spite of the weak legal framework, water resources management has been highly centralized at the state level and basically nonexistent at lower levels. Thus, stakeholders, such as industries and water and sanitation companies or civil society, have had no say in how to manage their water resources and render their use more sustainable.

4.12 Given the weakness of the current institutional framework, the outcome, namely increasing pollution loads due to population increase and economic development, is not surprising. The next section describes the country's approach to a new institutional framework that addresses the issues mentioned above.

BRAZIL'S NEW APPROACH TO POLLUTION CONTROL AND WATER RESOURCES MANAGEMENT

4.13 The new approach that has been developing in Brazil resembles the framework existent in France since 1964. Based on management at the riverbasin level, this new approach includes elements of stakeholder participation with a prominent role for municipalities and industries, as well as water pricing. Its organizational structures include a *riverbasin agency,* a technical entity that determines investment plans for wastewater treatment, makes suggestions for water tariffs, financial forecasts, contracting of utility or reservoir construction, etc.

4.14 The agency operates as the executive arm of the *basin committee.* The basin committee consists of the stakeholders in the basin, e.g. municipalities, water and sanitation companies, farmers, industries, civil society, environmental interest groups, and state and federal government representatives. Based on proposals elaborated by the agency, it is these stakeholders that will decide on the policy for the basin, including investment priorities and tariff levels.

4.15 Recent water resources laws passed in Brazil follow this basic model, with some variation due to local differences. The Ceará law, for example, presupposes only one agency for the state's 11 basins due to their limited size even though each basin is supposed to have its own user committee. Eventually, the agency will have local branches, but for now it is located in the capital Fortaleza. Conversely, in Paraná's draft law, a reverse approach is planned.

Each basin will have its own User Association, which will create a Technical Entity as its executive arm. Whatever is decided by the User Association must be endorsed by the Basin Committee, which consists of state agencies and members of civil society. The User Association itself has only a consultative seat on the Basin Committee. Thus, while in Ceará the agency was created first (as a mixed company by the State) and is now responsible for creating committees in the different basins, in Paraná the User Associations will create themselves first - as private entities - which will be followed by concomitant creations of Basin Committees by the State.

4.16 Obviously, although the ingredients of the system look the same on the surface, the incentives that emerge for the different stakeholders to institute and maintain such a system are different and will be discussed in the following section. For the new approaches to become legal, new laws are needed. Table 4.1 shows four states and the federal level and their achievements in the legal realm to date.

4.17 As evidenced by the table, actual practice is quite different from the conceptual framework that is so well accepted among water resources professionals and policy makers. Although the framework laws exist, the actual institutional set-up that would make water resources management possible is not in place in any state. An exception is the state of Ceará, which recently introduced bulk water pricing in a riverbasin (the Metropolitana riverbasin around the state capital Fortaleza) and has a water resources management agency as well as committees in two out of eleven basins.

4.18 In addition, São Paulo has a number of basin committees, but since neither agency nor pricing laws have passed, the committees' activities are restricted. They have started to receive some money through the State Water Resources Fund (FEHIDRO) which is replenished by royalties from the energy sector. This money is certainly welcome as a start-up, but will hardly be sufficient in the long run. The Alto Tietê Committee, for instance, is supposed to receive about 30 million US$ in 1997, but this sum cannot meet the needs of a basin with roughly 40 municipalities and a population of over 20 million.

4.19 A first conclusion is that while Brazil has taken the first important steps to improving water resources management, practical implementation is still lacking. The question arises why the process is taking such a long time, given that framework laws in some states were passed three to five years ago. Are the reasons just general political inertia or is there active resistance?

INCENTIVES TO PROMOTE INSTITUTIONAL CHANGE

4.20 To answer this question, one has to examine the underlying incentive structures that promote institutional change, i.e. from the current situation of a number of dispersed agencies at the state and federal levels to a more integrated view that would provide ample opportunities for stakeholders to decide their own fate.

4.21 Institutional change may be driven by several different factors; for example, one strong committed individual. This is in part the case in Ceará and in Rio Grande do Norte where committed governors have put water high on their agenda. Institutional change may also come about when stakeholders feel the necessity for change in such a way that the costs they incur in terms of finances, time, and effort are smaller than the benefits they expect to receive. For example, in the case of extreme water pollution which implies high costs, consumers may press for change more actively than when they are not substantially affected.

Table 4.1: Institutional Requirements For New Approaches To Water Resources Management In São Paulo, Paraná, Minas Gerais And Ceará As Of March 1997

Institutional Requirements	State				
	Guarapiranga (SP)	Paraná	Minas Gerais	Piracicaba (SP federal)	Ceará
State Water Resources Law	1991	prepared but not passed yet	1994	n a[a]	1992
Other laws in place?	yes	yes	yes	yes	no
Laws still required?	• state law for headwaters (draft)[b] • river basin agency law (draft State Assembly) • water pricing law (draft)	• pricing (draft to be developed)	• river basin agency law (to be developed) • water pricing law (to be developed)	• river basin agency law	Ceará has created agencies and pricing stipulations by decree
Basin committee?	consultative committee	no	no	yes	yes, two of 11 basins
Basin agency?	no	no	no	no	yes, 1 central agency
Water pricing?	no	no	no	no	yes for bulkwater; no for pollution loads

Notes:

a The federal water resources law (Lei No. 9.433) was passed by Congress on January 8, 1997. It permits water pricing and the creation of riverbasin agencies, which legitimates - retroactively - the approaches taken by various states in the past years.

b The current State Law for Headwaters which entered into effect in the 1970s, has up to now been decisive for water resources management in the state's headwater areas. It forbids, in a very simplistic manner, any industrial occupation in the designated areas in order to preserve water quality. The lack of enforcement, however, has led to two most undesirable effects. First, for example in the Guarapiranga basin, only industries were impeded from establishing themselves in the region because they would not be able to obtain a license. Housing, however, especially *favela*-like housing went uncontrolled so that today the Guarapiranga basin is entirely urbanized, but without adequate water and sewerage services. At the same time work opportunities are extremely limited due to the lack of industries. The entire area has thus turned into a 'sleep city' with people commuting to São Paulo. In recognition of the perverse effects that have emanated from the current legal stipulations, the purpose of the new Headwaters Law is to allow controlled soil and water management in the concerned municipalities since the pure policing approach has shown to be entirely unsustainable. The new law will be supplemented by the specific Guarapiranga law, permitting controlled industrialization, tourism facilities, installation of sewerage systems and housing improvements.

4.22 In the current situation, water pollution is either worsening or not improving. Though few figures about water quality are available, Appendix 4.1 highlights the prevailing trends. The table shows that water quality continuously deteriorated from 1978 to 1996.[3] Although fecal coli amounts were reduced, general BOD levels increased sub-

[3] The data used in this table are quite weak due to changes in laboratory methods over the time period observed. They nevertheless show the prevailing trends.

stantially, as did total nitrogen levels which multiplied by four in the 19-year period. Also, total phosphate levels have clearly shown an increasing trend.

4.23 Those affected by deteriorating water quality are domestic consumers who need water for drinking and cooking and certain producers who, depending on the type of their production, require different levels of water quality. These two groups are, at the same time, the worst polluters. In fact, most BOD pollution in Brazil stems from domestic wastewater.

4.24 Appendix 4.2 illustrates pollution abatement levels in a number of Brazilian states in 1988.[4] The data show that industry has been most efficient in removing organic pollution loads while only 15% of domestic wastewater loads were removed. A special effort would thus be needed to treat urban wastewater.

4.25 Another interesting point illustrated in the table is that organic loads due to cattle ranching are of major importance. This fact is generally overlooked and certainly merits further investigation, especially given the fact that the latest data available are from 1988.

4.26 Other stakeholders such as the environment, do not pollute but are adversely affected by deteriorating water quality. Fish disappear from rivers with additional negative impacts on fish feeding birds, etc. Yet, as long as water of more or less adequate quality is provided to domestic households and industries, the public at large will not hold the responsible agencies accountable. The problem is one of long distances, namely from the individual consumer to an unknown bureaucrat in a state agency (the transaction cost of registering complaints is high). Also, large groups generally have difficulty organizing for collective action since the input of the individual is hardly measurable, and many individuals assume that someone else in the group will take action, resulting in inaction.

4.27 Thus, the responsible agencies have hitherto not been subjected to much pressure to enforce zoning laws, water effluent standards, etc. On the contrary, as such enforcement implies costs to the polluters, they would resist any such change. In addition, the financial situation of state agencies has deteriorated continuously since the early 1980s, so that monitoring and enforcement of existing regulations has been difficult. In this situation, there now is the call for institutional change that would strip the state agencies of much of their remaining power by substantially decentralizing decision making to entities that until now have not played an active role in water resources management, namely municipalities, industries and civil society at large. Obviously, the state agencies are not very keen on this change, since it implies less control, possibly fewer staff, and also lower budgets for them.

4.28 Other entities are more interested in promoting change. Examples have been set by the *consórcio* movement, notably in SP, Paraná and Minas Gerais, where municipalities have joined in an effort to clean up their local rivers. Since institutional change has to be pushed by the current agencies in power, however, the will at the municipal and societal level is not sufficient to move things along. This power struggle can be observed in São Paulo with regard to the Piracicaba basin (see Box 4.2).

4.29 As long as no dramatic events occur, for instance algae poisoning of drinking water supplies, water is usually not high on the political agenda which might explain why different states are taking so long to

[4] More recent data are not available. These data were published in their current form in 1994.

approve draft laws in the State assembly. A counterexample is the state of Ceará in the semi-arid Northeast where water is one of the major issues on people's minds and where, once there was continuity in government, major changes in water resources legislation have taken place. In Ceará, the water resources law is used as a framework law and is complemented by decrees. Decrees can be passed by the government and need not pass through the legislative assembly. By contrast, in the South and Southeast, structures such as riverbasin agencies have to be enacted by law since they can otherwise be dismantled by the next government.

4.30 The above discussion illustrates some key points. First, it is not only political inertia that stalls effective actions concerning the new institutional framework for water resources management. Concrete reasons exist as to why the current stakeholders do not actively promote the decentralization necessary for the new models that have been approved in the framework laws. This has implications for future programs concerning water resources and pollution management. To be sure, a number of things have in fact

Box 4.2: River Basin Institutions In Piracicaba

In Piracicaba, a river basin committee was created in accordance with the State Water Resources Law of 1991. At the same time, however, there is also a consortium of municipalities formed before the creation of the formal riverbasin committee.

Due to the different structures of the two agencies, i.e. directly affected municipalities and a number of industries vs. a committee that also includes representatives from state institutions and civil society, there have been tensions between the consortium and the committee. The consortium, whose membership consists of the mayors of the municipalities along the Piracicaba river in São Paulo state, believes that it is best equipped to deal with the issues facing the basin. In their mind, the committee can merely play a consultant's role and has no financial basis. The consortium uses municipality membership funds which are not large but have permitted some investments since its inception in 1989.

State representatives on the other hand are of the opinion that the consortium represents limited interests because it only consists of water polluters, not state representatives or civil society. Until very recently, a solution to the institutional - and political - deadlock was not in sight. This situation may have changed with the passage of the federal Water Resources Law in January 1997 which renders the following two things possible.

First, agencies can be created and second, consortiums are allowed to act as basin agencies. The Piracicaba consortium has offered to provide the agency, but has not received a positive reaction from the state as yet. A complicating factor is that the federal law permits consortia to act as agencies only as transitory arrangements. Furthermore it stipulates that within 120 days, regulations will have to be passed as to the definition of agencies. It is not clear at present if this timetable, which implies effective regulation will be in place by mid-May 1997, will hold. And finally, the agencies will have to be approved by the National Water Resources Council which has not been created as of yet. In other words, for the purposes of a solution in the Piracicaba river, the federal law is not of much operational value. It has only opened some doors but has not provided clear guidance.

A further complicating aspect is the lack of clear stipulations concerning water pricing, which exist neither at the state nor at the federal level. In both instances, complimentary laws are planned, but have not yet been introduced to the legislating bodies.

As will be discussed later, an agency with the ability to institute water pricing would gain some financial sustainability. However, water pricing alone will not solve the need for the enormous investments necessary in the Piracicaba basin, which are currently estimated at about 2 billion US dollars over a 20-year period. Other financing sources and mechanisms will have to be found.

In spite of the Piracicaba basin being one of the basins in Brazil that was a forerunner in creating institutional structures to improve water quality, its advantage might disappear rapidly if the different stakeholders do not get to the table and capitalize on the newly-created legal possibilities.

One possibility would be to let the consortium play a more active role within the formal committee. In the committee, there are 16 municipalities (in addition to 16 state slots and 16 slots for civil society). Of these 16 municipalities, 14 are also members of the Piracicaba consortium and 2 of the Jundiaí consortium. Thus, the municipalities that are active in the consortia would be the same municipalities that are active in the committee.

changed. A federal law now exists and framework laws do exist in some states. Thus, projects such as the introduction of water resources management in federal rivers, such as the Paraíba do Sul and the São Francisco, now have a sound legal basis to build on. Also state based projects, such as the Guarapiranga in São Paulo and the Rio das Velhas in Minas Gerais, can proceed due to their state laws.

4.31 For future endeavors at the federal level and in those states with a legal framework, projects should therefore be more predictable than previous ones, especially once the agency aspect is resolved. That will allow implementation to focus on more practical issues, i.e. how to set up an agency, what kind of monitoring is required and how to involve stakeholders more effectively. In states with existing laws, projects can be designed within the current legal framework. Design can thus concentrate on how to tackle the problems in a specific basin and avoid the fight for an entirely new legal framework at the state level.

4.32 The second related aspect is that now there is a pool of both national and international experience. In states where laws do not yet exist, national experience from other states now is available. In addition, the federal law provides general guidance on how to design institutional arrangements for water resources management. It also legitimates some of the former stumbling blocks. In Minas Gerais, for example, all articles concerning pricing were vetoed in the State Water Resources Law of 1993 with the explanation that pricing was not a legally recognized instrument at national level. Although this opinion was not universally shared (pricing is already mentioned in Brazil Water Code of 1934), the new federal law now officially sanctions the principle.

4.33 The experience in a number of different states with different hydro-geological, climatic and socio-economic conditions can be used to tailor further state laws to the local circumstances. The World Bank can play a facilitating role by organizing workshops, financing studies, disseminating previous experience and helping identify national and international experts. While international expertise also plays a role, the existence of considerable Brazilian experience allows subsequent states to assess their possibilities and challenges with local assistance - and to learn from the failures of others.

4.34 The other aspect to be learned from the discussion is that the current set-up of management units for such programs has to be reconsidered. Even though current stakeholders, i.e. state agencies, have their own agendas and may not easily accept decentralization, it may not be a good strategy to set up management units exclusively staffed by consultants which bypass important agencies. Management units ought to include staff from existing key agencies so that change comes from within. As it is now in several states, the management units may be seen as 'foreign organisms' that are biased towards certain Secretariats and State agencies, undermining their diplomatic position. Their distance from some of the principal stakeholders might also be interpreted as an unwillingness by the state government to let them play an effective role in the creation of the new management systems. In this case, agencies like the World Bank could be led to believe that local stakeholders are being incorporated into the new institutional framework, when in reality, they continue to be outside the system.

4.35 Inclusion of important agencies in the process is necessary because of the need for sustainability. Given the committee structure that is being implemented throughout the country, state agencies will continue to play a role in water resources management. Therefore, they will have to be involved with the implementation process of the new system from the beginning. Otherwise, the consultant firms leave and no in-

stitutional memory or new technical skills have been created to perpetuate the process.

4.36 Having analyzed and possibly mitigated the impediments to institutional change, the next step is to design a system that will be sustainable, financially and institutionally, in the long run. The subsequent sections concentrate on two key issues in this context, i.e., the design of the water resources management agency and incentives for stakeholders to participate in the management design.

DESIGN OF WATER RESOURCES MANAGEMENT AGENCIES

4.37 As noted above, state and federal agencies have been very weak in regard to pollution management in Brazil and hope is vested in the new committee-agency structures endorsed by the budding legal water resources framework. Careful consideration should to be given to the design of the new institutional arrangements in order to avoid the pitfalls of previous frameworks. Certainly, a number of solutions exist and will depend on local circumstances in the different state or federal riverbasins.

4.38 A large problem for state agencies has been the lack of funding and the ensuing difficulties in attracting and retaining qualified personnel as well as in building and maintaining monitoring and enforcement systems. More often than not there has been a lack of priority in budget allocations. Many times, governments prefer to build new visible works such as reservoirs, parks, and highways rather than invest in monitoring and maintenance of existing systems. The consequence has been a deterioration of existing structures and institutions, increasing pollution and an enormous lack of basic information about water quality, pollution loads, etc. For these reasons, agencies ought to be as independent from public budgets as possible. The Water Resources Management Agency in Ceará, COGERH, for instance, which was designed with the explicit goal to provide independence both functionally and financially, experienced considerable difficulties in achieving its mission. COGERH, a mixed company integrated into the state's public service system, is faced with unpredictable budgets and deteriorating salaries, along with the well-known manifestations of such problems.

4.39 This situation is expected to change shortly, however, because COGERH has recently taken over parts of the State Water and Sanitation Company's (CAGECE) bulk water supply network and is now supplying - and charging for - bulkwater in the metropolitan region of Fortaleza. These tariffs will provide sufficient revenues to render the company independent from state financing for operation, maintenance and certain future reinvestments. They will also permit the company to increase salaries to more competitive levels in order to retain and attract qualified personnel. In addition, COGERH will pay a percentage of its revenue to a State water resources fund that will permit a limited amount of future investments in structural works.

4.40 This experience shows that an agency provided with initial funding - preferably through stable multi-year budgets - can become financially independent once it has its own revenues through service provision and pricing. By giving it a sustainable start, i.e. in a smoother manner than happened in Ceará, the basis is created for sustainability of the entire water resources management system.

4.41 Although Ceará is the first state in Brazil to charge for bulkwater, it has to be pointed out that the industries that will now pay COGERH formerly paid CAGECE, although the water was considered to be treated and thus the tariff was higher. The political price to make the companies accept

paying for bulkwater was thus very low. Industries now pay less because the bulkwater tariff charged by COGERH is about half of the tariff for treated water charged by CAGECE.

4.42 The political fight took place between the agencies because COGERH's assumption of bulkwater responsibilities implies a revenue loss for CAGECE with implications for its cross subsidization of other parts of its supply system. The real test will be the charge for irrigation bulkwater pricing which has not yet taken place. It also has to be taken into account that Ceará water tariffs are not linked to water quality. The state's experience is cited here because, in general, Ceará is the state that is the most advanced in setting up its institutional arrangements, which are relevant regardless of whether the approach focuses on water pollution or water quantity. However, in states where water pollution is the principal issue, tariffs will imply *additional* costs to water user, not lower costs as in Ceará.

4.43 The fact remains, however, that with the recent arrangements COGERH will be financially independent of the State and will have an incentive to act as a commercial company if it wants to survive, i.e. it will have to enforce its tariff system, inter alia, by providing quality in its services to the users. This institutional framework is designed to avoid the failures of the former system where no entity had an incentive to adequately operate and maintain the state's extensive water supply infrastructure. COGERH thus was designed as a public mixed company. As we have seen, however, the water resources management system in Ceará remains very centralized. It is COGERH that is responsible for creating riverbasin committees and, as of yet, it has not been decided if such committees will ever have a deliberating power in regard to their budgets.

4.44 In other states, and in the federal law for that matter, agencies are perceived as the executive arm of the user committees, i.e. the committees are created first and then in turn they create the agency. Here again, in order to avoid problems such as overstaffing, deteriorating salary levels, etc., agencies could be designed as foundations or as private entities.[5] Furthermore the agency ought to be as lightly staffed as possible and rely on contracting out the better part of its functions. This *terceirização* could take place by contracting out to both public state or federal agencies and to the private sector. Such an approach would provide some competition and hopefully lead to cost-effective management.

4.45 This latter approach is the one foreseen in the draft water resources law of Paraná. The User Association of each riverbasin, which would be an entirely private entity created by the water & sanitation company, industries and municipalities, would be responsible for, inter alia, elaboration and implementation of a basin management plan, tariff proposals, tariff implementation, mobilization of financial resources, etc., but would work with only a small technical *núcleo*. Most of the technical works, such as monitoring activities, would be contracted out.

4.46 It remains to be seen, however, what incentives are needed in order to effectively implement this system. In theory, the water users are regarded as willing financiers of the riverbasin management system who will happily leave most technical works to state agencies. They would, in addition, agree to quite rigorous oversight by the riverbasin

[5] At the federal level, an alternative is currently being explored that would create an agency of quasi-private nature that would have the least public interference possible. Some public element has to be preserved because otherwise the state is prevented by law from participating in the agency.

committee in which they only have a consultative role.

4.47 It is not entirely clear if the users have an incentive to actively promote this arrangement or if they are not better off by leaving things unregulated, as they are now. The State, on the other hand, is going to lose power by this arrangement and that may be one of the reasons why the legal process has progressed so slowly.

4.48 A further issue is related to staffing uncertainties at the managerial level. In the Brazilian public sector, it is common to replace managerial staff at all levels as soon as political constellations change. Since elections take place every two years, either at the municipal, state or federal levels, political constellations change often and, consequently, so do staff. The ensuing lack of continuity regarding planning, implementation and institutional memory has been a major reason why many potentially good innovations have not been successfully implemented. If the new agencies are to succeed, serious consideration should be given to offering managerial staff the highest level of time-bound contracts of up to four or five years which would prevent removal for political reasons. Independent auditors could instead judge the performance of the agency, and only in the case of obvious mismanagement would managers be displaced. Given that the strategic decisions are made by the basin committees and that the agencies have a primarily executive function, this approach would provide managers, i.e. technical professionals, with sufficient resources and stability to meet their agency's objectives.

INCENTIVES FOR STAKEHOLDERS TO PARTICIPATE IN WATER RESOURCES MANAGEMENT

4.49 An important task is how to create incentives for the various stakeholders to participate in both committees and agencies. As in all countries, laws are not sufficient to ensure interest in and sustainability of new institutional arrangements. Stakeholders must have reason to spend time and money to participate. Apart from sanctions for non-participation, other mechanisms can provide positive incentives.

4.50 For example, in Minas Gerais, recently the 'ecological VAT' (ICMS *ecológico*) was introduced. When a municipality invests a certain amount in environmental improvements, it will receive a higher than usual return on ICMS from the state for further improvements. By explaining to municipalities that a river basin agency might help them qualify for the ecological VAT, they might be able to see benefits in participating. In fact, the Paraopeba consortium has spread word about this program in one of its recent training courses, illustrating the importance of such initiatives to other municipalities.

4.51 Also, the Bank-financed SOMMA program seems to be popular in Minas Gerais. If a river basin organization can provide municipalities with access to such a program, it will be of more interest than if it is perceived as just another bureaucratic layer. Obviously, the possibility of active participation is an incentive to get involved. In this context, the size and scope of management systems has to be considered.

Water Catchment vs. Social Catchment

4.52 The Alto Tietê in São Paulo has a river basin committee (instituted according to the State Water Resources Law), but it consists of diverse municipalities and is experiencing a vast array of problems. The assessment by a number of committee members is that the Alto Tietê committee is not functioning because it is too large to adequately take into account the sub-basins. Therefore, participation in the Alto Tietê

committee has been weak and in decline. In this case, tensions exist between hydrological and social realities. While the hydrological reality is that management of water quality in the Guarapiranga sub-basin has an important impact on the overall basin, the social reality is that human beings are usually most interested in their immediate environment. The Guarapiranga municipalities have no interest in spending their time in a committee of 38 municipalities if they are not affected by the problems of 33 of these.

4.53 The Alto Tietê committee has now started to create sub-committees for the sub-region Cotia-Guarapiranga as stipulated in the State Water Resources Law. In the case of Guarapiranga, the fact that the Cotia and the Guarapiranga regions are entirely different has regrettably not been taken into account. Although this shows that this type of decision had better be left to the committee - according to the principle that management decisions are best taken at the lowest appropriate level - a sub-committee which covers a smaller region will provide more incentives for the municipalities in the Guarapiranga basin to make the management of their basin work.

4.54 At present, a sub-agency is not being planned due to the lack of agency law in São Paulo state. As soon as the creation of an agency is possible, it should be instituted in the sub-basin. Once there is an agency for the entire Alto Tietê basin, the agency in the Guarapiranga basin might become a sub-agency with a certain degree of liberty. This institutional set-up is perfectly compatible with the new laws to be passed in São Paulo (the umbrella law for the headwaters and the specific Guarapiranga law). The complication in São Paulo consists of the fact that the State Environment Secretariat favors the idea of management at the level of the entire Alto Tietê Basin and is not likely to work actively for an agency in the Guarapiranga basin.

4.55 In this context, the Guarapiranga basin can be defined as a *social catchment* with common economic and social concerns. This stands in contrast to the larger hydrologically defined basin, which many stakeholders do not perceive as one unit. The concept of a *social catchment* permits the interests of local stakeholders to be taken into account and relates their interests and incentives to the natural environment. The approach facilitates the analysis of the relationships between socio-economic and natural systems and enhances the possibilities of developing adequate institutional arrangements for environmental management. Such relationships ought to be taken into account when decentralization of riverbasin management 'to the appropriate levels' is expected. The appropriate level might be lower than the hydrological unit of a riverbasin.

4.56 One solution might be, for instance, to create working groups that provide a bridge between sub-basin committees and committees of the main river so that planning is made compatible overall. This approach is being discussed in Paraná.

CONCLUSIONS AND RECOMMENDATIONS

4.57 From the above discussion, it becomes clear that Brazil, while in the process of implementing considerably improved approaches to water resources management and pollution control, has only taken the initial steps, and it remains to be seen what impacts the laws will have in practice. It has also become clear that the different states, while based on the same principles, are developing different approaches based on their institutional, political and hydro-climatic realities.

4.58 This latter development should be actively encouraged by the World Bank. Just as one recipe is not automatically applicable in different countries, so is the case for a large federal country like Brazil.

A Call For Simplicity

4.59 Certain common conclusions can be drawn from the experiences above. One concerns the approach to the drafting and implementation of laws. Both the São Paulo and the Minas Gerais approach are excessively legalistic. In spite of the existence of framework laws, the process of implementing water management has been stalled because of the need for further regulations. Such a process, i.e. to pass legislation on the same topic twice, is extremely costly in terms of time, finance and lost opportunity to fight pollution and should be avoided.

4.60 A first step has been made in Paraná where no specific agency law will be required once the main law is passed. A draft law in Rio de Janeiro would permit both creation of an agency and water pricing from the beginning. In Ceará, the issues were resolved by decrees. This is a possible approach with a stable succession of governments, but is more insecure than passing a comprehensive law.

4.61 Thus, future state projects should avoid these unnecessary costs. The role of the World Bank should be to point to the problems that have occurred in the past and to point to the benefit of increased flexibility. For example, instead of stipulating the formation of certain institutions and regulations by law, important decisions should be left to the stakeholders.

Different Incentives For Different Contexts

4.62 Since 1992, the World Bank has been financing pollution control management projects in the states of São Paulo, Minas Gerais and Paraná. One of the objectives of the projects has been to finance structural works for pollution control, such as sewerage systems, anti-flood works, and solid waste disposal systems and to use these investments as incentives for the introduction of riverbasin management pilot projects. Viewed in this light, the projects have not been successful. While the structural works are now progressing more or less satisfactorily (after serious initial counterpart funding problems), the riverbasin pilot projects have been mired in legal battles and are advancing quite slowly, as described in detail above.

4.63 The connection between a Bank-loan for engineering works and the implementation of a new legal system therefore has to be seriously questioned. The reason might be that the three states mentioned above are very large and that even multi-million dollar projects are not large enough a incentive to induce a process of institutional change. Possibly, in a smaller state, commitment by the state government might be more enduring. It also has to be taken into account that each of the projects in the three states involved only one pilot basin but required a new legal framework at the state level. That is a high price to pay for investments in one basin only.

4.64 In the future, a distinction should be made between a state such as Ceará, which already had a law in place when the water resources loan was negotiated, and a state where no legal framework is in place yet. The rationale for investments in infrastructure should be separated from the rationale for investments in a new management system. The distinction is important also because of the different time frames that have to be considered for institutional change, which is slow and not always controllable, and engineering works, which can be designed for a certain time period and are more predictable.

4.65 Another option is, of course, to make loan disbursements conditional on certain regulations. Again, this is difficult in a situation where no legal framework exists

at all. However, in the Piracicaba basin, for example, the legal options for an agency now exist through the federal law and a loan for the future investment package could be made conditional on the prior existence of a basin agency in order to facilitate the process.

Integration of Water Sector Modernization Regarding Sanitation Components

4.66 As mentioned above, the largest polluters in BOD terms are the water and sanitation companies. For instance, in the metropolitan areas of Belo Horizonte and Curitiba, industrial pollution plays a minor role while sewage is the main problem. In Belo Horizonte, 93% of all pollution is due to domestic sewage and only 7% due to industrial effluents. It is therefore necessary for the states and the Bank to integrate the on-going modernization efforts of the water and sanitation sector into the efforts of improved water resources management. If such an integration is neglected, an important opportunity will be missed to achieve better pollution control in the country. For example, the disclosure of certain quality data should be designated in contracts with private concessionaires. Concessionaires should also be made aware of existing or planned water resources management institutions and the possibilities, and obligations, for interaction and participation.

The 'Lowest Appropriate Level' For Management May Be A Sub-basin

4.67 As mentioned above, when riverbasins are very large and management effects are concentrated in only one part of the basin, such as a sub-basin, the decision might be made to institute management at the lower level. In order not to obstruct management of the basin at large, a representative of the sub-basin can be aggregated to the committee of the other parts of the basin. An approach being discussed in the state of Paraná is to create an intermediary committee that takes care of overlapping responsibilities. This approach might also be applied in the relations between states and the federal government when the state wants to manage a river that belongs to the state because it is entirely on state territory but belongs to a federal basin. This is the case, for instance, for various tributaries of the federal São Francisco river.

4.68 In addition, a distinction has to be made between rivers that require management along the entire river and rivers that have a problem area, such as the Alto Iguaçu in Paraná, where management is suggested to concentrate on the region of metropolitan Curitiba. Since resources, both in terms of finances and in terms of qualified expertise, are scarce, management efforts should concentrate on areas where the benefits of management will be highest and where clear targets can be achieved. Otherwise the incentives for stakeholders to participate will be very small.

4.69 This reasoning also implies that a state may not have committees in every basin but can concentrate on those that have critical problems. Therefore, State Water Resources Law should avoid stipulating that committees must be created in all basins, especially if no assessment has been made as to what kinds of problems the different basins are faced with.

Appendix 4.1: Guarapiranga Annual Average Of Water Quality Parameters And Indicators
Sabesp Water Intake Channel

Year	Water Temp.	pH	DO mg/l		BOD mg/l		Fecal Coli nmp/100 ml		Total Nitrogen mg/l		Total Phosphates mg/l		Total Sedi-ment mg/l	Turbi-dity UFT	IQA
			aver.	peak	aver.	peak	aver.	peak	aver.	peak	aver.	peak			
1978	22	6.9	7.5	8.6	2	5	274	1300	0.48	2.26	0.033	0.082	59	19	80
1979	21	6.6	7.6	8.4	2	3	46	230	0.82	1.10	0.065	0.338	71	32	81
1980	21	6.7	7.8	8.4	1	2	279	2200	0.76	0.97	0.053	0.136	57	21	83
1981	22	6.6	7.9	9.4	1	2	1091	2300	0.77	1.22	0.048	0.100	72	40	71
1982	21	6.7	7.4	8.7	1	1	3910	17000	0.90	1.14	0.060	0.125	71	32	69
1983	22	6.9	7.4	8.4	1	3	869	7900	0.83	1.24	0.064	0.135	53	14	82
1984	23	7.1	7.8	9.2	2	3	127	700	1.20	2.11	0.077	0.275	51	10	81
1985	21	6.9	7.6	8.2	4	16	190	330	0.83	1.50	0.053	0.090	60	18	76
1986	22	6.8	7.8	9.8	2	3	291	1300	0.83	1.22	0.046	0.080	69	23	78
1987	20	6.8	7.7	9.4	2	3	54	280	0.79	1.22	0.032	0.045	54	7	86
1988	21	6.6	7.7	9.6	2	4	91	230	0.96	2.84	0.031	0.060	60	2.3	84
1989	22	6.9	7.7	8.5	3	5	84	230	0.82	1.31	0.090	0.390	50	4	82
1990	21	7.0	7.9	9.3	3	4	23	50	1.82	4.28	0.121	0.275	53	3	79
1991	21	6.9	7.6	8.4	3	6	545	2300	1.12	2.41	0.050	0.100	54	4	78
1992	21	7.2	8.1	9.0	2	4	1648	8000	1.17	1.51	0.041	0.055	54	3	82
1993	21	6.9	7.5	8.2	5	10	433	1300	1.27	2.77	0.052	0.060	58	2	82
1994	21	7.0	6.8	9.9	6	16	7	7	1.19	1.55	0.046	0.060	60	3	83
1995	21	7.1	7.3	8.7	4	9	266	280	1.04	1.43	0.154	0.345	71	2	82
1996	21	7.0	7.1	8.7	4	5	39	140	1.88	3.56	0.030	0.050	61	2	82

Source: CETESB.

Appendix 4.2: Organic Pollution Loads Discharged In Water Bodies In 1988

		Potential Load (1000 ton BOD/year)										Remaining Load (1000ton BOD/year)	
Region	State	Industry	Urban Sewage	Rural Sewage	Cattle	Rural Run-off	Urban Run-off	Total	Diffuse Rural (Cattle+Run-off+Rural Sewage)	Diffuse Urban (Run-off)	Point Source (Ind.+ Esg.Urbano)	Industry	Urban Sewage
North	PA	11.532	48.098	45.540	166.772	321.836	12.210	605.988	534.148	12.210	59.630	9.948	37.665
North-east	MA	47.265	34.578	57.091	180.412	70.134	5.180	394.660	307.637	5.180	81.843	14.678	30.345
	CE	29.640	71.957	44.859	230.831	241.700	34.830	653.817	517.390	34.830	101.597	22.470	50.663
	PE	209.107	97.927	42.367	151.607	97.810	22.010	620.828	291.784	22.010	307.034	51.781	92.753
	BA	44.885	122.527	95.255	427.577	584.374	21.830	1.296.448	1.107.206	21.830	167.412	10.907	103.600
Center-West	GO	49.048	65.622	18.087	626.167	494.412	9.290	1.262.626	1.138.666	9.290	114.670	30.236	63.994
South-East	MG	212.036	218.601	80.240	1.091.010	880.640	36.700	2.519.227	2.051.890	36.700	430.637	150.283	217.292
	ES	37.526	30.288	13.601	95.842	83.202	810	261.269	192.645	810	67.814	18.611	26.991
	RJ	81.599	247.496	13.407	127.394	57.088	64.640	591.624	197.889	64.640	329.095	39.695	181.766
	SP	999.999	569.103	47.633	643.863	412.550	79.510	2.752.658	1.104.046	79.510	1.569.102	65.800	514.149
South	PR	321.064	118.171	48.641	461.043	312.332	87.630	1.348.881	822.016	87.630	439.235	80.601	95.980
	SC	60.988	51.144	26.997	334.492	126.250	4.510	604.381	487.739	4.510	112.132	45.577	31.810
	RS	101.185	121.480	44.135	513.994	491.730	58.060	1.330.584	1.049.859	58.060	222.665	53.644	83.193
	Total	2.205.874	1.796.992	577.853	5.051.004	4.174.058	437.210	14.242.991	9.802.915	437.210	4.002.866	594.231	1.530.201

Source: Leal, 1997.

5. POLLUTION CHARGES AT THE RIVER BASIN LEVEL[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
Water and pollution charges levied and invested at the river basin level are a crucial element of the new water resource management framework.
Pollution charges have both an incentive and a revenue function. However, the revenues from a pure incentive charge are likely to be higher than financing needs. At the same time, the charge would not be affordable for the sanitation sector. A two step-charge with tradable emission allowances would provide the right incentives for polluters while raising the desired level of revenues.
A simulation for the Rio Paraiba do Sul illustrates the choices in the design of charges. A full incentive charge would reach US$ 1,100 per ton of BOD at 50% of abatement, raise revenues of about US$ 100 million per year and could finance the necessary investments. However this charge would not be affordable for the sanitation sector. In contrast, a pollution charge to finance only system administration would start at US$ 12 per ton of BOD and later reach US$ 150. In this case, capital for investments would have to come from outside the system. In a more realistic intermediate scenario, first-step charges would be set at US$ 200 per ton of BOD. This charge would initially raise US$ 30 million per year which would finance 75% of investments. This scenario could lead to 78% abatement after 15 years and would be affordable to polluters.

STRATEGY AND RECOMMENDATIONS
A (low) administrative charge appears preferable if outside capital is available and sanitation companies have the clout to raise household tariffs to the necessary levels. A system with higher charges would spread the burden of treatment investments by individual companies.
In principle, the benefits of a low-charge system in which polluters are fully responsible for financing their control investments appear to outweigh the benefits of a high-charge system with investment financing from revenues. In practical terms, however, many sanitation companies do not have the necessary access to outside financing, and a high-charge system may be the only path toward available. If this is the case, financing from external sources, such as the World Bank Group, can assist in tilting the balance toward a lower charge system which ultimately has a higher chance of successful implementation.

INTRODUCTION

5.1 Over the last years, relatively broad consensus has been achieved on the principles of an integrated water resource management strategy for Brazil: (a) water resources are managed in an integrated manner across water users and sectors; (b) water resources are managed at the lowest appropriate level, usually the river basin; and (c) water is treated as an economic good whose use has an opportunity cost.

[1] This paper was prepared by Joachim von Amsberg with contributions from Gordon Hughes.

5.2 After several States have passed water resource laws that follow these broad principles of integrated water resource management, the federal level has followed with a similar national water resource law (Law No. 9,433 of January 1997). Most of these laws foresee the formation of river basin committees composed of representatives of all river users as decision making entities at the level of the river basin. River basin agencies would be the executive arm of the system, implementing the decisions of the basin committees. Water resource councils at the state and federal levels would oversee the management arrangements at the basin level.

5.3 While discussions of water resources management in Brazil have tended to focus on issues of water allocation within river basins, the structure that is proposed can be used to meet much broader concerns. In particular, it allows for the integration of pollution management and coastal zone management with river basin management. As such, the creation of the new institutional framework for water resource management is both an opportunity and a challenge for more effective pollution management.

5.4 Based on the broad agreement on integrated water resource management and the legal basis that has been created in selected cases, the next set of questions to be addressed in this section includes the mechanisms for implementation and integration of the new framework with pollution management instruments. This paper focuses, in particular, on the relation between incentive and revenue functions of pollution charges and the process of targets setting and instrument implementation.

THE ROLE OF CHARGES

5.5 The emerging legal framework for water resource management includes as a critical element the levying of charges for water use and effluent discharges. The revenues from these charges would remain under the control of the basin committee. The decision to retain revenues in the basin and not channel them through public budgets is important for overcoming resistance by water users, generating confidence that charges will be used to generate benefits locally, thus, increasing the likelihood that charges will actually be collected in the first place.

Conceptual Issues

5.6 Pollution charges, levied on emissions that enter water bodies -- untreated effluent or residual emissions after treatment -- have an incentive and a revenue function. In terms of the incentive function, polluters will control emissions up to the level at which marginal abatement costs are equal to the per-unit-of-pollution charge. In order to provide the right incentives to polluters, pollution charges per unit of pollution would have to be set at the level of marginal environmental damage costs (Pigouvian Charges) or, in the absence of such information, at the level of marginal abatement cost at the level (of abatement) that corresponds to emission reduction targets.

5.7 In the example shown in Figure 5.1, a charge of $750 per ton would induce emission abatement of around 43%. At this level of aggregate abatement, pollution abatement will obviously differ drastically between individual polluters. Some polluters would be able to control all of their pollution at less than $750 per ton and would do so in order to avoid paying the charge. Other polluters with abatement costs above $750 per ton would choose to pay the charge in order to avoid the higher treatment costs. Marginal abatement costs across polluters would be equal, thus ensuring implementation of cost-effective pollution controls.

5.8 If the pollution charge was levied on the entire remaining pollution load, the charge would generate revenues that are equivalent to the charge times the quantity

of remaining emissions (the areas A and B to the right of the abatement cost curve in Figure 5.1). The revenues generated by such a "full incentive charge" would differ with the level of abatement and depend on the abatement cost profile of the polluters in a specific basin. The revenues from a full incentive charge are the maximum revenues that can be generated from a pollution charge at different levels of abatement. However, there is no reason why these revenues would coincide with the financing needs at the river basin level. In fact, revenues from a full incentive charge will often be rather high, thus generating unnecessary resistance against their implementation by polluters who will have to pay this charge in addition to the cost of partial pollution abatement.

5.9 An alternative to a full incentive charge is a "pure financing charge." This charge per unit of pollution would be set to meet specified financing needs but must be lower than the full incentive charge. This charge would have no incentive effect since it is less than marginal abatement costs at the desired level. Pollution control targets would be implemented through an additional instrument, such as emission standards. The disadvantage of this approach is the inefficiency introduced by administratively setting emission standards for polluters with different abatement cost curves. Since regulators cannot possibly know the abatement cost curves for each polluter, they are bound to introduce inefficiency in their regulation.

5.10 There are two feasible options to combine the efficiency advantage of a full incentive charge with a specific revenue target and a lower financial burden for polluters. One option is a system of refunds in which revenues exceeding financing needs (the area B in Figure 5.1) are returned to polluters according to some criterion other than emissions. For example, excess revenues could be returned to sanitation companies on the basis of population served. The net charge that each sanitation company pays would be the difference between its full incentive charge and the refund determined on the basis of population served. The charges from industrial sources could be refunded to industry on the basis of, for example, employment or included in the refunds for the sanitation sector, which in

Figure 5.1: Charges

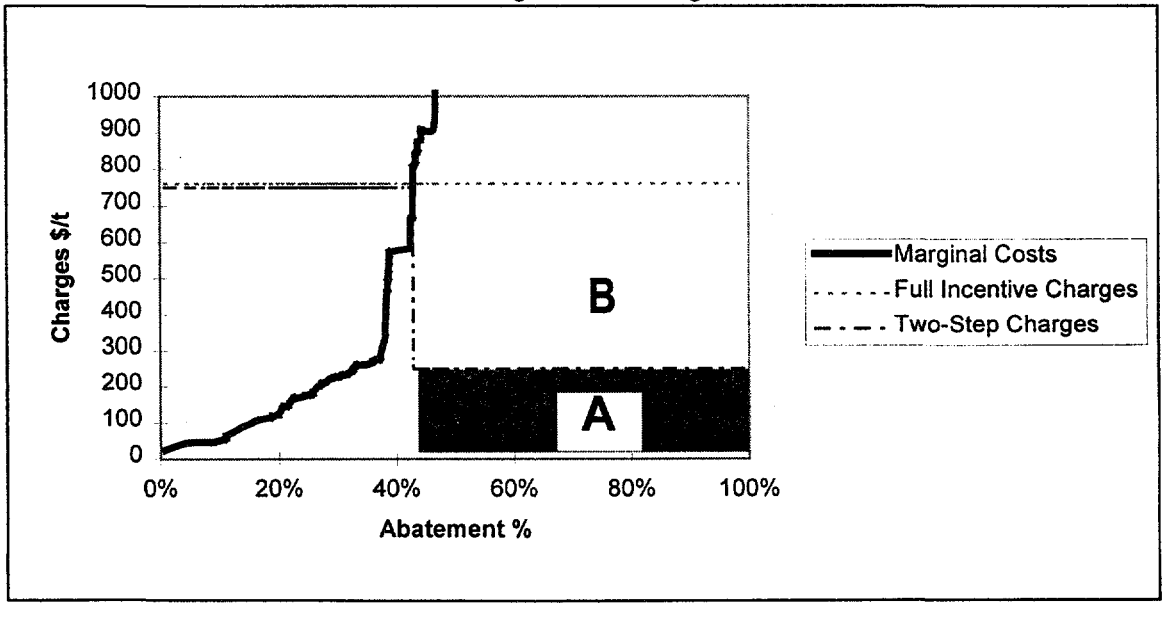
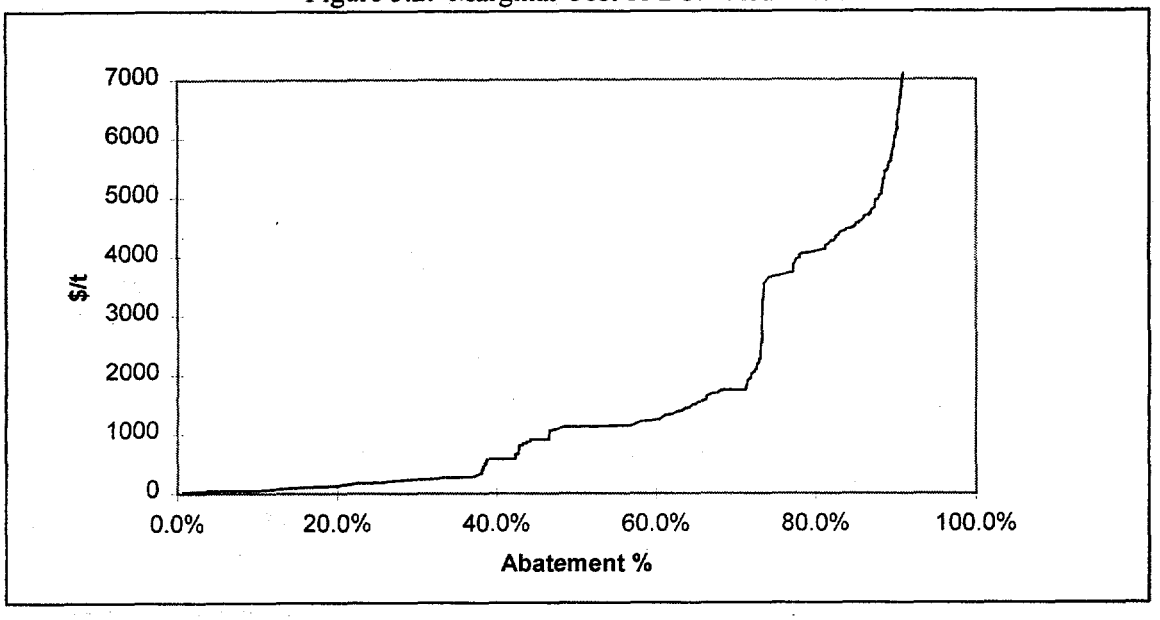


Figure 5.2: Marginal Cost of BOD Abatement



general will face higher treatment costs and more serious financing problems.

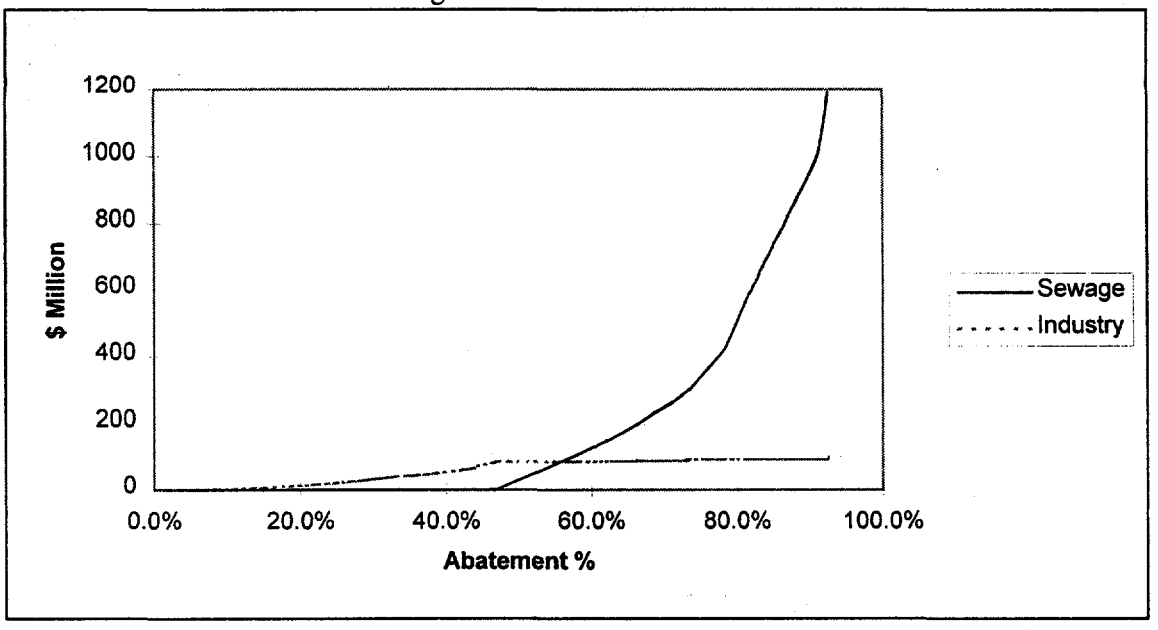
5.11 The second option is a system of two-step charges. The charge up to the aggregate emission target would be set according to revenue needs while the charge above the aggregate emission target would be set at the level of marginal abatement costs. Figure 5.1 shows the two-step charge (at the right, the first-step charge; and at the left, the higher second step charge) with the same efficiency and incentive effect as the full incentive charge but revenues equivalent to only the area A which can be adjusted by changing the level of the first-step charges. Theoretically, the second-step charge would never be paid and its level would not matter as long as it was above marginal abatement costs. Practically, however, its level matters since regulators have incomplete information and will likely miss the true abatement cost curve. The level of the second-step charge would thus serve as an upper limit on costs for polluters in case of regulator error.

5.12 How can two-step charges be implemented in practice? In simple terms, all polluters would have to pay the second-step charges unless they hold an allowance (in tons per year) for first-step charges. Allowances for first-step charges would be issued by the system administrator up to the aggregate emission targets. They can be allocated by historic pollution load but should be tradable among polluters in order to ensure an efficient outcome.[2] If regulators miscalculate the aggregate pollution abatement cost curve (which they are likely to do in the beginning), they can adjust either the quantity of allowances issued in subsequent years or the level of the second-step charges. Tradability of the allowances ensures that pollution reduction is cost-effective even in the case of error or incomplete information. In summary, this mechanism results in a combination of charges with a system of tradable pollution permits.

5.13 The question at which level first-step charges are to be set depends on the revenue needs and the affordability for pol-

[2] Allowances could be allocated annually based on a declining share of historic emissions. To avoid windfall profits for low-control-cost sectors (industry), allowances would decline faster for industry than for sanitation.

Figure 5.3: Investment Costs



luters. Revenues are needed to operate the river basin management system including water quality monitoring, planning and a small administrative staff. In addition, revenues are needed for communal investments for the improvement of water quality such as watershed protection measures to reduce non-point run-off of nutrients. In addition, revenues can be used to help polluters finance the costs of pollution control investments. Whether the latter use of revenues is desirable depends on polluters' access to outside capital, on the one hand, and the impact on the affordability of charges, on the other hand.

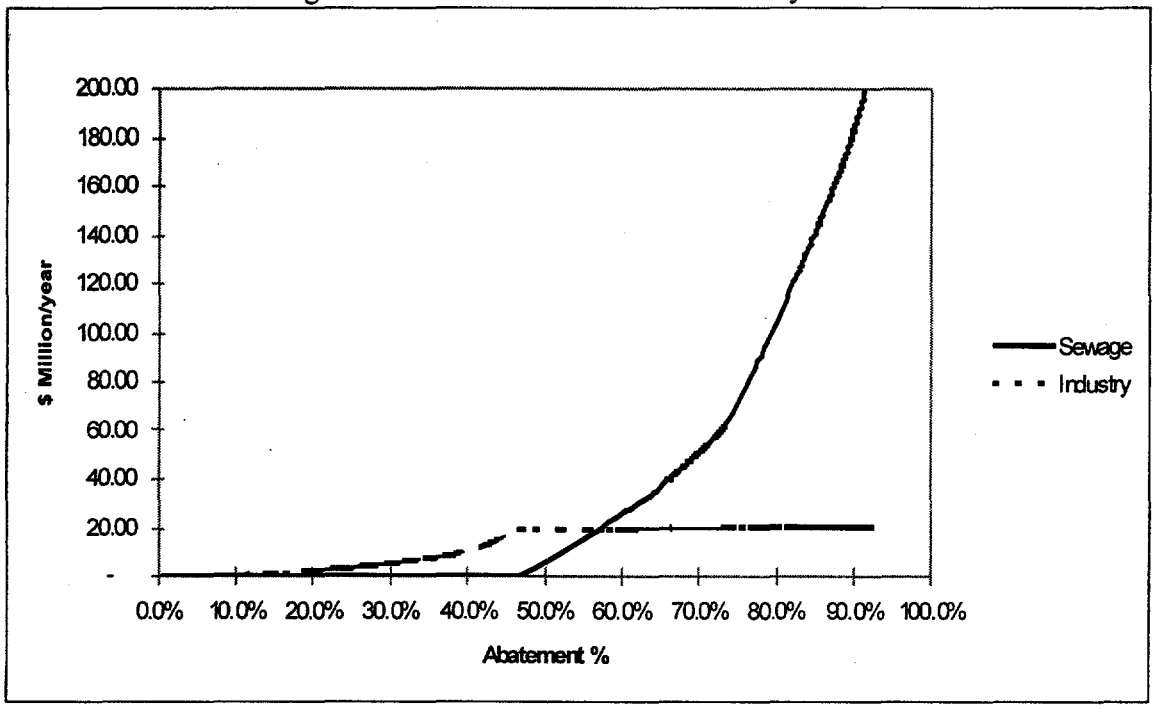
A Case Study: The Rio Paraiba do Sul

5.14 The trade-offs involved in setting up a charge system based on the principles outlined above can be best understood by considering a numerical example of an important river basin in Brazil. The Rio Paraiba do Sul Basin covers an area of 57,000 km^2 in the states of São Paulo, Rio de Janeiro and Minas Gerais with dense populations (4.8 million people living in the basin) and large industrial concentrations. The river is heavily polluted from industrial and domestic sources. This pollution is of concern because the river supplies drinking water not only to the basin population but also to a much larger population in the Rio de Janeiro Metropolitan Area. The following case study simplifies the problems faced in the basin by focusing entirely on basin-wide aggregate BOD emissions.

5.15 Basin-wide BOD emissions are currently estimated at 168,522 tons per year, 50.5% of which are from industrial sources and 49.5% from domestic sewage. The estimated marginal control cost curve is shown in Figure 5.2. The total annualized and investment costs for both sectors at different levels of aggregate abatement are shown in Figure 5.4 and Figure 5.3.[3] In this specific case, it is noteworthy that industrial and sewage control options barely overlap. Almost all controls up to 48% of aggregate load reduction are in industry at a marginal cost of up to US$ 1,000 per ton while most

[3] Note that the horizontal axis shows aggregate abatement in the order of cost-effectiveness. Sectoral abatement levels (industry and sewage) may be very different at the same level of aggregate control.

Figure 5.4: Annualized Abatement Costs by Sector



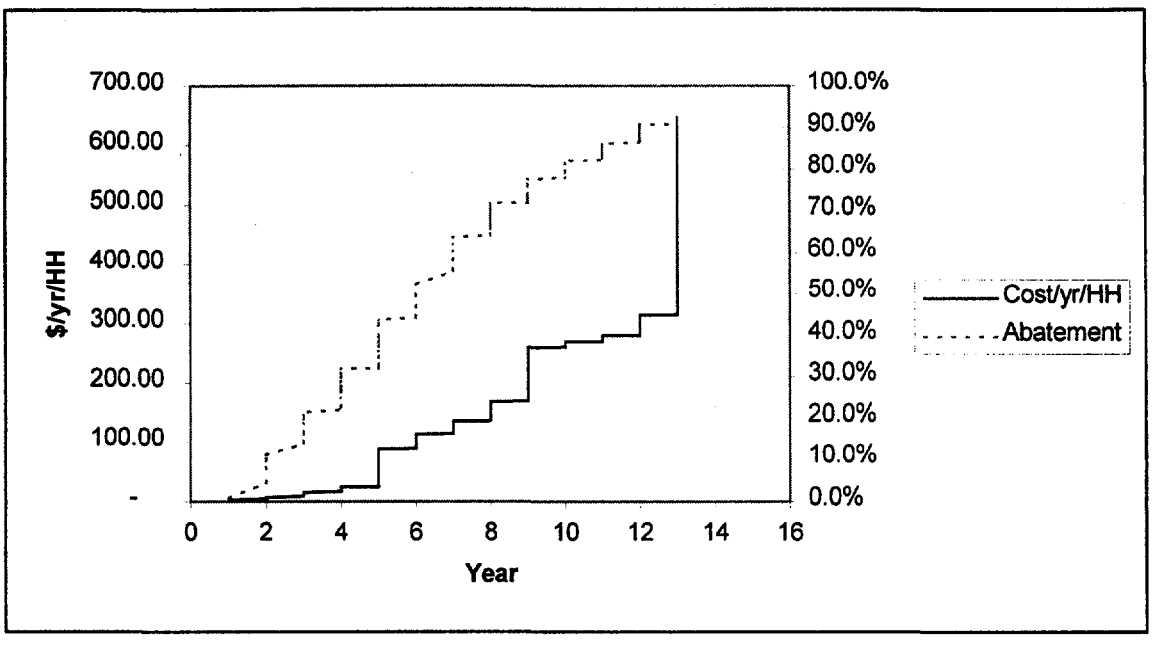
controls over 48% of aggregate load reduction are in domestic sewage with marginal costs ranging from US$ 1,000 up to US$ 40,000, for 92% aggregate load reduction. Investments of about US$ 90 million in industry and US$ 1.19 billion in sewage would be required to reach this abatement level. Annualized costs (assuming a real cost of capital of 10%) would reach up to about US$ 20 million in industry and US$ 230 million in sewage.

5.16 Four charge scenarios are compared below; a full incentive charge, a two step charge with a constant first-step charge, a two-step charge designed to cover system administration costs only (administration costs are assumed to be US$ 2 million per year) and a mixed charge that would cover some but not all investment costs. All scenarios can be implemented through charge refunds instead of two-step charges. Separate scenarios are not provided since the results are identical at the sectoral level.[4]

5.17 Given the relatively small burden that either charge would pose on industry, affordability for industry is not considered a major issue. Affordability for households, however, is a critical issue. In contrast to water supply and sewage collection, sewage treatment does not provide a direct benefit to the households paying for the service since benefits accrue to the downstream population at large. Also, and in contrast to industry, sewage treatment charges have no significant incentive effect for households since there are no options for emission reduction at source. Therefore, the question of sewage treatment charges for households is essentially a question of raising the neces-

4 At the level of individual polluters, however, the outcome may well differ. In particular, the net charge will be higher under a refund system than under a two-step charge for polluters which maintain a higher share in emissions than their share in the refund basis, and vice versa.

Figure 5.5: Abatement and Affordability under Full Incentive Charge



sary revenues, on the one hand, and affordability, on the other hand.

5.18 Based on Brazil's average annual household income of US$ 9,000 and a typical willingness to pay of 5% for water and sanitation services (US$ 450 per year per household at the average household income), it is assumed that US$ 100 per year per household is the upper limit of an affordable sewage treatment tariff[5] embedded in an overall water and sanitation tariff of up to US$ 450 per year per household for the average Brazilian household.[6] The three charge scenarios show the costs per year per household calculated as the total of treatment costs incurred and the total pollution charges levied on the sanitation sector divided by the number of households discharging into the basin (assuming an annual per capita load of 20 kg BOD or 100 kg BOD per year for a five-head household).

Full Incentive Charges

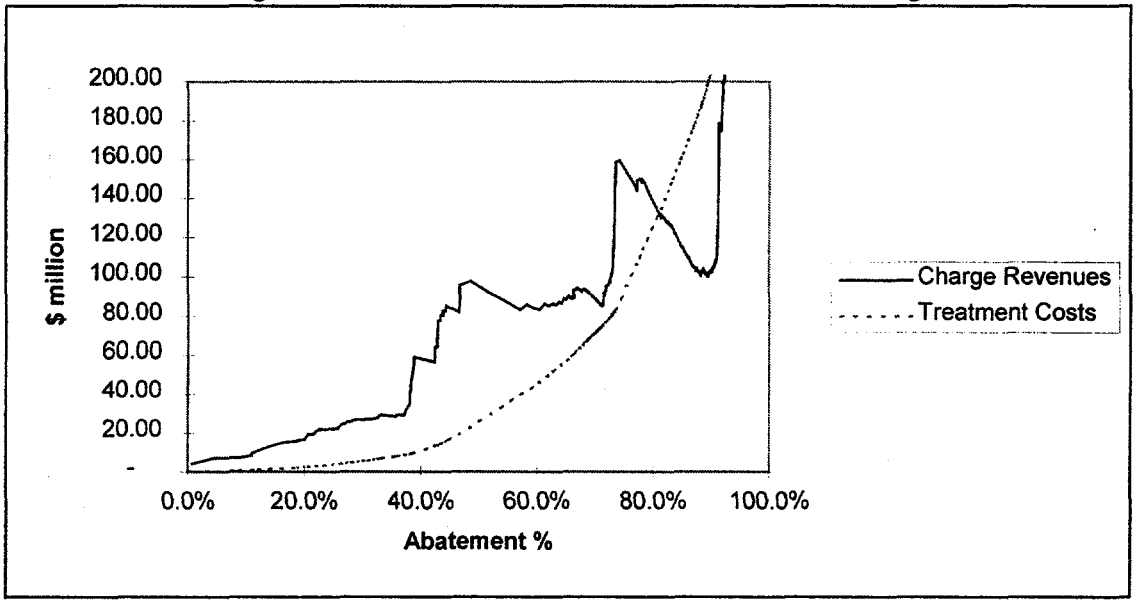
5.19 The first scenario assumes a full incentive charge equal to the marginal abatement costs at the respective abatement level. Figure 5.6 shows the total annual revenues from charges and treatment costs by abatement level. In this scenario, polluters would pay the sum of both treatment costs and charges on the remaining load. Note that such a system would generate revenues in excess of US$ 80 million above 43% abatement levels (when charges would reach US$ 830 per ton). The generated revenues would immediately exceed the system administration costs of US$ 2 million, thus generating resources that could be made available to polluters to cover their investment costs.

5.20 If the excess revenues of the system were used to finance all pollution control investments leaving payment of the operating costs and 10% interest on the capital to

[5] Throughout this paper "tariff" denotes the payments from households to the sanitation company. Payments from sanitation companies and industry to the river basin agency are denoted "charges".

[6] Given Brazil's income distribution, the median household income and affordability threshold will be lower than the average.

Figure 5.6: Cost and Revenues under Full Incentive Charge



the polluters, a schedule for raising charges over time can be determined that would exactly balance the revenues raised with the investments made by polluters. The results are shown in Figure 5.5. High levels of pollution reduction would be achieved very quickly (90% in year 14), however, affordability is a major problem. In year 6, the pollution charge would reach US$ 1,000 per ton and costs per household would reach the threshold of US$ 100 per year, later exceeding US$ 300. At the time when household cost reaches US$ 100 per year, pollution abatement of 47% would be achieved. Thus, after this threshold is reached, the system becomes essentially unaffordable for the sanitation sector.

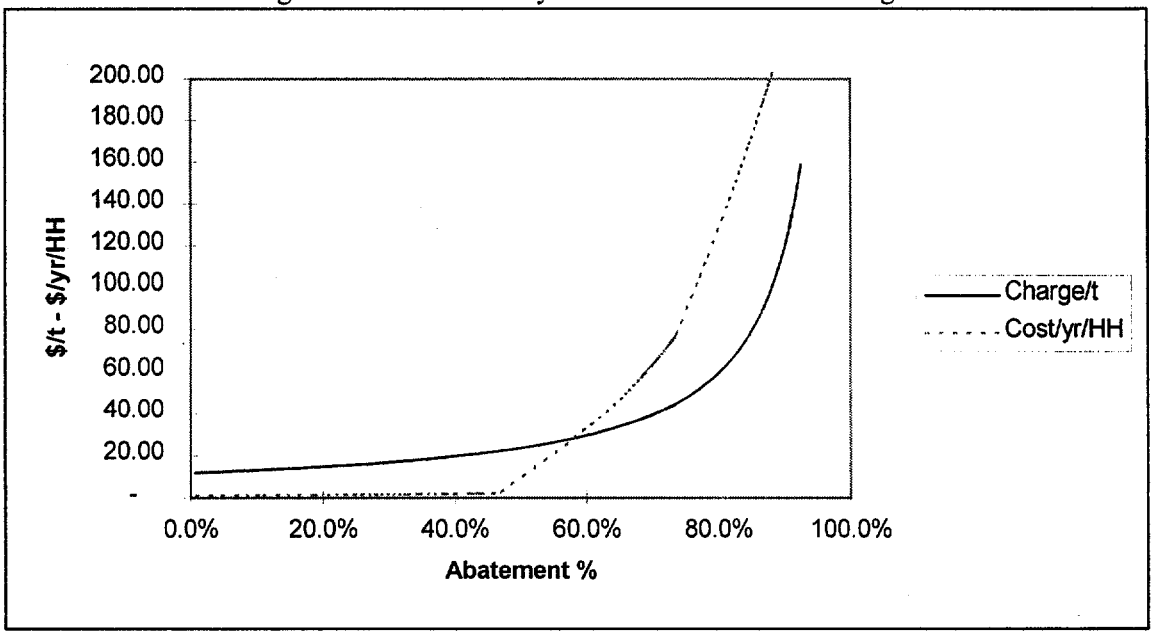
Administrative Charge

5.21 The second charge analyzed is a two-step charge with a first-step charge that is designed to cover only the system's administration costs. Since the base of the charge shrinks with increasing abatement, charges would rise over time from an initial US$ 12 per ton to US$ 150 per ton at 92% abatement (see Figure 5.6). The resulting cost to households would be affordable (less than US$ 100) up to 77% abatement. The main problem of this charge system is that it does not generate investment funds. It is only viable if outside capital (at an assumed cost of 10% per year in real terms) can be mobilized for the necessary pollution control investments.

Constant Charges over Time

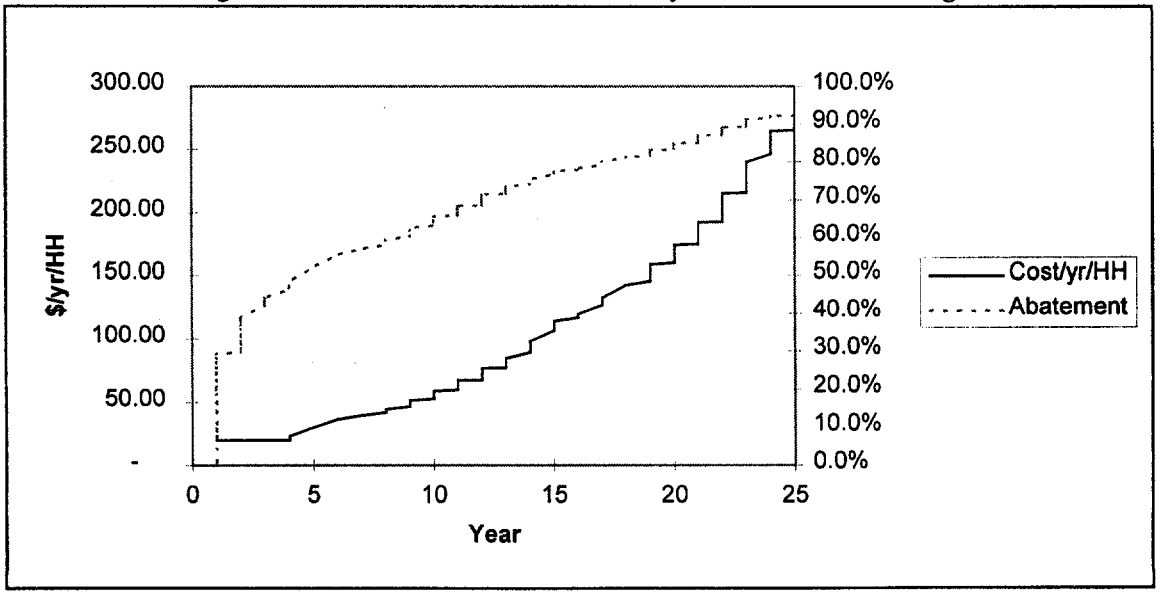
5.22 The third scenario is based on a first-step charge constant over time and the assumption that all pollution control investments need to be financed out of charge revenues. The level of the constant charge depends on the speed at which control investments are desired. For illustration, Figure 5.8 shows a constant US$ 200 per ton charge that would allow reaching a 92% abatement target by year 25. However, the charge would be affordable for households only until year 15 when a 78% abatement level would be achieved. Note that the cost for households increases even with constant charges since increasing abatement costs contribute to the total cost borne by households.

Figure 5.8: Affordability Under Administrative Charge



5.23 Obviously, combinations and modifications of the three prototype scenarios are possible. In particular, a higher charge can be phased in over several years to reduce resistance by polluters. Also, charges can be set at an intermediate level that is sufficient to provide some but not all necessary investment funds. In addition, at the moment when costs to households reaches the affordability threshold, additional treatment costs would have to be subsidized from the returns to the capital accumulated by the system over the previous years. This would slow down further emission reductions but still provide for gradual further improvements. In effect, the river basin would at this stage return to polluters the stock of capital accumulated during the initial years. Finally differences in treatment between industry and sanitation are perceivable.

Figure 5.7: Abatement And Affordability Under Constant Charge



Mixed Administrative/Incentive Charges

5.24 A possible pragmatic combination of scenarios is shown in Figure 5.9. Here it is assumed that 75% of all investment costs have to be financed from charge revenues. The constant first-step charge is US$ 200 per ton. However, charges for the sanitation sector are limited by the assumed affordability threshold of US$ 100 per year per household. After this threshold is reached in year 13, only few additional investments can be financed from the now reduced charges, essentially limiting abatement to 80% in the long-term.

Comparison of Charge Systems

5.25 The key considerations in choosing between the different charge systems include: (a) the ability to access outside capital to finance necessary investments; and (b) the acceptability and affordability of charges to polluters and households. The latter point includes the important question about which system will make it easier for sanitation companies to raise household tariffs to a level that will allow recovery of the costs of sewage treatment. This will be necessary regardless of the charge system adopted.

5.26 A (low) administrative charge appears preferable if outside capital is available and sanitation companies have the clout to raise household tariffs to the necessary levels. It would clearly lead to less resistance by polluters against the introduction of charges. On the other hand, a system with significant charges that would finance the investments has advantages if one considers the level of an individual sanitation company rather than the sector as a whole. With higher charges, the burden of treatment investments by individual companies would be spread between all companies that contribute through their charges. This spreading of costs is also reasonable given that treatment benefits water users at large rather than the polluters. As a result, individual companies would be less likely to resist the need for investing in treatment once it is their turn. Also, higher charges would provide a rationale for the necessary early but gradual increase in tariffs. The advantages and disadvantages of the two fundamental approaches are summarized in Table 5.1. The full incentive charge is not considered since it is fundamentally unaffordable.

Figure 5.9: Abatement And Affordability Under Mixed Charges

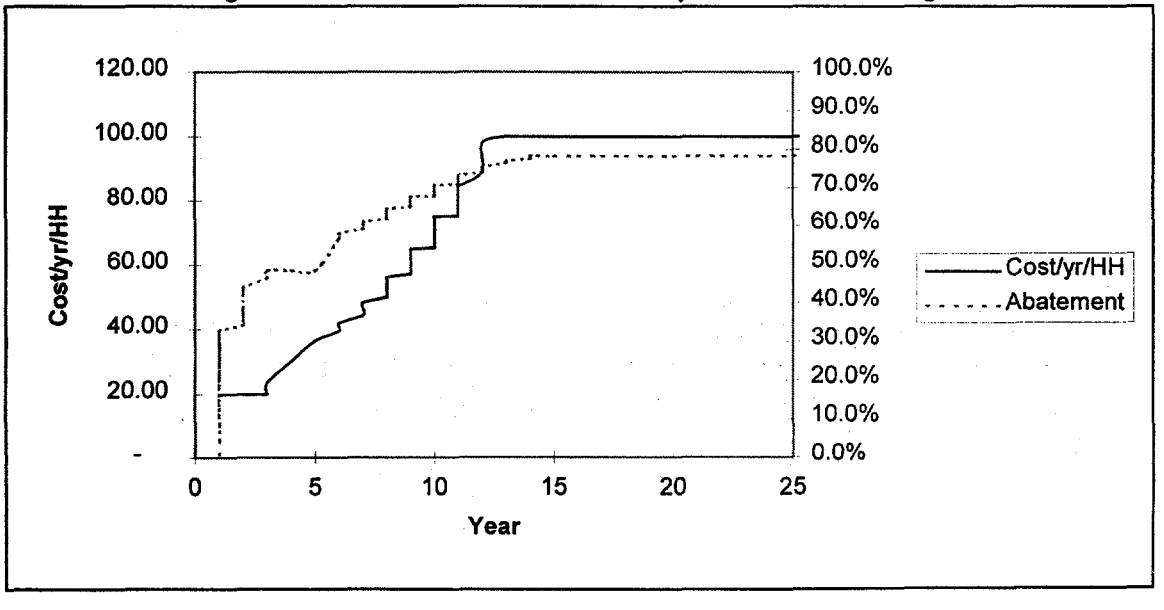


Table 5.1: Advantages And Disadvantages Of Low And High Charges

	Advantages	Disadvantages
Low charges for administration only	Less initial resistance against the introduction of charges	Only feasible if investors have access to outside capital
	No danger of river basin agency becoming an inefficient and politicized banker	Drastic increase in tariffs necessary at the time treatment is introduced in a specific system may lead to resistance by households
	No danger of subsidies implicit in financing mechanism	
High charges to finance investments	Tariffs can be raised gradually since treatment costs for individual systems are smoothed over time	High charge may lead to resistance by polluters
	No, or less, need for outside capital	River basin agency could become an inefficient and politicized financial agent
		Danger of implicit subsidies messing up incentives

5.27 From a purist point of view, the benefits of a low-charge system in which polluters are fully responsible for financing their control investments appear to outweigh the benefits of a high-charge system with investment financing components. In practical terms, however, many sanitation companies simply do not have the necessary access to outside financing, and a high-charge system may be the only path toward cost-effective pollution control. If this is the case, financing from external sources, such as the World Bank Group, can assist in tilting the balance toward a lower charge system which ultimately has a higher chance of successful implementation.

5.28 Regardless of the aggregate level of charges, a choice has to be made between the use of two-step charges or charge refunds to match charge revenues with expenditures. Given the practical complications that a system of tradable pollution allowances is likely to imply, a refund system appears to be preferable if agreement can be achieved on the appropriate basis for charge refunds, i.e. population served.

5.29 The simulations presented in this paper are obviously a simplification of the real choices that will have to be made in the Paraiba do Sul Basin. In particular, pollutants other than BOD and locational aspects will have to be incorporated into the charge system. In this respect, a trade-off between simplicity and economic efficiency will have to be made under highly incomplete information. Initial charges would probably be based on an index of a small number of key pollutants differentiated only by a small number of geographic zones, or sub-basins. The index would be developed based on broad water quality targets applied to a crude water quality model. All of the analytical elements would be refined throughout the process.

RELATION TO OTHER INSTRUMENTS AND INSTITUTIONS

5.30 River basin committees would have responsibility for a variety of matters, but one of the most important would be the management of water quality within the basin. The basin committee or its agency would develop a water resource and water quality management plan for the river basin. This plan would be presented for approval to the responsible State agency. The approved plan would constitute an agreement that would specify: (a) levels of ambient water quality to be achieved in different parts of the river basin -- e.g. not more than

10% of the length of the Pirai river should have a level of BOD exceeding 10 mg/l; (b) the date by which these targets are to be met together with, if appropriate, intermediate water quality goals; (c) general targets for the reduction of pollution loads required to meet the ambient water quality goals;[7] and (d) the measures that the river basin committee intends to implement in order to achieve the water quality targets (to ensure that they are consistent with other State environmental policies). The agreed dynamic targets for water quality would replace the rather rigid and static classification of water bodies that is currently applied.

5.31 After reaching an agreement with the responsible State agency, the river basin committee would proceed to develop and implement the outline measures specified in the agreement. These may include: (a) the introduction or adjustment of effluent charges, (b) varying discharge permits for individual point sources, (c) financing investments for wastewater treatment plants by large polluters, (d) constructing communal wastewater treatment plants for groups of municipalities, and (e) undertaking watershed protection measures such as reforestation to reduce non-point run-off of nutrients, etc. The finance for capital projects may be obtained from the fund which receives all revenues from effluent discharge fees.

5.32 If the intermediate or final water quality targets specified in the agreement with the State environmental management agency are not met, there are two courses of action open to the State. First, the river basin committee may have achieved the agreed targets for load reduction but this did not have the anticipated impact on water quality. In this case the two bodies would have to renegotiate the agreement, extending the time allowed to meet the quality targets and setting a new set of load reduction targets. Alternatively, the river basin committee may have failed also to meet the load reduction target in which case some collective penalty would be imposed on the users in the river basin -- probably in the form of an increase in the effluent discharge fee for as long as the load reduction targets are not met.

5.33 It should be recognized that the process of arriving at an agreement on aggregate targets is likely to be a time-consuming and difficult one. River basin committees, on behalf of their users, may have an incentive to delay the finalization of such agreements, so the environmental agency must have the ultimate power to impose interim targets if negotiations continue beyond some reasonable time period and to impose penalties for failure to abide by these targets.

5.34 Moving to a full system of river basin management is likely to take many years, but it is possible to introduce a number of transitional measures that will both accelerate the process of forming river basin management committees and reaching the environmental management agreements. One important issue is the potential incentive to resist the formation of a river basin committee on the grounds that this will lead to the imposition of effluent discharge fees. Thus, the states must take the power to introduce a uniform effluent discharge fee on point sources. Such a fee would be levied on all plants, municipalities, water and sanitation companies, and other bodies which discharge water pollution above the threshold either to surface or ground waters unless their discharges were regulated by a river basin agency for the relevant river basin

[7] While this might appear to over-determine the actions to be taken by the river basin committee, the discussion of load reduction targets provides a basis for avoiding conflicts that may arise if the environmental and river basin agencies have very different models of the relationship between emissions and ambient water quality in the river basin.

(which would also use effluent discharge fees as one of its instruments).

5.35 Pollution management instruments applied at the level of the river basin have to be closely coordinated with those applied by State environmental agencies. In particular, the relation to environmental licensing needs to be carefully considered. The relationship between the river basin agency and the polluter cannot replace environmental licensing since the environmental impact of a polluter may include aspects outside the responsibility of the river basin agency. On the other hand, the licensing process needs to be compatible with the rules and instruments implemented at the river basin level. In this case, the river basin committee would determine the basic parameters on which the relevant aspects of environmental licensing would be based.

5.36 In terms of institutional arrangements, there are basically two options that can be pursued. One option is for the state environmental agency to retain responsibility for the entire licensing process but replaces the current emission standards, etc., applied in the licensing process with the parameters on emissions and charges established by the river basin committee. The other option is for river basin agencies to take over the water pollution related aspects of the licensing process. In this case, the river basin agency would prepare the applicable (sub-) license for polluters discharging into the river basin. Both arrangements appear feasible as long as clear rules of the game and unambiguous responsibilities are established and the actions of both entities are consistent and coordinated. Legal considerations may ultimately decide which option is preferable. In particular, it would be desirable that the agency responsible for preparing a license also has the legal power to enforce its conditions.

6. URBAN ENVIRONMENTAL MANAGEMENT[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
There are currently no consistent mechanisms for cross-jurisdictional strategic environmental planning or coordination of environmental service provision in metropolitan areas in Brazil (either inter-municipal or metropolitan-wide).
There is no single federal government agency that deals specifically with urban and metropolitan environmental issues, or with metropolitan issues generally.
There is significant disparity in income levels, tax base, service provision (in both quantity and quality), institutional capacity, and environmental awareness between the central and peripheral municipalities in Brazilian metropolitan areas.
Information on urban brown pollution problems is inadequate.
Inter-municipal environment-related interventions (e.g., in the area of solid waste) continue to be adversely affected by political factors, specifically periodic changes in municipal administrations due to the regular cycle of local elections and because of differences in the political party affiliations of state and local officials, on the one hand, and among municipal authorities in each metropolitan area, on the other.

STRATEGY AND RECOMMENDATIONS
Urban environmental management should start with an analysis of the underlying problems on a citywide basis, careful identification of alternatives and definition of priorities for public and private sector action, and the selection of cost-effective interventions.
Greater attention should be given to the institutional and financial dimensions of urban environmental service provision, particularly at the municipal level, including the development of adequate normative, operational, and financial frameworks, and the creation, strengthening, or consolidation of the appropriate agencies.
The substantial human and financial resources and comparatively long time horizons required for the attainment of many urban environmental goals and the political sensitivity of many environmental management decisions should be clearly recognized and taken into account in formulating and implementing urban environmental strategies and lending operations.
Key preconditions for successfully dealing with urban environmental problems: (a) an active and informed public; (b) a solid information base on the nature, extent, and associated costs of local environmental problems; (c) systematic analytical and participatory mechanisms for defining and building consensus around local environmental priorities; and (d) adequate local technical, institutional, and financial capacity to design, coordinate (especially across municipal boundaries), and implement cost-effective solutions to priority problems, and to monitor and evaluate the results of these interventions.
Environmental services in low income neighborhoods should be improved.
Define roles of federal, state, metropolitan, and municipality governments in regard to urban pollution problems.

[1] This paper was prepared by John Redwood

INTRODUCTION

6.1 In most metropolitan and urban areas in Brazil, the principal environmental problems (to varying degrees) are:

(a) surface and groundwater pollution due to poor basic sanitation, particularly inadequate domestic sewage collection and treatment, and inadequate solid waste collection and disposal;

(b) flooding and landslides due to poor drainage and the location of low-income (and generally informal or illegal) settlements (*favelas*) in high risk areas (*areas de risco*) from an environmental standpoint;

(c) air pollution from vehicular, industrial and other sources (particularly in Sao Paulo and, to a lesser extent, Rio de Janeiro and Belo Horizonte); and

(d) noise pollution in central city areas and higher density neighborhoods.

6.2 Some metropolitan areas also have specific environmental problems due to their locations or the proximity of particular economic activities -- e.g., beach erosion in the coastal city of Recife, and mining-related pollution in Belo Horizonte.

6.3 The main institutional/political problems affecting environmental management at the metropolitan level in Brazil are the following:

(a) Except for urban transport in some cities (such as Belo Horizonte and Recife) and the provision of water supply and sewerage services (through municipal concessions to state water utilities), there are currently no consistent mechanisms for cross-jurisdictional strategic environmental planning (or planning for metropolitan development, more generally) or coordination of environmental service provision in metropolitan areas in Brazil (either intermunicipal or metropolitan-wide). However, different institutional arrangements have evolved or are evolving in each of the various metropolitan regions with Recife and Belo Horizonte illustrating two quite different approaches.

(b) There is no single federal government agency that deals specifically with urban and metropolitan environmental issues, or with metropolitan issues generally; several federal agencies, however, deal with key urban environmental issues, especially: (i) the Secretariat of Urban Policy (SEPURB) in the Ministry of Planning and Budget (MOP), which focuses on housing and basic sanitation infrastructure and is responsible for the national component of the Brazil Water Quality and Pollution Control Project (Loan 3503-BR, approved in June 1994) known as "PQA"; (ii) the Institute of Economic and Applied Research (IPEA), also in MOP, which is coordinating the preparation of metropolitan environmental diagnostic studies under the Bank-assisted Water Sector Modernization Project (PMSS) (Loan 3442-BR, approved in December 1992); and (iii) the Environmental Secretariat of the Ministry of Environment, Water Resources, and Legal Amazon (MMA). In addition, a semi-private entity, the Brazilian Institute of Municipal Administration (IBAM), which provides training and technical assistance to municipal governments on demand, organized local and national consultations on sanitation and urban environmental management during 1994 under PMSS and with financial support from the IBRD/UNDP/UNCHS Urban Management Program (UMP).

(c) There continues to be a significant disparity in income levels, tax base, service provision (in both quantity and quality), institutional capacity, and environmental awareness between the central and peripheral municipalities in Brazilian metro-

politan areas. This strongly affects their capacity to plan, implement, and coordinate interventions to improve environmental conditions at the metropolitan level.

(d) In most metropolitan areas (the one significant exception being Sao Paulo, particularly with respect to air quality), information on environmental quality, including the monitoring of water and air pollution sources, is poor.

(e) Inter-municipal environment-related interventions (e.g., in the area of solid waste) continue to be adversely affected by political factors, specifically periodic changes in municipal administrations due to the regular cycle of local elections (the most recent change in Mayors and municipal legislative bodies having occurred on January 1, 1997) and because of differences in the political party affiliations of state and local officials, on the one hand, and among municipal authorities in each metropolitan area, on the other.

(f) The above problems have been exacerbated by the recent creation of new (and, in most cases, even weaker) municipalities within some metropolitan regions (e.g. Belo Horizonte, where the number has reportedly grown from 14 to 24 in recent years).

6.4 Despite these complicating factors, several urban, inter-municipal and metropolitan scale diagnostic, sector-specific, and more integrated planning/coordination and management initiatives are currently underway in the various metropolitan regions, as can be illustrated by recent experience in Recife and Belo Horizonte. Among the most important elements of promoting improved inter-municipal, if not metropolitan-wide, coordination in terms of environment-related planning and service provision, however, are Bank and other externally-funded pre-investment (e.g., PQA in Recife) and investment (PROSAM in Belo Horizonte) projects. In some cases, local NGOs have also played a relevant role. At the national level, recent efforts to diagnose metropolitan environmental priorities include:

(a) **IBAM**, "National Consultation on Managing Sanitation and the Urban Environment," (final report 1995). Each of the 14 metropolitan areas and large cities that participated in this process, including both Recife and Belo Horizonte, produced reports presenting the results of local consultations. The local consultation for Recife was organized by FIDEM (the Recife Metropolitan Region Development Foundation) and that for Belo Horizonte was organized by FEAM (the State Environment Foundation) and ABES/MG (Minas Gerais chapter of the Brazilian Sanitary Engineering Association).

(b) **IPEA** (Urban Policy Coordination Unit), as part of PMSS, is currently coordinating a study entitled "Strengthening Environmental Management in the Metropolitan Regions." This study involves the Recife, Belem, Curitiba, Porto Alegre, Salvador and Sao Paulo (but not Belo Horizonte, Fortaleza or Rio de Janeiro)[2] metropolitan areas. The first stage of this exercise consists of diagnostic studies involving the

[2] These areas were excluded from the study either because their former metropolitan planning/ coordination agencies have been abolished (Belo Horizonte and Rio de Janeiro) or because they did not submit a preliminary diagnostic study of metropolitan environmental problems (Fortaleza) to IPEA. See Heitor Matallo Junior, (1996). Environmental problems in Rio de Janeiro have been the focus of two recent Bank studies, however: Kreimer, Alcira, et. al., "Towards a Sustainable Urban Environment: The Rio de Janeiro Study," World Bank Discussion Paper No. 195, March 1993, and "Brazil - Managing Environmental Pollution in the State of Rio de Janeiro," Report No. 15488-BR (two volumes), August 22, 1996.

Table 6.1: Summary Data For Eight Largest Metropolitan Regions

RM	Population	<2 SM (%)	Water (%)	Sanitation (%)	Trash (%)
Sao Paulo	16,567,317	24.4	95.7	85.4	96.3
Rio de Janeiro	10,389,441	44.5	86.5	77.8	79.2
Belo Horizonte	4,623,620	52.0	88.5	69.2	67.8
Porto Alegre	3,757,500	44.1	84.8	79.9	86.0
Salvador	3,134,886	55.1	80.8	53.4	66.8
Recife	2,921,665	54.5	88.2	44.0	72.1
Fortaleza	2,357,100	63.5	68.5	39.2	76.0
Curitiba	2,319,526	38.1	85.8	72.3	84.3

systematic compilation of environmental quality and service data (step 1), mapping of this information (step 2), and analysis and recommendations (step 3).[3] The Recife study is being undertaken by FIDEM.

METROPOLITAN ENVIRONMENTAL PROBLEMS IN BRAZIL: AN OVERVIEW

6.5 Table 6.1 summarizes the following data from the 1991 census for the eight largest metropolitan regions (RMs): population, percentage of family heads who earned less than 2 minimum salaries (SMs) -- an indicator of urban poverty -- and households with access to water supply, sewerage systems/septic tanks (sanitation), and solid waste collection (trash).

6.6 Among the eight RMs surveyed, Belo Horizonte ranked third in population, second in water supply coverage, fifth in relative poverty, fifth in sanitation service coverage, and seventh in terms of solid waste collection. Recife ranked sixth in population, third in relative poverty, third in water supply coverage, seventh in sanitation service coverage, and sixth in solid waste collection.[4]

6.7 As in other metropolitan regions, center-periphery differences in service coverage were significant in both Belo Horizonte and Recife. Table 6.2 likewise indicates the distribution of low income families between the central and peripheral municipalities. The corresponding figures for Sao Paulo and Rio de Janeiro are reported for purposes of comparison.

6.8 Planning/coordination agencies for six metropolitan regions, including Recife and Sao Paulo, but not Belo Horizonte or Rio de Janeiro, have also provided IPEA with a preliminary ranking of environmental problems based on their intensity, spatial distribution (localized vs. diffuse), and social incidence (poor vs. non-poor populations), both for their central municipalities and for those on the periphery. An overall index of environmental quality was then calculated on the basis of these rankings, with Sao Paulo, Recife and Porto Alegre having the lowest ratings (i.e., poorest envi-

[3] The methodology used in these studies is essentially that described in Leitmann (1994).

[4] When water supply, sanitation services and solid waste collection coverage were combined using principal component analysis, Belo Horizonte ranked fifth and Recife sixth among the eight metropolitan regions examined. Overall, the eight metropolitan areas fell into two clusters in terms of basic sanitation service coverage, the better supplied "southern" RMs of Sao Paulo, Porto Alegre, Rio de Janeiro and Curitiba falling into one category and the less well supplied "northern" ones of Belo Horizonte, Recife, Salvador and Fortaleza in the other. A similar pattern exists with respect to urban poverty levels.

ronmental quality) and Curitiba,[5] Belem and Salvador possessing the highest in this order.

6.9 *In the Recife metropolitan region*, environmental problems were ranked by FIDEM as follows, from most to least serious on the basis of the three dimensions cited above: (1) surface water pollution, noise pollution, and loss of natural resources due to the reduction of water availability; (2) groundwater pollution, pollution from industrial emissions, and loss of natural resources due to pressure on remaining native forests; (3) natural resource loss due to erosion; (4) pollution from motor vehicle emissions, inadequate municipal solid waste disposal, inadequate industrial and medical waste disposal, environmental risks of flooding, fires, and toxic contamination; and (5) environmental risk of landslides. Rankings for all of these factors were similar for both central and peripheral municipalities except for the risk of landslides and loss of natural resources due to erosion, which were greater for the city of Recife than for the surrounding municipalities.

6.10 In metropolitan Sao Paulo, by contrast, the most serious environmental problems, according to EMPLASA, are pollution from industrial emissions and from inadequate disposal of industrial and medical wastes, followed by pollution of surface and groundwaters, risk of toxic contamination, and loss of natural resources due to the reduction of water availability. Risk of landslides, erosion, flooding, and fires, in turn, were comparatively much less important. Unlike metropolitan Recife, however, there were important differences between the central city and the periphery, with most pollution problems being of greater intensity in the municipality of Sao Paulo than in surrounding areas, and the reverse occurring with the risk of landslides and natural resource losses due to erosion, deforestation, and reduction in water availability.[6]

---

[5] The comparatively successful urban development and environmental management experience in Curitiba over the past several decades has been the subject of two recent Bank studies: Rabinovich and Leitmann (1993), and Tlaiye and Biller (1994).

[6] Sao Paulo was also one of the cities included in the rapid urban environmental appraisal exercise carried out by the Urban Management Program, whose overall methodology and results are summarized in the papers by Leitmann (UMP Discussion Papers No. 14 and 15, May 1994) cited above. For this exercise, an "Environmental Profile of Sao Paulo" was also prepared by Josef Leitmann in draft form in August 1991. Preparation of this profile involved both a local public consultation process and a "data and criteria-based" problem ranking through which priority urban environmental issues were tentatively identified. High priority environmental problems identified through the consultation process in Sao Paulo included: (a) substandard housing; (b) lack of urban infrastructure for the poor; (c) settlement of risk-prone areas; and (d) lack of green space. Problems of "medium" priority were: (a) inadequate sewage treatment; (b) unprotected water supply; and (c) flooding. Low priority problems were: (a) vehicular air pollution; and (b) poor transport management. This more analytical approach, which sought to rank problems on the basis of their relative impacts on human health, economic losses, impact on the urban poor, irreversibility, and unsustainability of resource consumption, in turn, led to the following high priorities in the Sao Paulo case: (a) surface water pollution; (b) environmental hazards; (c) forest/agriculture-related problems; (d) hazardous waste; and (e) poor sanitation. "Medium" priorities identified on this basis included: (a) ambient pollution; (b) solid waste; (c) noise pollution; and (d) indoor air pollution. Impacts on rural ecosystems and cultural property were identified as comparatively low priorities (see Tables 2.1 and 2.2 in UMP Discussion Paper No. 14). Another key finding of this study, which is clearly

Table 6.2: Center/Periphery Comparison

MR	%<2SM		Water (%)		Sanitation (%)		Trash (%)	
	Center	Periphery	Cen	Peri	Cen	Peri	Cen	Peri
Belo Horizonte	25.0	75.0	97.9	93.4	86.8	63.0	86.7	60.0
Recife	70.0	30.0	94.6	82.7	51.9	37.3	82.5	63.4
São Paulo	54.0	46.0	98.4	91.6	91.1	77.0	93.4	93.4
Rio de Janeiro	42.0	58.0	97.6	73.0	92.2	60.2	95.7	59.0

6.11 When all six of the metropolitan areas for which data are available are considered, surface water pollution was found to be the most serious problem in the Recife, Belem and Curitiba RMs, risk of flooding was reported to be the most important problem in metropolitan Porto Alegre, inadequate disposal of industrial and medical waste was considered the most serious environmental issue in metropolitan Sao Paulo, and reduction in water availability the most serious problem in the Salvador RM (Table 6.3).

Table 6.3: Summary Of Environmental Problems

RM	Most Serious Environmental Problem
Recife	Surface water pollution
Belem	Surface water pollution
Curitiba	Surface water pollution
Porto Alegre	Risk of flooding
São Paulo	Inadequate industrial and medical waste disposal
Salvador	Reduction in water availability

generalizable to other Brazilian metropolitan and large urban areas, was that low-income residents have the greatest exposure to environment-related causes of mortality and morbidity, have the least access to health care, environmental infrastructure and services, and are most likely to be occupants of hazard-prone lands.

ENVIRONMENTAL PROBLEMS/PRIORITIES IN METROPOLITAN BELO HORIZONTE AND RECIFE

6.12 The IBAM-sponsored local consultations on sanitation and the urban environment (1994) provide further information on critical environmental problems in the Belo Horizonte and Recife metropolitan regions. The reports by FEAM-ABES/MG and FIDEM also provide an overview of state and local institutional arrangements and capacity in Minas Gerais and Pernambuco for addressing environmental problems at the metropolitan level. Highlights from these reports are summarized below.

Belo Horizonte

6.13 The local consultation for the Belo Horizonte metropolitan region (BHMR) focused on the following priority environmental problem/intervention areas: basic sanitation (i.e., water supply and sewerage); drainage and water resource management; urban and industrial solid waste; and control of disease vectors. According to the corresponding report, water supply and sewerage coverage for selected (generally larger) municipalities within the metropolitan region are presented in Table 6.4.

6.14 As is generally the case in Brazilian metropolitan areas, water supply coverage in the Belo Horizonte MR is significantly greater than that for sewage collection, and peripheral municipalities are less well served than the central city, particularly in terms of sewerage infrastructure. In the

Table 6.4: BHMR Water And Sewer Coverage Percentages

Municipality	Water Supply (%)	Sewerage (%)
Belo Horizonte	93	78
Contagem	93	51
Betim	97	35
Santa Luzia	87	56
Vespasiano	86	49
São Jose de Lapa	95	26
Ibirite	71	--
Igarape	97	--
Lagoa Santa	88	--
Mateus Leme	84	--
Nova Lima	96	--
TOTAL BHMR	93	69

BHMR, water supply and sewerage services are provided by the state water company, COPASA, under concessions from each of the municipalities. At the state level, unaccounted-for-water is a significant problem, reportedly representing 35 percent of the total distributed. There are three major sources of water supply for the BHMR: (a) Rio das Velhas; (b) Paraopeba; and (c) isolated systems. Some municipal governments, such as that for Belo Horizonte, have established formal agreements with COPASA to extend water supply to low-income neighborhoods (*favelas*). COPASA has also developed master plans for water supply and sewerage for the metropolitan region. These were revised in 1994 for the period extending through the year 2000.

6.15 At present, only a very small percentage of the sewage generated in the BHMR region undergoes any form of treatment. The principal on-going investment in sewage collection and treatment, which seeks to partially remedy this situation, is the Bank-financed Environmental Sanitation Program (PROSAM), described in further detail below. Expansion of water supply systems (i.e., construction of additional aqueducts) in the eastern and western parts of the metropolitan area is being financed predominantly with COPASA's own resources. However, additional investments are required in order to provide complete coverage to the metropolitan population. The principal persisting obstacles to extending water supply and sewerage infrastructure, other than the limited availability of financial resources, include: (a) informal settlements (*invasoes*) in risk areas, involving an estimated 18,000 families in the metropolitan region in 1994; (b) areas of low demographic density; (c) areas subject to erosion; (d) non-urbanized areas; and (e) informal settlements (*favelas* and *vilas*), more generally. Integrated community action and sanitation programs (PACs), which include drainage and solid waste, as well as sewerage interventions, have recently been developed by COPASA and the municipality of Belo Horizonte as one way of dealing with these problems.

6.16 Given its irregular topography and history of unplanned/uncontrolled settlement in many areas, parts of the BHMR also face serious drainage problems. These are being addressed in the municipalities of Belo Horizonte and Contagem, which together house roughly two-thirds of the metropolitan population, under PROSAM. In addition, an inter-institutional Sanitation Group (1994) was reportedly elaborating a macro-drainage plan for the region, which would include actions to rehabilitate degraded areas and provide environmental and sanitation education together with physical works (dredging, removal of debris, etc.) to improve local drainage channels.

6.17 It is estimated that roughly 2000 tons of domestic solid waste are produced daily in the BHMR. Implementation of a new sanitary landfill in Belo Horizonte (Fazenda Capitao Eduardo) in 1994, however, has reportedly reduced the average distance required for solid waste vehicles to travel from their collection points by more than half (i.e. from 15.6 km to 6.7 km), as well as representing the first such facility in

Brazil with the capacity to treat leachate. In addition, the municipality of Belo Horizonte, has apparently proposed an integrated system of urban cleansing (*limpeza urbana*) in order to "universalize" the service and reduce costs. This system is based on a German model which includes resource recovery and recycling of paper and other reusable materials. As of 1994, the BHMR contained 14 authorized trash dumps (12 in Belo Horizonte and two in Ibirite) and 134 clandestine dumps. Some 300 tons/day of construction and other debris (out of an estimated total production of 1,200 tons/day) were being collected by the Belo Horizonte municipal government, and a proposal has been put forward to establish "voluntary delivery sites" (PEVs) to help induce proper disposal of such materials. Medical wastes are reportedly buried in a special section of the sanitary landfill. Finally, hazardous solid wastes from larger industries located in the BHMR are incinerated at seven locations, but collection and disposal of such wastes generated by small and medium enterprises continues to be a problem.

Recife

6.18 The local consultation in Recife, organized by FIDEM (1994), also focused primarily on basic sanitation services, especially sewerage and solid waste. At the time of the 1991 census, the Recife metropolitan region (RMR) involved 13 (now 14) municipalities and a total population of 2,916,663. The largest municipalities in demographic terms (with their respective 1991 populations) were Recife (1,296,995), Jaboatao (486,774), Olinda (341,059) and Paulista (211,017), which together account for more than three-quarters of the metropolitan total. As elsewhere, water supply and sewerage services are provided, under concessions from the municipalities, by the state water company, COMPESA, and solid waste collection and disposal is carried out by local governments. Water supply and sewerage coverage for the entire metropolitan region in 1994 were reported to be 87.4 percent and 23 percent, respectively.

6.19 Solid waste production in the RMR was estimated to be on the order of 3,200 tons/day in 1994. However, with the exception of the city of Recife, which has a specific municipal enterprise (EMLURB) for this purpose, solid waste services in other metropolitan municipalities were reportedly in a state of "collapse" as evidenced by the advancing age and "precarious condition" of trucks and other collection equipment. Other urban cleansing services (street sweeping, cleaning of parks and beaches, etc.) are also carried out by local governments to the extent permitted by available resources. In most cases, some or all of waste collection, transport, sweeping, and disposal services are contracted out to private enterprises (*terceirizados*). Of the 2,560 tons/day of domestic solid waste that are collected, 40 percent are deposited, without any kind of treatment, in large open air dumps, some of which are used by more than one municipality, together with medical and other types of wastes. Reusable materials are generally separated either before wastes are transported to the dumps or at the dump sites by low-income informal sector operators (*catadores*). As of 1994, just two metropolitan municipalities (Olinda and Itapissuma) had formal recycling programs.

6.20 The principal environmental problems identified at the metropolitan level by the local consultation, and which were attributed largely to several decades of rapid population growth, were (in no apparent order of priority): (a) uncontrolled occupation of hillsides; (b) uncontrolled occupation of mangroves or areas subject to periodic flooding; (c) mining activities without adequate environmental precautions in urban areas; (d) clearing of the few remaining areas of forest in the interior of the watersheds; (e) discharge of untreated sewage

directly into local watercourses due to insufficient sewerage infrastructure; (f) discharge of raw sewage into existing drainage canals; (g) discharge of treated effluents from the existing sewage treatment plant (Cabanga) of a quality not compatible with the dilution capacity of the receiving waters (Jiquia, Pina, Jordao, Tejipio and Capibaribe Rivers); (h) non-regulated use of groundwater resources, resulting in their contamination, salinization and, even exhaustion; (i) disposal of urban solid wastes in drainage canals, mangroves, and vacant lots; and (j) the existence of 14 open air solid waste dumps, without any treatment, contributing to groundwater pollution and the proliferation of disease vectors, and informal trash collectors (*catadores de lixo*) in conditions of extreme poverty (*miseria absoluta*).

INSTITUTIONAL ARRANGEMENTS FOR METROPOLITAN ENVIRONMENTAL MANAGEMENT

6.21 There are few systematic metropolitan-wide environmental planning and coordination mechanisms in Brazil, and metropolitan level agencies, more generally, are in a substantial state of flux. Eight MRs (Sao Paulo, Belo Horizonte, Porto Alegre, Recife, Salvador, Curitiba, Fortaleza, and Belem) were legally established by the Federal Government in June 1973 and a ninth (Rio de Janeiro) was added in early 1974, each with its respective state government-level planning/coordination agency. However, most of these agencies were either formally abolished and not replaced (as in the cases of Rio de Janeiro and Belo Horizonte, for example) or considerably weakened during the 1980s and 1990s (as is the case with Recife), while the 1988 Federal Constitution delegated authority to the states to determine how best to organize public interventions at the metropolitan level.[7] This has led to a variety of local responses, as can be illustrated with reference to the Belo Horizonte and Recife MRs. [8]

Belo Horizonte

6.22 The former metropolitan planning agency in Belo Horizonte, PLAMBEL (Planning Superintendency for the Belo Horizonte Metropolitan Region), was abolished in 1996 and part of its former staff and research activities transferred to the Center for Municipal and Metropolitan Studies at the Joao Pinheiro Foundation, which is subordinated to the state Secretariat of Planning. As its name suggests, however, this Center does not focus exclusively on metropolitan issues but provides support to municipal governments more generally, of which there are well over 800 in Minas Gerais. The only remaining formal metropolitan-wide institutions, which are largely political in nature, are GRANBEL, a forum of Mayors, and AMBEL (or Metropolitan Assembly), established in 1993, which is composed of representatives of municipal legislative assemblies and includes a number of councils (*camaras*) that are convened on an *ad hoc* basis to discuss specific topics of common interest. Neither of these collegiate bodies is reportedly very active at present, nor do they generally focus on environmental issues. The area of urban transport, however, provides a partial exception. Here, a Regional Transportation Coordination Commission (RTCC) has been established in conjunction with the Bank-financed Metropolitan Transport Decentralization Project for Belo Horizonte (see section on metropolitan environmental planning and management initiatives below).

---

7 For a discussion of the political-institutional aspects of the metropolitan regions in Brazil, see Ferreira de Araujo Filho (1996).

8 For recent environmental and pollution-related initiatives in the municipality of Sao Paulo, see Zulauf (1997).

6.23 As a result, environmental management activities in the Belo Horizonte MR involve a variety of state and local agencies. At the state government level, in addition to COPASA, the principal entities involved are: (a) the state Secretariat of Planning (SEPLAN/MG), which is responsible for coordination of PROSAM (involving the municipalities of Belo Horizonte and Contagem); (b) the state environmental council (COPAM), which is composed in equal parts of public and private sector, including NGO, representatives and has a number of very active technical councils (*camaras tecnicas*) to discuss specific environmental issues (e.g., water resource management); (c) the state environmental agency, FEAM, subordinated to the state Secretariat for Environment and Sustainable Development (SEMADES)[9] and the executive secretariat of COPAM, is responsible (as in other states) for environmental licensing of productive and infrastructure activities, and provides technical support on environmental management to the municipalities; and (d) the Minas Gerais Development Bank (BDMG), which is the implementing agency for SOMMA (Municipal Management and Environmental Infrastructure Program), another Bank-supported program (Loan 3669-BR, approved in October 1993) which features a credit line and technical assistance to local governments -- including those in the metropolitan region -- for investments in basic sanitation and other municipal services (see section on metropolitan environmental planning and management initiatives below).

6.24 At the local level, in addition to the enterprises or departments specifically responsible for solid waste services, most municipalities have Environment Secretariats or Departments, in some cases possessing professional staff with considerable relevant experience. One particularly noteworthy recent local initiative, which has occurred at the instigation of AMDA (Minas Environmental Defense Association), a local environmental NGO, is the creation of a forum of municipal Environment Secretaries in the Belo Horizonte MR. These officials, who met for the first time as a group in March 1997 at AMDA's invitation, have now recognized the need to coordinate local activities in certain areas, such as solid waste collection and disposal and urban transportation, and agreed to meet on a bi-monthly basis to discuss topics of mutual interest and recommend joint actions.[10] A number of localities, both within and outside the metropolitan area also have municipal environmental councils, or COMDEMAs, with public and private sector representatives and deliberative functions similar to those of COPAM at the state level.

Recife

6.25 In institutional terms, the current situation in Recife differs from that in Belo Horizonte in that, although technically weakened, a metropolitan planning agency, FIDEM, continues to exist and is actively working to coordinate environmental and other interventions among municipalities in a participatory way. The main mechanism for this coordination is the Recife Metropolitan Development Council (CONDERM). Together with FIDEM and the Recife Metropolitan Development Fund (FUNDERM), CONDERM forms the "Metropolitan Management System" (*Sistema Gestor Metro-*

[9] Formerly the state Secretariat of Science, Technology and Environment (SECTMA), whose name was changed in December 1995.

[10] The municipalities which have more active environmental Secretaries (Belo Horizonte, Betim, Brumadinho and Nova Lima) also see this forum as a way of raising the environmental awareness and increasing the effectiveness of their colleagues in other parts of the BHMR.

politano), which was established by law in 1994.[11]

6.26 CONDERM is a deliberative and consultative council, which is formally linked to the state Secretariat of Planning (SEPLAN/PE). It is composed of all (14) Mayors in the RMR, together with an equal number of representatives of the state government, who are nominated by the Governor, all with the right to vote (deliberative members). In addition, its "consultative members" (who do not posses the right to vote) include one representative of each municipal legislature and three representatives of the state Legislative Assembly. CONDERM is chaired by the Secretary of Planning with FIDEM as its technical secretariat. Its functions are to: (a) determine activities, enterprises and services that represent public functions of metropolitan-wide interest; (b) establish policies and guidelines for metropolitan region development and standards for public service performance; (c) encourage integrated action on the part of the agents involved and supervise the execution of public functions of common interest; (d) decide on initiatives to elaborate plans, programs and projects; and (e) comment on proposals regarding metropolitan-wide planning instruments. CONDERM is organized into a number of sectoral technical councils (*Camaras Tecnicas Setoriais*) for: (a) plans and projects for urban development and territorial organization; (b) social development; (c) transportation; and (d) environment and basic sanitation. These councils are each composed of six representatives from the public sector and six from civil society in order to ensure "equilibrium in terms of participation" and create "an intergovernmental model of shared responsibility."[12] CONDERM also considers and approves an annual metropolitan action plan, which indicates specific investments for economic and tourism development, transportation, sanitation and environmental protection, social development, and metropolitan planning and management.[13]

6.27 In addition to SEPLAN/PE, CONDERM, FIDEM, and COMPESA (*Companhia Pernambucana de Saneamento*), as in Minas Gerais, the state Secretariat of Science, Technology and Environment (SECTMA/PE) and the state environmental agency, CPRH (*Companhia Pernambucana de Controle da Poluicao Ambiental e de Administracao dos Recursos Hidricos*), are directly involved in metropolitan environmental management through environmental licensing, industrial pollution control, and other activities. SEPLAN/PE is also taking the lead on water resource management activities in the state, including ongoing Bank-financed basin studies for four rivers that traverse the metropolitan region (see section on PQA below). FIDEM and CPRH likewise participate in this initiative.

6.28 The municipality of Recife is similarly active in environmental improvement efforts through its Secretariat of Urban and Environmental Planning and the municipal enterprise responsible for solid waste collection and disposal and other urban cleansing activities (EMLURB). A number of environmental projects are currently under development by the municipal government, most notably a proposal for IDB funding for basic sanitation and other improvements in the Tejipio and Jordao River Basins (see paragraph on metropolitan environmental initiatives below). As in the BHMR, however, other metropolitan mu-

[11] For further information on this system see FIDEM (1997).

[12] The above information is drawn from a pamphlet entitled "O CONDERM Esta Planejando o Futuro Metropolitano" ("CONDERM is Planning the Metropolitan Future").

[13] See, for example, CONDERM (1996).

nicipalities have considerably less environmental management capacity.

CURRENT METROPOLITAN ENVIRONMENTAL PLANNING AND MANAGEMENT INITIATIVES

Belo Horizonte

6.29 Except for the recently created forum of municipal environmental secretaries and, for urban transport, the Regional Transport Coordination Commission (RTCC), there is no systematic mechanism at the metropolitan level in Belo Horizonte for the development and implementation of environmental strategies and action plans. Several state government, inter-municipal and local initiatives are, nevertheless, worthy of note. At the state government level, the PROSAM and SOMMA programs, together with FEAM's efforts to orient municipalities with respect to environmental management, both in the metropolitan area and elsewhere in the state, have already been mentioned, but should be described in somewhat further detail, as should innovative state and municipal (Belo Horizonte) legislation and a Bank-supported project for improvements in the metropolitan transport system (Loan 3916-BR, approved in June 1996).

PROSAM

6.30 The Environmental Sanitation Program is coordinated by SEPLAN/MG, with active involvement of other state agencies such as FEAM and COPASA and the municipalities of Belo Horizonte and Contagem. Its general objective is to assist the state of Minas Gerais in developing a cost-effective approach to control water pollution. Its specific objective is to rehabilitate the environmentally deteriorated urban basins of the Arrudas and Onca Rivers in the BHMR and, beyond the metropolitan area, to protect the das Velhas River, into which the Arrudas and Onca Rivers flow. The project, whose total cost was estimated at appraisal at US$ 307.6 million and was awarded a Bank loan of US$ 145.0 million in January 1993, has five main components: (a) flood control and urban drainage; (b) municipal and industrial sewage collection and disposal, including the construction of two sewage treatment plants on the Arrudas and Onca Rivers; (c) municipal and industrial solid waste disposal and collection; (d) environmental protection and urban land use; and (e) river basin management, including development and implementation of a proposal to establish a Basin Committee and Agency for the Rio das Velhas.[14] Once all project investments are completed, it is expected to have a substantial positive environmental impact both by reducing domestic and industrial water pollution and by improving water resource management in the Arrudas/Onca/das Velhas basins. It is also expected to improve solid waste collection and disposal in Belo Horizonte and Contagem.[15]

SOMMA

6.31 The Municipal Management and Environmental Infrastructure Program, whose principal executing agency is BDMG, has as its principal objectives to: (a)

---

[14] For additional information on the proposed das Velhas River Basin Agency, see a PROSAM newsletter recently issued by SEPLAN/MG (Volume 1, No. 1, March 1997).

[15] Additional information on the design and implementation of this project can be found in the Staff Appraisal Report (No. 10805-BR, dated December 1, 1992) and in periodic Bank supervision reports, as well as in a document issued by the Government of Minas Gerais entitled "Programa de Saneamento Ambiental," Belo Horizonte, October 7, 1996

strengthen municipal financial management in support of recent state decentralization reforms; and (b) improve environmental management, through development of a coherent state strategy for local provision of water and sewer services, investment in priority basic sanitation infrastructure, and provision of technical assistance and training for municipal administrations in environmental management. The project, which has an estimated total cost of US$ 333.1 million and is supported by a Bank loan of US$ 150 million, has four main components: (a) institutional development to upgrade municipal financial administration and improve municipal management and environmental planning; (b) environmental infrastructure to upgrade basic sanitation and related services, primarily water, sewerage, drainage, solid waste, and street paving and lighting; (c) small pilot programs to test private sector provision of municipal services; and (d) studies on the development of a statewide strategy for local provision of water and sewer services and on medium-term options for municipal finance. The project is open to all municipalities in Minas Gerais, including those in the metropolitan region, (as well as to municipal water and/or sewerage authorities and COPASA) as long as they meet certain eligibility criteria. Thus far, however, within the BHMR, only Betim, an important industrial district and the third largest metropolitan municipality in demographic terms, has made use of SOMMA resources for an environment-related project, specifically for installation of a sanitary landfill.[16]

FEAM's Support to Municipalities

6.32 The state environmental agency, FEAM, gives considerable priority to providing orientation in environmental management to municipal governments, including those in the BHMR. This is part of broader environmental education activities, which take several forms including training courses for local officials and preparation of guidance documents with assistance from the Environmental Sanitation Department of the Federal University of Minas Gerais (DESA/UFMG) and financial and technical support from GTZ. Thus far, three volumes of a "Sanitation and Environmental Protection Manual for the Municipalities" have been produced[17] and others are under development on specific environmental management instruments (licensing, monitoring, enforcement (*fiscalizacao*), etc.). FEAM has also recently (1995) published a manual targeted primarily at local governments on how to dispose of urban solid wastes, with financial support from a large private mining company (Belgo Mineira).[18]

[16] For further information on this project, see the respective SAR (Report No. 11714-BR, dated June 21, 1993) and subsequent supervision mission reports.

[17] These volumes are on the following specific themes: (a) The Municipality and Environment (1995); (b) Basic Sanitation (1995); and (c) Environmental Education: Basic Concepts and Action Instruments (1996). They appear to be of excellent quality. The one on basic sanitation, for example, has chapters on sanitation and the municipality, sanitation and the environment, sanitation and public health, water supply, sewerage, stormwater drainage, solid waste and public cleansing (*limpeza publica*), and useful information for municipal administrations. IBAM also has a basic guidance document for municipalities entitled "Municipio, Desenvolvimento e Meio Ambiente," issued in 1992, but the FEAM publications provide more technical information and appear to be examples of "good practice" in terms of guidance to local governments in Brazil.

[18] This publication, which is also an example of "good practice," has chapters on the characteristics of solid waste, alternative treatment and disposal methods, recycling, recuperation of areas degraded by trash

Innovative State and Municipal Legislation

6.33 In addition to being one of the first states in Brazil to adopt water resource legislation, Minas Gerais has also gone farthest in using fiscal incentives to induce municipalities to improve environmental management. Like several other states, including Parana, Sao Paulo and Rio de Janeiro, Minas Gerais uses an instrument known in Brazil as *ICMS Ecologico* to transfer (value added) tax revenues to municipalities which have legally established conservation units in their territories.[19] In Minas Gerais, according to legislation approved in December 1995 (Law No. 12.040, known locally as the "Robin Hood Law"), among the criteria utilized to determine how the 25 percent of resources returning to the municipalities would be channeled are the existence of conservation units that are formally registered with SEMADES and the existence of solid waste disposal and/or sewage treatment disposal systems licensed by COPAM.[20] This legislation, in short, not only provides a compensation mechanism for municipalities that possess formal protected areas, but also creates an incentive to reduce pollution (and associated public health risks) by improving their basic sanitation services.[21] The municipality of Belo Horizonte has also had its own environmental legislation (*Lei Ambiental*) since December 1985. Among other provisions, this law specified the functions of the Municipal Environment Secretariat (created in June 1983) and established the Municipal Environmental Council for Belo Horizonte.[22]

Metropolitan Transport Decentralization Project

6.34 This project, approved in June 1995, involves a total cost of US$ 197.3 million and a Bank loan of US$ 99 million. It seeks to: (a) develop an integrated urban transport system for the BHMR under a Regional Transportation Coordination Commission (RTCC);[23] (b) complete the decentraliza-

dumps, organization and administration of solid waste treatment and disposal services, environmental licensing, and relevant state (COPAM) regulations in this area.

19 ICMS refers to the Tax on Operations involving the Circulation of Goods and Provision of Interstate and Inter-municipal Transport and Communications Services. Under the 1988 Federal Constitution, 75 percent of the proceeds of this tax collected in each state are allocated to state governments to help finance their operations and investments and 25 percent are distributed to the municipalities. Of the latter 25 percent, 75 percent are allocated to the municipalities in proportion to their contributions to value added in the state and the remaining 25 percent are allocated according to the criteria set out in specific state legislation.

20 Within the metropolitan region, and presumably on the basis of the sanitary landfill implemented with financial support from SOMMA, the municipality of Betim has already been declared eligible to receive an additional ICMS transfer of US$ 2 million in 1998 under the provisions of this law.

21 Details on this legislation can be found in a recent (March 1997) publication by FEAM entitled "ICMS Ecologico." In addition to the existing law, FEAM is presently developing draft legislation (known as the "Robin Hood Law II") to establish tax penalties for municipalities that do not properly protect environmentally sensitive areas (*areas de risco*) and to reward those that develop action plans to reduce pollution. This is described by the President of FEAM as the "protector or non-polluter receives" principle, or the reverse of the "polluter pays" principle.

22 For further information, see "Lei Ambiental do Municipio de Belo Horizonte," 1993.

23 According to the draft agreement (*convenio*) to establish RTCC, its overall objectives are to carry out transport planning of

tion of the Belo Horizonte Subdivision (STU-BH) of the Brazilian Urban Train Company (CBTU) from the federal to the state and municipal levels; (c) reduce environmental (mainly air quality and noise) impacts on the BHMR due to motor vehicles and promote non-motorized transport modes; and (d) develop special strategies and actions to improve accessibility of low-income populations to employment centers and health and education facilities. The project consists of three major components: infrastructure and equipment; environmental and traffic safety; and institutional and policy development. The latter includes: (a) creation of the RTCC; (b) preparation of an integrated Transport Policy, Land Use, and Air Quality Management strategy for the metropolitan region to meet both transport and air quality targets and to introduce sound cost recovery, tariff, regulatory and subsidy policies; (c) implementation of a cost-based financial management system in the STU-BH; (d) development of an enabling environment and financial instruments for more substantial participation of the private sector in the investment and operation of the operating agencies; and (e) strengthening of air quality planning and monitoring of vehicle-based emissions.[24]

the BHMR to ensure that state and municipal transport plans and programs are compatible with metropolitan plans, to define transport policy and standards, to prioritize investments, and to coordinate transport investment expenditures. As proposed, RTCC would be chaired by a state Secretary and include the municipal Secretary of Transport of Belo Horizonte and the Mayors of all the municipalities that compose the metropolitan region.

[24] For more detailed information on the design and implementation of this project, see the SAR (Report No. 14265-BR, dated June 5, 1995) and subsequent supervision reports.

Recife

6.35 Among the most important environmental planning and management-related activities involving the Recife MR are: (a) the new regional master plan (*plano diretor*), which is currently being elaborated under FIDEM's coordination; (b) solid waste management studies, also coordinated by FIDEM, and water supply and sewerage service management studies for the municipality of Recife, undertaken under the auspices of the Bank-funded Water Sector Modernization Project (PMSS); (c) diagnostic and preliminary basin management studies for four rivers that cross the metropolitan region, coordinated by SEPLAN/PE, and funded under the national component (PQA) of the Bank-assisted Water Quality and Pollution Control Project; (d) the Bank-financed (Loan 3915-BR, approved June 1995) Recife Metropolitan Transport Decentralization Project; and (e) existing environmental legislation and environmental sanitation project proposals by the Recife municipal government.

Metropolitan Master Plan

6.36 Preparation of this plan, which will be normative and strategic in character, was initiated in 1996 by FIDEM in its capacity as executive secretary of CONDERM and is expected to be completed by the end of 1997. It is being carried out as the metropolitan scale counterpart to an earlier sustainable development planning exercise undertaken for the state as a whole, known as "Pernambuco 2010,"[25] and has the same

[25] See SEPLAN/PE, "Pernambuco 2010: Estrategia de Desenvolvimento Sustentavel," Recife, 1996, for details. This exercise was carried out in the context of a broader strategic planning activity for the Brazilian Northeast Region as a whole, known as "Projeto Aridas." See Ministry of Planning and Budget (MPO)/IPEA (1995).

time horizon. Its objective is to "provide the various 'metropolitan agents' [e.g., municipalities, state government, civil society] with a policy instrument for metropolitan development that should orient future interventions both in the urban and rural segments of the Recife MR and establish a basis for shared management of public services of common interest (*gestao compartilhada de servicos publicos de interesse comum*), considering regional problems and potentialities and observing the principles of sustainable development."[26] The plan will be prepared in a participatory manner, through a series of workshops and seminars, using the sectoral technical subcommittees (*camaras tecnicas setoriais*) of CONDERM described above and focusing on four major themes: (a) urban development and territorial organization (*ordenamento territorial*); (b) socio-economic development; (c) transportation; and (d) sanitation and environmental protection. In addition, specialized consultants will work with the inter-institutional technical teams in all four areas to ensure that the three guiding principles mentioned in the general objectives of the exercise -- shared management, citizenship (*cidadania*), and sustainable development -- are adequately reflected in their deliberations.[27]

Metropolitan Solid Waste, Water Supply and Sewerage Service Management.

6.37 FIDEM contracted the Technical Association of Pernambuco at the Federal University (UFPE/ATEPE) to undertake studies, in consultation with the municipalities, on solid waste treatment and disposal for the metropolitan area.[28] On the basis of these studies, FIDEM has recently proposed a management system for the treatment and disposal of solid wastes in the RMR.[29] This proposal features six subsystems centered around six sanitary landfills (one each in Olinda, Itapissuma, Paulista, Sao Lourenco da Mata, Jaboatao, and Ipojuca) that would receive wastes from neighboring municipalities, to be operated through some sort of state-municipal government partnership arrangement. In parallel to these metropolitan scale studies, the city of Recife, using resources from PMSS, has contracted studies for the establishment of a regulatory framework and development of a management and operational model for water supply and sewerage services at the municipal level. Preliminary diagnostic reports for both of these studies are now available.[30]

---

26 FIDEM, "Plano Diretor da Regiao Metropolitana do Recife: Termos de Referencia," Recife, December 1996, pg. 5. This document provides details on the scope and procedures for elaboration of the proposed master plan.

27 Unlike in previous metropolitan planning exercises for the Recife MR (which were largely technocratic and "top down" in nature), FIDEM's role will be largely one of facilitating and providing technical support to sectoral diagnoses and priority setting by the various thematic teams, all of which will include representatives from the municipalities as well as state and federal (local representatives) government agencies.

28 For the results of these studies, see UFPE/ATERPE, "SGRS - Sistema de Gestao do Tratamento e Destinacao dos Residuos Solidos na RMR: Concepcao Basica Operacional, Institucional e Financeira," Recife, March 1996.

29 FIDEM, "Sistema de Gestao do Tratamento e da Destinacao Final de Residuos Solidos na RMR," Recife, January 1997.

30 See, Deloitte Touche Tohmatsu, "Estabelecimento de Marco Regulatorio para a Gestao de Servicos de Agua e Esgoto no Municipio de Recife: Diagnostico Inicial," January 13, 1997, and Condominium, "Modelo para Gestao e Operacoes de Servicos de Agua e Esgotos no Municipio de Recife: Diagnostico," Recife, January 1997.

Basin Diagnostic and Management Studies

6.38 With financing under the national component (PQA) of the Bank-assisted Water Quality and Pollution Control Project, SEPLAN/PE, in conjunction with SECTMA/PE, the state Secretariat of Infrastructure, CPRH, COMPESA, FIDEM, and FIAM (the Foundation for Municipal Development in the Interior of Pernambuco), is in the process of contracting comprehensive diagnostic studies on which to base preparation of an environmental sanitation investment program (similar in nature to PROSAM in the Belo Horizonte MR) for the Recife MR.[31] The primary focus of these studies and of the future investment program will be reduction of water pollution and improved water resource management in the four main river basins (Capibaribe, Beberibe, Jaboatao, and Ipojuca) that bisect the metropolitan area. The two studies that are presently being contracted are for consolidation of a diagnosis of water quality and an analysis of alternatives for development of metropolitan sewerage and drainage systems.[32]

Metropolitan Transport Decentralization Project

6.39 This project, which is estimated to involve a total cost of US$ 203.8 million and is partially financed by a Bank loan of US$ 102 million, has objectives and components which are virtually the same as those for the Belo Horizonte Transport Decentralization Project described above (and thus not repeated here). The one significant difference between the two operations is institutional in nature. Instead of establishing a new metropolitan level coordination mechanism, the Recife project proposes transforming an existing structure, the Metropolitan Urban Transport Enterprise (EMTU), into a Regional Transport Coordination Commission (RTCC).[33]

Environmental Legislation, Policy, and Environmental Sanitation Projects in Recife

6.40 Like the city of Belo Horizonte, the municipality of Recife has its own environmental policy (1994),[34] legislation, and (in this case, Urban and) Environmental Planning Secretariat. It also has a master development plan (*Plano Diretor*), formally adopted in 1991, that includes chapters on urban environment and urban services (water, sewer, drainage, and *limpeza urbana*).[35] Recent environment-related legislation of relevance includes an environmental code and a land use and occupation law for the

[31] A preliminary (outline) version of this program, under the tentative title of "Recife Metropolitan Environmental Project," was discussed by local officials with a Bank supervision mission that visited Recife in March 1997. In addition to SEPLAN/PE, COMPESA, and FIDEM, and the other agencies that compose the proposed state coordination unit, implementation of this project would involve the municipalities of Recife, Olinda, Camaragibe, and Jaboatao.

[32] For greater detail, see SEPLAN/PE, "Consolidacao e Complementacao de Diagnostico sobre Qualidade das Aguas: Termos de Referencia" and "Esgotos e Drenagem da Regiao Metropolitana do Recife - RMR," Recife, April 1997.

[33] This proposal and other aspects of the project are described in the corresponding SAR (Report No. 14264-BR, dated June 5, 1995).

[34] See Prefeitura da Cidade do Recife, "Politica de Meio Ambiente para a Cidade do Recife," Recife December 1994.

[35] Prefeitura da Cidade do Recife, Plano Diretor de Desenvolvimento da Cidade do Recife, Law No. 15.547/91, Recife 1992.

city of Recife, both of which were formally adopted in 1996.[36] In addition to its participation in the river basin studies and preparation of the proposed environmental sanitation project mentioned above, the municipality of Recife is developing several other environmental sanitation projects, including one whose first stage is presently under discussion with the Inter-American Development Bank (IDB) for possible financing. This project, known locally as PROEST I (Tejipio River Urban and Environmental Recuperation Program), would involve four components: sewage collection and treatment, solid waste collection, *favela* relocation and upgrading, and environmental education. Its estimated total cost is US$ 96 million, for which an IDB loan of US$ 72 million is being sought.[37] Beyond this, the local government is developing a project and seeking funding for the recovery of a large heavily polluted reservoir (Apipucos) and is attempting to implement a number of protected areas in ecologically sensitive zones within the municipality.[38]

[36] Prefeitura da Cidade do Recife, "Uso e Ocupacao do Solo da Cidade do Recife," Law No. 16.176/96, April 9, 1996 (regulated by Law No. 16.289, January 29, 1997) and "Codigo de Meio Ambiente e do Equilibrio Ecologico da Cidade do Recife," Law No. 16243/96, September 13, 1996. The government of Pernambuco also recently (January 17, 1997) approved a law (No. 11.427) for groundwater protection in the state.

[37] See Prefeitura da Cidade do Recife, "Programa de Recuperacao Urbana e Ambiental - Bacia do Rio Tejipio - PROEST I: Sintese do Programa," 1996.

[38] With respect to the former, an earlier project document entitled "Revitalizacao do Acude de Apipucos, 1987-89" is in the process of being revised and updated by the Prefeitura of Recife. As concerns the latter, see Prefeitura da Cidade do Recife, "Unidades Ambientais do Recife."

KEY LESSONS OF EXPERIENCE WITH URBAN AND METROPOLITAN ENVIRONMENTAL MANAGEMENT IN BRAZIL

6.41 The Bank has financed a number of projects in urban and metropolitan areas in Brazil. Many of these operations have had environmental sanitation components, including sewerage (including the use of innovative low-cost approaches, such as "condominial" sewage systems, in low-income urban neighborhoods), drainage, and solid waste collection and disposal. Urban transport, both in metropolitan areas and other large cities, has also been an important part of the Bank's lending program in Brazil over the past several decades. Many of these operations have been subject to completion reports, OED audits,[39] and, in some cases, impact studies.[40]

6.42 While these evaluation studies do not specifically address the issue of urban and metropolitan environmental management *per se*, they do contain lessons that are of relevance to it, and to project design and implementation more generally. Bank experience worldwide with urban environmental management was likewise one of the sub-

[39] See, for example, OED Project Performance Audit Reports (PPARs) No. 8302, "Brazil - Medium-Sized Cities Project (Loan 1720-BR), December 29, 1989, and No. 10832, "Brazil - Third Urban Transport Project (Loan 1965-BR); Recife Metropolitan Development Project (Loan 2170-BR); Parana Market Towns Improvement Project (Loan 2342-BR); and "Northeast Urban Flood Reconstruction Project (Loan 2545-BR)," June 26, 1992.

[40] OED has recently carried out an impact study on several completed urban projects including the Medium-Sized Cities and Parana Market Towns Improvement Projects mentioned in the preceding note. A workshop was recently (April 1997) held in Brasilia to discuss the results of this study and a report is under preparation.

jects examined in OED's annual review of evaluation results for 1991.[41] Among the general conclusions and recommendations emerging from these ex-post assessments of Bank experience with urban environmental management that continue to be relevant to the contemporary Brazilian metropolitan setting are:

(a) Given the increasing levels of urbanization in the developing world, greater priority should be given to urban environmental issues in general and to urban sewerage, drainage and pollution control in particular, especially in the largest and most rapidly growing cities.

(b) Urban environmental management should start with an analysis of the underlying problems on a citywide basis, careful identification of alternatives and definition of priorities for public and private sector action, and the selection of cost-effective interventions.[42] In general, prevention (i.e., waste reduction, demand management) should be favored over "clean-up" approaches. In dealing with urban environmental problems, moreover, land use and traffic management, as well as technological measures, should be considered. Both in borrowing countries and the Bank, this implies a need for closer coordination across infrastructure sectors to achieve greater consistency in policies relating to urban water supply and sanitation, land development, and transport.

(c) The Bank should give greater attention to the institutional and financial dimensions of urban environmental service provision, particularly at the municipal level, including the development of adequate normative, operational, and financial frameworks, and the creation, strengthening, or consolidation of the appropriate agencies. Adequate inter-institutional (including public-private and cross-jurisdictional) coordination, public awareness, and NGO and community participation, together with enhanced local resource mobilization, are likely to be essential for improved urban sanitation, solid waste management, and pollution control.

(d) The substantial human and financial resources and comparatively long time horizons required for the attainment of many urban environmental goals and the political sensitivity of many environmental management decisions should be clearly recognized and taken into account in formulating and implementing urban environmental strategies and lending operations.

6.43 Beyond these general lessons, Bank experience with metropolitan development in Brazil (and elsewhere), particularly in the problematic Recife Metropolitan Development Project, point to the need to avoid interventions which are either excessively complex (in institutional terms) or excessively "top-down" technocratic approaches to address environmental (and local development) priorities, once these have been clearly defined. Current efforts to increase awareness among local officials (both Mayors and legislative assemblies), as well as among the general population, of the human

[41] See, OED, Evaluation Results for 1991, World Bank, Washington, D.C., March 1993, Chapter IV "Aspects of Urban Environmental Management." This chapter specifically addresses Bank experience in projects completed through the early 1990s in three main areas: urban water supply and sanitation; solid waste management; and urban-industrial pollution control.

[42] See also, Bartone, Carl, Bernstein, Janis, Leitmann, Josef, and Eigen, Jochen., "Toward Environmental Strategies for Cities: Policy Considerations for Urban Environmental Management," UMP Discussion Paper, No. 18, 1994, and, for similar recommendations at the national level, World Bank Environment Department, National Environmental Strategies: Learning from Experience, Washington, D.C., 1995.

health and other costs of pollution and of the need to design and coordinate cost-effective inter-municipal or metropolitan scale interventions to address critical environmental problems, as are presently occurring in both the Recife (CONDERM) and Belo Horizonte MRs (FEAM, forum of municipal Secretaries of Environment) are clearly steps in the right direction.

6.44 Past experience also indicates that a lack of inter-municipal cooperation in metropolitan service provision can involve significant costs. Two examples from completed Bank urban pollution control projects in Brazil illustrate this. Under the Greater Sao Paulo Sewage Collection and Treatment Project (Loan 1525-BR, approved in February 1978), which was intended to partially finance implementation of the metropolitan sewerage master plan (SANEGRAN) prepared under an earlier Bank project, three new sewage treatment plants were to be built in the northern, southern, and eastern parts of the Sao Paulo MR, respectively. Successful operation of the southern treatment plant required construction of sewage interceptors by three important municipalities with their own resources. For a variety of financial and political reasons, however, the municipalities decided to not to build the interceptors, resulting in the need to drop the southern treatment plant and deferring the potential health and environmental benefits expected to be generated under the project.[43] The second example involves the solid waste component of the Recife Metropolitan Development Project which failed to achieve its objectives because of the inability of the participating municipalities to agree on a location for a sanitary landfill in the northern part of the metropolitan region. In both cases, lack of coordination among metropolitan municipalities led to the non-implementation of key environmental sanitation facilities.

STRATEGIC DIRECTION FOR INSTITUTIONAL DEVELOPMENT FOR METROPOLITAN AND URBAN ENVIRONMENTAL MANAGEMENT

6.45 As the preceding paragraphs suggest, there is likely to be no single "magic formula" in institutional terms for addressing urban and metropolitan environmental problems. However, there appear to be several key preconditions for successfully dealing with such problems: (a) an active and informed public; (b) a solid information base on the nature, extent, and associated costs of local environmental problems; (c) systematic analytical and participatory mechanisms for defining and building consensus around local environmental priorities; and (d) adequate local technical, institutional, and financial capacity to design, coordinate (especially across municipal boundaries), and implement cost-effective solutions to priority problems, and to monitor and evaluate the results of these interventions.

6.46 Of the two cases considered in more detail, it would appear that Recife is presently farther along this path than Belo Horizonte, both in terms of institutional arrangements at the metropolitan level (CONDERM, FIDEM, etc.) and in terms of attempting to develop a broader strategic vision for metropolitan development (new indicative master plan) over the next decade or so, including environmental management priorities. Part of the reason for this is historical, as Recife was one of the first metropolitan areas in Brazil to establish a metropolitan planning agency (FIDEM) and to elaborate and attempt to implement (with

[43] See OED Report No. 7016, PCR for Loan 1525-BR, dated November 18, 1987; and OED, World Bank Approaches to the Environment in Brazil: A Review of Selected Projects, Volume II ("Pollution Control in Sao Paulo"), Report No. 10039, April 30, 1992, for details.

World Bank support) a metropolitan development plan.[44] However, what was originally a technocratic, "top-down" -- and ultimately only partly successful -- approach to metropolitan planning has clearly evolved in recent years to a more democratic, participatory, "bottom-up" approach, in which FIDEM's role has become one of providing technical support to and facilitating dialogue between the municipalities that compose the metropolitan region. Recife has also gone farther than Belo Horizonte in terms of the integration of environmental and sustainable development concerns in development planning at the metropolitan level.

6.47 The Belo Horizonte MR presents an alternative "model." Here, except in the urban transport sector, a metropolitan-wide planning agency no longer exists. However, a local NGO has recently induced municipal environmental officials to meet periodically to better coordinate their actions at the metropolitan level. In addition, the state environmental agency, FEAM, actively provides technical assistance and training to municipalities in key areas of urban environmental management.

6.48 In both the Recife and Belo Horizonte MRs, the central cities are also very active in terms of environmental management initiatives. However, there is a considerable imbalance in both environmental awareness and planning and implementation capacity (as well as in many other respects) between the central and peripheral municipalities. Both the metropolitan council approach in Recife and the recently created Forum of Municipal Environment Secretaries in Belo Horizonte are potential ways of redressing this imbalance, although in both cases targeted institutional capacity building efforts are clearly necessary in most peripheral municipalities. Given that all of the municipal administrations are still relatively new, this is an opportune time to undertake such initiatives.

6.49 Among the policy instruments that should be utilized in addressing urban and metropolitan environmental issues, in addition to priority investments in pollution control (including basic sanitation and solid waste infrastructure and services)[45] are planning and regulatory measures, including land use zoning and building codes, which can result in important environmental benefits. As the experience in Curitiba over the past several decades clearly demonstrates, coordinated urban land use and transportation planning can both rationalize the location of new urban productive and residential activities (and associated physical infrastructure investments) and maximize the efficiency of collective transport services, while at the same time reducing vehicle congestion and associated air pollution.[46] Urban development planning, infrastructure provision, and associated legislation, together with appropriate housing policies, can also effectively "lead" settlement away from environmental "risk areas," such as hillsides and low-lying areas subject to

[44] See, for example, FIDEM, Regiao Metropolitana do Recife: Plano de Desenvolvimento Integrado, Recife 1976.

[45] For a systematic discussion of such instruments, see Bernstein, Janis, "Alternative Approaches to Pollution Control and Waste Management: Regulatory and Economic Instruments," UMP Discussion Paper, No. 3. April 1991. For a more recent discussion of policy instruments for environmental management, see Environment Department, Five Years After Rio: Innovations in Environmental Policy, Rio + 5 Edition, Draft for Discussion, March 1997.

[46] On the experience with urban transportation in Curitiba, in addition to the references cited in note 4 above, see Campbell, Tim, "Innovations and Risk Taking: The Engine of Reform in Local Government in Latin America and the Caribbean," World Bank, November 18, 1996.

flooding, as well as play a key role in the preservation of environmental resources and provision of open space through the establishment of urban parks and protected areas. When properly applied, moreover, urban zoning and environmental licensing can avoid incompatible land uses (e.g., housing and certain types of industry) and minimize the impact of potentially polluting economic activities on urban populations.[47]

6.50 Many urban and metropolitan environmental problems in Brazil and elsewhere are directly associated with an inadequate residential environment, both in terms of housing location, quantity and quality and the lack of basic sanitation infrastructure and services. While the focus of most of the above discussion has been on poor infrastructure and services, urban land tenure and housing also require attention. As a recent Bank policy document affirms, there are important linkages between housing, poverty and the urban environment:

Slums, dilapidated urban neighborhoods, and squatter settlements which provide housing to the majority of the urban poor are very often the places of lowest environmental quality....Poor environmental health is a consequence of both inadequate infrastructure provision and insecure tenure. Illegal neighborhoods are less likely to be adequately serviced by residential infrastructure, and households uncertain of their physical security are not only less likely to invest in improving their housing but less likely to invest in improving the quality of their local environments. Housing policies that pay inadequate attention to the housing conditions of the poor are therefore associated with worse environmental conditions in cities. As a result, there are strong complementarities in policy changes necessary to address the problems of the urban poor and the major environmental problems associated with poor housing sector performance.[48]

6.51 Among the significant implications of these linkages are that "environmental and housing goals can be addressed simultaneously by good housing policies."[49] Granting secure property rights in low-

[47] For further information on this topic, see Bernstein, Janis, "Land Use Considerations in Urban Environmental Management," UMP Discussion Paper No. 12, January 1994.

[48] World Bank, Housing: Enabling Markets to Work - A World Bank Policy Paper, Washington, D.C., April 1993, pp. 31-32. Not all of the linkages are positive however. "Land use regulations and infrastructure investment policies have important incentive effects as well as direct effects on the spatial layout of cities. In some cases, the resulting outcomes may diminish access to open space, parks, and playgrounds; aggravate air pollution associated with commuting on congested roads; and lead to energy wastage from unnecessarily long commutes." In addition, "despite good reasons for protecting local environments, and the best of intentions, implementation of certain 'environmentally friendly' regulations has not always been friendly to the operation of urban land and housing markets, and has, too often, been less effective than hoped for in meeting environmental objectives. Greenbelt regulations have often unnecessarily restricted the supply of residential land, leading to high land and house prices and often, because of high development pressure, to the elimination of accessible parks and open space within the metropolitan area. Unenforceable zoning of large green areas has often been an open invitation to squatting, and has thus led to the disappearance of open space. Similarly, when artificial shortages of land have been created through inappropriate land use regulations, environmentally fragile areas have sometimes been assaulted by housing developers. " (pp. 32-33).

[49] Ibid., pg. 32.

income urban areas, for example, can lead to increased investment in sanitation facilities at both the household and the neighborhood levels with associated environmental and public health benefits. A second implication is that there is a "clear need for greater understanding of the consequences of environmental regulations as they affect land and housing markets, but also a need to understand better the environmental consequences of housing policies."[50] This analysis has yet to be done for Brazilian metropolitan areas and could well be undertaken with federal government coordination. More generally, priorities for future lending, with a continued focus on the urban poor, that emerge from the Bank's 1993 review of its experience in the housing sector[51] include:

- property rights development;
- enhancement of housing finance;
- rationalization of subsidies;
- infrastructure for residential land development:
- large-scale trunk infrastructure projects;
- infrastructure upgrading in slums and squatter settlements;
- infrastructure provision in sites and services;
- enhancing the efficiency of the building industry;
- regulatory reform; and
- institutional reform.[52]

6.52 Finally, it is important to remember that many metropolitan and urban environmental problems require considerable time to solve and that, therefore, in addition to participatory strategic planning and priority setting, cost-effective interventions, and adequate coordination across municipal boundaries, continuity of vision -- and action -- is essential. Such continuity is often difficult given the frequent political-administrative changes at the local level. However, experiences such as that of Curitiba and CETESB, the state environmental agency in Sao Paulo, confirm that it is possible. In both cases, successful outcomes over an extended period of time have been due to a combination of sustained institutional capacity and political support, including that of the affected local communities. In the case of CETESB, continued World Bank support and that of other external agencies has also been a relevant factor.

6.53 A recent Bank study of the Curitiba experience identifies three key elements which appear to have been essential to its positive environmental performance: (a) policymakers recognized that environmental problems are cross-sectoral in nature and, in translating this recognition into action, proved capable of influencing decisions in different sectors of the local economy by taking a multi-disciplinary approach and successfully integrating environmental concerns into overall urban planning activities; (b) environmental planning centered on pre-

[50] Ibid., pg. 33.

[51] Among the key lessons from past Bank experience in the housing sector were: (a) the macroeconomic and regulatory environment is important; (b) the informal housing sector has a significant contribution to make; (c) projects have limited impact; (d) attention should continue to shift to the housing sector as a whole; (e) emphasis should continue to shift from projects to institutional reform; (f) a variety of approaches is needed; and (g) past emphasis of Bank housing lending on the poor is important and should continue. Ibid., pp. 58-60.

[52] Ibid., pp. 64-69.

vention rather than correction and clean up, took complementarities and trade-offs into account at an early stage, built on a flexible regulatory framework, and benefited from cost-saving approaches, such as market-based incentives, and stakeholder participation; and (c) the local planning agency was able to secure the financial resources necessary to fulfill its mandate and to influence overall local government resource allocation, thus ensuring the critical linkage between planning and implementation.[53]

6.54 Among the relevant conclusions of an OED study of Bank experience with urban-industrial pollution control in Sao Paulo, in turn, are the following:

- [One] major lesson...is the fundamental importance of an adequate legal framework, sufficient institutional (including technical and administrative) capability, and strong control and other environmental protection efforts. Institutional capacity, together with an adequate legislative and judicial framework, is essential in order to properly design viable and effective pollution control strategies and to administer the instruments necessary to implement these strategies. This, in turn, requires adequately trained personnel and proper logistical support, together with adequately equipped monitoring and laboratory facilities and other installations.

- Strong political commitment to the goals of environmental betterment must also be present....Furthermore...it is likely that the mobilization of public opinion and the participation of non-governmental organizations, both at the national and the local level, will be relevant factors in, and possibly necessary preconditions for, generating and maintaining political commitment to pollution control and other environmental preservation goals. [54]

6.55 CETESB presently possesses the technical and administrative capacity, as well as the legislative mandate, to successfully oversee pollution control activities in Sao Paulo. Bank support over the past decade has further strengthened its capabilities in this area. It is important to remember, however, that while CETESB was formally created in 1975, its foundations were laid with establishment of the State Basic Sanitation Fund in 1968 and a major UNDP/PAHO technical cooperation project on pollution control in the early 1970s. Nearly a decade, therefore, preceded the Bank's first interventions with CETESB, which was already a fairly well developed institution by the time the initial industrial pollution control operation was approved (1980).

6.56 All of these lessons are germane for future Bank efforts to support improved pollution management -- and environmental management more generally -- in metropolitan and urban areas in Brazil. Successful environmental outcomes will also require a range of complementary actions at the federal, state, metropolitan and municipal levels. Some of these are briefly described below.

---

53 See Tlaiye and Biller, op. cit., pp. 25-26. These three elements were found to characterize other successful environmental management experiences in Latin America, such as those of the Corporacion Autonoma del Valle del Cauca (CVC) and the Corporacion Autonoma Regional Rionegro-Norte (CONARE) in Colombia, as well.

54 World Bank Report No. 10039, Volume II, op. cit., Executive Summary, pp. x-xii.

RECOMMENDED ACTIONS AT THE FEDERAL, STATE, METROPOLITAN AND MUNICIPAL LEVELS

6.57 The brief survey above of contemporary metropolitan and urban environmental management experience in Brazil, with an emphasis on metropolitan Belo Horizonte and Recife, provides the basis for the following preliminary recommendations at different levels of public administration and intervention.

Federal

6.58 Among the actions that should (continue to) be taken at the federal level, perhaps in collaboration with entities such as IBAM, are: (a) promotion of environmental diagnosis/priority setting processes at the metropolitan and urban levels; (b) promotion of interchanges of experience among metropolitan and large urban areas with respect to alternative instruments for and approaches to addressing local environmental problems; (c) financing of pre-investment studies for metropolitan/urban environmental management; and (d) development and dissemination of guidance materials on key aspects of urban environmental management. There is also a need to better coordinate federal government activities involving metropolitan/urban environmental management among SEPURB and IPEA in the Ministry of Planning and Budget (MPO), together with the Caixa Economica Federal (water supply and sewerage), and with the Ministry of Environment (MMA), as well as to considerably strengthen the capacity of the latter ministry in this area.

State

6.59 As presently appears to be the case in Pernambuco, state governments can play an important catalytic and technical support role in inducing municipal governments, individually and collectively, to address pollution and environmental management issues more broadly in a strategic and cost-effective way at the metropolitan level. Furthermore, as is now the case in Minas Gerais, they can provide needed technical guidance and support to local governments on urban environmental management issues. Clearly, state water and sewerage companies (such as COPASA and COMPESA), whether they remain as government enterprises or are privatized, will continue to be important actors in urban and metropolitan environmental management. However, they will need to improve the administrative, operational and financial efficiency of their operations, while giving greater attention to the needs of the urban poor and helping to enhance urban environmental quality, primarily through improved sewerage collection, treatment, and disposal. Wherever possible, the Bank and its borrowers should take these factors into account in the preparation of state reform programs, as has recently occurred in the case of Rio de Janeiro. The actions of state water and sewer utilities also need to be better coordinated with other urban infrastructure (e.g., drainage and transport) and solid waste interventions, as well as across municipal boundaries, at the metropolitan level. Water resource management at the river basin level and coastal zone management for the urban/metropolitan region are also areas where inter-municipal coordination is essential and, therefore, where state governments (and metropolitan agencies) can play a useful catalytic and technical support role.

Metropolitan

6.60 Strategic environmental diagnostic and priority-setting exercises for specific metropolitan areas should be carried out at this level. All major stakeholders, including state and municipal governments, local NGOs and other representatives of organized civil society (neighborhood associations, etc.), should be actively involved in

this process so as to generate maximum consensus around priority problems and maximum local "ownership" of proposed solutions. Furthermore, permanent deliberative and consultative mechanisms, such as CONDERM in the Recife MR (both the overall Council and the *camara tecnica setorial* on sanitation and the environment), should be established to ensure adequate fora for participatory priority setting, consensus building, and coordination of environmental (and other) interventions at the metropolitan level over time. State (environmental) and metropolitan level technical agencies can also play a key role in the generation and public dissemination of information concerning the evolution of environmental quality in urban and metropolitan areas over time. More specifically, they should carefully monitor both ambient air and water quality and specific sources of air and water pollution in large cities and metropolitan regions. Both in the Belo Horizonte and Recife MRs, there is a clear need to strengthen environmental monitoring activities. These same agencies, working closely with local governments and NGOs, can likewise be an important source of strategies and materials for environmental education to be used in urban and metropolitan areas (and elsewhere) in order to raise public awareness about environmental problems and potential solutions more generally. Finally, solid waste management, particularly treatment and disposal, in urban agglomerations that involve numerous municipalities requires planning and coordination at the metropolitan level. This continues to be a major problem in the Recife MR, for example.

Municipal

6.61 Local governments also have many important roles and responsibilities with respect to urban environmental management. Belo Horizonte and Recife are good examples of how urban municipal governments can be proactive in this regard, both in terms of local legislation, policies and plans and specific pollution reduction and other environmental action programs, whether carried out individually or in coordination with neighboring metropolitan municipalities. In addition, municipal governments are generally in the best position to deal with local land use planning and environmental nuisance issues such as noise pollution. As noted in the previous section, however, both general awareness of the need for and institutional capacity to undertake urban environmental management activities at the municipal level are extremely uneven both within and outside metropolitan regions in Brazil. Environmental management capacity building at the municipal level, thus, should be strongly and more systematically supported by federal and state agencies, both through specific environmental outreach and education activities and by Bank-supported municipal development projects at the state level, such as SOMMA in Minas Gerais, PROURB in Ceara, and the recently approved project for Bahia.

References

Bartone, Carl, Bernstein, Janis, Leitmann, Josef, and Eigen, Jochen., "Toward Environmental Strategies for Cities: Policy Considerations for Urban Environmental Management," UMP Discussion Paper, No. 18, 1994.

Bernstein, Janis, "Alternative Approaches to Pollution Control and Waste Management: Regulatory and Economic Instruments," UMP Discussion Paper, No. 3. April 1991.

Bernstein, Janis, "Land Use Considerations in Urban Environmental Management," UMP Discussion Paper No. 12, January 1994.

Campbell, Tim, "Innovations and Risk Taking: The Engine of Reform in Local Government in Latin America and the Caribbean," World Bank, November 18, 1996.

CONDERM, Plano de Acao Metropolitana - 1997, Recife, December 1996.

Condominium, "Modelo para Gestao e Operacoes de Servicos de Agua e Esgotos no

Municipio de Recife: Diagnostico," Recife, January 1997.

Deloitte Touche Tohmatsu, "Estabelecimento de Marco Regulatorio para a Gestao de Servicos de Agua e Esgoto no Municipio de Recife: Diagnostico Inicial," January 13, 1997.

Ferreira de Araujo Filho, Valdemar, "Antecedentes Politico-Institucionais da Questao Metropolitana no Brasil" in IBAM, Gestao Metropolitana: Experiencias e Perspectivas, Rio de Janeiro, 1996.

FIDEM, "Plano Diretor da Regiao Metropolitana do Recife: Termos de Referencia," Recife, December 1996.

FIDEM, "Sistema de Gestao do Tratamento e da Destinacao Final de Residuos Solidos na RMR," Recife, January 1997.

FIDEM, "Sistema Gestor Metropolitano," Recife, March 1997.

FIDEM, Regiao Metropolitana do Recife: Plano de Desenvolvimento Integrado, Recife 1976.

Government of Minas Gerais entitled "Programa de Saneamento Ambiental," Belo Horizonte, October 7, 1996.

Kreimer, Alcira, et. al., "Towards a Sustainable Urban Environment: The Rio de Janeiro Study," World Bank Discussion Paper No. 195, March, 1993.

Leitmann, Josef, "Rapid Urban Environmental Assessment, UMP Discussion Paper No. 15, Volume II ("Tools and Outputs"), Washington, May 1994.

Matallo, Heitor Junior, "Fundamentos e Criterios de Selecao das RMs Integrantes da Fase I do Componente," *Fortalecimento da Gestao Ambiental das Regioes Metropolitanas,* Brasilia, May 1996.

Ministry of Planning and Budget (MPO)/IPEA, Projeto Aridas: A Strategy for Sustainable Development in Brazil's Northeast, Brasilia, October 1995.

Prefeitura da Cidade do Recife, "Politica de Meio Ambiente para a Cidade do Recife," Recife December 1994.

Prefeitura da Cidade do Recife, "Programa de Recuperacao Urbana e Ambiental Bacia do Rio Tejipio - PROEST I: Sintese do Programa," 1996.

Prefeitura da Cidade do Recife, Plano Diretor de Desenvolvimento da Cidade do Recife, Law No. 15.547/91, Recife 1992.

Rabinovich, Jonas and Leitmann, Josef, "Environmental Innovation and Management in Curitiba," Urban Management Program Working Paper, No. 1, June 1993.

SEPLAN/PE "Esgotos e Drenagem da Regiao Metropolitana do Recife - RMR," Recife, April 1997.

SEPLAN/PE, "Consolidacao e Complementacao de Diagnostico sobre Qualidade das Aguas: Termos de Referencia" Recife, April 1997.

SEPLAN/PE, "Pernambuco 2000: Estrategia de Desenvolvimento Sustentavel," Recife 1996.

Tlaiye, Laura and Biller, Dan, "Successful Environmental Institutions: Lessons from Colombia and Curitiba, Brazil," LATEN Dissemination Note No. 12, 1994.

UFPE/ATERPE, "SGRS - Sistema de Gestao do Tratamento e Destinacao dos Residuos Solidos na RMR: Concepcao Basica Operacional, Institucional e Financeira," Recife, March 1996.

World Bank, Brazil - Managing Environmental Pollution in the State of Rio de Janeiro," Report No. 15488-BR (two volumes), August 22, 1996.

World Bank, Housing: Enabling Markets to Work - A World Bank Policy Paper, Washington, D.C., April 1993.

Zulauf, Werner E., "Cidade Ecossistema: Gestao Ambiental e Despoluicao," Inter-American Development Bank, City Symposium, Barcelona, Spain, March 13-15, 1997.

7. MUNICIPAL SOLID WASTE MANAGEMENT[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS

There are a number of issues to be addressed if substantial improvements are to be achieved:

- the extension of service coverage especially into *favelas* and other poor neighborhoods based on the concepts of demand management and affordability;
- the closure or rehabilitation of existing open dumps while at the same time protecting the livelihood and health of waste pickers and their families;
- the introduction of sanitary landfills as the backbone of disposal operations, often in the face of strong social opposition (the NIMBY syndrome);
- the integration of complementary systems such as transfer, selective collection, recycling, composting and/or incineration, where it makes economic sense;
- the definition of better hospital waste management systems;
- the introduction of adequate user charges and collection mechanisms so as to achieve self-financing, along with needed cost accounting and management information systems;
- the promotion of private sector participation as a response to often weak municipal operational capacity; and
- the development of cooperative mechanisms that would enable municipalities to undertake regional disposal solutions especially in metropolitan areas.

STRATEGY AND RECOMMENDATIONS

A more comprehensive policy framework is needed at the national and state level which should link public health, environmental and decentralization policies more closely together.

Large municipalities and metropolitan regions should be encouraged to undertake city-wide strategic planning to design and implement integrated solid waste systems. Strategic planning starts with the formulation of short, medium and long term goals based on the needs of a particular municipality, followed by a medium-term action plan to meet the goals that identifies a clear set of integrated actions, responsible parties and needed human, physical and financial resources. For Brazil, the following priorities have been suggested for strategic solid waste planning and management:

- to collect all of the solid waste for which the municipality is responsible;
- to provide adequate final disposal for all municipal solid waste;
- to seek alternatives for treating and recycling municipal solid waste – keeping in mind that these alternatives will only yield positive and sustainable results when they make economic sense and meet environmental standards;
- to implement educational campaigns and programs aimed at raising awareness about the importance of keeping cities clean and promoting actions to reduce waste generation; and
- to facilitate municipal acces to credit for solid waste investments and to strengthen local financial management systems for cost-recovery, accounting and budgeting.

---

1 This paper was prepared by Carl Bartone. The author gratefully acknowledges review and comments provided by Luiz Edmundo Costa Leite, Fernando Paraguassú de Sá, José Henrique Penido and Christopher Wells.

7.1 According to a national survey on environmental sanitation conducted by the *Instituto Brasileiro de Geografia e Estatística* (IBGE) in 1989, the population of Brazil produced about 242,000 tons/day of solid waste, of which 90,000 tons/day was urban residential and commercial solid waste.[2] Roughly 60% of the urban solid waste was collected. The remainder was left in the streets, drains or empty lots, or is burned by households – in all cases creating a public health risk and contributing to degradation of the urban environment due to noxious odors, the proliferation of flies, mosquitoes and rats, increased flooding, and local air pollution from smoke.

7.2 The same IBGE study found that only about 24% of the urban solid waste collected received environmentally sound treatment and disposal – 23% deposited in controlled landfills (10% in sanitary landfills), 0.9% composted, and 0.1% incinerated. The remaining 76% was dumped indiscriminately on open land or in water courses. Further analysis showed that 88% of Brazilian municipalities practiced open dumping and only 12% used landfills. With respect to the landfills, 86% were controlled landfills, 10% sanitary landfills and 4% special landfills. Only about 1% of the municipalities had compost or recycling plants, or incinerators.

7.3 On average, each urban resident in large and intermediate cities in Brazil generates 0.8 kg of solid waste daily. These numbers, however, mask considerable variation across urban areas and a trend toward better MSWM, especially in the large and intermediate cities of the south. For example, Table 7.1 shows the variation in waste generation and collection for the State of Rio de Janeiro.[3] Most of the unserved population in the Municipality of Rio de Janeiro live in *favelas* where garbage collection is practically impossible by conventional trucks, and at best, residents are asked to bring their wastes to centrally located communal bins. Note that while the weighted service coverage in the State was about 62%, because of the differences in per capita waste generation rates in larger and richer urban areas, the amount of solid waste collected was closer to 65%.

7.4 While MSWM has long been recognized as a municipal responsibility in Brazil, the process of decentralization in place since 1988 has raised the consciousness of municipal administrators about the importance of this sector – both because the voting public is now demanding improved urban services, and because the provision of this service represents a major expenditure item for local governments. At the same time, there is increasing pressure on municipalities from state environmental agencies to properly dispose of the solid waste that is collected. There are, however, a number of issues to be addressed if substantial improvements are to be achieved:

- the extension of service coverage, especially into *favelas* and other poor neighborhoods, based on the concepts of demand management and affordability;

[2] See Fundação IBGE, "Pesquisa Nacional de Saneamento Básico, PNSB, 1989," São Paulo, 1992. For the study, municipalities with population greater than 20,000 were classified as urban. These urban municipalities represent about 27% of the total of 4,974 municipalities in Brazil and account for 85% of the total national population.

[3] Reported in Paraguassú de Sá, Fernando, "Diagnóstico da Situação de Resíduos Sólidos no Brasil," report prepared for PAHO, May 1989.

Table 7.1: Rio De Janeiro Population, Per Capita Waste Generation And Service Coverage c. 1989.

Municipalities	Population	Waste Generation (kg/cap/day)	Collection Service (%)
Municipality of Rio de Janeiro	6,000,000	1.0	74
Other municipalities of the Metropolitan Region	5,000,000	0.8	60
Remaining municipalities in the State	2,600,000	0.6	40

(Source: Paraguassú, 1989)

- the closure or rehabilitation of existing open dumps while at the same time protecting the livelihood and health of waste pickers and their families;
- the introduction of sanitary landfills as the backbone of disposal operations, often in the face of strong social opposition (the NIMBY syndrome);
- the integration of complementary systems such as transfer, selective collection, recycling, composting and/or incineration, where it makes economic sense;
- the definition of better hospital waste management systems;
- the introduction of adequate user charges and collection mechanisms so as to achieve self-financing, along with needed cost accounting and management information systems;
- the promotion of private sector participation as a response to often weak municipal operational capacity; and
- the development of cooperative mechanisms that would enable municipalities to undertake regional disposal solutions, especially in metropolitan areas.

7.5 To better address this set of issues, progress on two other fronts is also needed. First, a more comprehensive policy framework is needed at the national and state level. It should link public health, environmental and decentralization policies more closely together so that they are mutually supportive.[4] (As just one example, consider the difficulties that municipalities in watershed protection areas encounter in finding a disposal solution). It should also provide incentives to municipal authorities to deliver better services, recover more costs from users, and cooperate with neighboring municipalities. For smaller or weaker municipalities, there should be a focus on technical assistance and access to finance.

7.6 Second, large municipalities and metropolitan regions should be encouraged to undertake city-wide strategic planning to design and implement integrated solid waste systems. Strategic planning starts with the formulation of short, medium and long term goals based on the needs of a particular municipality, followed by a medium-term action plan to meet the goals that identifies a clear set of integrated actions, responsible parties and needed human, physical and financial resources. For Brazil, the following priorities have been suggested for strategic solid waste planning and management:[5]

---

4 See IBAM, "Consulta Nacional sobre a Gestão do Saneamento e do Meio Ambiente Urbano: Sintesis do Relatório Final," Rio de Janeiro, Janeiro 1995.

5 Suggested by IPT/CEMPRE, "Lixo Municipal: Manual de Gerenciamento Integrado," São Paulo, 1995. For a description of a detailed framework strategic solid waste planning, see Schubeler, Peter, et tal, "Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries," Urban Management Pro-

- to collect all of the solid waste for which the municipality is responsible;
- to provide adequate final disposal for all municipal solid waste;
- to seek alternatives for treating and recycling municipal solid waste – keeping in mind that these alternatives will only yield positive and sustainable results when they make economic sense and meet environmental standards; and
- to implement educational campaigns and programs aimed at raising awareness about the importance of keeping cities clean and promoting actions to reduce waste generation.

LESSONS OF DIFFERENT MANAGEMENT APPROACHES

7.7 A number of different approaches to MSWM are observed in Brazil today, some offering important lessons that could prove useful to other municipalities. Several of these are briefly summarized below.

Institutional Arrangements

7.8 Three types of institutional arrangements defined by law are commonly adopted by Brazilian cities for the provision of solid waste services:

- *Autarquia* - an autonomous legal entity with its own patrimony and revenues, set up to carry out typical public administration functions with a limited degree of management and financial decentralization. Examples are DMLU in Porto Alegre, the SLU in Belo Horizonte and the SLU in Brasília.
- *Empresa Pública* - a quasi-private entity created by law and set up exclusively with public capital to carry out administrative functions, with limited freedom to define its organizational and financial structure. Some examples are LIMPURB in São Paulo, LIMPURB in Salvador, EMLURB in Fortaleza, and EMLURB in Recife (the latter was only recently converted from an autarchy to a public company).
- *Sociedade de Ecônomica Mista* - a corporate entity created by law to carry out economic activities, with the government (federal, state or municipal) holding a majority of the voting shares. Examples are COMLURB in Rio de Janeiro, COMCAP in Florianópolis, and URBANA in Natal.

7.9 While these institutional arrangements have served individual larger municipalities well and are adaptable to medium size cities, there is currently a real institutional vacuum in the metropolitan regions with regard to shared service arrangements. Although most metropolitan regions do have metropolitan planning agencies that are dependent on the state government, these agencies generally are weak and lack any capacity or authority for implementing metropolitan plans or for mobilizing the needed resources. Thus far, the only success has been where voluntary inter-municipal arrangements have sprung up. For example, in the Curitiba Metropolitan Region (CMR) the constituent municipalities are working together to find a regional solution to their disposal problems. As the Cachimba sanitary landfill of the Municipality of Curitiba is close to reaching capacity, the city needs a new landfill site. The adjacent municipalities, in turn, currently do not have any landfill and are dependent on the city for disposal of their wastes or simply engage in open dumping. A regional plan is being prepared, coordinated by COMEC and funded by the Bank-supported Water Qual-

gramme Working Paper Series No. 9, St. Gallen, Switzerland, August 1996.

ity and Pollution Control Project (3503-BR), for raising waste collection in the outlying municipalities from 40% to 90%, developing a new sanitary landfill in the northern part of the CMR, and strategically locating transfer stations to minimize the waste transport costs. As part of the cooperative agreement, the city proposes to operate the new sanitary landfill in exchange for the landfill capacity it would utilize.

7.10 Such cooperative arrangements are not always possible. In a similar Bank-supported endeavor for the Guarapiranga watershed in the São Paulo Metropolitan Region (SPMR), it is not possible for outlying municipalities to agree on shared facilities since most of them have local ordinances prohibiting the import of refuse for treatment or disposal. This leaves municipalities in the interior of the watershed with an impossible situation as state public health laws prohibit them from siting landfills within the watershed limits! Among the reasons for such ordinances appear to be a combination of NIMBY and distrust of shared funding arrangements. At the metropolitan level, EMPLASA and CETESB formulated an "Emergency Program for Solid Waste Disposal – SPMR" (1983) proposing 13 regional landfills to be managed by an Intermunicipal Consortium, but it was never implemented. In 1993, EMPLASA again proposed a comprehensive metropolitan solid waste disposal plan, but it has not yet been possible to formulate and implement such a plan.[6] In the absence of a regional solution, the Municipality of São Paulo developed its own plan for final disposal of the 13,000 tons/day of municipal and industrial (non-hazardous) solid waste generated in the capital city, based on a combination of incineration and composting at a cost per ton far in excess of what a regional solution based on sanitary landfills and transfer facilities would likely cost.[7]

7.11 A final example of interest is the Recife Metropolitan Region (RMR) where in the mid-1980s a Bank loan for a Metropolitan Development Project included a solid waste component that failed over a landfill siting dispute. After the project had been approved and the sanitary landfill studies and design completed, municipal elections led to an opposition party gaining control of the municipality where the landfill was to be sited and where 120 squatter families would have to be relocated. The refusal of the new mayor to agree to the landfill construction became a stumbling block – a clear example of NIMBY. An alternate site in another municipality was proposed, but again failed since the municipality was not a beneficiary of the project – subsequent negotiations to include some host community benefits were unsuccessful.[8] Today, the RMR is trying once again under the leadership of the Recife Metropolitan Development Council (CONDERM) and the metropolitan planning agency, FI-

6 See EMPLASA, "Fundamentos para o Equacionamento de Destinação Final dos Resíduos Sólidos na RMSP," São Paulo, June 1992.

7 A rough comparative cost analysis of disposal options entirely within the municipality is provided in the report of the Secretaria de Serviço e Obras, "Diretrizes para a Destinação Final dos Resíduos Sólidos no Município de São Paulo," Prefeitura do Município de São Paulo, Agosto 1992. The disposal cost of a scenario based primarily on landfill was less than one-third the disposal cost of a scenario based on primarily on composting and incineration (US$31.7 million per year compared to US$100.9 million per year, respectively).

8 The history of this component is described in Ford, Fitz, "Review of the Institutional Development Subproject of the Recife Metropolitan Region Development Project," TWURD, June 1992.

DEM.[9] A metropolitan plan for the "Management System for the Treatment and Disposal of Solid Wastes in the RMR" has been prepared by a university group, ATEPE, for FIDEM.[10] The ATEPE report analyzes the technical and financial feasibility of an integrated transfer, treatment and disposal system and also proposes two institutional schemes – one based on the creation of an inter-municipal *consórcio* in which FIDEM would participate as executive secretariat and technical adviser, and another based on FIDEM signing separate bilateral agreements with each municipality and taking on the role of manager of the integrated system. There is no discussion in the ATEPE proposal of the political feasibility of siting the transfer, treatment and disposal facilities (bioreactor landfills) – such as consideration of land disappropriation, community consultation and participation in siting decisions, host community fees, implicit or explicit subsidies, etc. These are crucial decision elements that should be addressed very early in the siting process, not after the design studies are completed.

Strategic Planning

7.12 Following the Rio Conference in 1992, many Brazilian cities are giving increasing attention to solid waste management. With the adoption of Agenda 21, the waste management hierarchy (minimize, recycle, treat, dispose) is widely accepted and has given new impetus to the development of an integrated approach to solid waste management and the introduction of strategic planning. Only a few large cities, however, have successfully formulated and implemented such plans – one of the most successful being Belo Horizonte as described in Box 7.1.[11] In most cities, however, the basic components of collection and disposal are still the priority.

Private Sector Participation

7.13 Considerable progress has also been made on solid waste collection efforts. In 1982, a survey was conducted of 367 urban municipalities covering 40% of the total population.[12] In spite of a finding a fleet of vehicles that numerically was sufficient to collect more than all of the waste produced, the survey confirmed high vehicle downtime and low collection efficiency due to poor operational management and maintenance deficiencies. Only 14 of the cities could even provide data on the volume and weight of waste generated and collected, fundamental management indicators for basic operations. To complicate this problem, the economic crisis of the 1980s and poor local financial management meant that, in many cities, an aging fleet was not renewed, a shortage of spare parts was evident and skilled maintenance workers were hard to retain – all factors leading to an erosion in fleet capacity at the same time that urban population and waste generation was steadily growing.

---

9 Both CONDERM and FIDEM are described in detail in the companion document by Redwood, John, "Metropolitan Environmental Management in Brazil: Problems, Institutional Arrangements, Current Initiatives, and Recommendations," ENVLW, May 1997.

10 See ATEPE, "SGRS - Sistema de Gestão do Tratamento e Destinação dos Resíduos Sólidos do RMR: Concepção Básica Operacional, Institucional e Financeira," Recife, Março 1996.

11 Described in Tavares Campos, Heliana Katia and Abreu, Maria de Fátima, "A Gestão do Resíduos Sólidos em Belo Horizonte," in *Memórias Técnicas*, XXV Congresso Internacional de AIDIS, Mexico, 1996. Also see a companion paper by the same authors entitled "A Coleta Seletiva de Lixo e a Redução do Desperdício."

12 Paraguassú, op cit.

Box 7.1: Integrated System Of Solid Waste Management In Belo Horizonte

Beginning in 1993, with the advent of a new municipal administration, an integrated waste management strategy was formulated and implemented by the *Serviço de Limpeza Urbana* (SLU) of Belo Horizonte. Today, just four years later, Belo Horizonte's integrated system is fully functional and is being held up by others as a system to emulate. The SLU strategy included the following three basic modules:

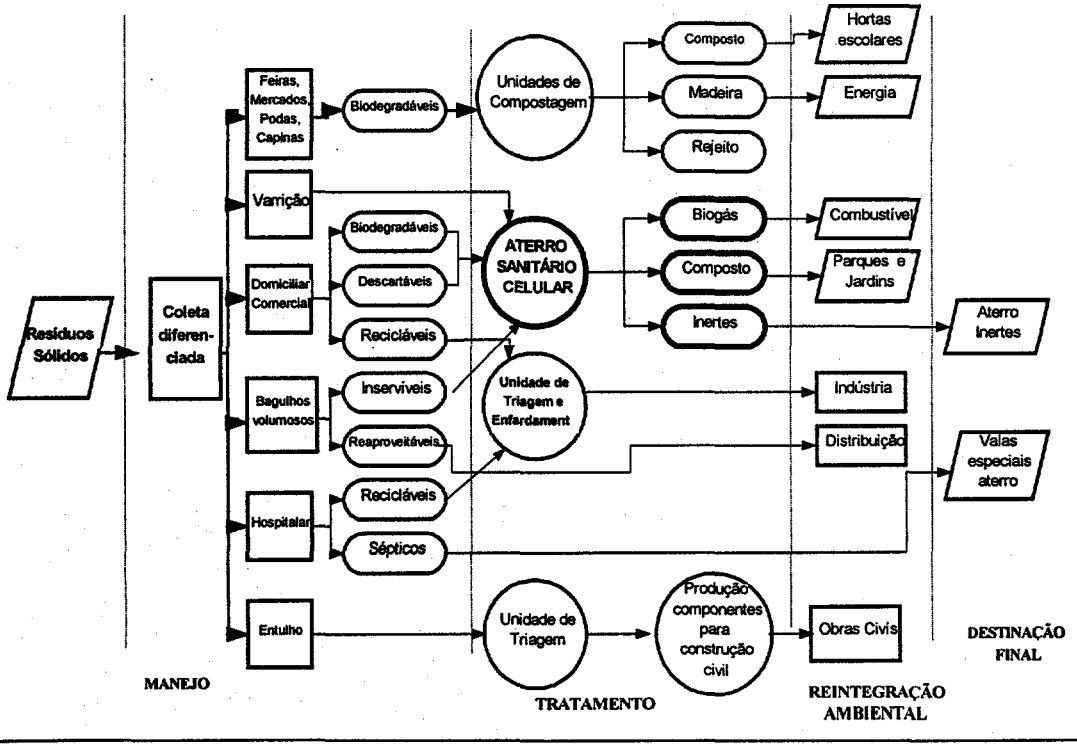
A *technological model* (see below), based on the concept of differentiated management and recycling of wastes, provides an integrated and rational solution for such wastes as construction debris (that makes up 33% of the waste stream), organic wastes (25% of the waste stream), recyclable materials, and hospital wastes. Thus the technological model includes differentiated collection systems, three materials recovery plants, two construction debris recycling plants, a composting plant, and the conversion of the BR-040 landfill to an anaerobic bioreactor landfill which will extend its life from 2 to 18 years.

The *modernization of SLU* includes quality management based on worker participation, the introduction of efficient management instruments, and an intensive human resources development program.

Active *citizen participation* is promoted through a permanent dialog between SLU and the community, stressing concepts of mutual responsibility and accountability.

SISTEMA INTEGRADO DE LIMPEZA URBANA - BELO HORIZONTE

Manejo Diferenciado de Resíduos (Modelo Tecnológico)



(Source: Tavares and Abreu, 1996)

7.14 Today the situation has improved significantly, largely as the result of a quiet but steady rise in the participation of the private sector in MSWM services. A recent survey by the *Associação Brasileira de Empresas de Limpeza Pública* (ABRELP) found that the refuse of about 65% of urban residents in Brazil is already collected by private enterprises. The survey identified some 40 enterprises ranging from large contractors, originally in the road or dam construction sectors, to small haulers and transportation companies.[13]

7.15 The experience with and the form of private sector participation in Brazilian cities vary greatly, but follow common models utilized in most industrialized countries. The most intensive and expensive component of a MSWM system is the provision of collection services – normally accounting for at least two-thirds of total costs – which by nature has limited economies of scale but significant economies of contiguity. This makes it possible to divide a city into collection zones and contract out each zone independently, thus creating competition for the market. Under this contract arrangement, the municipality bills customers directly and pays an agreed price to the private operator for each ton of refuse collected. Zone franchising is also possible, with the private operator charging customers directly for collection services, but this system has not worked well in other developing countries (because of non-participation and dumping) and is not utilized in Brazil. Other system components with significant economies of scale such as transfer stations, landfills, composting or recycling plants, or incinerators are amenable to bidding out as management contracts, or concessioning out through such arrangements as BOT, BTO or BOO. In practice, most Brazilian cities have limited private sector engagement to some form of contracting out of collection or street sweeping services, or of *terceirização* of secondary activities such as vehicle maintenance, security, or administrative services.

7.16 An important benefit of increased private sector involvement is that it permits local authorities to concentrate on regulating the quality of the service instead of being bogged down in operations, and avoids the conflict of interest that arises from being both provider and regulator of the service. In Volta Redonda, for example, the *Secretário Municipal de Serviços Públicos e Meio Ambiente* (SMSPMA) signed a technical cooperation agreement with FEEMA to train local environmental inspectors, and has focused attention on monitoring and supervising contracted collection and disposal operations.[14] Some contractors are developing their own TQC programs in order to obtain ISO certification because the market (customers like COMLURB) is beginning to demand it.

7.17 In many of the large cities of Brazil like São Paulo and Curitiba the operation of urban solid waste management systems have been almost entirely put in private hands. In other cities like Rio de Janeiro, Belo Horizonte, Salvador, Manaus, Recife and Niterói, private contractors already have a significant share of the service provision. Private sector participation is also observed to be spreading rapidly in the medium size cities of the states of São Paulo, Rio de Janeiro and Paraná. Box 7.2 illustrates how the private sector has been engaged in service provision in four large cities. Also, a significant share of commercial and industrial waste

[13] Reported in Costa Leite, Luiz Edmundo, "Urban Solid Waste Management Privatization Schemes in Latin America," draft report for PAHO, March 1997.

[14] See PMVR, "Consulta Local de Volta Redonda: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Volta Redonda, Agosto 1994.

Box 7.2: The Experiences Of Four Cities With The Private Delivery Of MSW Services.

São Paulo - The participation of private contractors in the solid waste sector in Brazil began in São Paulo some 20 years ago. Initially, LIMPURB contacted out 67% of the collection services to three different firms in 1977. By 1987, all services were contracted out including collection and street sweeping services and the operation of transfer stations, composting plants, incinerators, hospital waste collection and treatment, and sanitary landfills. Capital intensive assets such as transfer stations, treatment plants and landfills still belong to the Municipality of São Paulo, but vehicles and equipment used in operations are provided by the private contractors.

Such is the magnitude and variety of the services being contracted out by São Paulo (to manage 13,000 tons/day of municipal and industrial solid waste) that 16 different contracts are involved. The city government decided to hire an engineering management firm to control and monitor the services, under government supervision. The total payments disbursed by the city for solid waste services are about US$30 million per month, and the engineering management firm claims to have reduced the bill by about 10% through better management and control.

Rio de Janeiro - Prior to 1990, the Rio de Janeiro solid waste management company, COMLURB, was prevented by municipal government policy from contracting out with private operators. Today it engages private contractors under several different arrangements. One is the traditional contracting for collection services in a zone of the city. A second type is the leasing of vehicles with drivers and specialized equipment from the private sector to be operated by COMLURB crews. A third arrangement is a contract for multiple services within a zone including street sweeping, beach cleansing, weed removal, drain cleaning and container management. There is also a concession arrangement in which COMLURB licenses private operators who are then free to contract directly with all refuse producers generating more than 100 liters of refuse per day – such as restaurants, hotels, shopping centers, supermarkets and industrial producers, none of which are serviced directly by COMLURB. Customer prices are set by the market, but in practice companies tend to operate only in certain areas of the city taking advantage of economies of contiguity.

Belo Horizonte - In Belo Horizonte, the state capital of Minas Gerais, solid waste management services are handled by an autarchy, the *Superintendência de Limpeza Urbana* (SLU). In recent years, the SLU has significantly increased the contacting out of operations with the private sector. Today, over half the operations are contracted as shown in Table 7.2.

Salvador - In the city of Salvador, Bahia, solid waste services are managed by the municipal company LIMPURB. Today there is a contact with a single company to collect 50% of the total waste generated in the city; LIMPURB is responsible for the remaining share. Some other services are also contracted out such as sanitary landfill operations, however, problems of contract payment have reportedly jeopardized the proper operation of the landfill.

from large generators are also collected by private haulers and there is a trend across municipalities, and especially the larger cities, not to provide services to these large generators, rather to have them contract directly with private haulers.

7.18 Similar involvement of the private sector is seen across metropolitan areas. In the SPMR, 21 of 39 constituent municipalities contract out the entire service, and another four contract collection and transport services.[15] In the Recife Metropolitan Region, the majority of constituent municipali-

[15] Reported in EMPLASA, "Consulta Local de Região Metropolitana de São Paulo: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," São Paulo, Agosto 1994.

Table 7.2: Percent Share Of Service Provision In Belo Horizonte, 1995.

Type of Service	SLU (%)	Private Contractor (%)
Household and commercial waste collection	46	54
Container collection	62	38
Weed cutting	-	100
Street sweeping	40	60
Hospital waste collection	100	-

(Source: Costa Leite, 1997)

ties contract out a broad range of solid waste services as is shown in Table 7.3.[16]

7.19 Experiences in Brazil and elsewhere in LAC have shown that private sector participation can be an efficient and cost-effective way of providing this essential public service as long as conditions of competition, transparency and accountability are met.[17] As this practice spreads to medium size and small cities, with weaker local governments and less professional capacity, it will be more difficult to ensure these conditions. Attention should be given to setting the legal and regulatory basis for the operation of private enterprises in the market of solid waste management services; the development of guidelines and criteria for solid waste service provision and for environmental protection; strengthening enforcement capacity to have the guidelines and criteria observed; upgrading the technical and managerial capacity of professionals in the sector so that they can manage, coordinate, monitor and regulate the private sector; and the development of appropriate technologies in order to meet the needs and conditions found in poorer urban areas and open niche opportunities for microenterprises and waste picker cooperatives.[18]

Innovative Technologies

7.20 Among the innovations in solid waste management in Brazil, four have had some success – the bioremediation landfills now in operation in several cities, the mobile infectious waste incinerators utilized in Curitiba, the creation of waste-picker cooperatives in a number of cities, and the recycling of construction debris.

16 See FIDEM, "Consulta Local de Região Metropolitana de Recife: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Recife, Agosto 1994.

17 See Bartone, Carl, et al., "Private Sector Participation in Municipal Solid Waste Services: Experiences in Latin America," Waste Management & Research, 9:495-509, 1991.

18 A recent survey conducted by a consortium of NGOs examined the performance of more than 80 microenterprises and cooperatives providing solid waste services in 8 LAC countries. The results, soon to be published by WASTE, show that such microentrepreneurs are providing cost-effective and affordable services that poor households are willing to pay for, in areas that larger private companies cannot service effectively by conventional technologies, and that when linked appropriately to the municipal solid waste management system are a sustainable form of private sector participation. An international assessment of the current global experience with microenterprise activities in this sector was formulated in an international workshop held in Cairo in October 1996, and is summarized in SKAT, "Micro and Small Enterprises Involvement in Municipal Solid Waste Management in Developing Countries," SKAT WasteNet Infopage, October 1996.

Table 7.3: Solid Waste Service Contracting In The RMR, c. 1994.

Municipality	Share of Private Sector Participation (%)	Services Provided by Private Sector
Abreu de Lima	80	Collection, transport, sweeping, disposal
Cabo de Santo Agostinho	40	Collection, transport, sweeping, disposal
Camaragibe	100	Collection, transport, sweeping, disposal
Igarassu	100	Collection, transport, sweeping
Ipojuca	0	-
Ilha de Itamaraca	50	Collection, transport, sweeping, beach cleaning
Itapissuma	0	-
Jaboatão do Guararapes	70	Collection, transport, sweeping, disposal
Moreno	30	Disposal
Olinda	70	Collection, transport, sweeping
Paulista	70	Collection, transport, sweeping
Recife	60	Collection, transport, sweeping, disposal
S.L. da Mata	50	Collection, transport, sweeping

(Source: FIDEM, 1994)

7.21 The term "bioremediation landfill" is used in Brazil to describe a sanitary landfill design aimed at remediating existing open dumps. Sanitary landfill cells are constructed and filled with a combination of old waste from the open dump and fresh waste (in proportions of 30%-70% up to 50%-50%). Leachate from the new landfill cells is collected, treated anaerobically and recirculated back to the cell – a process leading to the rapid biostabilization of the solid waste deposited in the cell (on the order of 3 to 5 years), the accelerated generation of landfill gas rich in methane content (55-70%), and ultimately to steady state conditions with low pollution potential.[19] The first such landfill was built in Americana (in the state of São Paulo) some ten years ago with the aim of remediating an open municipal dump filled with municipal and industrial wastes. The project was a success, and today the initial cell of the Americana landfill is being mined to recover recyclables and combustibles as well as a humus-like soil that can be utilized on-site as landfill cover material or applied to depleted lands. The space recovered in the emptied cell can then be refilled with fresh municipal solid waste, thus extending significantly the useful life of the landfill site.[20] This technology has spread to other cities for remediating open dumps and converting them to sanitary landfills, as well as for implementing entirely new sanitary landfills. Cities

19 This bioremediation landfill design, which has been pioneered and promoted in Brazil by Prof. Luiz Mario Queiroz Lima at the University of Campinas, is equivalent to the "bioreactor cell" design being promoted by the USEPA and which is in operation in landfills in the USA, the UK, Sweden and elsewhere. Interestingly, the bioreactor design is being promoted in those countries for energy recovery purposes more than for bioremediation – for example, in Sweden bioreactor landfills are referred to as "energy cells.". The World Bank is currently preparing bioreactor landfill projects in Lahore, Pakistan and Riga, Latvia with the aim of producing energy from methane and thus reducing the overall costs of disposal.

20 The practice of excavating landfill cells to recovery materials and space is known as "landfill mining" and is carried out at several landfills in the USA for economic reasons. In the case of the Canabrava landfill in Salvador, landfill mining was seen as one of the important features of the bioremediation approach because of the difficulties the municipality has encountered in finding new sites – primarily because of the NIMBY syndrome.

include Belo Horizonte, Campinas, Caxias do Sul, Porto Alegre, Recife, and Salvador – several of which have projects supported by the World Bank. The largest is the Canabrava landfill in Salvador that is currently operating at 2,000 tons/day.[21] Given the apparent success of this innovative approach, a serious technical evaluation should now be undertaken to help refine the design and disseminate it to other places. The lack of adequate documentation and technical information about the design and operational history of bioremediation landfills is a serious impediment to the spread of this technology, especially outside of Brazil.

7.22 Among several Bank-supported projects in Brazil that have hospital waste management components, the Water Quality and Pollution Control Project (3503-BR) for the Upper Iguaçú Basin included financing for procurement and installation of a 16 tons/day infectious wastes incinerator for the Municipality of Curitiba. The existing hospital waste management system in Curitiba included a municipal collection service by dedicated vehicles and disposal in a special landfill cell. After careful technical study, the *Comissão de Gerenciamento dos Resíduos Sólidos de Saúde* (CGRSS) concluded that the actual amount of infectious waste produced by hospitals and clinics in the metropolitan region after on-site separation was only a small share of the total hospital waste,[22] and that on-site incineration would be feasible utilizing mobile incinerator units – with the added benefit of avoiding the transport of infectious waste over city streets. The CGRSS proposed the procurement of 10 mobile units each with capacity of 30 kg/hr from the only known supplier of such incinerators, Kyowa Kako of Japan. Because of lack of experience with this type of equipment and concerns about local operation and maintenance capacity, the Bank initially approved the purchase of two units for demonstration purposes. Procurement arrangements included a 6-year warranty on the equipment, guaranteed provision of spares, and two months training in Japan for CGRSS operator staff. The CGRSS set up an evaluation program, operating the two units in a fixed location for two months followed by two months of mobile operation. The study demonstrated that the mobile units met all performance specifications including those for air emissions, and could be operated satisfactorily by CGRSS staff. It also permitted firmer cost estimates to be made (see below), and allowed time for the CGRSS to initiate an intensive training program for hospitals and clinics to improve on-site separation. Another result was that the CGRSS decided it would only require 6 units rather than 10 to service the municipality's hospitals, medical laboratories and blood banks. These were procured and the system is in full operation today. A comparative analysis of the Curitiba experience with that of other Brazilian cities utilizing standard fixed incinerators for hospital wastes would be advisable in order to assess the relative merits and costs of these options.

7.23 A third area of innovation observed in Brazil is in the development of cooperatives of waste pickers (*catadores*). The organization of these informal workers – in

[21] However, after two years of successful operation of the Canabrava bioremediation landfill, problems have since resulted from a change in administration and the failure to pay the contracted operator (Queiroz Lima, Luiz Mario, personal communication, June 1997).

[22] Out of a total of 18.3 tons/day in the CMR, only 4.2 tons/day was classified as infectious while 11.9 tons/day was classified as inert and 2.2 tons/day as recyclable. The infectious waste stream is still relatively high, averaging 0.25 kg/bed/day – almost double the WHO estimate of 0.12 kg/bed/day. This number is expected to come down as hospitals gain experience in on-site separation.

Box 7.3: "Catador Recycling Co-Ops A Success In Rio"

Rio de Janeiro already has six fully operational recycling cooperatives, formed by a total of 1,300 waste pickers (*catadores*) in seven neighborhoods. Another 11 co-ops, to be set up by the local government, are planned by the end of the year. Waste pickers are currently separating an average of around 1,800 tons of materials per month. Each co-op member earns an average income ranging from $500 to $700 per month. The minimum wage in Brazil is around $100 per month.

The program to create the co-ops, developed by COMLURB, the city cleansing authority, is aimed at giving due credit for the environmental contributions of waste pickers, their social function, and the great contribution toward curbside recycling.

In some areas, like the Barra de Tijuca co-op, a drive-thru system will be set up for the drop-off of recyclables.

"With unemployment, the number of people who collect recyclable materials from the waste has increased considerably," says Elinor Brito, coordinator of COMLURB's waste reduction projects.

(CEMPRE News, No. 24, August 1995)

addition to improving their working conditions and income earning opportunities – can help to rationalize the selective collection and sorting of solid waste, reducing costs and augmenting the flow of recyclable materials. This activity is actively supported by the *Compromisso Empresarial para Reciclagem* (CEMPRE),[23] which together with a group of NGOs has produced a educational kit to help waste pickers form co-ops, and has worked with municipalities and industries to marshal support for such cooperatives in São Paulo, Belo Horizonte, Porto Alegre, Salvador and other cities. Many other organizations are also involved in these efforts, such as COMLURB in Rio de Janeiro (see Box 7.3). Without the development of alternatives like the waste picker cooperatives, it will be very difficult to close and/or rehabilitate many existing municipal dumps and shift to sanitary landfills.

7.24 Finally, both Belo Horizonte and Sao Paulo have successful ongoing programs to separately manage construction debris. In Belo Horizonte, where construction debris represents about one-third of the total municipal waste stream, the city has two recycling plants of 120 tons/day and 240 tons/day capacity.[24] Sao Paulo inaugurated the Itatinga special landfill for inert wastes in 1990, and initiated operation of a modern 1,800 tons/day construction waste processing plant for the production of pavement aggregates.[25]

Technical Resources For The MSWM Sector

7.25 Brazil is one of the few countries in Latin America to have reasonably well developed technical resources and professional development programs in the field of solid waste management, even though the number of professionals working in the sector is still well below the number needed, particularly

[23] CEMPRE is a non-profit association dedicated to the recycling of waste materials within the framework of integrated solid waste management. Members include Brahma, Coca-Cola, Enterpa, Gessy-Lever, Mercedes-Benz, Nestle, Paraíbuna, Pepsi-Cola, Procter & Gamble, Rhodia-ster, Souza Cruz, Suzano, Tetra Pak and Vega Sopave. In addition to assisting in the development of waste picker cooperatives, CEMPRE also manuals of selective collection and recycling of municipal solid waste, assists industries in conducting waste audits and setting up waste reduction and recycling programs, and evaluates the impact of such programs in Brazil.

[24] Tavares and Abreu, op cit.

[25] Secretaria de Serviços e Obras, op cit.

in smaller municipalities. The training of solid waste workers, however, is an area requiring greater attention.

7.26 Technical and managerial guidelines have been produced by a number of organizations. The following are just a few examples:

- A comprehensive strategic planning and technical guide has been prepared by IPT and CEMPRE (*Lixo Municipal: Manual de Gerenciamento Integrado*, São Paulo, 1995).

- A simple guide on how to manage solid waste – in plain language and with clear graphics – has been produced for local decision makers and those responsible for solid waste actions by IBAM and MBES (*O que e preciso saber sobre limpeza urbana*, Rio de Janeiro, 1993).

- Technical manuals have been prepared by FEAM to orient and assist municipal staff carry out their responsibilities in the area of solid waste disposal (*Como Destinar os Resíduos Sólidos Urbanos?*, Belo Horizonte, 1995) and basic sanitation (*Manual de Saneamento e Proteção Ambiental para os Municípios: Volume 2 - Saneamento*, Belo Horizonte, 1995).

- The Secretary of Environment, State of São Paulo, has produced educational material for the public on the problems of garbage and how cities can solve them (*Lixo: Soluções ao Alcance do Município*, São Paulo, 1989).

7.27 Education, training and research are also carried out by a number of universities (UFRJ, UERJ, USP, USC, ISAM/UCP, ATEPE/UFP), institutes and technical centers (IBAM, FIOCRUZ, FEEMA, COMLURB, CETESB), and professional associations (ABES, ABLP, ABRELP), in addition to external sponsors such as PAHO and ISWA. Many of these same institutions maintain documentation centers of solid waste management that are tied to the Brazilian national network on environmental information (SISIMA) and to the Pan American Network for Information and Documentation on Environmental Engineering and Sciences (REPIDISCA) managed by CEPIS/PAHO in Lima, Peru.

Legislation, Regulations And Standards

7.28 Public cleansing (*limpeza pública*), more commonly known as municipal solid waste management, is constituted in Brazil as one of the few public services that is the exclusive responsibility of the municipal level of government. This normally includes the collection and disposal of residential solid waste, and the cleaning of streets, storm drains, beaches, parks, markets, etc. The Constitution of 1988, in article 23, established municipal responsibility for environmental protection in common with the Union and the States – more for enforcement than legislating, although article 30 gives municipalities the power to supplement federal and state environmental legislation.

7.29 For industrial wastes, the legal responsibility for transport and final disposal rests with the generator, and the State (and Federal) governments are responsible for promulgating the corresponding regulations and standards and enforcing them. The Constitution of 1988 conferred on the Federal Union the power to promulgate general standards aimed at controlling pollution and preventing the degradation of the environment, thereby establishing that solid waste disposal is subject to federal public health and environmental legislation and regulations.

7.30 The States should also regulate and enforce municipal disposal. In general, in the large municipalities in the south and southeast of Brazil, domestic solid waste is disposed of in controlled or sanitary land-

fills, and there is a growing tendency to introduce compost plants. In other parts of the country, open dumping of municipal solid waste is the common practice.

7.31 As a result of a Federal order (*portaria*) in 1979 that obliged municipalities to incinerate infectious waste from hospitals and clinics, about 10% of Brazilian municipalities now operate such incinerators – almost all in the south of the country. However, CONAMA Resolution No. 6 (September 1991) moved away from obligatory incineration, opening the door to other forms of treatment including sterilization by autoclaving, microwave, or chemical or thermal means, or by ionizing radiation.

7.32 Other Federal legislation related to specifically to solid waste or industrial waste includes several resolutions:

- *Portaria 53, Ministério do Interior, 1979, Disposição de resíduos sólidos e de natureza tóxico.*
- *Resolução 05, CONAMA, 1985, Necessidade de elaboração de EIA/RIMA para aterros sanitários, processamento e destino final de resíduos tóxicos.*
- *Resolução 06, CONAMA, 1988, Necessidade dos Estados elaborarem inventário de resíduos sólidos industriais.*

7.33 Related Federal legislation includes a number of instruments on urban planning, and on public service concessions. The Constitution of 1988 requires all municipalities of more than 20,000 inhabitants to prepare a *Plano Diretor* along with a multi-year municipal plan for basic sanitation, land use plans, and other planning and budgeting instruments that apply to municipal services, including public cleansing. A set of laws on public licitations (8.666/93 and 8.883/94) and concessions (8.987/95) provide the framework for public service concessions, including the establishment of intermunicipal consortia.[26]

7.34 The *Associação Brasileira de Normas Técnicas* (ABNT) has promulgated a number of national standards related to solid waste management:

- *NBR 8418, Apresentação de projetos de aterros de resíduos industriais perigosas.*
- *NBR 8419, Apresentação de projetos de aterros sanitários de resíduos sólidos urbanos.*
- *NBR 8849, Apresentação de projetos de aterros controlados de resíduos sólidos urbanos.*
- *NBR 8843, Tratamento de lixo em aeroportos.*
- *NBR 9191, Sacos plásticos para acondicionamento de lixo.*
- *NBR 9690, Mantas de polimeros para impermeabilização*
- *P-EB 558, Recipientes padronizados para lixo.*
- *NBR 10.004, Resíduos sólidos - Classificação.*
- *NBR 10.005, Lixivação de resíduos - Procedimento.*
- *NBR 10.006, Solubilidade de resíduos - Procedimento.*
- *NBR 10.007, Amostragem de resíduos - Procedimento.*
- *NBR 12.807, Resíduos de serviços de Saúde - Terminologia.*
- *NBR 12.808, Resíduos de serviços de Saúde - Classificação.*

---

26 A detailed presentation of federal legislation related to municipal services, and in particular to MSWM, in provided by IPT/CEMPRE, op cit., "Anexo A - Legislação."

- *NBR 12.809, Manuseio de resíduos de serviços de Saúde - Prodecimento.*
- *NBR 12.810, Coleta de resíduos de serviços de Saúde - Procedimento.*
- *NBR 12.980, Coleta, variação e acondicionamento de resíduos sólidos urbanos - Teminologia.*

7.35 While there appear to be an abundance of federal legal instruments, an examination of the above lists reveals a collection of casuistic measures, not closely interconnected, and which cannot be considered to provide or form part of a national solid waste sector policy.[27]

7.36 Similar legislation, regulations and standards have also been promulgated by some states and municipalities. For example, CETESB has issued standards for the State of São Paulo regulating sanitary landfills and industrial wastes.[28] COMLURB, in 1977, issued its own technical standards that continue to apply in Rio de Janeiro today.

7.37 Finally, most major municipalities have issued local ordinances governing the generation, storage, collection, transport and disposal of residential, commercial and industrial solid waste within municipal boundaries. A recent example is the *Código do Meio Ambiente e do Equilíbrio Ecológico da Cidade do Recife*, with a special chapter on solid waste, which was signed into law by the Municipal Prefect on 13 September, 1996.

[27] In response to this lack of a comprehensive policy framework, Deputado Federal Sérgio Aronca has drafted a proposal for establishing a Sistema Nacional de Resíduos. At the time of preparing this report, however, the details of the proposal were not available (Costa Leite, Luiz Edmundo, personal communications, June 1997).

[28] Summarized in IPT/CEMPRE, op cit., "Anexo B - Normas."

ECONOMICS OF MSWM

7.38 Solid waste services fall into the classical "public good" category being non-exclusive and non-divisible, in addition to being strongly linked to public health and environmental concerns. Where the service is not provided, there is a proliferation of rats, flies and mosquitoes that transmit many common tropical diseases. The resurgence of dengue fever observed in several LAC cities, for example, has been linked to the breeding of *Aedes aegypti* mosquitoes in rain water that collects in empty bottles and cans littered near homes, or in discarded tires.[29] Rubbish blocking storm drains results in increased flooding and damages to roads and walks, building foundations and the drainage system itself. Disposal sites are also the source of many negative impacts, including air pollution from uncontrolled fires fed by methane from the anaerobic decomposition of garbage, and water pollution from leachate – made up of water formed by the hydrolysis of organic wastes and rain water that seeps through the waste piles leaching out soluble pollutants. Groundwater is particularly at risk from leachate infiltration and the pollution effects of a leachate plume reaching a high quality groundwater source may be quasi-irreversible.

[29] See for example Barrera, R., Navarro, J.C., Mora, J.D., Dominguez, D. & Gonzalez, J., "Public Service Deficiencies and *Aedes Aegypti* Breeding Sites in Venezuela," PAHO Bulletin, 29(3):193-205, 1995. Dengue has been reported as an emerging public health problem in Belém as reported in SEGEP, "Consulta Local da Região Metropolitana de Belém: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Belém, Agosto 1994. A complete description of diseases linked to deficient solid waste management is provided by Cointreau-Levine, Sandra, "Occupational and Environmental Health Issues of Solid Waste Management," draft

Box 7.4: Relative Price Of MSWM Services In LAC.

With an average per capita production of household waste in the LAC region on the order of 0.7 kg/capita/day and an average family size in urban areas of 4 members, the annual waste production per household is about 1 ton. Typical refuse collection prices charged by private contractors are in the range of US$20-30/ton – thus the average collection cost per household is around US$20-30/year or some US$1.67-2.50/household/month. By Latin American standards this appears to be affordable for most households. Keep in mind that this cost does not include the cost of disposal nor of street sweeping, which may raise overall cost by another 50% – still less than US$1/capita/month and representing an average price much lower than other household infrastructure utility prices.

(Source: Costa Leite, 1997)

7.39 Some of the pollution impacts can be significant. Studies on sources of greenhouse gas emissions have found that decomposing garbage in landfills is responsible for between 6-20% of global methane emissions.[30] In Rio de Janeiro, refuse burning might be responsible for 17% of all fine particulate emissions – an air pollution parameter known to pose major health hazards to the urban population.[31] Landfill leachate discharges into Guanabara Bay from the Gramacho and Caju landfills as well as from similar disposal sites in the basin also represent an important source of water pollution. Treatment of these leachate discharges has been identified as an essential element of a cost-effective program of control measures to improve water quality in Guanabara Bay.

7.40 The ultimate responsibility for managing urban solid waste in all countries is placed on the local government sector and, with the exception of some industrialized countries, is generally paid for out of local revenues or intergovernmental transfers.[32] On the other hand, there is some evidence in developing countries of household demand for collection services to remove refuse from neighborhood streets and drains, but scant evidence of willingness to pay for disposal services (similar to wastewater treatment and disposal). Also, services are not very expensive and should be affordable to all but the poorest urban households (see Box 7.4). Local authorities should seek to recover the full cost of service provision from beneficiaries through user charges based on the average costs of residential waste management. To protect poor households, targeted subsidy schemes can be developed. Intergovernmental transfers should be limited to promoting environmentally sound disposal options.

7.41 The relative importance of MSWM in the overall municipal operational budget is significant. For medium and small cities,

chapter for International Occupational and Environmental Medicine, 1997.

30 Methane is a greenhouse gas of particular concerns as its effects are estimated to be 20 times greater than the equivalent mass of carbon dioxide. Global methane emissions from land fills and open dumps were estimated by the Intergovernmental Panel on Climate Change, "Climate Change," IPPC/WMO/UNEP, Cambridge University Press, 1992.

31 See "Brazil: Managing Environmental Pollution in the State of Rio de Janeiro," Report No. 15488-BR, The World Bank, Washington DC, 22 August 1996.

32 In the USA, for example, a growing number of local authorities are introducing volume based rates (e.g., pay by the bag) so that households that generate more trash pay more. This is a sound principle to apply in developing countries to large generators, but has little applicability to households that presently do not generate excessive quantities of waste and have only limited opportunity for waste minimization. Flat user charges are recommended.

it may be on the order of 7-15% or higher, and the solid waste department is often the largest employer in city government. In large cities, this share is normally much lower given the large programs that the big cities run in the areas of health, education, urban transport, etc. In Rio de Janeiro, COMLURB's solid waste budget in 1990 was on the order of 10.8% of the total municipal budget with an average cost estimated at US$27/ton when equipment depreciation is taken into account.[33] In São Paulo during the same year, the solid waste expenditures represented only 4.4% of total municipal budget with an average cost of US$41/ton for a high quality service.[34] While these shares may seem low, recall that São Paulo is currently spending US$30 million per month on solid waste services.

7.42 Only isolated cost data exist for solid waste services in Brazil, making cross city comparisons difficult. A selection of data from myriad sources is listed below, but should only be considered as indicative of costs in Brazil.

Collection

7.43 Collection costs generally represent the largest share of total solid waste service costs – about two-thirds of full service costs. Where open dumping is practiced, collection costs may represent as much as 95% of overall costs. The following data for collection only have been reported for major cities:[35]

São Paulo, 1994	
-private contractors	US$25/ton
Rio de Janeiro, 1997	
-private contractors	US$30/ton
Belo Horizonte, 1994	
-private contractors	US$17/ton-
-SLU	US$23/ton
Natal, 1994	
-private contractors	R$16/ton
-URBANA, leased vehicles	R$34/ton
-URBANA, own-managed	R$53/ton

7.44 For medium and small cities, these costs are likely to be lower. In the Florianópolis urban area, with a population of about 500,000, total costs for collection, transfer/transport and disposal by a private contractor is US$24/ton. The disposal method is reported to be sanitary landfill.[36]

7.45 Street sweeping is another element of solid waste collection that can impact significantly on overall costs. Street sweeping costs were only reported for Rio

33 As reported by Beture-Setame, "Solid Waste Management Regional Study: Case Study of São Sebastião de Rio de Janeiro," prepared for LATAD, February 1990. The authors point out that the budget was higher than previous years because a long-delayed renewal of COMLURB's fleet was underway. On the other hand, disposal costs represented just US$0.90/ton as the dumpsites were not being operated as sanitary landfills at that time. With proper disposal in sanitary landfills the average cost would likely have been closer to US$30-32/ton.

34 Secretaria de Serviços e Obras, op cit.

35 Costa Leite, op cit.; FEAM/ABES, "Consulta Local de Região Metropolitana de Belo Horizonte: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Belo Horizonte, Agosto 1994; Lins Guimarães, João Rafael and Magno de Montenegro Miranda, Alexandre, "Avaliação de Custos Unitários da Limpeza Urbana: Gestões Própria, Semi-Terceirizada e Terceirizada, " 18° Congresso de Engenharia Sanitária, 1994.

36 See PMF, "Consulta Local do Município de Florianópolis: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Florianópolis, Agosto 1994.

Table 7.4: Comparative Costs Of Disposal Options

Disposal Option	Operational Costs (US$/ton)	Investment Costs (US$/ton capacity/day)
Sanitary landfill	7 - 12	5,200
Composting plants	20 - 45	25,000 - 45,000
Incinerators	20 - 60	80,000 - 130,000

(Source: IPT/CEMPRE, 1995; FEAM, 1995)

de Janeiro where private sweepers are currently contracted at US$20/km.[37]

7.46 Source separation and selective collection of residential solid waste for subsequent recycling is practiced in a number of Brazilian cities. In 1994, CEMPRE carried out a study of the effectiveness and costs in eight cities.[38] On average, 4.6% of the residential waste stream was diverted to recycling in the eight cities studied. The study found that the average cost of collecting recyclable materials is US$240/ton, while the average sale price of the recovered materials is only US$30/ton. An additional benefit is the avoided cost of conventional collection and disposal which, in Brazil, is on the order of US$25-45/ton, as shown above. Thus, a simple benefit-cost analysis indicates that selective collection is not self-financing. While there may be other social and environmental benefits from recycling, lower cost alternatives to selective collection are needed to make it attractive for municipalities, in addition to greater participation rates achieved through public education and awareness campaigns.

Disposal Options

7.47 The three main disposal options for municipal solid waste are landfilling, composting or incineration. When composting or incineration are utilized, there will still be a need for a landfill to dispose of rejects (40-50% after composting the organic waste fraction) or ash (15-20% after incineration). The comparative costs of these three options in Brazil have been estimated by CEMPRE as summarized in Table 7.4.

Landfill

7.48 Reported landfill costs are often much lower than shown in Table 7.4, since landfills are not always run as sanitary landfills. Open dumping with some waste leveling and compaction only costs about US$1/ton. Also, there are significant economies of scale in landfills. The 2,000 tons/day Salvador bioremediation landfill costs about US$5.50/ton to operate, but land costs are not included and bottom liner preparation and storm drainage control are minimal.[39]

7.49 The strategic plan prepared for the Recife Metropolitan Region found that a regional system of transfer and disposal in four sanitary landfills (bioremediation design) would cost about US$12/ton, with the landfill cost estimated at US$7/ton.[40] Based on a number of site visits, observed tipping fees paid to contractors ranged from US$4/ton in Rio up to US$18/ton for a small landfill in Macaé. Tipping fees, however, only reflect current operational costs but do not include recovery of investment costs.[41]

37 Costa Leite, op cit.

38 IPT/CEMPRE, op cit.

39 Notes from author's field visit, 1995.

40 ATEPE, op cit.

41 Johannessen, Lars Mikkel, "Brazil: The Emerging Approach to Landfilling of Municipal Solid Waste", Back to Office Re-

7.50 Landfill gas (LFG) recovery is not common, even though bioremediation landfills are ideal for this technology. One experience has been developed by COMLURB at the closed Cajú landfill where an LFG recovery system was built including gas wells, a piped collection system, removal of carbon dioxide and hydrogen sulfide, and gas compression. The compressed gas was used to fuel part of COMLURB's vehicle fleet and over 60 taxis. COMLURB is considering extending LFG recovery to other landfills in Rio de Janeiro. The economic viability of LFG projects depend on the value of the energy end use in the form of fuel, electricity or steam. Hundreds of such systems are in use in the USA and Europe and demonstrate economic viability under a variety of circumstances.

Composting

7.51 A survey conducted in 1990 found 57 municipalities had composting plants (most with materials separation and recovery), of which only 18 were operating and 15 were under construction. The remaining 24 plants were shut down as the result of operational or financial failures. Composting was promoted in Brazil by official credits from BNDES channeled to contractors whose technical and marketing assumptions were not always in line with municipal needs and specifications. In many cases, municipal managers were frustrated by an erroneous vision of making a profit on the operation, or by the inability to produce compost of the quality required by the market or imposed by legislation.[42]

7.52 It is not only the small municipalities that have experienced difficulties with composting. The city of Rio de Janeiro reportedly invested US$30 million in a 1,200 tons/day plant utilizing TRIGA technology. The plant was commissioned in 1993, but one year later was shut down because of operational and odor problems and remains closed.[43]

7.53 The largest successful composting operation in Brazil, and possibly the world, is in the Municipality of São Paulo where two materials sorting and composting plants based on the DANO design have been in operation since the early 1970s – one in Vila Leopoldina with a capacity of 900 tons/day and one in São Mateus with 600 tons/day capacity. The plants have been modified and enlarged by the municipality since their installation. A study of the efficiency of the São Mateus plant showed that for each ton of solid waste processed (input), the output consisted of 53% compost, 4% recyclable materials and 43% rejects which are disposed in sanitary landfills. After taking into account income from compost sales (US$5.80/ton of compost, or US$3.08/ton of waste processed) and recyclable sales, the municipality must subsidize the operation at a cost of US$10.76/ton of waste processed.[44]

7.54 There are also significant economies of scale in composting operations. For example, a study of very small plants (1.5 ton/day) in three interior cities of Rio Grande do Norte resulted in total costs on the order of US$56-62/ton of waste processed.[45] These simplified plants trans-

port for 14-29 June mission, TWURD, 17 July 1997.

42 The survey results and analysis are reported in IPT/CEMPRE, op cit.

43 Costa Leite, Luiz Edmundo, personal communication, June 1997.

44 Reported in Avezum de Castro, Marcus Cesar and Schalch, Valdir, "Avaliação da Eficiência de uma Usina de Reciclagem e Compostagem: Estudo de Caso," in *Memórias Técnicas*, XXV Congresso Internacional de AIDIS, Mexico, 1996.

45 See Mesquita de Oliveira, Erivaldo, "Usinas Simplificadas de Reciclagem e Compostagem de Lixo," in *Memórias Técnicas*,

formed 44-60% of the waste processed into compost and reclaimed 5-9% in recyclable materials. However, information on revenues derived from the operations were not provided.

Incineration

7.55 Today there are no major municipal solid waste incinerators operating in Brazil. The Municipality of São Paulo has called for bids for two large incinerators with energy recovery (1,250 tons/day each), but has not yet obtained the environmental operating license required from the State Environmental Secretary. The estimated concession price for operating these waste to energy plants is on the order of US$65/ton net of energy revenues.[46] The IFC is analyzing the feasibility of participating in these concessions. Also, the IFC has been invited to analyze another proposed incinerator for the Municipality of Campinas.

7.56 Hazardous waste incineration is being carried out in Minas Gerais in a cement kiln licensed by the *Conselho de Política Ambiental* (COPAM) at a cost of US$600/ton. This compares to a reported cost of hazardous waste incineration in São Paulo of US$1,200/ton.[47]

7.57 It is of interest to note that due to federal regulation most of the international airports in Brazil incinerate their waste in well designed incinerators, including airports in Brasília, Manaus, Belo Horizonte, São Paulo, Rio de Janeiro, Foz de Iguaçú and Belém. The airports also have their own refuse collection system. Airports in Brazil belong to INFRAERO, a public entity under the control of the Air Force. The refuse collection and operation of the incinerators are contracted out by INFRAERO. This federal regulation requiring on-site incineration of waste also pertains to ports, but presently there is no post in Brazil in compliance with this regulation.[48]

Hospital Waste

7.58 Two major cities in Brazil that have built proper municipal incinerator plants for hospital wastes are Brasília (in 1974) and Belém (in 1988). The Municipality of São Paulo has two aging incinerators (the Ponte Pequena incinerator installed in 1959 and the Vergueiro incinerator installed in 1968 operating at a combined capacity of 175 tons/day) which are used to incinerate infectious hospital wastes from 15 municipalities in the SPMR. Both are in serious need of rehabilitation and the installation of emission control equipment.[49]

7.59 A preliminary analysis of the Curitiba hospital waste system described above shows an overall cost of US$215/ton for all hospital waste, and US$1,055/ton of infectious waste incinerated (including all opera-

XXV Congresso Internacional de AIDIS, Mexico, 1996.

46 Reported by Zulauf, Werner, "Solid Waste Management in the City of Sao Paulo, Brazil: A Macro-Recycling Strategy for Organic Wastes," paper presented at ESD Conference on Recycling Urban Waste for Agricuilture, World Bank, 24-24 September 1996. However, a new pricing proposal is reportedly being considered by the municipality based on a rapid payoff of investment costs to the private concessionaire: a payment of US$103/ton in the first seven years of operation, followed by payment of US$30/ton for the remainder of the 20 year concession (personal communication, Jerry Esmay, IFC, April 1997).

47 As reported in FEAM/ABES, op cit.

48 Paraguassú de Sá, Fernando , personal communication, June 1997.

49 Secretaria de Serviços e Obras, op cit.

tional costs and amortization of the mobile incinerators). This appears to be high in comparison with experience in other countries where infectious waste incineration costs per ton run between US$500 to 900. Looked at from the point of view of hospital administration, and recalling that the infectious waste generation rate in Curitiba is 0.25 kg/bed/day, the incremental cost to hospitals is about US$0.26/bed/day.[50]

FINANCING MSWM

7.60 Solid waste operations in Brazil are financed primarily from a *taxa de limpeza pública* and from general municipal revenues. In a case involving COMLURB, a 1980 Brazilian Supreme Tribunal decision struck down the use of tariffs for solid waste collection services, arguing that it is an essential and obligatory public service and therefore limited to remuneration through taxes or user charges. The common practice in Brazil is to recover the service costs through a benefit tax or user charge (*taxa*) collected with the property tax. In some municipalities, the *taxa* is computed based on the previous year expenditures divided by the number of lots, or prorated by the built-up area of urban lots. The *taxa* also varies for residential or commercial services. Except in periods of high inflation, this approach normally leads to self-financing ratios on the order of 75-95%. Many municipal prefects, however, find it politically difficult to update the *taxa* since it requires the approval of the municipal council, resulting in increasingly lower levels of cost recovery. Deficits need to be made up from local general revenues or transfers.

7.61 For municipalities which have not established some form of autonomous public cleansing agency, including most medium and small municipalities, the resources collected through the *taxa* go directly to the municipal treasury and may be applied to other uses. This makes it difficult for the city solid waste manager to properly budget for and operate the service. Another common difficulty in updating the *taxa* is that many municipalities do not maintain sufficiently detailed and discriminated accounts for service operations, and too often do not account for equipment depreciation.

7.62 Investment financing requirements include short-term financing for collection trucks, and medium- to long-term financing for transfer, treatment and disposal facilities and heavy equipment. Solid waste collection is a labor intensive activity with high operational costs, and sanitary landfill disposal operational costs are high compared to initial investments. Thus, the investment needs of the solid waste sector are not great by comparison to the water and sewerage sector. For example, according to an ABES study of investment requirements in basic sanitation for the period 1988-90, solid waste requirements represented only 6.3% of the estimated water and sewerage investments needs.[51]

7.63 The increasing participation of private operators in the sector means that they will normally finance rolling stock and sometimes even heavy equipment. Facilities financing, however, is almost always done by the public sector except in a few cases where BOT-type concessions are awarded (such as the São Paulo incinerator proposal). It would be advantageous to significantly increase the use of BOT concessions for large scale landfills and recycling and composting plants, as well as specialized facilities such as hospital waste incinerators.

[50] Notes from author's supervision visits, 1994-95.

[51] Paraguassú, op cit.

7.64 Municipalities seeking investment financing can turn to federal or state sources of loans or grants, such as:

- BNDES/*FINAME Social* line of credit for financing collection vehicles and heavy equipment for municipalities or intermunicipal consortia with greater than 30,000 population.
- BNDES special fund for recycling or composting plants, available to municipalities, autonomous agencies, or concessionaires.
- CEF/FAS (*Fundo de Apoio ao Desenvolvimento Social*) for health, sanitation, education and other social projects in under-developed regions or for low-income populations.
- FINEP (*Financiadora de Estudos e Projetos*) for the promotion of research projects and programs aimed at socio-economic, scientific and technological development.
- FIPEC (*Fundo de Incentivo a Pesquisa Técnico-Científica*) of the Banco do Brasil for applied research and development projects.
- State Municipal Development Projects, such as the World Bank-supported projects in Paraná, Santa Catarina, Rio Grande do Sul and Minas Gerais, that can be used to lend for environmental infrastructure and services including solid waste management.[52]

7.65 Notwithstanding multiple financing sources, many municipalities have difficulties accessing these funds because they cannot demonstrate creditworthiness, have not done the necessary planning and project design, or do not meet other eligibility criteria. On the other hand, the existing financing sources sometimes are not being accessed because of too much paperwork, or a mismatch between the restricted use of funds compared to what mayors want to do. Federal and state grants should be more carefully targeted to assisting municipalities in meeting environmental objectives. Lines of credit need to be accompanied by institutional development and technical assistance for needed studies and pilot programs.

7.66 Additional World Bank support for MSWM has been channeled through a variety of other projects such as the integrated water pollution control projects for urbanized river basins in Minas Gerais, Paraná and São Paulo, metropolitan development projects in Salvador and Recife, the PROSANEAR project, and the Rio flood emergency project.[53]

Role Of External Assistance

7.67 Refuse production in Brazilian cities is an inevitable phenomenon, occurring daily with volumes and compositions that depend on the size of the population and the

[52] The Bank-supported projects include the Paraná Market Towns Project - PRAM (2343-BR), the Santa Catarina Small Towns Development Project - PROURB (2623-BR), the Municipal Development Projects in the States of Paraná -PEDU (3100-BR) and Rio Grande do Sul - PIMES (3129-BR), and the Minas Gerais Municipal Management and Environmental Infrastructure Project - SOMMA (3639-BR).

[53] Minas Gerais Water Quality and Pollution Control Project (3504-BR), São Paulo Water Quality and Pollution Control Project (3503-BR), Paraná Water Quality and Pollution Control Project (3504-BR), Salvador Metropolitan Project (2681-BR), Recife Metropolitan Region Project (2170-BR), Water Project for Municipalities and Low-Income Areas -PROSANEAR (2983-BR), Rio Flood Reconstruction and Prevention Project (2975-BR).

level of economic development. This review has found that MSWM in Brazil is highly variable with larger municipalities often, but not always, performing quite well, and medium and smaller municipalities doing less well. Failures in performance are evidenced by low service coverage rates and widespread open dumping, and result in public health and environmental problems. The task of solid waste management, always a municipal responsibility, is complicated by such problems as:[54]

- lack of a coherent sector policy framework for municipal solid waste management;
- financial limitations – inadequate budgets, unbalanced cash flow, out-of-date *taxas*, insufficient collection, and lack of access to credit;
- need for better technical and professional training – from the laborer to the chief engineer;
- discontinuity in local policies and administration; and
- lax environmental controls.

7.68 External assistance should focus on these problems, providing technical and financial assistance to the federal and state governments as well as to municipalities. Specifically, support activities should focus on developing a national sector strategy, formulating region-wide strategic solid waste strategies and action plans for larger urban areas, strengthening the municipal management and investment capacity of smaller municipalities, and developing environmental management capacity at all levels.

[54] IPT/CEMPRE, op cit.

Sector strategy

7.69 A simple starting point for the development of a sector strategy is to undertake a national solid waste sector study. With the support of an interagency working group, five LAC countries have already conducted such studies.[55] The approach – based on a consultative process – provides for a sector assessment, identification of key policy areas requiring attention including the linkages with basic sanitation, environmental and decentralization policies, and the formulation of specific studies or follow-up actions that can be incorporated in subsequent donor projects to complete the formulation of the sector strategy and initiate implementation.

7.70 In the case of Brazil, given its size and federal structure, it would be advisable to conduct the sector work in two stages; first, to conduct a national consultation, and second, to develop a detailed solid waste strategy at the state level in a group of selected states. These efforts could be linked to ongoing Bank-supported efforts such as the PMSS or the Minas Gerais Municipal Management and Environmental Infrastructure Project, or to future operations. In addition to federal and state sector agencies and representative municipalities, the exer-

[55] The interagency working group, comprising PAHO, IADB, USAID and the World Bank, developed a methodological approach that was initially field tested in Colombia and Guatemala with World Bank support (PAHO, "Guideline for National Solid Waste Sector Assessments," Washington, DC, 1994). Subsequently, the approach was applied in Cuba, Mexico and Uruguay. An assessment of the five country experience, carried out in CEPIS, Lima in March 1997, confirmed the validity of the approach and recommended its use in other countries; it is now being applied in Bank-supported projects in Argentina, Bangladesh, Indonesia and the Philippines.

cise would benefit from the participation of such groups as IBAM, ABES, ABLP and ABRELP, and external support agencies such as PAHO and IADB. Also, a national training program covering all aspects of solid waste management is needed to support the sector, including courses to assist municipal leaders in making decisions.

Urban solid waste management strategies and action plans

7.71 A number of large metropolitan areas in Brazil have already begun to develop and/or implement strategic solid waste plans, many with World Bank support such as Curitiba, Belo Horizonte, Recife, Salvador and São Paulo (IFC). This practice should be extended to most of the 60 plus cities with more than 500,000 inhabitants which will be the future metropolitan areas and are of a size to require multiple facilities for transfer, recycling, treatment and disposal. Similarly, urban regions with clusters of smaller cities can benefit from a shared strategic plan that allows them to capture major economies of scale, particularly in disposal operations.

7.72 The World Bank, as a member of another interagency working group on solid waste management, is presently preparing a Guide for Strategic Solid Waste Planning in Large Cities and field testing it in two Asian countries. The IADB and PAHO have expressed interest in collaborating to test the guide in LAC. Within Brazil, IPT and CEMPRE are among the vanguard institutions already promoting strategic solid waste planning.

Municipal development

7.73 World Bank support for municipal development projects in Brazil has evolved significantly over the past decade, culminating in the latest operation in Minas Gerais which is specifically focused on the provision of environmental infrastructure, including solid waste. The Minas Gerais project goes to the heart of the problems afflicting many weaker municipalities and impeding their capacity to deliver public services – lack of clear priorities, poor operational management capacity, financial limitations, turnover associated with changing political administrations, and others. To help municipalities be successful, the Bank's experience shows that municipal development projects should create local demand for resources, stress demand management and willingness to pay when reforming service provision, increase municipalities' own resources for financing services, seek efficiency gains through institutional reform and private sector participation, aim to start up at the beginning of a new mayoral cycle, and promote political continuity by having development plans responsive to community priorities.

Environmental management

7.74 The decentralization of environmental management in Brazil has primarily focused on the deconcentration of activities in the federal system, and from it to the state environmental entities – the municipal role visualized in the 1988 Constitution has yet to be operationalized.[56] Key local roles include some exclusive ones such as land use planning and licensing, some shared with the states such as control of industrial solid waste, and some which should be developed jointly, such as within consortia, basin committees and metropolitan regions. An exchange of international experience in the effective decentralization of environmental management roles to the local level would be of considerable benefit to Brazil and should be a focus of external assistance.

---

56 Conclusion of the national consultation on basic sanitation and the urban environment, IBAM, op cit.

References

ATEPE, "SGRS - Sistema de Gestão do Tratamento e Destinação dos Resíduos Sólidos do RMR: Concepção Básica Operacional, Institucional e Financeira," Recife, Marco 1996.

Avezum de Castro, Marcus Cesar and Schalch, Valdir, "Avaliação da Efficiência de uma Usina de Reciclagem e Compostagem: Estudo de Caso," in *Memórias Técnicas*, XXV Congresso Internacional de AIDIS, Mexico, 1996.

Barrera, R., Navarro, J.C., Mora, J.D., Dominguez, D. & Gonzalez, J., "Public Service Deficiencies and *Aedes Aegypti* Breeding Sites in Venezuela," PAHO Bulletin, 29(3):193-205, 1995.

Bartone, Carl, et al., "Private Sector Participation in Municipal Solid Waste Services: Experiences in Latin America," Waste Management & Research, 9:495-509, 1991.

Beture-Setame, "Solid Waste Management Regional Study: Case Study of São Sebastião de Rio de Janeiro," prepared for LATAD, February 1990.

Cointreau-Levine, Sandra, "Occupational and Environmental Health Issues of Solid Waste Management," draft chapter for International Occupational and Environmental Medicine, 1997.

Costa Leite, Luiz Edmundo, "Urban Solid Waste Management Privatization Schemes in Latin America," draft report for PAHO, March 1997.

EMPLASA, "Consulta Local de Região Metropolitana de São Paulo: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," São Paulo, Agosto 1994.

EMPLASA, "Fundamentos para o Equacionamento de Destinação Final dos Resíduos Sólidos na RMSP," São Paulo, June 1992.

FEAM/ABES, "Consulta Local de Região Metropolitana de Belo Horizonte: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Belo Horizonte, Agosto 1994.

FIDEM, "Consulta Local de Região Metropolitana de Recife: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Recife, Agosto 1994.

Ford, Fitz, "Review of the Institutional Development Subproject of the Recife Metropolitan Region Development Project," TWURD, June 1992.

Fundação IBGE, "Pesquisa Nacional de Saneamento Básico, PNSB, 1989," São Paulo, 1992.

IBAM, "Consulta Nacional sobre a Gestão do Saneamento e do Meio Ambiente Urbano: Sintesis do Relatório Final," Rio de Janeiro, Janeiro 1995.

IPPC/WMO/UNEP, "Climate Change," Cambridge University Press, 1992.

IPT/CEMPRE, "Lixo Municipal: Manual de Gerenciamento Integrado," São Paulo, 1995.

Johannessen, Lars Mikkel, " Brazil: The Emerging Approach to Landfilling of Municipal Solid Waste", Back to Office Report for 14-29 June mission, TWURD, 17 July 1997.

Lins Guimarães, João Rafael and Magno de Montenegro Miranda, Alexandre, "Avaliação de Custos Unitários da Limpeza Urbana: Gestões Própria, Semi-Terceirizada e Terceirizada", 18° Congresso de Engenharia Sanitária, 1994.

Mesquita de Oliveira, Erivaldo, "Usinas Simplificadas de Reciclagem e Compostagem de Lixo," in *Memórias Técnicas*, XXV Congresso Internacional de AIDIS, México, 1996.

PAHO, "Guideline for National Solid Waste Sector Assessments," PIAS, Washington, DC, 1994

Paraguassú de Sá, Fernando, "Diagnóstico da Situação de Resíduos Sólidos no Brasil," report prepared for PAHO, May 1989.

PMF, "Consulta Local do Município de Florianópolis: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Florianópolis, Agosto 1994.

PMVR, "Consulta Local de Volta Redonda: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Volta Redonda, Agosto 1994.

Redwood, John, "Metropolitan Environmental Management in Brazil: Problems, Institutional Arrangements, Current Initiatives, and Recommendations," ENVLW, May 1997.

Schubeler, Peter, et al. "Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries," Urban Management Programme Working Paper Series

No. 9, St. Gallen, Switzerland, August 1996.

SKAT, "Micro and Small Enterprises Involvement in Municipal Solid Waste Management in Developing Countries," SKAT WasteNet Infopage, October 1996.

Secretaria de Serviço e Obras, "Diretrizes para a Destinação Final dos Resíduos Sólidos no Município de São Paulo," Prefeitura do Município de São Paulo, Agosto 1992.

SEGEP, "Consulta Local da Região Metropolitana de Belém: Relatório sobre a Gestão do Saneamento e do Meio Ambiente Urbano," Belém, Agosto 1994.

Tavares Campos, Heliana Katia and Abreu, Maria de Fátima, "A Gestão do Resíduos Sólidos em Belo Horizonte," in *Memórias Técnicas*, XXV Congresso Internacional de AIDIS, Mexico, 1996.

Zulauf, Werner, "Solid Waste Management in the City of Sao Paulo, Brazil: A Macro-Recycling Strategy for Organic Wastes," paper presented at ESD Conference on Recycling Urban Waste for Agricuilture, World Bank, 24-24 September 1996.

8. INFORMATION IN POLLUTION MANAGEMENT: THE NEW MODEL[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND RECOMMENDATIONS
Sound environmental management must be a continual process of information gathering and dissemination, negotiation, and adjustment by the interested stakeholders. Although much of the process should be participatory, the regulatory agency plays a leading role in the gathering and analysis of technical information about environmental quality and pollution sources.
An effective regulatory agency will therefore allocate fewer resources at the margin to conventional enforcement and more to the generation and distribution of appropriate information products.
A pollution control agency is only one player in the environmental performance game. Agency activities which influence polluters *indirectly*, through other agents, may be as important as direct enforcement. Potentially high-leverage programs include community environmental education, public disclosure of factory performance ratings and technical training programs for environmental personnel in polluting factories.
Equipped with appropriate information, regulatory agencies can play a key role in facilitating negotiations between local communities and neighboring factories. This role includes provision of reliable information on emissions and local ambient quality, technical advice on abatement alternatives, and the transfer of experience from other locations.
Agencies should initiate a variety of pilot projects, use their information systems to monitor developments, and build larger programs as experience accumulates.
Newly-industrializing economies can experience rapid changes in ambient quality across air- and watersheds. Since regulation should primarily serve environmental quality objectives, it should be focused on adaptation to these rapid changes.

INTRODUCTION

8.1 This report describes the expanded role of information in new models of pollution management. Timely, accurate and appropriately-packaged information is the key to several features of the new approach: tracking environmental quality; measuring and publicly rating the environmental performance of polluters; and comparing the benefits and costs of alternative approaches to pollution control. Information has become more important in regulation for three main reasons. First, it has become much cheaper to gather, process and distribute environmental information. Secondly, rising levels of public education and political representation in many countries have widened the circle of participation in environmental management. These new constituencies need appropriate information in order to participate effectively. Finally, rising acceptance of cost-benefit analysis has increased the demand for information which contributes to the systematic assessment of regulatory policy options.

8.2 Section 2 provides an overview of information in regulatory operations, with a particular focus on systems for monitoring

[1] This paper was prepared by David Wheeler.

ambient quality and emissions. It stresses the value of appropriate information in establishing and achieving environmental quality objectives. Sections 3-5 examine new roles for regulatory information in the public domain. Section 3 describes ways in which information systems can strengthen agency operations by promoting effective input from stakeholders. Section 4 considers the role of public information in 'informal regulation' -- the complex set of interactions between polluters and non-governmental agents whose influence on environmental performance may be as powerful as that of formal regulation. Section 5 uses a major environmental policy reform in Indonesia to illustrate the new approach. Finally, Section 6 concludes the report by identifying several key principles for effective use of information systems in pollution regulation.

INFORMATION IN FORMAL REGULATION

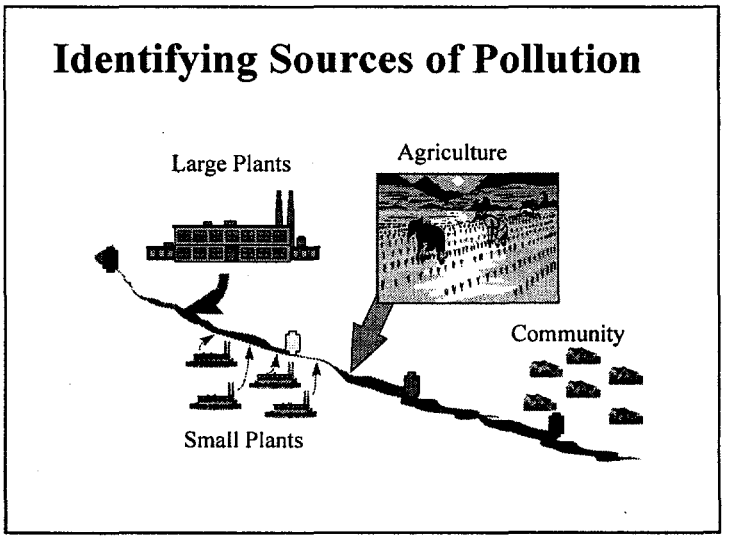
8.3 To illustrate the development of an information system for modern regulation, it is useful to consider a simplified case of river basin management. Figure 8.1 sets the stage, depicting a pattern of diverse activities along the river: a large factory, numerous small ones, a farming district, and a riverside community. Pollution from each activity has at least some adverse consequences for its downstream neighbors. The basic task of environmental management in the river basin is to assure that overall environmental damage is reduced to the point where the social benefits and costs of regulation just balance at the margin.

Monitoring

8.4 While easy to state, this principle is difficult to implement because the basin is home to multiple actors, with diverse economic incentives, environmental interests, and willingness or ability to pay for pollution reduction. In practice, sound environmental management must be a continual process of information gathering and dissemination, negotiation, and adjustment by the interested stakeholders. Although much of the process should be participatory, the regulatory agency plays a leading role in the gathering and analysis of technical information about environmental quality and pollution sources.

8.5 Part of the agency's technical role is to discipline regulation by focusing on pollutants which are the most serious threats to human or ecosystem health. Once these have been selected, environmental monitoring can focus on frequent and accurate measurement. Figure 8.1 represents initial establishment of agency monitoring at several points for four pollutants: heavy metals, fecal coliforms, biological oxygen demand (BOD), and phosphorus. The first and second pollutants can pose serious threats to human health, while the third and fourth can cause significant damage to ecosystems by reducing dissolved oxygen and promoting eutrophication. In this illustration, a change in the summary monitoring index from

Figure 8.1: Pollution Sources



Green to Red reveals a pattern of progressive decline in water quality as the river flows downstream.

8.6 Having established a pattern of potentially-damaging pollution, the next task of the information system is to identify and analyze its sources. These may include industrial facilities, households, and farms. Analysis involves monitoring to measure their relative contribution to different problems, and identification of characteristics which will have a bearing on cost-effective pollution control strategies. Included among the latter are location, sector of activity, operating scale, current pollution control efforts, and the likely cost of further abatement.

8.7 Information about pollution sources is gathered in a variety of ways. Self-reporting is a critical part of the system: all significant polluters are expected to submit periodic reports on emissions which have been certified by outside auditors. The auditors' business is dependent on a reputation for accuracy and acceptance by the regulatory agency. They will be unlikely to distort information for one polluter, since any short-term financial advantage would be outweighed by the risk of discovery, agency 'blacklisting,' and exclusion from further business. The agency keeps the probability of discovery at credible levels with its own program of random, surprise inspections and monitoring of emissions. Furthermore, systems for receiving citizen complaints and publishing ratings of polluters' performance assure that the risk of cheating will be minimal. Other important information on plant characteristics is entered in the system as part of standard licensing procedures for plant operation.

8.8 Figure 8.2 illustrates the operation of the full reporting and monitoring system. Monitors in the river and emissions reports from each source provide data which are indexed as Green (no problem), Yellow (cautionary), Orange (serious) and Red (potentially critical). The source indices measure potential for damage; the actual impact of pollution on river quality depends on the assimilative capacity of the river itself (a function of flow rate, volume, temperature, etc.).

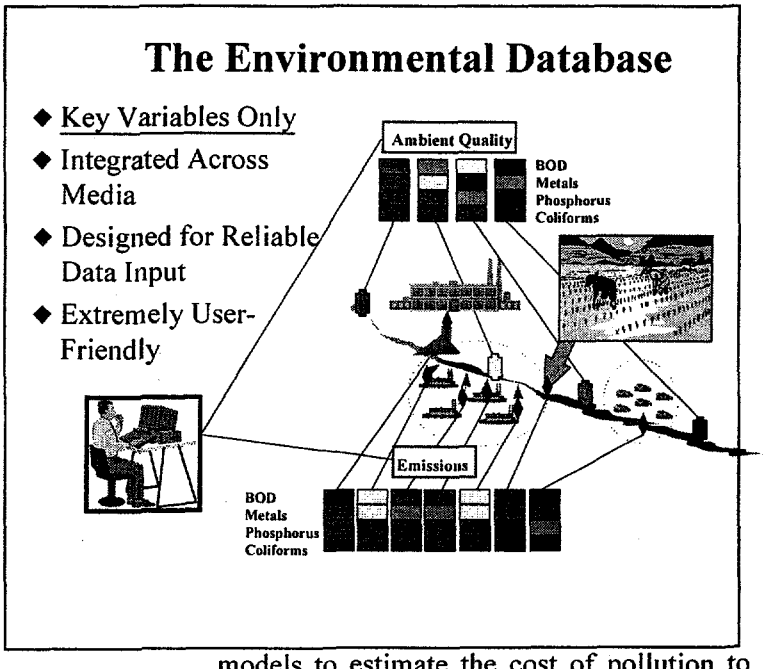
8.9 Upstream, the first monitor reads all 'Green' – no significant pollution of any kind. Downstream from the monitor, a large food processing plant is pumping effluent into the river. The plant reports a heavy BOD load, but no significant volumes of other pollutants. Somewhat further downstream, reports from a complex of small tanneries and textile mills indicate substantial volumes of heavy metals and some additional BOD. The second river monitor shows that these discharges are significantly affecting water quality: BOD is now Orange, and metals are Yellow. Below the industrial area, several large farms abut the river. Analysis of runoff reveals a heavy phosphorus load from large-scale application of fertilizer to some of the crops. Further downstream, the third river monitor indicates some assimilative action for BOD, which has retreated to Yellow. However, metals are now Red and phosphorus is Orange.

8.10 Finally, the river flows past a community which is discharging untreated sewage. This contains heavy concentrations of BOD and fecal coliforms, along with phosphorus from household detergents. At the fourth monitoring station, BOD and coliforms become Red, from the community effluent; the metals reading improves to Orange, because no further metals have entered the stream and some have settled to the bottom (later to appear in the tissues of fish caught in the area); phosphorus is Red from the combination of agricultural runoff and community sewage.

8.11 To summarize, establishment of the monitoring system has revealed a serious situation. As the river leaves the monitored area, it is for all practical purposes 'dead': contaminated by pathogens, it is dangerous to drink or swim in; its dissolved oxygen level is too low to support many species of fish, and the metals content is too high for safe consumption of those which remain. Eutrophication is well-advanced, and the color and odor of the water are both strongly affected by the growth of algae. Communities further downstream are inheriting a very costly legacy from their neighbors' uncontrolled pollution.

8.12 The regulatory information system has now executed its first three responsibilities: identification of major pollution sources, measurement of their effluent, and registration of the effect on ambient environmental quality. As shown in Figure 8.2, all relevant information is stored in a system of networked PC's using standard, user-friendly software. The system is focused only on the important problems; it is not designed to be an unwieldy catalog of all possible environmental data. Pollution reporting software is integrated with a Geographic Information System, and simple 'point/click' queries call up tables or maps which can report ambient quality at each point on the river, and trace excessive pollution back to its sources. Information on these sources can be called up with equal ease, and the system is geared to track compliance with regulations so that inspections and enforcement activity can be targeted on the worst problem cases.

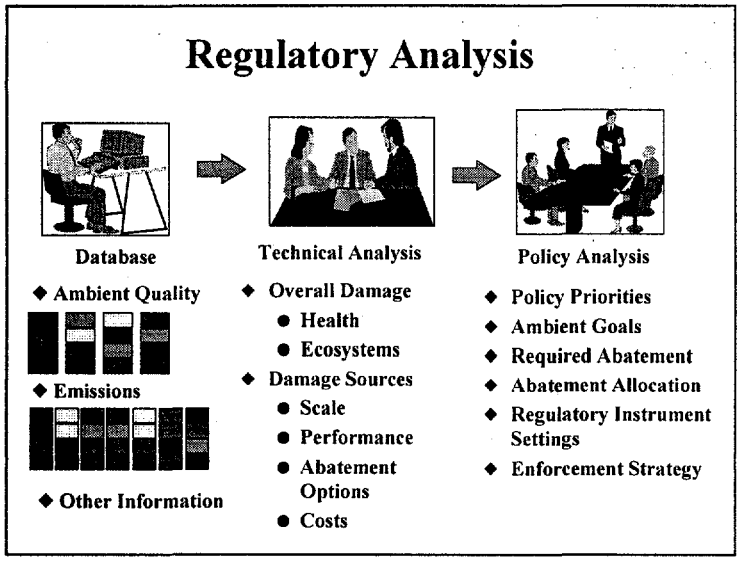
Figure 8.2: Environmental Database



Technical Analysis

8.13 Monitoring of sources and ambient quality provides the 'raw material' for regulatory action. However, these materials go through a process of refinement and analysis before serving as the basis for policy implementation. Figure 8.3 illustrates some critical steps in the process. First, the agency's technical team uses the information for building a dispersion model, which relates monitored emissions to river quality. This provides the basis for rapid identification of sources' contributions to pollution problems. Secondly, the team uses its own information and the best available impact models to estimate the cost of pollution to the community: human health damage, and losses in aquatic life, economic output and recreational amenities. Third, the team uses the available data on pollution source characteristics to identify polluters which can respond rapidly and at low cost to tighter regulation.

Figure 8.3: Regulatory Analysis



Policy Analysis

8.14 Figure 8.3 also tracks the information flow to the next stage of regulation – policy analysis. At this level, critical decisions are made about valuation, priorities and trade-offs. It is not economically feasible to eliminate all pollution, and the cost of abatement differs greatly across pollutants and polluters. Some pollution sources are large local employers, so regulatory decisions are affected by local political and economic considerations. Pollutants also differ in their impacts on health, ecosystems and environmental amenity, so different actors in the river basin will experience very different effects from alternative policy packages.

8.15 The policymakers are faced with a complex set of decisions as they weigh all of these factors. Conceptually, their task is to set regulations so that incremental social benefits and costs are just balanced for the river basin community. To the extent possible, they use the available information to fulfill this task. Inevitably, some of their 'ideal' solutions will be modified by the process of political consensus-building and implementation. Nevertheless, at the end of the day, the policymakers' job is to use the available information to develop clear statements about the current state of the environment; ambient quality goals; a timetable for reaching them; the pollutants which will be regulated; and the instruments which will be applied.

8.16 The final step in formal regulation is implementation: applying the regulations case-by-case to polluting factories, farms and communities. The regulatory instruments may be pollution charges, tradable permits, or quantity-based emissions standards. While the market-based instruments are generally preferable on efficiency grounds, none of these approaches can function well unless the information system has laid the foundations for effective policies. Constant feedback from the system is also necessary for judging whether implementation is having the desired effect.

STAKEHOLDER INPUT

8.17 The preceding description of information and regulation has stressed the 'technical' side of the system. As Figure 8.4 shows, however, an equally important part of effective regulation is input from stakeholders – polluters, pollutees, interested citizens, academics, scientists, NGO's, etc. The second major task of the information system is therefore to promote effective communications with these stakeholders. The river basin community, and the larger community in which it resides, have access to many kinds of information which cannot be collected and processed directly by the regulatory agency. The agency's information system is structured to receive and utilize these inputs.

Complaints

8.18 Damaging pollution will often be apparent to local citizens even if the environmental monitors haven't recorded it. To tap this information, the agency's system provides facilities for rapid communication and routing of citizen complaints about pollution. Traditionally, the telephone has been the primary instrument in this context. However, the agency has also developed a PC-based reporting system, in which local community centers have sites for menu-driven on-line entry. The system provides automatic logging, categorizing, routing and storage of information about complaints. Digital storage and retrieval make it much easier for the agency's technical team to identify significant patterns. The user-friendly system also encourages citizens to engage in the process.

Feedback

8.19 A regulatory plan reflects assumptions about community values, modes of behavior, and implementation costs. Any of these assumptions can easily be wrong, and continuous feedback from stakeholders provides a good basis for in-course correction. Polluters are, of course, likely to provide self-serving feedback, but inappropriate regulation may damage them in ways which affect the community's economic interests. Victims of pollution may also perceive problems which have escaped the notice of the technical team; scientists, academics, NGO's and concerned citizens frequently have insights which have not occurred to the regulators. For these reasons, and because consensus ultimately depends on open communication, the information system also includes facilities for entering, summarizing and channeling diverse forms of community feedback to the regulators.

THE POWER OF INFORMAL REGULATION

8.20 The agency works better with information from stakeholders, but it also provides them with information. To participate effectively in environmental management, the public needs to be fully informed about the same factors which motivate regulatory policy: environmental quality trends, goals, sources of pollution, damages, compliance records, and abatement costs. Therefore, the flow of information in Figure 8.3 does not stop with the policymakers but passes through to the public, in an easily digested form.

8.21 What happens once the public has information about polluters and their effect on the environment? Figure 8.5 summarizes what we know about the impact of public information. Recent research has shown that this information becomes an important part of 'informal regulation' – the pervasive process by which communities and markets influence polluters' behavior even if formal regulation is absent. Factories in developing countries exhibit great variety in environmental performance despite the widely ac-

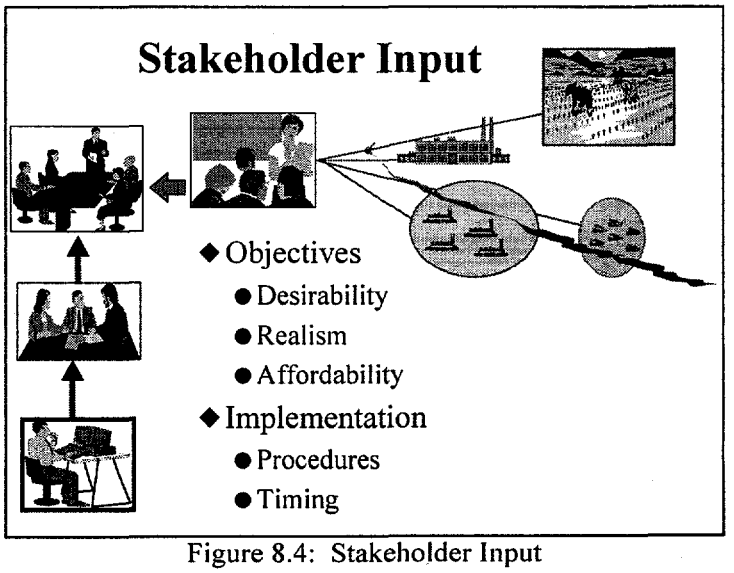


Figure 8.4: Stakeholder Input

knowledged weaknesses of their regulatory systems. Even in the poorest countries, some plants would satisfy OECD emissions standards.

8.22 In countries as different as China, Brazil, Mexico and Indonesia, local communities find many ways of enforcing their environmental norms.[2] Where formal regulators are present, they use the political process to influence the tightness of enforcement. Where formal regulators are absent or ineffective, 'informal regulation' is implemented through community groups or NGOs. The agents of informal regulation vary from country to country -- local religious institutions, social organizations, community leaders, citizens' movements or politicians -- but the pattern is similar: factories negotiate directly with local communities, responding to social norms and/or threats of sanctions if they fail to reduce the damages caused by their emissions.

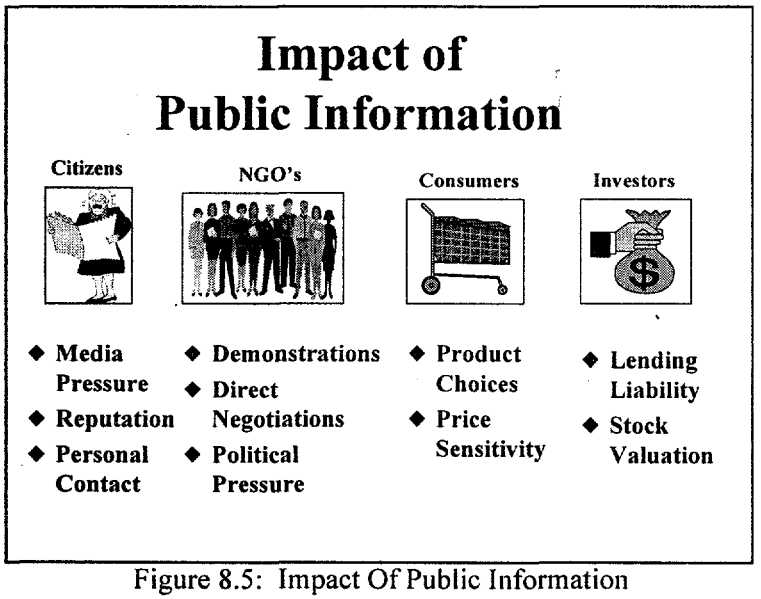


Figure 8.5: Impact Of Public Information

8.23 Market forces are also powerful determinants of environmental performance under some conditions. Evidence from both the OECD and developing countries suggests that environmental reputation matters for firms whose expected costs or revenues are affected by judgments of environmental performance by customers, suppliers, and stockholders.[3] For reputation-sensitive companies, public recognition of good or bad performance may translate to large expected gains or losses over time. These can affect lending decisions by bankers, who may also be concerned about legal or financial liability for polluters who are not complying with regulations.

8.24 Once informal regulation is recognized as an important force, regulatory agencies experience a role change. While retaining ultimate responsibility for monitoring and enforcement, they assume new importance as sources of environmental information. Figure 8.6 illustrates the effect of public information on activities in the river basin: as full information about environmental quality and polluters' performance is released to the public, communities and market agents began to operate. Polluters find it impossible to 'hide' from so many interested parties, and a complex set of new relationships and nego-

[2] For evidence from Asia, see Pargal and Wheeler (1996), Hettige, Huq, Pargal and Wheeler (1996), Huq and Wheeler (1993), and Huq, Hartman and Wheeler (1996). Evidence from Brazil and Mexico can be found in Wheeler and Witzel (1995) and Hettige and Witzel (1996). Most of these papers can be found at PRDEI's Internet Website, WWW.NIPR.COM.

[3] See Hettige, et. al. (1996) and Laplante and Lanoie (1994).

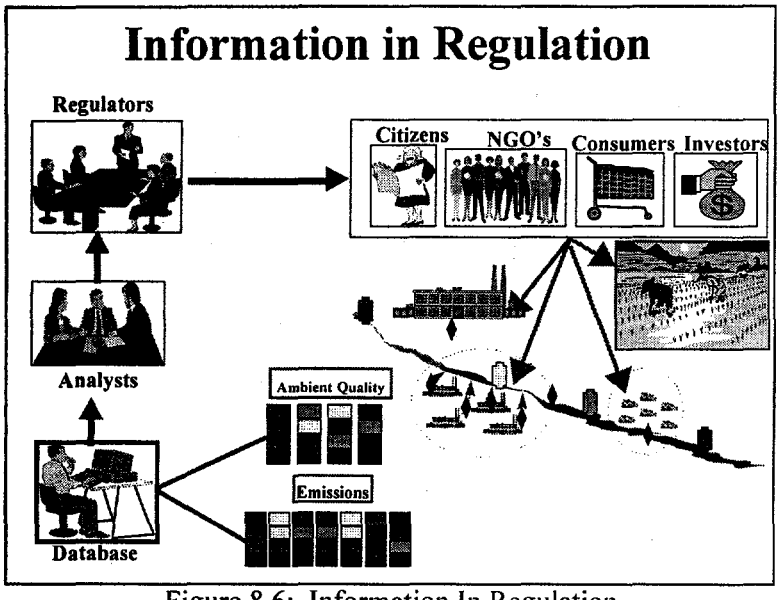


Figure 8.6: Information In Regulation

tiations is established. Pollution declines significantly in some areas, even though the regulatory agency takes no additional measures.

INFORMATION IN ACTION: TWO CASES

8.25 The preceding sections have provided a simple illustration of an integrated information system which can support both formal and informal regulation of pollution. Is this just a hopeful concept, or is there some prospect that environmental agencies in developing countries can actually implement such a system? In fact, several agencies are now putting these ideas into practice. In this section, we provide concrete examples from Brazil and Indonesia.

Integrating Environmental Information For Rio de Janeiro State[4]

8.26 During the past two years, the government of Rio de Janeiro State has developed a new structure for environmental management. Part of the restructuring has involved integration of environmental information at FEEMA, the State's pollution control agency. FEEMA's new information system provides a concrete illustration of many features described in the earlier sections of this paper.

Supporting Regulatory Policy Analysis

8.27 Integrated information is the key to regulatory policy analysis, as depicted in Figure 8.3.

8.28 An appropriate information system should monitor ambient quality and emissions from major polluters, along with their compliance records. FEEMA's new system was designed to provide supporting information in all three dimensions. When development began in 1995, sufficient data existed in the agency to establish a profile of ambient quality, an inventory of emissions sources, and a record of inspections and complaints for each major source. Since the data were scattered across departments within FEEMA, however, the primary task was to develop an integrated information system.

[4] This section draws heavily on the experience of a World Bank team which collaborated with the Rio State Government on restructuring environmental management. For a detailed study of the restructuring issue, see Von Amsberg (1996).

Networking the Agency

8.29 Before the new initiative, FEEMA's regulatory planning and implementation were hampered by the division of planning, monitoring and enforcement tasks among several departments, with little information-sharing or coordination of activities. The difficulties were compounded by the lack of an integrated digital information system. Paper files were maintained separately by each department, or stored in separate computers with different data formatting standards. Much of the agency's critical information on pollution sources was stored on an archaic minicomputer which could not communicate directly with the agency's scattered PC's.

8.30 Without common digital hardware and software standards, FEEMA's managers had great difficulty in analyzing environmental conditions, tracing problems to pollution sources, and effectively targeting their limited monitoring and enforcement resources. The new initiative attacked this problem directly, by developing and installing a PC network based on low-cost hardware and standard commercial software. As the system came on-line, it became possible for different departments to store records in a common database which could be accessed by any unit in FEEMA. Agency managers began asking for reports which required integrated analysis, and most department managers quickly perceived the political importance of participation in the network. The demand for PC's expanded rapidly, and all departments began entering new data in a standard format. Agency technical staff experienced a jump in effectiveness, as it became much easier to analyze levels and trends in emissions, community complaints, inspection reports, and air/water quality readings from many monitoring stations.

Integration with GIS

8.31 To regulate effectively, FEEMA needed geographic information -- on pollution sources, air- and watersheds, transport networks, and exposed populations. A Geographic Information System (GIS) was the right tool for supplying this information, so GIS capability was developed at the outset. Three examples will serve to illustrate the potential of the system after only a few months of development:

- Combined display of major water pollution sources (industries, population centers) and readings from water monitoring stations provided a systematic basis for addressing critical pollution problems in the State's rivers and coastal bays.

- Combined display of major air pollution sources, major transport arteries and affected populations provided similar capability for critical air pollution problems.

- Once the GIS was integrated with FEEMA's environmental information, it became possible to move to a new level of monitoring and enforcement capability. For example, the GIS provides 'point-click' access to information on any data source which is identified on the geographic display. A GIS map can be used to identify all large emissions sources in an area with a particular symbol. A click of the cursor on one of these symbols brings up the data file on that source: its emissions, facility characteristics (e.g., sector, employment, output, use of raw materials, energy use, etc.); inspection data; outstanding complaints; and enforcement actions. Equipped with this kind of information, agency managers are in a much better position to target their scarce monitoring and enforcement resources.

Involving the Community

8.32 FEEMA's system can also provide much better environmental information to the public. The State's new approach to environmental management stresses community participation in planning and implementing pollution regulation. To play an effective role, the community needs good information about ambient quality, goals for the future, progress toward those goals, and the regulatory status of major pollution sources. FEEMA is now positioned to provide this information, through reports which plot trends in ambient quality and emissions against objectives, and maps which convey detailed information about ambient quality, emissions sources and affected populations.

8.33 FEEMA also has the capability to prepare and publish detailed profiles or performance ratings for major pollution sources in the State. Such performance ratings are proving quite effective as a new tool for pollution control. In the following section, we describe a successful initiative on performance ratings at BAPEDAL, Indonesia's national pollution control agency.

RATING ENVIRONMENTAL PERFORMANCE: INDONESIA'S PROPER PROGRAM[5]

Setting The Stage

8.34 Environmental agencies in developing countries have a mandate to regulate industrial pollution, but they often lack institutional capacity. Although equipped with conventional options such as regulatory standards and/or market-based instruments (e.g., pollution taxes, tradable permits), they remain hard-pressed to achieve substantial results. A good example is provided by BAPEDAL, Indonesia's Environmental Impact Management Agency. During the late 1980's, BAPEDAL introduced several measures to counter rapidly-increasing pollution from the manufacturing sector. However, monitoring and enforcement problems frequently limited the agency to voluntary agreements, out-of-court settlements and other ad hoc approaches.

8.35 This set the stage for experimentation. In 1993, BAPEDAL's Deputy for Pollution Control began to develop the Program for Pollution Control, Evaluation and Rating, now known as PROPER. In PROPER, the agency would receive pollution data from factories, analyze and rate their performance, and disseminate the rat-

[5] This section draws heavily on the work of the PRDEI: the Environment, Infrastructure and Agriculture Division of the World Bank's Policy Research Department. During the past two years, PRDEI has provided technical assistance to the PROPER project. We gratefully acknowledge the support and inspiration provide by Mr. Nabiel Makarim, Deputy for Pollution Control in BAPEDAL, who has directed PROPER from its inception. This section has been prepared in collaboration with Shakeb Afsah, Benoit Laplante and David Shaman. Detailed information on public disclosure as a regulatory tool can be found at PRDEI's Internet Website, WWW.NIPR.ORG.

ings to the public. The initiative signaled a bold move toward transparency by recognizing the new power of the media and public participation in a rapidly-industrializing economy. BAPEDAL hoped that public performance ratings would recruit two major allies in its effort to reduce pollution. *Local communities*, worried about health consequences, would pressure poorly-rated neighboring plants to pollute less. In *financial markets*, access to capital or stock values would fall for firms whose low ratings increased the risk of liability suits, regulatory shutdowns, or reduced product demand. By mobilizing these agents, BAPEDAL hoped to strengthen the regulatory 'stick' faced by heavy polluters. But the program was also designed to recognize excellent performance, in the hope that this would promote the adoption of clean technologies and development of in-house environmental management capabilities.

Getting Started

8.36 When it 'goes public' with performance ratings, an agency invites close scrutiny by many interested groups, including, of course, those who receive poor ratings. From the beginning, it was obvious that PROPER had to focus on data integrity – in collection, verification and analysis. One bad mistake in the first implementation might well undermine the entire program by destroying public credibility, or by inciting a successful lawsuit by a firm whose reputation was wrongly damaged.

8.37 The first critical decisions concerned selection of pollutants and factories for initial rating. While it had very limited information on air pollution or hazardous waste, the agency had significant data on industrial water pollution from two sources: its Clean River Program (PROKASIH), which was introduced in 1989, and its regulatory monitoring and enforcement activity (JAGATIRTA). Given its relative depth of experience with regulation of water pollution, BAPEDAL decided to focus on compliance with water regulations in the first phase of PROPER. Air and toxic pollution would be incorporated in the next stage of development. Combined with self-monitoring reports from polluters, the information from PROKASIH and JAGATIRTA was judged sufficient for a careful compliance assessment in Phase I. The PROPER team designed a data management system for the program, and tailored it to help field teams organize and quantify results of on-site inspections and monitoring activities. The system also incorporated a broad range of information on economic activity, emissions control equipment and in-house pollution monitoring.

8.38 In February 1995, the PROPER team sent survey questionnaires to approximately 350 factories. The pilot group included plants from thirteen Indonesian provinces, and from all fourteen industry sectors which had effluent discharge standards. In response, 176 plants provided sufficient data for BAPEDAL to perform an initial rating. Eleven other factories volunteered to take part in the program, bringing total first-round participants to 187. The team supplemented the survey information with a rigorous inspection program to verify the data *on site*.

Going Public

8.39 Since PROPER is a *public* performance rating system, its disclosure strategy has also been a primary focus of attention. Certain problems had to be confronted at the outset. First, the grading system adopted by the agency had to accommodate polluters with widely different characteristics. Second, the ratings had to be simple and their implications easily understood by the public. Third, the system had to clearly discriminate between firms in compliance with the regulations and those out of compliance. Fi-

nally, the program had to provide incentives for progressive firms to go beyond compliance. BAPEDAL settled on the five-color scheme shown in Figure 8.7. Its color-coding is a simple but effective format for communicating environmental information about individual plants to the public, media, judicial system and financial markets. The colors of the rating system are easily identifiable and, in the Indonesian cultural context, symbolic of the polluters' environmental performance.

8.40 For its first disclosure, BAPEDAL decided on a sequential strategy which would publicly recognize the best performers at the outset and give others a chance to improve before bad ratings were revealed. This approach was intended to serve several objectives. First, it would promote an image of fairness in the business community by allowing time for adjustment to the new program. Second, it would develop a new alliance between the regulatory agency and firms whose good performance was publicly recognized. The latter, having already invested in costly abatement, could be counted on to support PROPER because it would 'level the playing field.' Finally, and perhaps most critically, BAPEDAL wanted time to gauge the possibility of extreme reactions to Red- or Black-rated plants by neighboring communities.

Initial Impact

8.41 PROPER PROKASIH was introduced in June 1995, and was extensively covered in the national and international press. Five factories were publicly awarded the Green rating (no factories were rated Gold). For the remaining 182 plants, only the distribution by color rating was disclosed: 61 were Blue, 115 were Red and 6 were Black. This announcement was, in itself, a remarkable exercise in self-criticism. By announcing that almost two-thirds of the plants were non-compliant, BAPEDAL was confessing its own previous ineffectiveness to the Indonesian public.

8.42 BAPEDAL gave plants rated Black or Red until December 1995 to improve their performance before their names and ratings were publicly disclosed. Under the threat of public disclosure, ten factories managed to improve their rating to Red or Blue within six months. The primary driving force behind these improvements was probably concern about potentially strong responses from local communities and markets. In December, PROPER was fully implemented: a sequenced disclosure campaign was launched by industry sector, with new announcements at regular intervals to keep the media interested. Disclosure included the color ratings, the locations and names of the plants, their managers, and their parent companies.

8.43 Figure 8.8 shows the evolution of ratings for PROPER's original 187 factories during the first fifteen months of the program. The movement of firms from non-compliance to compliance is impressive. In

PERFORMANCE LEVELS	PERFORMANCE CRITERIA
GOLD	**Clean technology, waste minimization, pollution prevention, conservation, etc.**
	Above standards & good maintenance, housekeeping, sludge management, etc.
BLUE	**Efforts meet minimum standards**
RED	**Efforts don't meet standards**
BLACK	**•No pollution control effort, •Serious environmental damages**

Figure 8.7: Performance Criteria

June 1995, 65% of the factories were rated Black or Red. By September 1996, non-compliant plants had dropped to 47%. Since it is highly unlikely that other Indonesian polluters improved at the same rate, this reaction suggests that PROPER is creating strong new incentives for pollution control.

Figure 8.8: PROPER'S Impact

PROPER's Impact

	June 1995	Dec 1995	Sept 1996
GOLD	0	0	0
[illegible]	5 (3%) →	4 →	5
BLUE	61 (33%) →	72 →	94
RED	115 (61%) →	108 →	87
BLACK	6 (3%) →	3 →	1

8.44 While incentives geared to preserve reputations are obviously at work, it is interesting to note that PROPER was frequently the means by which factory owners first learned about the environmental performance of their plants. In direct consultations between BAPEDAL and the owners, it became clear that PROPER performs a valuable educational function, both by increasing the awareness of owners, managers and employees and by providing guidelines for improved performance.

8.45 It is also interesting to note that factories volunteering to participate in PROPER doubled from June to December of 1995 (from 11 to 23). Clearly, these factories expected disclosure to enhance their market position. This illustrates a primary strength of the approach: unlike many previous environmental initiatives, PROPER supplies incentives to polluters to move beyond compliance and toward attainment of higher performance ratings. By improving a firm's reputation in the competitive marketplace, higher ratings can raise expected profitability.

8.46 PROPER has also had an important impact on BAPEDAL itself. The need for accuracy in the ratings has compelled the agency to increase its factory inspections, and to improve the quality and reliability of its data collection and verification. The information collected through PROPER also provides BAPEDAL with solid evidence of a factory's compliance status, supporting stronger action in cases where conventional enforcement action is appropriate.

The Lessons Of PROPER

8.47 BAPEDAL's initiative reflects powerful incentives for reducing negative externalities from private or public activities. A well-designed PPA (Public Performance Audit) system can increase both the transparency and accountability of public institutions. It can improve resource allocation by reducing transactions costs and encouraging socially desirable behavior. It can also induce improvements from private agents whose poor performance would otherwise require costly enforcement activity and/or litigation.

8.48 The PROPER experience suggests four important principles for successful implementation of PPA:

Starting Small

8.49 While PPA provides many advantages, developing a credible system is not an easy task. Once public confidence in performance ratings is lost, it will be hard to regain. Therefore, it is crucial that a regulatory agency undertake a pilot program before committing itself to a full PPA. The pilot could be confined to a geographical area, a particular medium, an industry sector or a limited set of critical polluters. The important thing is to gain experience with careful data-gathering, validation, analysis, strategies for public communication, and mechanisms for learning from experience. In the course of a pilot program, the agency can gain experience in dealing with multiple stakeholders, managing a core PPA team, and effective public communications. The pilot will also provide the opportunity to weigh the benefits of PPA against the costs of developing and maintaining the system.

Integration

8.50 A successful PPA system requires all relevant agencies to integrate their information systems and cooperate in pollution management. Because they reveal existing compliance levels, public performance ratings also provide an indicator of the regulators' own performance. Greater requirements for data reliability give regulators a strong incentive to operate more efficiently. In addition, the need to verify, process and analyze comprehensive information for public performance ratings will substantially increase the technical and analytical skills of agency staff members. Given budgetary limitations, the positive pressure from public performance ratings will also give regulators a good reason to adopt the most cost-effective regulatory tools.

Simplicity

8.51 A crucial element of a good PPA program is simplicity. Although the supporting information should cover all major environmental performance factors, it should be processed using a simple, predetermined methodology and provided to the public in a very clear summary format. The details should be available to those who are interested, but it is critical that the summary information be easily understood by local communities, business managers, investors and other interested parties. Experience to date with PROPER suggests that simple color coding of performance categories may be the most effective approach.

Public Acceptance

8.52 A PPA will succeed in improving environmental performance only if the public accepts and supports it. Inevitably, some subjectivity will be introduced into performance evaluations even when data and methods are treated very carefully. At critical moments in the development and operation of the system, a supporting public consensus will be essential. For this reason, the PPA system should be developed in close consultation with community leaders, industrialists and concerned academics. Maximum transparency and continued consultation will be essential to long-term public support of the system.

Conclusions

8.53 This new approach to regulation in Indonesia is showing that local communities and market forces can be powerful allies in the struggle against excessive industrial pollution. PROPER's ratings are designed to reward good performance, and to call public attention to polluters who are not in compliance with the regulations. Armed with this information, local communities can negotiate better environmental arrangements with neighboring factories; firms with good performance can advertise their status and earn market rewards; investors can accurately assess environmental liabilities; and regulators can focus their limited resources on the worst performers. Moreover, transparency is increased because the environmental agency itself is opened to public scrutiny. By committing itself to a public disclosure

strategy, it chooses to reveal its own ability to process information reliably and enforce the existing regulations.

8.54 Public disclosure seems to be having an important impact on industrial pollution in Indonesia. Encouraged by program results to date, BAPEDAL plans to rate 2000 plants by the year 2000. Other countries have also been inspired by this example of public information in action. Philippines has already launched its ECOWATCH program, which is quite similar to PROPER, and Colombia and Mexico are moving rapidly toward development of their own public disclosure programs.

INFORMATION IN POLLUTION REGULATION: FIVE PRINCIPLES

8.55 This report has highlighted the importance of information in modern systems of pollution regulation. It is not difficult to manage pollution more cost-effectively once regulators have high-quality information, more integrated information systems, more internal capacity for priority-setting, and stronger public participation. This new approach also implies a new role for regulators as public information agents. Although the state can and should have a continuing role in the regulation of pollution, the importance of providing information to communities and markets must also be recognized.

8.56 When these two sets of factors are taken into account, a new model of pollution management emerges. It incorporates five key principles for the use of information in regulation:

Focus On Information Products

8.57 Effective pollution management is impossible unless regulators have reliable data, integrated information systems and the capacity to set priorities which reflect comparative benefits and costs. Markets and communities need timely, accurate, public information to make appropriate assessments of factories' environmental performance. An effective regulatory agency will therefore allocate fewer resources at the margin to conventional enforcement and more to the generation and distribution of appropriate information products.

Orchestrate, Don't Dictate

8.58 A pollution control agency is only one player in the environmental performance game. Agency activities which influence polluters *indirectly*, through other agents, may be as important as direct enforcement. Potentially high-leverage programs include community environmental education, public disclosure of factory performance ratings and technical training programs for environmental personnel in polluting factories.

Encourage Public Participation

8.59 Equipped with appropriate information, regulatory agencies can play a key role in facilitating negotiations between local communities and neighboring factories. This role includes provision of reliable information on emissions and local ambient quality, technical advice on abatement alternatives, and the transfer of experience from other locations.

Learn From Policy Experiments

8.60 Environmental policy implementation is a complex business, which will inevitably be subject to many uncertainties. Because it is difficult to know exactly what will work in advance, new policy initiatives should emphasize structured learning. Rather than pre-committing to broad-based programs, agencies should initiate a variety of pilot projects, use their information systems to monitor developments, and build larger programs as experience accumulates.

Use Flexible Instruments

8.61 Newly-industrializing economies can experience rapid changes in ambient quality across air- and watersheds. Since

regulation should primarily serve environmental quality objectives, it should be focused on adaptation to these rapid changes. Regulators should be empowered to counter environmental degradation by tightening existing regulations. On the other hand, the system should minimize disruption for investors. Meeting both objectives implies:

- Transparent adjustment rules, linked to publicly-available data from the agency information system on ambient quality and emissions; and

- Adjustment which is, to the extent politically possible, automatically triggered by deterioration of ambient quality below mandated levels. Again, the information system will play a critical role in successful implementation of this principle.

References

Hettige and Witzel (1996). PRDEI's Internet Website, WWW.NIPR.COM.

Hettige, Huq, Pargal and Wheeler (1996), PRDEI's Internet Website, WWW.NIPR.COM

Huq and Wheeler (1993), PRDEI's Internet Website, WWW.NIPR.COM

Huq, Hartman and Wheeler (1996) PRDEI's Internet Website, WWW.NIPR.COM.

Laplante and Lanoie (1994). PRDEI's Internet Website, WWW.NIPR.COM.

Pargal and Wheeler (1996), PRDEI's Internet Website, WWW.NIPR.COM

Wheeler and Witzel (1995) PRDEI's Internet Website, WWW.NIPR.COM

9. POLLUTION MANAGEMENT IN A FEDERAL SYSTEM[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
Environmental matters are not incorporated into macroeconomic and sectoral planning and continue to be subordinate to economic decisions.
Poor coordination among agencies within the same level of government and across levels caused largely by individual agencies pursuing localized and sectoral objectives.
Lack of accountability due to unclear institutional assignments across tiers of governments.
Weak institutional capacity due to diminished budgets and lack of performance-based salary structure.
Lack of priorities due to emphasis placed on green environmental issues.
Limited range of instruments for monitoring and enforcement are rigid and do not reflect social, economic, political, and environmental differences.

STRATEGY AND RECOMMENDATIONS
Environmental policy needs to be based on dynamic targets agreed upon across sectors, for example through Environmental Action Plans. Performance contracts with environmental agencies could be based on the targets of these plans.
Better integration of environmental agencies in sectoral policy making and planning is important. It requires more realistic and gradual environmental targets and early participation of environmental agencies in sectoral policy making.
The establishment of the *Lei Complementar* to clarify the roles of different government levels should receive high priority.
The responsibility of the national government should focus on and be limited to: (a) the management of genuine national pollution problems; (b) integration of environmental aspects in national policies; (c) setting federal framework regulations; (d) setting some national minimum ambient quality standards; (e) preventing unfair competition between states; and (f) providing assistance and information services, especially for weaker states.
Outside of the direct national responsibilities, the federal government and its agencies should not enforce regulations directly with polluters unless specifically contracted to do so by the responsible state.

RATIONALE FOR A NATIONAL POLLUTION MANAGEMENT SYSTEM

9.1 The public good nature and the market failures that characterize environmental problems justify government intervention in the sector. Even in industrialized countries with established commercial environments, the reliance on market mechanisms in environmental policies has not precluded strong government regulation. Further, striking income disparities, regional differences (urbanization and concentration of economic activity), and the federal political system in countries like Brazil call for government intervention. The demand for

[1] This paper was prepared by Sergio Margulis

such a regulatory framework partly conflicts with the deregulation and divestiture of State enterprises, a top priority since the early 1990's.

9.2 A pollution management strategy consists of allocating responsibilities across government agencies ensuring effectiveness and the minimization of costs. However, since environmental problems are local problems, states and municipalities are in a far better position to address environmental problems, and thus should have the freedom to choose the most appropriate policies and instruments to do that. This raises the questions whether a national environmental management system is desirable and also what is the role of the federal government in such a system. The degree of decentralization is indeed subject to choice. Decentralizing environmental management has two main advantages: (i) it reduces information costs - residents of a jurisdiction know their interests better; and (ii) it allows environmental quality and policy instruments to vary across regions according to their priorities for environmental protection and budgetary constraints. It has some problems, notably in cases where local governments do not set environmental standards high enough; it may lead to tax exporting, in cases where local governments have residents of other jurisdiction pay for their environmental protection polices; and it can make it difficult to internalize externalities created by spillovers. An upstream municipality may have no incentive to curtail water pollution if the suffered are residents of other municipalities (World Bank 1993).

9.3 As to the roles of the federal government, the Brazilian legislation says that State and municipal governments are responsible for implementing the control strategies of most environmental problems. The efforts by these two tiers of government, which may include the federal government's assistance, clearly depend on their level of commitment to environmental protection. If neither local governments nor local communities choose to give priority to environmental issues, federal government involvement may indeed be questionable. However, the federal government does have a major role to play in the management of pollution problems in Brazil: in addition to being a constitutional assignment, this is also economically justified.

9.4 Two arguments justify federal government involvement in relation to the environment. First, only the federal government can perform certain functions, such as addressing international environmental problems, resolving inter-state disputes, coordinating with national economic and sectoral policies, etc. The second is essentially political. Since environmental problems are local, it is plausible to ask whether a set of minimum national environmental quality standards should exist, not to mention a national environmental management system itself. Minimum standards are required mainly for health reasons. It is legitimate for the federal government not to accept that the health conditions of any citizen in the country fall below a set of minimum standards, which in turn converts directly to the formulation of minimum environmental quality standards. Since it is the federal government that establishes health standards and also is the major financier of the health sector, it naturally follows that it is the federal government that should set minimum national environmental quality standards. The decision, however, remains political since it could still be argued that if neither local governments nor local communities care about environmental problems (having access to all relevant information, including potential health risks), then the national standards impose an inefficiency in local decisions. It is precisely the basic minimum standards to be found throughout the country that make it a federation of states, rather than a mere ensemble of them. Assuming that this principle is accepted by all federated states, it must take precedence over

Box 9.1: Pollution Management Systems of Federal Countries

Like in Brazil, in most federated nations environmental policies and guidelines are established by the federal governments, while states and lower levels are responsible for implementation and enforcement. The federal government through its agencies attempts to ensure compliance with the national standards, but different levels of income, of political support, of technical skills, plus other factors cause enforcement of environmental legislation not to be uniform across different states and regions. This is perhaps the overall major problem of most national environmental systems in the world.

United States. In the United States the division of jurisdiction between state and federal authorities is not always well defined and has led to considerable debate and litigation. The main feature of the US system is its "adversarial regulatory framework", coupled with an enforced compliance model. Courts have assumed a fairly prominent role in the system as a consequence. The federal agency (EPA) has responsibility and statutory authority for pushing the national system (ie., forcing states to comply with regulations) and for establishing national regulations (which States, in most cases, may go beyond). USEPA's enforcement role has been considered extremely interventionist within the States, often pushing for the adoption of the most stringent standards adopted by any one state (typically California). In other areas, however, it has been blamed for poor enforcement action. In addition to its enforcement role, the USEPA has largely been assuming regulatory functions, through the expedition of detailed technical requirements and command and control regulations and standards such as New Source Performance Standards - NSPS: this has originated serious disputes with the national Congress and with various States, who want to have greater discretion in the enforcement of the national policies and guidelines.

The European Union. The European Union (EU) is an integration of sovereign countries and this alone makes it difficult the establishment and acceptance of common legislation. The three key legal instruments of environmental policy in the EU are (i) directives, which are the main legal instrument: once approved by the Council of Ministers they become binding to all member states, although the choice of instruments and methods for states to implement and comply with are left for individual decision; (ii) regulatory acts, which must be directly implemented by states; and (iii) recommendations, which are non-binding. Like in national federated systems, the main problem of the EU environmental policy is the difficulty of enforcement and the different degrees of competence among member states. The main difference with the federal systems is that the EU is not expected or able to intervene: it essentially provides the guidelines and overall objectives, with the implementation being extremely decentralized. The areas where the guidelines become more interventionist have to do with trade, in a context where environment and health have typically been a barrier, typically standards for buses and trucks. As to the individual member countries of the EU, the major common feature which is drastically different from the US is the negotiated compliance model, where regulations are not established before some form of agreement is reached between the various interested parties, rendering implementation more easy and certainly less conflictive.

Mexico. Mexico has an extremely centralized political system, and so is the tradition of its national environmental management system. The new Environmental Law (following the 1988 Law) further decentralizes enforcement responsibilities to the States; but the capacity of state environmental agencies remains very weak, since many of them are still being formed. The federal government usually does not have local capacity to implement policies or to make states implement the law. So the enforcement of environmental regulations has been most successful in areas where the federal government has a direct interest, such as the Mexico City Metropolitan area and various national protected areas, or in the States which have their own environmental agendas and better prepared agencies, such as in the Northern border and in the States around the Mexico City metropolitan Area, subjected to greater population pressures.

other, more localized interests. This is a matter of political choice, and not of immediate economic rationality.

9.5 Therefore, the two core functions of the federal government - those which require above-State level decision-making power (international affairs, inter-state disputes, coordination with macroeconomic and sectoral policies) and setting and enforcing national minimum standards (together with promoting the national pollution management system) - are justified on economic efficiency as well as on political grounds. But in the specific Brazilian context an additional function of the federal government is crucial, and that is balancing between efficiency and equity objectives in the federal pollution management system. To put it more explicitly, should environ-

mental policy in Brazil be used for redistributive purposes or should equity consequences be managed by the central government through explicit distributional policies?

9.6 One of the key reasons why the Ministry of Environment has fundamentally focused on green issues, in addition to responding to international pressures, is the perception that brown pollution problems affect more intensely the richer states, and that any support from the federal government would mean an additional subsidy to them. In the case of the Mata Atlântica, for instance, the federal government is not subsidizing the richer states such as São Paulo and Rio de Janeiro, while its position towards the states in Amazonia is almost paternalistic when supporting and defending local interests. Whichever type of environmental problem, a typical Northeastern State may consider it unacceptable for the federal government to spend resources in exerting control in the richer Southeastern States. On the other hand, since the costs of environmental degradation in the Southeast are much greater than in the other regions, the returns to investment are likely to be greater in that region, making it a priority for federal government intervention. This equity and efficiency dilemma is an extremely sensitive issue and, in practice, a balance will only be achieved in political terms. As Seroa da Motta and Reis (1994) put it, "it is always possible to stick to the efficiency criteria and to propose compensation measures to alleviate poverty and reduce inequality. However, apart from the intrinsic difficulties in the implementation of compensation schemes, inefficiencies are likely to emerge elsewhere in the system."

9.7 Jack (1992) proposes another rationale along similar lines: the choice "will clearly depend on the efficacy of the redistributive programs. If these are weak or non-existent, weight may also have to be given to the distribution of income in the design of pollution control policies. For example, suppose a low income town is ad-

Table 9.1: Summary Of Environmental Responsibilities By Levels Of Government

	National	States	Municipalities
Target	-Minimum national air quality standards -Water Quality Classification -National zoning	-Ambient standards for State ecosystems at least as stringent as national -Excludes noise and domestic solid waste	-Ambient standards for Municipality ecosystems at least as stringent as State standards -Municipal zoning -Noise standards
Framework/ Guidelines	-Criteria for licensing, including EIAs -Criteria and methods for sampling and analyzing materials (air, water, soils) -Classification and procedures for handling hazardous materials -Legislation for nuclear, energy and waters	-Establishing fines and sanctions -Creating and establishing guidelines for application of environmental management instruments (complementary to licensing)	-Domestic solid waste procedures/practices -Noise pollution criteria and procedures for monitoring and enforcing
Monitoring/ enforcement	-Criteria for licensing -Federal ecosystems -International issues -Interstate ecosystems -Resolving interstate disputes	-Procedures for licensing -Monitor State ecosystems (air, waters, soils) -Inspect and apply sanctions/ fines to all polluting activities not under federal control (industries, cars, etc.)	-Permits for location of polluting activities -Monitor and apply sanctions/fines on sources of noise pollution -Collect and dispose of domestic solid waste

versely affected by the discharges of an upstream factory. Even if the property rights are distributed "evenly", the downstream town may not be able to afford to pay for a further reduction in emissions. If redistributive programs are ineffective, it may be better for the central government to directly intervene and force a further reduction. The efficient discharge level may not result, but without increasing the poor town's income explicitly, this central intervention may at least improve the outcome."

CURRENT ISSUES AND PROBLEMS

9.8 Pollution control in Brazil is currently decentralized. The federal government is responsible for establishing the general guidelines for pollution control (*normas gerais*), and States and municipalities for the formulation of supplemental legislation and its enforcement. The choice of enforcement mechanisms is also largely left to the lower levels of government within the constraints of relevant national laws (the tax system). Table 9.1 summarizes the responsibilities of the three tiers of government with respect to policy definition and implementation. Box 9.1 summarizes the main features of the national pollution management systems of the United States, Mexico, and the one agreed by member States of the European Union.

Institutional Organization At The Federal Level

9.9 Law 6938, enacted in 1981, established the national environmental system, SISNAMA. The Constitution of 1988 made provisions for vertical integration in the environment sector. However, these provisions have not been put into practice due to delays in passing the *Lei Complementar*. The current system is comprised of representatives from all tiers of government (in addition to civil society and NGO's), and assigns the responsibilities of the following key institutions: the Ministry of Environment, Water Resources and Legal Amazonia (MMA); the National Environmental Council (CONAMA); the federal executing agency (IBAMA); and State and municipal environmental secretariats/agencies.

9.10 The Ministry of Environment, Water Resources and Legal Amazon (MMA) was established in late 1992, with the primary responsibility for planning, coordinating and implementing control actions prescribed by the National Environment Policy (PNMA). The Ministry is organized into four Secretariats: Environmental Matters (planning, international matters), Institutional Development (technical cooperation and financial instruments), Legal Amazonia (coordination of local agencies) and Water Resources (water management). The personnel obtained from such diverse agencies as the former *Secretaria Especial do Meio Ambiente* (SEMA), *Companhia de Desenvolvimento do Vale do São Francisco* (CODEVASF) and the short lived Ministry of Amazonian Affairs have diverse backgrounds and different levels of understanding in relation to environmental matters. A comprehensive career plan still does not exist within the Ministry, so the incentives for real commitment by staff are minimal.

9.11 With regard to IBAMA, "since its creation in 1989, it has suffered from a series of difficulties that have hampered the accomplishment of its environmental management functions. Those difficulties stem from both public administration conjuncture and from internal issues concerning the organization and shortage of human and financial resources. IBAMA was formed by merging a number of agencies and by inheriting their legal jurisdictions, staff, institutional problems, and deficiencies. For instance, IBDF's two contradicting functions of promoting forest development and protecting natural forests have been maintained in IBAMA. The difficulties experienced in integrating the diverse staff and activities of those agencies were aggravated by frequent changes of high level administrative staff

(eight from 1989 to 1992) and policy directives" (IDB 1996).

9.12 Even though the underlying concept of the current system is quite advanced relative to most developing countries in theory, an integrated environmental and pollution management system does not exist in practice. The organizational difficulties faced by both institutions are less important than the incapacity to identify the core activities and functions of each, to clarify individual responsibilities, and to work on priorities. IBAMA, designed to be the executive arm of the MMA, still today regulates a number of activities. Its relations to State environmental agencies are almost entirely independent from those established at a higher level between MMA and State Secretariats of Environment. The brown environmental agenda is determined more by periodic crises and isolated individual initiatives than by clearly established priorities and supportive institutions. The major weaknesses of the national pollution management system in Brazil are discussed below.

Environmental matters not incorporated into macroeconomic and sectoral planning

9.13 Despite the immense progress achieved since the inclusion of environment issues in the Constitution, as well as the increased debate and awareness of environmental problems at all levels of society, environmental decisions continue to be subordinate to economic decisions in Brazil. At all levels of government, great resistance to incorporating environmental matters in the planning of core economic and sectoral decisions remains. Even 15 years after SISNAMA was established, environmental matters continue to be addressed in a reactive, rather than a proactive, manner. Licensing requirements for polluting activities, including the preparation of environmental impact assessments (EIAs) and associated public hearings, have been implemented, but more as bureaucratic requirements of the law than planning instruments.

9.14 Examples where environmental issues have not been mainstreamed into economic and sectoral policies are abundant. For instance, the sanitation sector is now coordinated by the Ministry of Planning: decisions regarding the privatization of sanitation companies in the states have typically been made without incorporating the relevant environmental aspects. Another recent example is the approval of the water law by Congress. The main conflict was whether revenues from water fees should be channeled to the federal revenue system or remain under the control of water basin authorities which would both establish and collect the fees. Only after years of pressure and explanations regarding the benefits of the innovative system was the law passed and at least partly absorbed by other Ministries.

9.15 In recent years, cases where the environmental dimension has been incorporated into the planning of sectoral policies and projects are increasing in number. For example, in the State of Rio de Janeiro, the environmental agency FEEMA has been an active participant in the planning of the proposed gas-chemical complex to be installed next to the Duque de Caxias refinery and a system of emission compensation has been proposed.

Poor coordination

9.16 Different government agencies within and across government levels have different objectives. This derives from the fact that agencies do not have the common incentive to maximize social welfare, but rather pursue localized, sectoral and often myopic objectives. Since environmental targets depend on the costs and benefits of the various problems and proposed actions, and since the evaluation of such benefits and costs in turn depends on the level of gov-

ernment responsible for making the evaluation, different government agencies will typically have different objectives. This applies to agencies within the same tier of government as well as across tiers. In principle, the federal government is best suited to assess the direct and indirect benefits and costs associated with controlling environmental degradation. However, lower levels of government have a much better understanding of the complexities of localized environmental problems, so the federal government may tend to underestimate local costs.

9.17 Situations abound where the incentives given to polluters by environmental agencies conflict with those given by ministries and secretariats in charge of promoting economic growth, such as agriculture, industry and energy. For example, in the early 1980s, the fiscal incentives given by SUDAM to attract investments in cattle ranching in Amazonia were proportional to the area cleared (deforested), while the IBDF (the National Forestry Agency) required the preservation of 50 percent of the original forest in the same region.

9.18 Though the Constitution establishes concurrent responsibility over environmental matters, the complementary law (*Lei Complementar*) specifying the scopes of operations of the three tiers of government has not been passed as of yet. Manifestations of this lack of coordination include disputes between states and municipalities regarding zoning in the licensing process; legal disputes among firms and governing bodies due to the fact that IBAMA's and state environmental agencies' inspections are uncoordinated; inadequate water resource regulation by a myriad of agencies from all tiers of government (state water supply companies, state environmental agencies, Ministry of Environment, Ministry of Energy and Mining, Ministry of Planning, various municipalities, secretariats of agriculture, and others); and the misuse of scarce resources as agencies from different tiers of government engage in similar activities, often competing for "political visibility" rather than attempting to provide better public service through coordination. Even when formal contracts are signed or informal agreements are reached between agencies of different tiers, actual compliance typically fails. At the federal level in particular, there is little coordination between the various ministries involved with pollution issues. Even within the domain of the Ministry of Environment, as mentioned, IBAMA still establishes norms and regulations (instead of attending to its more executive duties), while the Ministry itself is not technically organized to completely undertake these regulatory functions.

Lack of accountability

9.19 As institutional assignments across tiers of government are not clearly established, the responsibility for ensuring that the overall system functions, and that each agency is meeting its objectives, is also poorly defined. For instance, is IBAMA responsible for checking the effectiveness of state environmental agencies? Whose responsibility is this? Such lack of accountability provides a major disincentive for all agencies to fulfill their legal assignments. Even if the federal government agency (IBAMA in this case) would oversee the work of the state agencies, would it realistically impose any type of sanction or fine? Has that ever happened or is likely to ever happen in the environmental sector? States have the perception that such an approach does not work because it simply does not work in any other sectors (the most dramatic example being found in the financial sector, where until very recently the Central Bank has always intervened in favor of State Banks). To avoid being mired in the inefficiency of the government system, decisions must be transparent, allowing all segments of society to exert control over the govern-

ment's performance. This applies evenly to all tiers of government. However, in practice, there is limited experience in involving all interested stakeholders in the decision-making processes for environmental management in Brazil. Currently, the trend is to make decisions more transparent and to work in greater partnership with various segments of society. The more active and participatory involvement by NGO's is slowly breaking the resistance of government agencies, which are beginning to work in partnership. More progress needs to be made towards forging partnerships with industries and affected local communities.

Weak institutional capacity

9.20 Due to the government's attempt to cut the budget deficit, the hiring of new personnel has been extremely rare in the last ten years at the federal and state levels. For the relatively new environment sector, this has hindered a better understanding of problems, the incorporation of knowledge and experience from other countries, and maintenance of staff who are familiar with effective and efficient management techniques. Due to the structure of salary incentives which has little to do with performance, the "stability" of civil servants, and resource constraints, training has also not proven sufficiently effective. At the federal level, the new Ministry of Environment, Water Resources and the Legal Amazon has not yet managed to create a clearly established career plan and associated salaries for its own staff resulting in job insecurity and minimal accumulation of experience. At the state level, the financial crises of the public sector have led to an acute deterioration of institutional capacity, like in Rio de Janeiro. Currently, environmental agencies are being forced to take on greater responsibilities due to increased social pressure while, at the same time, financial crises are causing resources to diminish.

Lack of priorities

9.21 In 1996, CONAMA and its members made its first attempt to identify an agenda of priorities, but failed to incorporate it into their annual meetings. Further, there was no agreement on the criteria for its members to select their own priorities. Since CONAMA's agenda is mostly dictated by the Ministry of Environment, brown pollution issues receive far less attention than green issues, reflecting the priorities of the Ministry. In addition, the national brown agenda is almost entirely dictated by the more urgent needs of the State of São Paulo. The norms proposed by the technical "chambers" (*câmaras técnicas*) established by CONAMA are typically approved with little involvement of the poorer States. Consequently, the norms are established on a national basis, even though they may be neither appropriate to all states nor feasible given the states' differing capacities of implementation and enforcement. At the federal level, the focus on brown issues is more in terms of projects than on the systematic establishment of norms and policies. At the state level, priorities for brown issues are in most cases also non-existent. Lack of information, political pressures to cover all areas, and the incapacity to involve relevant stakeholders prevent the establishment of effective priorities.

Limited range of instruments

9.22 Management of brown pollution issues in Brazil is essentially limited to licensing, with little follow-up or inspection, except in the case of São Paulo. There is an overall tendency in the government sector to regard the exertion of police power as the primary function of the state, even though the capacity to do so is minimal. Flexible, market based instruments are in the early stages of formulation and encounter resistance from most stakeholders, including the government environmental agencies. For

pollution problems, the main exception is water discharge fees on industrial effluents, which are relatively common in the laws of many states even though actual collection is less frequent. Water basin authorities and agencies are only now beginning to be formed. Cooperation with various stakeholders (private sector, affected communities, NGO's, the scientific community and other government agencies) is rather limited, as is the transparency of decisions mentioned above.

ROLES OF THE NATIONAL GOVERNMENT IN POLLUTION MANAGEMENT

9.23 According to Law 6938 (1981) which established the national environmental management system, the federal government is responsible for promoting and supervising the system, including ensuring that all state environmental agencies are performing their assignments and also are accountable for their work. The law establishes that in order for this system to work effectively and efficiently, priorities must be established at all levels, including the national level. With the enactment of the 1988 Constitution, the definition of the roles of the three tiers of government as stated in Law 6938 (and all prior laws and decrees) require adjustments. In fact, the *Lei Complementar* should clearly define responsibilities and functions of the various tiers of government. This section presents the core responsibilities of the federal government in a national pollution management system. Two functions relate directly to national environmental policies: (i) management of national pollution problems; and (ii) coordination with other national policies. Three functions relate to oversight of the federal system: (iii) federal framework regulation; (iv) prevention of unfair competition; and (v) provision of assistance and information services.

Management Of National Pollution Problems

9.24 The Federal Government is directly responsible for a range of pollution problems of an international or interstate scale, as well as pollution from sectors where highly specialized knowledge is necessary for monitoring and regulation. Examples of these problems that must be addressed by the federal government include the implementation of commitments to address global environmental issues (greenhouse effect, ozone layer depletion, international waters); the management of international and federal rivers (rivers that cross State boundaries); and coastal zone management. In addition, the federal government directly controls the implementation of multi-state, nuclear energy and other highly technical and sensitive projects. The federal government is also responsible for establishing programs of national interest, creating a cadastre for and licensing polluting activities under federal jurisdiction, as well as monitoring them, and also has to act suplementary to States and municipalities following decisions by the Justice, the Public Ministry or by CONAMA.

9.25 The federal government, however, should not directly intervene into areas outside the responsibilities mentioned above. Even though the frequency of such interventions differs from State to State, it undermines the States' accountability and causes confusion as to which level of government has the authority to do what. The future *Lei Complementar* should clearly establish that the federal government's scope of responsibility and authority does not include areas outside typical national pollution problems.

Coordination With Other National Policies.

9.26 Environmental policies have not permeated macro and sectoral planning in

Brazil. To a large extent, environmental matters are still seen as obstacles to growth and are not addressed in a preventive way in the planning phases of projects and policies, but rather through more expensive, remedial actions. Nevertheless, Law 6938 makes explicit reference to the need for the federal government to "make compatible economic and social development with environmental quality." It also makes the federal government responsible for "imposing on polluters the obligation to pay for recovering environmental degradation, or compensating damages, as well as a fee for the utilization of natural resources." The latter is an attempt to introduce the Polluters Pay Principle in the national system, but the difficulty (and often alleged unconstitutionality) of introducing taxes with environmental purposes requires more subtle mechanisms and arrangements.

9.27 The principle that environmental matters are better addressed in a preventive rather than curative manner makes clear the need to incorporate environmental issues into national public policies (export incentives, macroeconomic stabilization and market-reforms), national sectoral policies (industry, energy, water supply, sanitation, and transport policies), as well as projects/programs of a national scope (Brasil em Ação, privatization, PROALCOOL, energy cogeneration). Policies and actions in these various sectors may both affect and be affected by environmental considerations. The non-consideration of environmental factors will typically lead to excessive social costs, in the short or long terms, whereas prevention will typically impose minimum, often negative costs on projects and policies. The fear of integrating environmental issues most often results from lack of information regarding the real benefits and costs of environmentally safe policies (i.e. the common misconception that pollution control is necessarily costly and leads to decreased output, employment and tax revenues still prevails). Undoubtedly, the federal government has a major, but not exclusive, role in disseminating information about the real benefits involved in combining economic and sector policies with sound environmental policies.

9.28 Since direct environmental policies have proven costly and largely ineffective in too many cases, future environmental policies will have to be incorporated into policies of other sectors and programs, including fiscal, industry, energy, mining, transport, water and sanitation, privatization programs, among others. Key challenges remain in the water sector where major institutional and power changes are taking place.

Federal Framework Regulation

9.29 An optimal pollution management strategy allocates responsibilities across government agencies, maximizing efficiency and minimizing associated costs. Effective allocation of responsibilities includes deciding which level of government and which agency (i) sets environmental objectives; (ii) chooses the appropriate instruments; and (iii) implements the control strategy. In addition, for the strategy to work, it is necessary to make the responsible agencies accountable for their work. In Brazil, CONAMA is the technical and political forum where such basic elements of the national system SISNAMA are discussed and eventually approved. Implementation of the national guidelines are left to States and municipalities.

9.30 The federal government is responsible for ensuring that the Constitutional concepts and principles, as well as the resolutions from CONAMA are translated into clear laws and regulations. These include national minimum standards and all specific laws, regulations, procedures, methodologies and criteria for actions, practices, and analyses of the national environmental system which serve as references for all agencies integrating the SISNAMA. In one form

or another, this requirement is explicit in Law 6938 and in a few subsequent modifications and include the following responsibilities:

- establishment of criteria, norms and procedures for environmental licensing, including defining activities which require full environmental impact assessments;
- establishment of criteria for the classification of waters;
- establishment of air and water quality standards, and criteria and methods for sampling and analyzing materials; and
- definition of classes of hazardous materials and establishment of criteria and procedures for their safe handling and disposal.
- establishment of a national environmental zoning;
- standardization of data requirements and information by all agents, such as environmental quality, industrial cadastres and emissions inventories;
- establishment of the penalties and fines related to non-compliance with the law, or criteria for states establishing them; and
- definition of criteria and procedures for the utilization of environmental funds, particularly the National Environmental Fund (FNMA), as well as assurance that resources are utilized in a cost-effective manner.

9.31 Most of these legislative functions are in fact the responsibility of CONAMA, which serves as a consulting body to the Superior Environmental Council (consisting of the President, all Ministries, and representatives from the national Congress, NGO's and the scientific community). All norms and regulations are initially proposed by CONAMA's technical chambers. In reality, however, Brazil has no research capacity on many issues in the brown pollution agenda, and basically has been following WHO standards and OECD countries norms, criteria and procedures. São Paulo has taken the lead in proposing new norms and usually serves as the spokesperson for IBAMA. Technical agreements between the two agencies are in fact almost permanent. The practice is that CONAMA is the main legislative body in environmental matters, and the federal government is responsible for organizing and pushing its agenda (originally through IBAMA, now through the Directorate of Norms and Planning of MMA).

9.32 Even though most of these "umbrella" functions appear clear, the specific roles of the federal, state and municipal governments in environmental legislation are far from precise. The main reason is probably the fact that although the Constitution establishes concurrent responsibilities of the three tiers of government over environmental legislation, the *Lei Complementar* defining the specific assignments of each tier has not been passed. The question of whether the federal government should regulate more or less than it is now doing essentially has to do with the degree of decentralization of the pollution management system discussed above.

9.33 In addition, the fact that the federal government has never really challenged state governments on any major economic issues has prompted states to implement environmental policies without regard to national norms and standards. Actions by federal government agencies, particularly IBAMA, are uncoordinated with those by state environmental agencies. As indicated above, IBAMA regional offices in turn act largely independently from Brasília and do not necessarily monitor the activities of state

agencies. In addition, most decisions at all tiers of government lack transparency. Lack of coordination and transparency result in environmental agencies not being accountable for their work. Environmental agencies should open up the process, working more closely with polluters, NGO's, affected communities, and the media. Pressures from the Public Ministry and the Ministry of Justice may also accelerate the introduction of accountability into the system, and the federal government again has a lead role in promoting such changes.

Prevention Of Unfair Competition

9.34 Even after a national system has been endorsed by all federate members, State and local governments may have a real incentive not to enforce the environmental legislation. On the one hand, there is the perception that non-enforcement will increase economic activity and thus generate more employment and revenues in the form of state taxes. In attracting new investment, for instance, states may indicate to investors their interest by providing different kinds of incentives, which may include more lenient environmental standards (the standards *per se*, or their enforcement). There is clearly a role for the federal government in preventing this kind of unfair competition (assuming that there are indeed the minimum national standards that are to be applied uniformly to all states). In addition, federal environmental agencies may have to protect state environmental agencies engaged in internal disputes with different secretariats within state governments, typically the secretariats of planning, finance, industry and commerce, and others whose ultimate assignment is to push economic activity at any cost. Politically, environmental agencies are typically in a fragile position in relation to these other secretariats, and the federal government can provide major support to them by enforcing State compliance to national standards.

9.35 In addition to unfair competition, the federal government has a role in resolving the "moral hazard" incentive: states may correctly assume that the federal government will end up ensuring compliance with minimum national standards, either by directly exerting control on polluters or by subsidizing the state environmental agency. Penalizing states for not enforcing the national minimum standards is, in practice, a near impossibility. Real mechanisms do not exist inside the system that make agencies accountable for their actions (although there is a clear tendency to change, if the experience from other sectors, such as the financial sector, is followed). Unless local governments are really interested in enforcing the legislation, there may be little the federal government can do. In the end, enforcement of national environmental standards will require some form of subsidy from the federal government.

9.36 Fortunately, the reality is less severe than the extreme case just described. Except for specific problems which may warrant some assistance or subsidy from the federal government,[2] State governments do perceive the costs imposed by pollution and thus have the internal incentive to control the most serious problems. Even today, the state environmental agencies in the Southeastern States, particularly CETESB in São Paulo, and until the mid-80's FEEMA in Rio de Janeiro, are technically better prepared than federal government agencies, and

[2] Such problems include the cases where the state government does not have *de facto* the technical or financial capacity to address a very serious pollution problem, or problems which may have effects on a national scale. An example could be the pollution of the Guanabara Bay in Rio de Janeiro State, which has an international visibility that may affect tourism in the entire country (particularly in face of the city's and the country's desire to host the 2004 Olympic Games).

in fact give support to these federal agencies in assisting the poorer states. In the more developed states, IBAMA's role in pollution issues is rather limited, if not counterproductive, due to its poor coordination with state environmental agencies, limited capacity, lack of a clear agenda and poor central (Brasilia) control over the work by its regional inspectors. In the poorer Northeastern states, IBAMA is perhaps not doing enough: the average number of inspections on brown issues has been below 1 per year. In relation to the green agenda, especially in the case of the Amazon region where international pressures are greater and national sovereignty issues are involved, subsidies from the federal to state governments are more prevalent.

9.37 There is a political economy caveat to what has been mentioned regarding the role of the federal government in preventing unfair competition and supporting weaker states: the federal government is perhaps in a more favorable position to better resist pressures from both polluters and green activists towards (or against) pollution control because it is more distant from the real problems. On the other hand, however, too much power and discretion is given to inspectors from federal agencies, who then become prone to corruption in much the same way as inspectors from the lower tiers of government. There is no reason to believe that federal government inspectors are currently less susceptible to bribes than those from state or municipal governments, so the undermining of the implementation of the system can come from all tiers of government.

Assistance And Information Services

9.36 In a national pollution management system, the federal government naturally takes on the responsibilities for its promotion and supervision. This includes basic functions of the federal administration which are often replicated at the State and local levels. One of the main attributes in this regard is the demonstration effect, in that the federal government provides a model for states to carry out their legal responsibilities. This includes institutional structure, information management, use of policies and instruments, participation by stakeholders, coordination with other government agencies, establishment of priorities, and all relevant activities and functions involved in environmental management. Deficient coordination among federal agencies, or corrupt behavior of any of them, also have major influence on states, so the federal environmental agencies again have a lead role in serving as a model. Other relevant functions include the following:

- Articulating activities carried out by agencies faced with similar problems, merging dispersed initiatives and promoting synergism;
- Disseminating best practices (information systems, establishment of priorities, decentralization, participation, application of instruments and policies, and other similar activities involved in environmental management);
- Disseminating environmental information and data to interested parties and civil society more generally, such as on environmental quality, cadastres of emission sources, affected and interested groups and organizations, existence of research centers and firms working in the environment field, etc.;
- Promoting pollution control by highlighting its private benefits (productivity gains) and indicating methods of assessing the costs and benefits involved. Since benefits largely accrue to society at large, the federal government has a role in deciding on financing, or perhaps subsidizing, some of this control, as discussed above; and

- Proposing and implementing funding instruments (such as the national environmental fund), and creating laws and incentives to channel general government revenues for environmental purposes. This not only secures its own resources, but also finances pollution abatement.

Final Considerations

9.37 Three additional issues in environmental management will become increasingly important in Brazil: the privatization process, environmental management by newly created water basin agencies, and the review of the licensing system. The process of privatization of state enterprises will create a unique opportunity for the preparation of comprehensive environmental audits of all major State polluting companies. The earlier and more comprehensively this *passivo ambiental* is evaluated, the better it will be both in economic and environmental terms. The process will also likely introduce new, independent regulatory bodies in the states, and the environmental responsibilities may in turn be redeployed. While states are already facing such problems and resolving them on an *ad hoc* basis, the federal government must propose a model to be followed by states.

9.40 With the passing of the new National Water Law, the creation of water basin committees and agencies is imminent and will cause a "shake-up" in the entire environmental management system since other loci of decision-making will be created, forcing the three tiers of government to more quickly define their individual roles. In this context, government environmental agencies should limit themselves to being normative bodies: agencies which are water users should not remain together with environmental regulators since conflict of interests will clearly arise. For example, the fact that the irrigation sector is currently under the auspices of the MMA may in this sense be inadequate.

9.38 The national licensing system, SLAP (*Sistema de Licenciamento de Atividades Poluidoras*), is currently under revision by a committee headed jointly by IBAMA and ABEMA (the association of state environmental agencies). The most important changes should be made in the following areas: (i) further decentralization of responsibilities to local governments (with states being responsible for all licenses, they easily get overburdened with licensing and monitoring activities far more appropriate to the local levels of government, such as gas stations, laundries, bakeries, garages, etc.; (ii) simplification of the rigid and often bureaucratic requirements of permits (licenses are often repetitive and non-specific to each project; environmental impact assessments are often too academic, with little analyses of alternative investment which might mitigate the impacts); and (iii) linkage of the licensing process to clear environmental targets, economic incentives, and other instruments, such as voluntary agreements which by definition require greater flexibility on the part of the licensing agency. The role of licensing in the creation of water basin authorities should also be addressed.

9.39 Finally, to be successful the national environmental system must count on the support of the broadest base of stakeholders as possible. A common vision of the future is fundamental. However, such a vision can only arise out of consensus. The more open and transparent the vision is, the more likely it is to be successful in introducing accountability and making policies far more acceptable, and thus easier to implement.

References

IDB. 1996. "Environmental Management in the Southern Cone: A Study on the Legal and

Institutional Framework - Background Study on Brazil."

Jack, William. 1992. "Power Sharing and Pollution Control: Coordinating Policies Among Levels of Government." World Bank Policy Research Department Working Paper WPS 887, Washington, D.C.

Seroa da Motta and Reis. 1994. "The Application of Economic Instruments in Environmental Policy: The Brazilian Case," in OECD/UNEP Workshop on the Use of Economic Policy Instruments for Environmental Management. Paris.

World Bank. 1993. "Brazil Water Pollution Control Management: Selected issues," Draft Report 11402-BR. Washington, D.C.

10. POLLUTION MANAGEMENT PRIORITIES IN MINAS GERAIS [1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
The major problem of the current environmental management system appears to be weak monitoring activity by FEAM, in part caused by a deficient environmental information system.
Coordination between departments of environmental quality and control is poor. Licensing, monitoring and enforcement are done independently by each department or division, with no adherence to a common set of priorities.
Many polluting activities do not presently have an environmental license. This problem may grow if FEAM follows its plan to abandon open-ended licenses in favor of fixed expiration dates, which will force all polluters into a renewal process.
The following brown priority problems were identified: • Water pollution in Rio das Velhas and Paraopeba basins; • Air pollution in Belo Horizonte Metropolitan Region; • Localized pollution - critical hot spots in the following areas/regions: ⇒ mining areas - sparse mining areas in the Quadrilátero Ferrífero and Vale do Jequitinhonha (garimpo) leading to water pollution and soil contamination; ⇒ largest municipalities - 20 largest are responsible for 50 percent of the total organic load in water bodies in the State; urban solid waste (*lixões*); and ⇒ industrial poles water pollution and potential hazardous waste disposal- Doce/Piracicaba Rivers, Juiz de Fora region, and Uberaba.

STRATEGY AND RECOMMENDATIONS
There is a need for improving the environmental information system, particularly at FEAM. This involves gathering existing information, putting it in standard formats, disseminating it, and linking it with other databases. The use of simulation models and GIS coupled with careful analysis and organization of data can provide fundamental support for policy decisions, including the establishment of priorities between hot spots and low pollution concentration problems affecting large populations (such as air pollution in Belo Horizonte.
The link between the participatory process and technical analyses is perhaps missing. This in fact calls for the preparation of a State Environmental Action Plan, where first-cut priority problems could be identified, greatly compensating for the lack of information and primary data. Ideally, such a process should be as transparent and participatory as possible.
Preliminary estimates suggest that the investments required to save a statistical life by controlling industrial PM10 emissions are in the order of US$ 50,000. To save a statistical life by providing urban piped water the costs are in the order of US$ 6,000. Even though water costs are much lower, the willingness to pay to have access to this service is unlikely to be so high, particularly for the poorer population, probably calling for some form of government intervention. For sewerage provision the situation is even worse, since the costs of provision are higher and the willingness to pay for the service is lower.

[1] This paper was prepared by Sergio Margulis with inputs from David Wheeler.

INTRODUCTION

10.1 A rational environmental management strategy involves three basic components:

- identifying priority environmental problems;
- setting realistic targets; and
- choosing appropriate policies and instruments.

10.2 Each of these components requires a minimum set of reliable data and information. For example, when identifying priorities and targets, it is necessary to know the extent of the various problems – the level of environmental degradation, the number of people affected, the irreversibility of ecological damage – and the social costs of each of these effects. Identifying cost-effective policies requires knowledge of the trade-offs between the costs of alternative abatement strategies and the benefits which they generate.

10.3 Such data are not presently available in Minas Gerais, or at least have not been gathered from dispersed sources and consolidated into a consistent framework. This hinders State environmental agencies from launching technically sound policies and actions. A high priority for FEAM (the State Environmental Agency) is therefore the creation of an integrated environmental information database. However, the existing limitations should not prevent SEMAD (State Environment Secretary) and FEAM from using the best available information to define priority problems, set realistic targets and identify appropriate policies and instruments.

10.4 In addition to the 'hard' data needed to support technical analyses, these three components also require participation by major stakeholders. This is fundamentally important because it legitimizes decisions and ensures a much greater likelihood of involvement and compliance with the established policies by polluters. Participation is also critically important in a State like Minas Gerais because local communities can best identify their most critical problems and propose appropriate solutions. While Minas Gerais' participatory tradition is probably the strongest in Brazil, it should be combined with sound technical analysis for maximum effectiveness.

10.5 **Objectives of the report.** The main objective of this report is to help the government establish an environmental strategy for the State. This involves establishing environmental priorities, analyzing pollution management instruments and institutional arrangements (with a focus on economic aspects), and formulating criteria for making decisions. The report illustrates the benefits of economic analysis by providing a detailed assessment of benefits and costs for selected pollution control alternatives in Minas. The results can assist in the identification of priority problems and interventions. The report consists of four sections: (i) a summary of the current environmental management system in Minas Gerais; (ii) identification of priority issues from existing information; (iii) a discussion of appropriate goals and instruments for managing water and air pollution, and solid and hazardous waste problems; and (iv) a summary of the main findings and key recommendations.

SUMMARY OF THE CURRENT ENVIRONMENTAL MANAGEMENT SYSTEM

10.6 Minas Gerais is located in the Southeastern part of Brazil and is the country's second largest industrial center. With an area of 587 thousand square kilometers and 16.5 million inhabitants, the State is divided into 853 municipalities. Minas is Brazil's largest producer of mining ores, with iron ore reserves estimated at 30 billion

tons. It has 14 major river basins, making the State the second largest producer and consumer of electric energy and a major site for irrigated agriculture. Minas reflects Brazil's marked differences in socioeconomic conditions: the poverty in the Jequitinhonha basin is comparable to that found in the Northeast, while the 3 million inhabitants of Belo Horizonte Metropolitan Area enjoy higher income levels and relatively good access to services.

10.7 The environmental management system in Minas Gerais is largely centered around the decisions and actions of COPAM - the Council of Environmental Policy - and its executive secretariat (FEAM). The main feature of COPAM is its extremely democratic and participatory nature. With 24 representatives from government, NGO's and private business, COPAM is responsible for establishing norms, giving licenses for polluting activities, establishing sanctions, and serving as a specialized tribunal on environmental matters. Such activities are carried out by special chambers comprised of 7 members, which meet once a month.[2] COPAM also serves as a forum for education and dialogue among the agents representing different interests.

10.8 The use of a transparent environmental management system that avoids litigation and works through consensus-building has produced significant progress, particularly on actions by industry, mining companies and larger enterprises. According to FEAM, the participatory system has made it possible for various stakeholders to form constructive partnerships. For instance, COPAM has signed a number of agreements with unions and federations of the more polluting sectors to work on consensual solutions and deadlines. Less promising results have been achieved with state companies and the public sector more generally, as well as with the agricultural sector. Experiences with small enterprises have been mixed, although negotiated agreements with the federation of industries provide a promising approach.

10.9 The system of chambers for licensing and resolving disputes at COPAM is extremely democratic and appears to have support from all stakeholders. It is a strong barrier against corruption, since decisions are made in a public forum rather than privately between industry and FEAM technicians. This system may, on the other hand, introduce a certain climate of collusion between the government and the private sector.

10.10 Another important issue for COPAM and the current FEAM administration is the decentralization of licensing and inspection activities to municipalities. FEAM has actively promoted municipal environmental secretariats, and has written simple manuals for the most important environmental activities. However, due to the large number of municipalities, it is nearly impossible for FEAM to work with each one individually. It might be useful to promote regional inter-municipal consortia, following the model developed by the health sector. The current creation of river basin agencies and consortia may be helpful in this respect. For FEAM itself, decentralization outside of the Belo Horizonte Metropolitan Region is probably not cost-effective because economic activity, population and environmental problems are localized and sparse.

10.11 Minas resembles other Brazilian States in relying essentially on the command-and-control regulations of the national system. The most recent and innovative instrument is the ecological ICMS (VAT system), by which allocation of State taxes

[2] The chambers are on environmental policy, mining, industrial pollution, water basins, ecosystems protection and agriculture/forestry.

to municipalities depends on the area under environmental protection and/or the investments made in sanitation and solid waste collection. The new system has been attracting strong interest from the smaller municipalities.

10.12 In 1995, the new Secretariat for Environment and Sustainable Development (SEMAD) was created, into which both COPAM and FEAM are now incorporated. Despite some overlap in officially-defined roles, SEMAD has focused on political and overall planning functions while COPAM and FEAM have assumed most of the administrative tasks. The latter two entities seem to work well together. Another institution which has existed for a long time and may now gain importance is the water resources agency - DRH. Its potential overlap with COPAM was not important as long as DRH remained inactive, but its new relationship with COPAM and the water basin agencies will have to be worked out carefully.

10.13 FEAM currently has only 130 employees (105 professional and 25 support staff), because it has pursued a successful policy of contracting services to the private sector. Salaries are close to (but yet below) market levels. An increase (perhaps 30 percent) in both technical and administrative staff may be justified, since a number of divisions are now under extreme pressure. FEAM has also managed to increase revenues from its services, although it remains fundamentally dependent on government budgets.

Major Weaknesses And Summary Recommendations

10.14 The major problem of the current environmental management system in the State appears to be weak monitoring activity by FEAM. At present there is little monitoring of major ecosystems in the State. Even for Rio das Velhas, the major river, monitoring is only sporadic. Industry has no incentive to report emissions honestly, and pressure from FEAM is not significant. The major force for emissions control is the set of agreements reached at COPAM. While these may work in many cases, they should not preclude inspections of major polluters. FEAM could cover the cost of inspections with modest charges levied on emissions sources.

10.15 FEAM's information system remains poorly developed. GTZ has already financed an attempt to gather all data available at FEAM, but this has produced no results. A new attempt to introduce computers and systematize information was negotiated with the Bank mission, and seems to be progressing as part of PROSAM.

10.16 Another area of concern is the poor coordination between the departments of environmental quality and control. Licensing, monitoring and enforcement are done independently by each department or division, with no adherence to a common set of priorities. The problem may be reduced when the information system is upgraded (this will also ease excessive staff competition for the few existing computers), but more concerted actions are needed in this area.

10.17 With regard to COPAM's participatory approach, the risk of collusion between government and industry may be lowered by separating the licensing technicians from those responsible for monitoring and enforcement as the latter activities are increased. Although participation is desirable, the current system is very time-consuming and may divert attention from some priority issues. This may explain why many polluting activities do not presently have an environmental license. This problem may grow if FEAM follows its plan to abandon open-ended licenses in favor of fixed expiration dates, which will force all polluters into a renewal process.

IDENTIFYING PRIORITY PROBLEMS

Criteria

10.18 Fiscal adjustments in the Brazilian economy, combined with tight budget constraints in all the States, have forced governments to restrict the range of problems to be addressed. This has reinforced the need to prioritize environmental problems and interventions.

10.19 Determining priority problems is ultimately a political process. Communities affected by environmental degradation, major polluters, environmental experts, NGO's and government agencies should reach a consensus on the most critical environmental issues. This consensus must be supported by sound technical and economic analyses.

Participation

10.20 Minas Gerais has a remarkable tradition of stakeholder participation but, as noted previously, this has not yet been complemented by appropriate technical analysis. For example, the state government prepared for the 1992 UNCED Conference in Rio with 33 pre-conferences (involving 160 municipalities), and a large final conference where priority problems and actions were discussed with representatives from all segments of society. This exercise revealed that local governments and communities have a serious lack of technical knowledge about environmental issues. Not surprisingly, 'environmental education' was identified as a major priority by all municípios. However, no município requested more scientific/technical knowledge about environmental quality or the health effects of pollution. Despite many recommendations for better collaboration, enforcement, etc., the incentives of polluting agents or the economic costs and benefits of their decisions were not considered. As a result, no attempt to address the incentive problem or set priorities was made, and little or no technical information was incorporated into the final document. Without technical analysis, the participatory approach did not yield a coherent strategy for improving environmental quality in Minas Gerais at feasible costs.

Introducing Technical Analyses

10.21 For a coherent strategy, priority-setting must be given a focus: pollutants, regions (ecosystems), major polluters, or some combination of these. It should be based on adequate and reliable information. Commonly used criteria for ranking objectives are : (1) ecological, such as physical impacts and irreversibility or recurrence of problems; (2) social, such as the number of people affected, health effects, and incidence among the poor; and (3) economic, such as effects on economic productivity and growth, and factors such as risk and uncertainty.

10.22 Economic analyses have been gaining increasing attention, primarily because comparison of the social costs of environmental problems and the costs of remediation can guide priority-setting within and across sectors. However, application of economic criteria can be difficult because the links between environmental problems and outcomes are not always easy to establish. For instance, predicting the impact of BOD discharges depends on knowledge of the receiving waters (flow rate, volume, etc.) and the availability of an appropriate dispersion model. Even when the physical impact can be predicted with a reasonable degree of confidence, it may be difficult to value in monetary terms.

10.23 Although precise predictions are often difficult, the Bank's international work has identified certain common problems which should be accorded high priority. For instance, it now seems clear that fine particulate matter (PM2.5) is the air pollutant which causes the greatest damage to health. Consequently, regulation of air pollution

Table 10.1: Population/Pollution Concentration Matrix

	Small number of people	Large number of people
Small pollution concentrations	Least Important	??
Large pollution concentrations	??	Most Serious

should focus primarily on PM2.5 unless other pollutants have reached alarming levels. For water pollution, the quantitative relationships between the lack of access to safe water supply and sanitation and morbidity and mortality rates have been established, and willingness to pay analyses for obtaining these services have been conducted in a number of different countries and contexts. Even though some of these relationships may be unique to specific conditions, the Bank's knowledge can be generalized to different contexts as a first-cut identification of priority problems. Such an exercise can hopefully serve as an input to the government's overall effort to establish priorities by combining more rigorous technical analyses with the involvement and participation by all segments of society.

10.24 The Bank mission met with experts at FEAM to identify the priority brown environmental problems in the State of Minas Gerais. While there is a clear indication of certain pollution hot spots in the State, some indecision remains as to the relative importance of two particular types of problems, namely the levels of pollution and the number of people affected. As illustrated in Table 10.1, small concentrations of pollution in unpopulated areas, the most common situation in the largest part of the territory, clearly poses no problem. Large concentrations of pollution affecting large numbers of people are clearly the priority problems, and usually occur in the greatest metropolitan regions. The two most difficult situations are the intermediate cases of either large populations being continuously exposed to some level of non-critical but relevant pollution, such as lower concentrations of sulfur dioxide in large metropolitan areas, and/or intense pollution levels affecting smaller municipalities, typically found in isolated and highly polluting industrial poles.

10.25 The selection of priorities in the case of Minas Gerais involves a critical assessment of the trade-offs (in terms of what is considered more important, such as costs) between the various conditions involved in the two situations denoted by the question marks in the box above. Economic analyses, as indicated below, may greatly facilitate such an assessment.

10.26 Two additional factors must be accounted for when identifying the most critical problems. First, for some problems, continuous exposure to low concentrations of pollutants (for instance, heavy metals) is, given certain limits, more damaging than occasional exposure to high concentrations. In other problems, such as fecal coliforms in water, the reverse is the case. Second, maximum acceptable levels of pollution for a given population and region must exist. Exposure of small populations to severe levels of pollution may be considered unacceptable, rendering such problems priorities in the state brown agenda, even though the total social costs incurred are not so high.

10.27 Based on the above factors and interviews at FEAM, the following brown priority problems were identified:

- Water pollution in Rio das Velhas and Paraopeba basins;
- Air pollution in Belo Horizonte Metropolitan Region;
- Localized pollution - critical hot spots in the following areas/regions:

⇒ mining areas - sparse mining areas in the Quadrilátero Ferrífero and Vale do Jequitinhonha (garimpo) leading to water pollution and soil contamination;

⇒ largest municipalities - 20 largest are responsible for 50 percent of the total organic load in water bodies in the State; urban solid waste (*lixões*); and

⇒ industrial poles water pollution and potential hazardous waste disposal-Doce/Piracicaba Rivers, Juiz de Fora region, and Uberaba.

CONTROLLING PRIORITY PROBLEMS: SETTING GOALS AND IDENTIFYING INSTRUMENTS

10.28 Assuming the above to be a reasonable list of priority brown environmental problems in Minas Gerais, it is then necessary to identify the immediate and underlying causes of each problem and then establish problem-specific goals and objectives. Establishing such goals is a consensus-building process requiring a balance of rigorous technical analysis with consultation among relevant actors. This process will eventually lead to the appropriate level of pollution control and to the selection of appropriate instruments and actions.

10.29 The establishment of goals depends on the costs of controlling environmental degradation. In principle, environmental legislation provides an indication of the desired ambient environmental conditions to be reached. Such conditions must be regarded as indicators, rather than strict objectives to be reached at any cost. Ideally, a benefit-cost analysis should be performed on each specific problem: in general, the costs of control should never be greater than society's willingness to pay for improved environmental conditions, which reflect the benefits associated with the control. In addition, efficiency conditions require that the incremental benefit-cost ratios be the same across interventions. However, the lack of information on the actual willingness to pay in Minas Gerais for attaining different levels of environmental quality prevents such benefit-cost analysis from being conducted for all problems.

10.30 In general, rather than conducting a full benefit-cost analysis of the various environmental problems and possible interventions, governments use the cost-effectiveness criterion. Under this criterion, the desired level of environmental quality is not determined according to the individuals' willingness to pay, but rather by legislation, FEAM or another government agency, or through direct negotiation between various agents. Once the target is determined, the cost-effectiveness criterion requires that the instrument(s) chosen attains the established target at the least possible cost. This in turn requires knowledge of the range of available instruments, their costs and their likely effects in terms of improving environmental conditions. In this subsection, economic analyses of available information are conducted, providing important clues about appropriate strategies for cost-effective environmental regulation in the identified priority areas/ecosystems.

Water Pollution In Minas Gerais

10.31 Water pollution has been on the agenda of priority problems in Minas Gerais and, overall, may be considered a more significant problem than air pollution. Too many water bodies have deteriorated to levels below their legal classification, and pollution from organic material, heavy metals and eutrophication are common to many important rivers in the State. In terms of health, even though the population around the major industrial areas typically has access to sanitation services and is thus less prone to contracting water-related diseases, the poorer populations in both urban and rural areas are at greater risk.

10.32 Unlike air pollution, the effects on human health from the discharge of a ton of a pollutant in a river are entirely unpredictable: even if the resulting effects in terms of concentrations of the pollutant in the river are known, the more important effects in terms of human health cannot be predicted (unlike the dose-response curve which is relatively well known in the case of air pollution). This is because people may live very close to polluted rivers, as is the case in most metropolitan regions, but not be exposed to waterborne diseases if sanitation conditions are good. Even without good sanitation, better educated families can avoid contact with polluted waters by filtering/boiling water before consumption and minimizing children's direct contact with contaminated waters. None of these factors, however, imply that there are no relationships between discharges of effluents in water bodies and pollution levels, or between pollution and health effects. But the approach for understanding such linkages is different from the case of air pollution.

10.33 The previous discussion is not a mere technical analysis of dose-response relations in the case of water pollution: it has very important implications in terms of policy choices. In the analyses of the environmental impacts of pollution problems, priority is given to their consequences on human health, since they are likely to be the highest in terms of the overall social costs. However, the above discussion implies that even if the most polluted rivers in Minas Gerais were identified, identifying the locations where the most serious cases of waterborne diseases occur may not be possible at this time. A corollary for policies in this area is that two fronts have to be addressed simultaneously to control the health effects from water pollution: controlling emissions (from both domestic and industrial sources) and targeting more sanitation services and other instruments, including education for the poorer segments of the population more vulnerable to waterborne diseases.

10.34 This subsection therefore concentrates on four key aspects of water pollution problems in the State. The first is the identification of the most polluted river basins, including the sources of pollution. The second is the application of a specially constructed dose-response curve (relating incidence of diseases to lack of sanitation services and other socioeconomic variables) to the municipalities of Minas Gerais. This may help indicate policies to mitigate the incidence of such diseases. The third is the identification of a cost-effective industrial pollution control strategy. This is done for the specific case of Rio das Velhas. The final subsection reviews some of the initiatives in Minas regarding water management systems, focusing on two additional major river basins - Doce and Paraopeba.

Identification of the sources of problems

Biological Oxygen Demand (BOD)

10.35 Organic water pollution (BOD) has two major sources: industrial emissions and household sewage. Knowledge of relative emissions volumes and abatement costs for the two sources is critical for formulating a regulatory strategy. If BOD pollution from large plants is the main problem, careful targeting of monitoring and enforcement activities can significantly reduce emissions in a short period of time. On the other hand, if household sewage is the main problem, it may be necessary to construct sewage and treatment systems for large areas.

10.36 Household BOD is directly proportional to population, while industrial BOD depends on the distribution and scale of activity in BOD-intensive industry sectors. For the industry analysis, emissions of all major pollutants were estimated using an IBGE database of approximately 156,000 Brazilian factories, categorized by 266 4-digit CNAE codes, employment size, and location (for over 5,000 municipios).

Table 10.2: Household And Industry Shares Of BOD Emissions

Municipio	Rank Household	Rank Industry	Household BOD (tons/yr.)	Industry BOD (tons/yr.)	Total BOD (tons/yr.)	Household Share (%)
Belo Horizonte	1	1	45,997	2,021	48,018	95.8
Contagem	2	5	9,981	859	10,840	92.1
Juiz de Fora	3	9	8,748	607	9,356	93.5
Uberlândia	4	6	8,288	809	9,097	91.1
Montes Claros	5	10	5,498	589	6,088	90.3
Governador Valadares	6	7	5,116	715	5,830	87.7
Uberaba	7	4	4,728	875	5,603	84.4
Ipatinga	8	118	4,094	46	4,140	98.9
Betim	9	34	3,817	218	4,035	94.6
Divinopolis	10	16	3,389	352	3,741	90.6
Sete Lagoas	11	11	3,248	568	3,816	85.1
Ribeirão das Neves	12	383	3,062	5	3,068	99.8
Teofilo Otoni	13	39	2,857	188	3,045	93.8
Poços de Caldas	14	14	2,466	467	2,933	84.1
Caratinga	15	33	2,418	218	2,636	91.7
Patos de Minas	16	189	2,206	21	2,227	99.0
Barbacena	17	67	2,128	112	2,240	95.0
Ibirité	18	209	2,100	19	2,119	99.1
Araguari	19	61	1,998	124	2,122	94.2

Emissions have been estimated using international parameters established in previous work with FEEMA (Rio) and FEAM (Minas Gerais). This large database has enabled the assessment of the distribution and severity of Minas' industrial pollution problems at an unprecedented level of detail.

10.37 Map 10.1 (Maps 10.1-10.3 at end of report) and Table 10.2 provide evidence on the distribution of BOD emissions by source. Map 10.1 makes it clear that households are the major source in the vast majority of municipios. However, significant threats to aquatic ecosystems are more likely in areas with heavy emissions volumes. As Table 10.2 shows, emissions from top-ranked municípios are also dominated by household sewage. Among the top group, households are accountable for over 90% in 15 cases and over 80% in the remaining 4.

10.38 Clearly, organic water pollution in Minas Gerais will not be controlled until household sewage is treated. Paradoxically, however, relative abatement costs are so skewed in favor of industrial BOD abatement that it makes sense to begin a program of organic pollution control with targeted regulation of emissions from large factories. For Minas Gerais households, the incremental cost of BOD removed through sewerage is approximately $1775/ton. In contrast, Table 10.3 provides a schedule of estimated relationships between % abatement of BOD and incremental cost for industry as a whole. Even at 99% abatement, the incremental cost of BOD control in industry is only $300/ton: less than 20% of the cost of

Table 10.3: Abatement Cost For Industrial BOD Emissions

% Abatement	$/Ton Abated
10	8
15	100
30	110
90	110
95	220
99	330

BOD control through sewerage.

10.39 Where should a targeted regulatory program begin? A complete answer depends on knowledge of receiving waterways (volume, flow rate) which is not available for this analysis. However, good candidates are factories in municípios where total BOD loads are high (indexing the potential threat to ecosystems) and industrial loads are also significant (providing scale economies for regulation). Municípios which rank high in both categories are Belo Horizonte, Contagem, Juiz de Fora, Uberlândia, Montes Claros, Governador Valadares, and Uberaba. These municípios should be investigated further to determine the areas where BOD-related damage is most severe.

Heavy Metals and Toxic Risk

10.40 Exposure to heavy metals and other toxins can pose serious short- and long-term risks to human health. Heavy metals can also accumulate in the food chain, ultimately manifesting in dangerous concentrations. To assess the relative risk for municipios in Minas Gerais, two sources of information have been drawn upon. The first is an estimate of industrial heavy metal emissions to water for each area. The second is a risk-weighted index of industrial toxic emissions to water (including heavy metals). The latter measure weights estimated emissions of individual toxins and heavy metals by Threshold Limit Values (TLV) for human exposure developed by the American Conference of Governmental Industrial Hygienists. Across chemicals, TLV's may differ by 1000:1 or more. They provide a more realistic estimate of risk than assessments based solely on emissions volumes. However, a separate estimate for emissions of heavy metals has been included because of the additional risk of bio-accumulation.

10.41 As in the case of other pollutants, heavy metals from industry are highly concentrated in a few municípios. Map 10.2 provides evidence on the geographic distribution of estimated metals emissions to water, and Table 10.4 lists the top 20 municípios in Minas Gerais. Both suggest that

Table 10.4: Estimated Metal Emissions By Municipality

Municipio	Rank: Toxic Met. To Water	Rank: Risk-Weighted Tox. To Water	Toxic Metals to Water (Tons/Year)	Risk-Weighted Index of Toxins to Water (per Year)
Contagem	1	1	373	201
Belo Horizonte	2	2	330	160
Ipatinga	3	6	300	93
Juiz de Fora	4	3	182	145
Belo Oriente	5	53	172	10
Timoteo	6	17	156	38
Divinopolis	7	8	154	79
Ouro Branco	8	19	135	34
Sete Lagoas	9	7	132	82
Betim	10	9	119	71
Arcos	11	13	109	49
Joao Monlevade	12	28	86	24
Pocos de Caldas	13	20	84	32
Itauna	14	4	79	106
Santana do Paraiso	15	22	78	31
Uberaba	16	29	67	24
Uberlandia	17	11	61	57
Barbacena	18	10	58	66
Santos Dumont	19	16	48	39
Para de Minas	20	12	39	51

heavy metal emissions are concentrated in a few areas. In Table 10.4, for example, the município ranked 20th in priority (Para de Minas) has approximately 10% of heavy metal emissions of the top-ranking município (Contagem).

10.42 Table 10.4 also shows that the distribution of risk-weighted toxic emissions is significantly different than the pattern for heavy metals alone. For example, Belo Oriente ranks 5th in volume of toxic metals to water, but only 53rd in risk-weighted toxic volume. Itaúna ranks 14th in heavy metals, but 4th in risk-weighted toxins.

Phosphorus

10.43 Phosphorus is another significant threat to aquatic ecosystems because it is an important determinant of eutrophication. Its two major potential sources are household waste water and runoff from agriculture. As in the case of BOD, appropriate targeting of regulation depends on three factors: the scale of phosphorus loading relative to the absorptive capacity of local waterways; the relative magnitude of phosphorus loading in different municípios; and the shares attributable to households and agriculture.

10.44 Evidence on the incidence of eutrophication problems by waterway is currently unavailable. This analysis will therefore be limited to identifying areas which may pose problems, and tracing potential phosphorus loading problems back to household and agricultural sources.

10.45 Map 10.3 and Table 10.5 provide information on the geographic and sectoral distribution of estimated phosphorus loads. For agriculture, the estimate is based on the assumption that 10 to 20 percent of total phosphorus fertilizer applications find their way into waterways through runoff.[3] Map 10.3 shows clearly that, under the 20 percent assumption, the major potential loadings in the state are in the northern agricultural region. The data on distribution by source in Table 10.5 compares potential contributions by both sectors - domestic and agricultural. If further investigation reveals that eutrophication is a problem in a specific area, the results suggest where the regulatory attention should be focused. In some municípios, treatment of household sewage would not significantly contribute to the solution of this problem.

Health effects from water pollution and socioeconomic conditions

10.46 Diarrheal diseases are a major cause of mortality among young children in Brazil, accounting for 13% of deaths of children from 0 to 4 years old. There is ample evidence that access to improved water supply and sanitation can have a significant impact in reducing the incidence of both morbidity and mortality associated with diarrhea, intestinal nematodes, and other water-related diseases. A detailed cross-sectional epidemiological study of the impact of water and sanitation on infant and under-5 mortality in Brazil was made to estimate and rank the net benefits of improvements in water and sanitation. This study is presented in detail

[3] Because phosphorus compounds are so tightly bound to the soil, even very heavy fertilization does not lead to the leaching of much phosphorus into groundwater and surface water. Fertilizer phosphorus that reaches waterways does so almost entirely by being carried along in eroded soil particles. Even in the water, most of that phosphorus remains in suspension (not in solution) so it is not readily accessible for use by aquatic plants. By far the largest source of soluble phosphorus in waterways is municipal sewage, which contains phosphorus both from excrement and from detergents (Ehrlich, P.R et al., 1977).

Table 10.5: Phosphorus Emissions From Households And Agriculture: Top 15 Municípios

Município	Households (tons/yr.)	Agriculture Runoff		Total		Household Share	
		10%	20%	10%	20%	10%	20%
Unaí	65	753	1,507	818	1,572	8	4
Uberlândia	400	365	730	765	1,130	69	35
Uberaba	228	414	829	642	1,057	35	22
Patos de Minas	106	460	921	566	1,027	9	10
Tocantins	841	11	22	852	863	99	97
Juiz de Fora	422	161	322	583	744	72	57
Porteirinha	45	294	589	349	633	13	7
Januária	74	270	541	344	615	21	12
João Pinheiro	45	277	554	322	599	14	8
Montes Claros	265	125	251	390	517	68	51
Contagem	482	2	4	484	485	100	99
Caratinga	117	182	364	299	480	39	24
Presidente Olegário	21	228	456	249	477	8	4
Gov. Valadares	247	84	168	331	415	75	59
Buritis	17	180	361	197	378	9	4

in Annex 2 of this volume. This sub-section summarizes the main results and applies them to Minas Gerais. Since sewage treatment on its own yields minimal or zero health benefits, it is not included in the analyses.[4]

10.47 **Epidemiological analysis.** The epidemiological analysis conducted on data from four states (see Annex 2) suggest that, in Minas, over 600 cases of under 5-year deaths could be avoided through better water and sanitation. It is possible to rank states and municipalities by the cost per DALY saved as a result of expanding access to water supply and sewers. The average investment per DALY per year saved is $13,600 for urban water supply and $33,600 for urban sewers. Converting investment costs to annualized costs and allowing for operating cost narrows the relative difference somewhat with average costs of $2,700 and $3,820 per DALY on an annual basis.

10.48 Other results obtained from the study indicate that about 83% of all urban residents in Minas without piped water live in municipalities for which the cost per DALY saved is less than $6,000. The corresponding figure for urban sewage is 76%. Providing every urban resident with access to piped water followed by sewage networks should be the first priority for reducing the burden of disease and ill-health via investments in water and sanitation.

10.49 In terms of cost per DALY saved by expenditures on urban water supply and sewers, estimates have been made for Belo Horizonte and Contagem. The urban populations without piped water and sewers are 41,000 and 262,000 respectively (Belo Horizonte) and 13,000 and 145,000 (Contagem). The annual cost per DALY saved by providing piped water is US$ 2,310 and 2,070, and by providing sewers US$ 3,270 and 2,990 for

[4] The overall burden of ill-health associated with transmission through contact with untreated sewage outside the local neighbourhood is relatively small. Children and adults may develop diarrhoea, cholera, typhoid, or hepatitis as a result of bathing in contaminated waters or eating contaminated shellfish, but both mortality and the overall loss of DALYs from such causes is small in countries where access to water supply and some form of sewage removal is widespread, such as in China.

Table 10.6: Estimated Pollution Loads In Arrudas And Onça Basins

Parameter	Total Load kg/day	Arrudas Basin kg/day	%	Onça Basin kg/day	%
BOD	9,620	6,319	66	3,301	34
COD	28,311	20,029	71	8,282	29
Suspended Solids	15,170	10,302	68	4,868	32
Arsenium	0.002	0.002	100	0.000	0
Cadmium	0.004	0.002	50	0.002	50
Lead	36.195	35.690	99	0.505	1
Copper	5.210	3.917	75	1.293	25
Cromium	1.964	1.287	66	0.677	34
Tin	3.441	3.407	99	0.034	1
Mercury	0.003	0.003	100	0.000	0
Nickel	4.613	3.956	86	0.657	14
Silver	0.004	0.002	50	0.002	50
Selenium	0.002	0.000	0	0.002	100
Zinc	23.049	20.483	89	2.566	11
Total Heavy Metals	74.487	68.749	92	5.738	8
Phenols	378.50	365.25	96	13.25	4
Total Phosphorus	53.72	31.74	59	21.98	41
Sulfates	2869.91	2623.98	91	245.93	9
Cyanides	11.45	11.33	99	0.12	1

(Source: PROSAM 1996)

Belo Horizonte and Contagem, respectively. Multiplication of these numbers by the average of 34 DALYs for each death of a child under 5 years old and with no discounting would give an average figure of US$ 78,000 to save a statistical life by providing water in urban Belo Horizonte and Contagem, and US$ 102,000 by providing sewerage.

A cost-effective industrial pollution control strategy for Rio das Velhas basin

10.50 Rio das Velhas is the main water body in the Belo Horizonte Metropolitan Area and indirectly supplies water to over 1.7 million people. Ribeirão do Arrudas and Ribeirão do Onça are the two main contributors, draining an area of 42,000 ha within the BHMA. Appendix 10.1 shows the geography of the basin. In the Rio das Velhas basin, there are over 3,125 industries of which 211 are actually polluting, 1,365 potentially polluting and 1,549 non-polluting. The 1,576 polluting and potentially polluting industries are extremely concentrated geographically and in terms of their total water consumption. Almost 1,400 of these industries (87%) have less than 50 employees, with 601 having less than 5. Table 10.6 summarizes the estimated pollution loads in both Onças and Arrudas basins.

10.51 Table 10.7 summarizes the classification and loads of the 32 major polluting industries in the Rio das Velhas basin and is based on industries with highest BOD (not shown), COD, suspended solids and heavy metals emissions. The bottom part of Table 10.7 includes industries with heavy metals emissions above 0.1 kg/day, irrespective of their emissions of other pollutants. Table 10.7 indicates that only 32 industries are responsible for 84 percent of the volume of industrial discharges, 86 percent of DQO, up to 95 percent of suspended solids, 96 percent of heavy metals, and 83 percent of BOD loads (not shown).

Non-industrial emissions

10.52 The apparently heavy loads from industrial emissions are in fact minimal when compared to domestic effluents, at least in terms of organic loads, phosphorus

Table 10.7 Industries Responsible For The More Relevant Pollution Loads

Industry	Sector	Effluent m3/yr	COD kg/d	COD %	Susp. Solids kg/d	Susp. Solids %	Hv Metals kg/d	Hv Metals %
Mannesmann SA	Steel	4,197,226	10604.3	37.4	5147.0	33.9	19,770	26.5
Frigorífico Modelo Ltda	Meat	255,291	3043.9	10.7	4338.4	28.5	-	-
Cia. Belgo Mineira	Metallurgy	364,165	2483.1	8.7	219.8	1.4	42,860	57.5
Fricon SA - Frigorífico	Meat	74,460	836.4	2.9	140.3	0.9	0.024	0.0
Industrial Horizonte Textil	Textile	154,864	729.7	2.5	36.0	0.2	0.293	0.4
Cia. Renascenca Indust.	Textile	230,600	1402.5	4.9	135.2	0.9	0.133	0.2
Franco Matos Malhas	Textile	193,033	792.1	2.8	-	-	0.201	0.3
Tecelagem São Geraldo	Textile	43,253	611.3	2.1	58.5	0.4	0.357	0.5
Refrigerantes Del Rey Llda	Beverage	58,606	645.4	2.3	7.7	0.1	-	-
Estamparia S.A,	Textile	116,089	562.9	2.0	-	-	0.095	0.1
Coop Central Prod. Rurais	Dairy	102,200	339	1.2	89.6	0.6	-	-
Carnes Delivados São João	Meat	45,051	533.2	1.9	25.4	0.2	0.025	0.0
Mate Couro S.A.	Beverage	135,154	557	1.9	90.7	0.6	0.963	1.3
Frigorífico Perrela Ltda	Meat	30,660	192.3	0.7	108.7	0.7	0.074	0.1
ModLine Perfilados Ltda	Metallurgy	8,028	251.6	0.9	4.8	0.0	0.016	0.0
Asea Brown Boveri Ltda	Metallurgy	52,185	85.6	0.3	3705.8	24.4	0.480	0.6
Magnesita S A.	Refractant	81,000	92.4	0.3	178.3	1.2	-	-
Textil Ferreira Guimarães	Textile	18,884	65.7	0.2	58.0	0.4	0.007	0.0
Colortextil Participações	Textile	148,920	322.3	1.1	18.7	0.1	0.233	0.3
Meta Galvanização Ltda	Galvanizat	14,596	0.7	0.0	-	-	1,352	1.8
Galvanoplaslia Moderna	Galvanizat	58,625	88.9	0.3	-	-	1,244	1.7
Isomonte Ltda	Galvanizat	34,229	52.4	0.2	-	-	0.920	1.2
Indústria Micheletto S A	Galvanizat	10,060	14.5	0.1	0.4	0.0	0.713	1.0
Indústria Santa Clara S.A	Galvanizat	10,877	58.2	0.2	-	-	0.505	0.7
Melalúrg. Triângulo Metrila	Mechanic	4,367	8.6	0.0	0.8	0.0	0.361	0.5
Nansem Instrum. Precisão	Galvanizat	7,526	3.1	0.0	-	-	0.282	0.4
FIAT Allis Latino Americana	Mechanic	41,382	0.0	0.0	0.0	0.0	0.206	0.3
Brafer Industrial S A.	Galvanizat	17,296	11.2	0.0	0.2	0.0	0.169	0.2
Madson Eletrometalúrgica	Galvanizat	7,821	13.6	0.1	-	-	0.132	0.2
Paraibuna Papéis S.A.	Paper proc	2,162	1.5	0.0	-	-	0.130	0.2
ABC EMEP El.Me Precisão	Electronics	14,600	3.6	0.0	2.7	0.0	0.122	0.2
Pohlig Heckel do Brasil	Mechanic	8,884	31.8	0.1	-	-	0.111	0.1
Total due to these industries		6,542,105	24,440		14,365		71,778	
Total estimated for Onça and Arrudas		7,791,455	28,311		15,170		74,487	
Percentage due to these industries		84%		86%		95%		96%

(Source: PROSAM 1996)

and in volume terms. Table 10.8 summarizes the relative contributions by each sector.

The proposed pollution control strategy

10.53 The industrial pollution control strategy is part of a broader sanitation program of the Rio das Velhas basin, which the Bank is helping to finance. In addition to expanding and upgrading the collection network, two sewerage treatment plants are to be located in each of the two major contributors - Ribeirões do Arrudas and Onça. Industrial discharges would be allowed in the sewage system as long as they comply with specified limits, so as not to threaten the infrastructure, including operation of the treatment plants, and prevent serious risks of accidents. Some indecision remains as to the level of treatment which is desired, essentially whether it should be primary or secondary.

10.54 The graph in Figure 10.1 illustrates the expected impacts in terms of improved water quality under primary and secondary treatments. The Bank has recommended that some economic analyses be made in order to estimate the potential benefits under the two scenarios: even a primary level of treatment might be economically hard to

Table 10.8: Total Pollutant Loads From Domestic And Industrial Sources

Source	BOD		Phosphorus		Heavy Metals		Phenols		Volume	
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	m^3/s	%
Domestic	118,431	92.5	5,871	99.1	0	0	0	0	6.16	96.1
Industrial	9,620	7.5	54	0.9	75	100	378	100	0.25	3.9
TOTAL	**128,051**	**100.0**	**5,925**	**100.0**	**75**	**100**	**378**	**100**	**6.41**	**100.0**

(Source: PROSAM 1996)

justify. This is essentially because once the Rio das Velhas leaves the Belo Horizonte Metropolitan Region, there is extremely low population density and limited economic activity. The 1996 projected population of the 23 downstream municípios together is 974,640: however, only 93,255 live in rural areas served by the river.

10.55 Fundação João Pinheiro has produced an extremely rough estimate of the potential health benefits associated with the implementation of the two treatment plants in terms of reduced incidence of water-related diseases, and has found an annual benefit of only US$ 610,000 (no details are provided on the methodology and how the calculations were made). Potential benefits include utilization of the sludge in agriculture, reduced cost of drinking water treatment or water supply from more expensive sources, increased water use in agriculture and industry at a perhaps lower cost, various recreation and amenity benefits (bathing, sports), reduced incidence of water-borne diseases, additional fisheries production, and increased ecosystems production. Even under the most "generous" assumptions, the estimated benefits have to be compared with investments ranging from US$ 45.4 million (low case scenario of primary treatment in both plants) to US$ 135 million (high case scenario of secondary treatment), and annual operating costs between US$ 3.1 to 11.2 million. Such costs are to be financed by increases in domestic water and sewerage tariffs of about 25-30% plus adjustments in industrial tariffs.

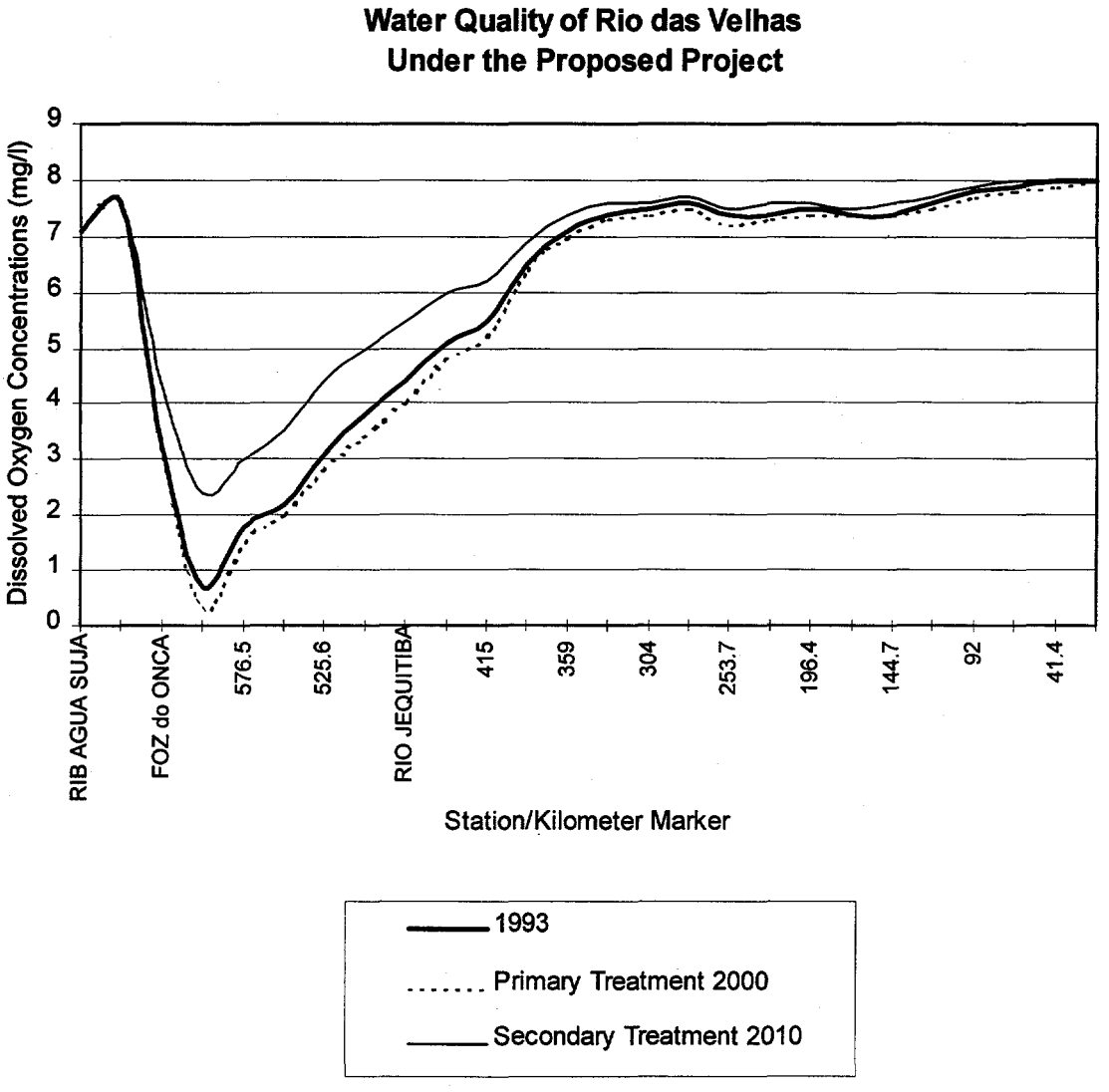
10.56 With regard to industrial emissions, it is legitimate to ask why attention should be focused on industries rather than municipalities. As discussed previously, the reason is that industry's abatement costs are much lower, in addition to the fact that controlling and regulating industries is easier (lower transaction costs) than municipalities.

10.57 Apart from the emissions from the two major industries - Mannesmann S/A and Cia. Belgo Mineira - all industrial effluents could be discharged into the sewage system with simplified pre-treatment processes without disrupting the system. The corresponding tariff would be lower than for each industry undertaking comprehensive pre-treatments of its own effluents and paying a discharge fee with reduced pollution loads. Mannesmann and Belgo Mineira must do a more comprehensive treatment of their effluents.

10.58 In the strategy being considered by the government, priority has been given to the 32 industries with highest total emissions of major pollutants (Table 10.9). However, the one aspect which has not been considered is cost-effectiveness. The list was selected based exclusively on loads, but are the costs of controlling unit pollutant levels necessarily the lowest possible? And how do costs compare among these 32 industries?

10.59 Information contained in the government financed study has been used to estimate the (operating) costs of each of the 32 priority industries to abate 1 kg of each major pollutant - COD, Suspended Solids and Heavy Metals, in addition to volumes. Since the proposed control is not made for each specific pollutant, but rather for total

Figure 10.1: Rio das Velhas Water Quality



discharges of each industry, it does not make sense to simply divide the total control cost by the total emissions of each one of the pollutants to obtain a unit value for each. However, this could not be avoided given the information available.[5]

10.60 Table 10.9 and Figure 10.2 illustrate the different control costs faced by the 32 priority industries. In volume terms, of course, the largest firms present the lowest treatment cost - typically Mannesmann and Belgo Mineira. In terms of the pollutants themselves, the costs are a function of both the volume (scale of operation) and pollut-

[5] The pre-treatment includes control of COD and heavy metals together, for example, so in identifying the control costs it is not possible to separate the individual cost for each pollutant.

Table 10.9: Estimated Pre-Treatment Costs Per Pollutant For 32 Priority Industries

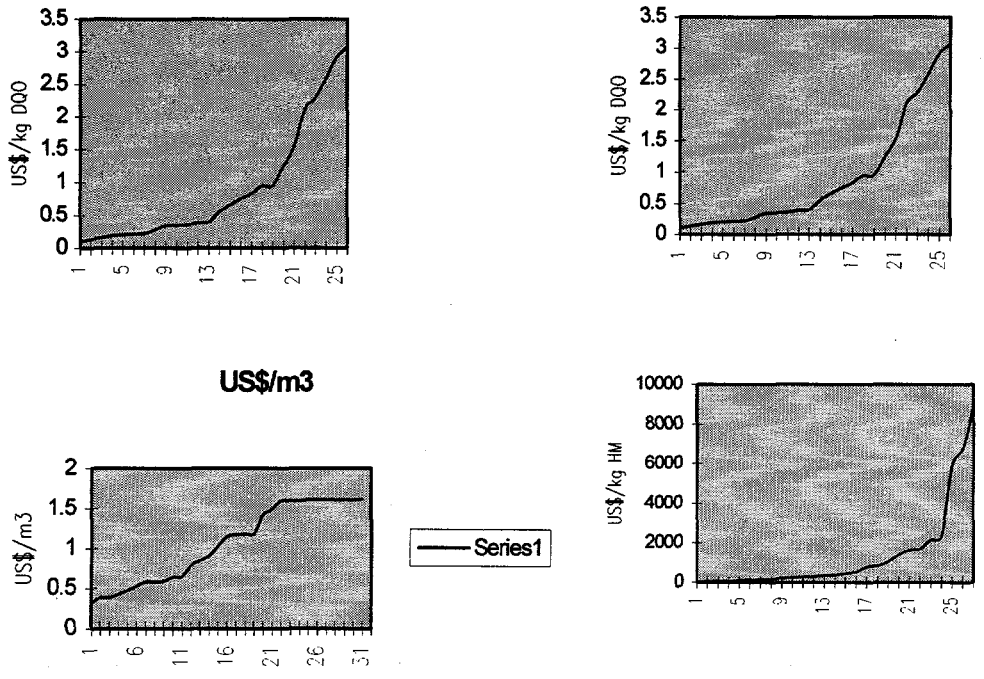
dustry Name	Activity	US$/m³ Treated	US$/kg COD Abated	US$/kg SS Abated	US$/kg HM Abated
annesmann SA	Steel	0.32	0.35	0.72	188.39
rigorífico Modelo Ltda	Meat	0.43	0.13	0.09	-
la. Belgo Mineira	Metallurgy	0.39	0.16	1.79	9.19
ricon SA - Frigorífico	Meat	0.79	0.19	1.16	6782.08
dustrial Horizonte Textil	Textile	0.58	0.34	6.88	47.24
ia. Renascenca Indust.	Textile	0.48	0.22	2.28	231.14
ranco Matos Malhas	Textile	0.53	0.39	-	1403.63
ecelagem Sao Geraldo	Textile	1.03	0.20	2.11	345.97
efrigerantes Del Rey Ltda	Beverage	0.85	0.21	17.93	-
slamparia S.A,	Textile	0.64	0.36	-	2157.37
oop Central Prod. Rurais	Dairy	0.65	0.55	2.07	-
arnes Delivados São João	Meat	1.18	0.28	5.82	5924.80
ate Couro S.A.	Beverage	0.59	0.40	2.43	228.88
rigorífico Perrela Ltda	Meat	1.49	0.66	1.17	1714.05
odLine Perfilados Ltda	Metallurgy	1.17	0.10	5.43	1635.00
sea Brown Boveri Ltda	Metallurgy	0.91	1.54	0.04	274.88
agnesita S A.	Refractant	0.39	0.95	0.49	-
extil Ferreira Guimarães	Textile	1.19	0.95	1.07	8897.14
olortextil Participações	Textile	0.58	0.75	12.88	1037.21
eta Galvanização Ltda	Galvanization	1.61	90.47	-	48.18
alvanoplaslia Moderna	Galvanization	1.15	2.11	-	151.14
omonte Ltda	Galvanization	1.61	2.91	-	165.90
dústria Micheletto S A	Galvanization	1.60	3.07	95.13	62.71
dústria Santa Clara S.A	Galvanization	1.61	0.83	-	96.16
elalúrg. Triângulo Metrila	Mechanic	1.62	2.28	22.60	54.46
ansem Instrum. Precisão	Galvanization	1.60	10.71	-	118.90
IAT Allis Latino Americana	Mechanic	1.42	8187.50	-	794.90
rafer Industrial S A.	Galvanization	1.60	6.80	405.68	456.09
adson Eletrometalúrgica	Galvanization	1.61	2.59		265.68
araibuna Papéis S.A.	Paper proc	1.61	-	--	-
BC EMEP El.Me Precisão	Electronics	1.61	18.09	23.95	533.93
ohlig Heckel do Brasil	Mechanic	-	1.25	-	357.66

ant concentration. For both COD and suspended solids, the lowest costs are in the meat processing and metallurgic sectors; and for heavy metals, since the lower part of the table includes specifically the industries with high emissions (above 0.1 kg/day), the lowest cost is primarily in the galvanization sector.

10.61 The cost-effectiveness can be clearly seen by comparing, for example, the costs of making all firms treat 50 percent of all their effluents versus the case in which only the lowest cost firms would have to do so, attaining the same 50 percent reduction in overall emissions. In the first case, the cost would be nearly US$ 1.5 million annually, while under the cost-effective strategy it would only be US$ 1.1 million annually (essentially only Mannesmann would have to control).

10.62 The proposed pollution control strategy considers the control of industries despite their much lower volumes and loads of non-toxic pollutants. Even though controlling industrial emissions would not "significantly" reduce total pollution, it is nevertheless cost-effective to begin any control strategy by addressing industries, because their unit control costs are much lower. On the other hand, the criterion for selecting the "priority" industries is based solely on loads of major pollutants, and no consideration is given to the different control costs among industries. This analysis has provided an initial ranking of which industries to focus on initially based on the lower abatement costs of each major pollut-

Figure 10.2: Cost-Effectivemness Curves



ant. As emphasized above, a more detailed study would be required to estimate the control cost of each individual pollutant. An index could also be used combining all pollutants. In any case, the strategy of addressing first the industries with lower abatement cost for the most critical pollutants must be pursued.

River basin management - Doce and Paraopeba Basins

10.63 With the approval of the new federal water law, river basin authorities and inter-municipal consortia have begun to emerge. Minas Gerais has been gradually implementing a water basin management system in its major river basins. A State Water Law was approved in 1994 and a Water Resources Committee was established in 1995. In COPAM, a Water basin chamber establishes priorities for classifying rivers and reviews the water basin management plans being prepared throughout the State. Inter-municipal committees and agencies, such as in Paraopeba and Verde rivers, have been created by municipalities and have received support from State agencies - notably FEAM and SEMAD. Experiences, however, have been mixed due to different factors.

10.64 Rio Doce. Rio Doce is located on the western part of Minas Gerais and passes through some of the most important mining areas of the State. In 1989 the National Department of Waters and Electric Energy (DNAEE), which makes most decisions regarding water management in Brazil, decided to experiment by implementing a French model of river basin management. In both Minas Gerais and Espírito Santo States (into which the Doce River drains), studies of the major sources of water degradation and estimates of the clean-up costs were conducted. The first phase was completed in 1992 with French support, and various models have been developed and a

significant database has been constructed. An action plan of up to 17 years was envisioned with an overall estimated cost of nearly US$ 2.2 billion.

10.65 Despite the extremely sophisticated technical analyses and information gathered since the formation of a studies committee in 1994, little progress has been achieved in terms of the formation of the river basin agency and committee, which was DNAEE's original intent. The basic reason has been the utilization of a top-down approach, resulting in little ownership by potentially interested municipalities. Because of limited technical expertise, the benefits of a "communal" system, as was the proposed model, were not perceived by the municipalities. DNAEE, on the other hand, has always been distant from these municipalities as well as the relevant social actors, so it has been difficult to overcome resistance and inertia in attempting to create new alliances and partnerships.

10.66 Paraopeba. In 1993, a few municipalities of the Paraopeba river took the initiative to create an agency to handle common problems of water resources, water supply, garbage disposal, sewerage supply and treatment, and related problems, leading to the formation of a water basin consortium - CIBAPAR. One year after its creation, 17 of the 45 municipalities were already part of the consortium and by early 1997 three more municipalities had joined. Contrary to the Doce basin, the specific objectives were not clear, and technical information was missing, particularly since it involved too many municipalities with very different socioeconomic conditions and expertise. Slowly, over time, CIBAPAR managed to sign agreements with technical institutions from State and federal levels, centralized dispersed information, trained people in the municipalities, disseminated information and created various fora for public participation and discussion.

10.67 CIBAPAR has recently initiated contacts with the main industries in the basin to forge partnerships and obtain much-needed financial support. This bottom-up approach has allowed for a firm commitment by most municipalities. With a few additional resources and technical information, it is possible to envision the gradual formation of a river basin authority. The Bank mission has encouraged CIBAPAR to submit proposals for technical assistance and eventual mechanisms for funding, such as small matching-grants.

10.68 The two experiences with the formation of river basin agencies/committees are entirely different and indicate the need for a bottom-up approach coupled with technical expertise. Because management by river basins introduces significant changes in the entire environmental management system, it is important that the environmental agencies are involved with the new water basin agencies and consortia, provide information, technical assistance, and ensure that environmental issues are incorporated into the new agencies' mandates.

Air Pollution In Minas Gerais

10.69 Air pollution has often been on the agenda of priority environmental problems in Minas Gerais. While air pollution may indeed be serious in certain localities during certain periods of the year, based on the existing information, however limited, and on estimated health consequences, air pollution should perhaps not be considered a major environmental problem in the State.

Cost-effective strategy

10.70 The critical steps involved in the implementation of a cost-effective strategy in the case of air pollution include the following five basic steps:

- monitoring environmental quality and identifying priority areas;
- identifying emission sources: transport, industries, natural sources, and other man-made sources;
- determining the effects of pollution on health, on economic productivity and on ecosystems integrity, as well as the costs of these effects (equivalent to the benefits of improving air quality);
- evaluating alternative control strategies: this includes technical, administrative and institutional feasibility, as well as the costs of each instrument vis-à-vis reductions in pollution levels; and
- assessing the trade-offs between the control costs and their benefits (cost-benefit analysis).

Existing information in Minas Gerais

10.71 FEAM has never carried out a systematic monitoring of air pollution in Belo Horizonte, nor in any other municipality in the State. Nevertheless, a few campaigns have been made for relatively long periods of time, and provide a good basis for a preliminary analysis. The most relevant data relate to the 1991-92 and the 1996-97 campaigns, both in the Greater Belo Horizonte Metropolitan Area. In the former, only particulate matter in the form of Total Suspended Particles (TSP) was monitored using HI-VOL equipment; in the latter, both PM10 and SO_2 were monitored by automatic stations.

10.72 The 1991/92 campaign consisted of six monitoring stations, three located in the industrial município of Contagem, and one each in Belo Horizonte, Vespasiano and Pedro Leopoldo.[6] The annual average geometric means of the monthly readings in Contagem were 79, 100 and 87 $\mu g/m^3$; 69$\mu g/m^3$ in Belo Horizonte; 103 $\mu g/m^3$ in Pedro Leopoldo; and 128 $\mu g/m^3$ in Vespasiano. In none of the cases were the violations of the national standard of 80 $\mu g/m^3$ too significant (except perhaps in Vespasiano, although the sampling in that station was restricted to the August/October period, where pollution levels are definitely much higher than in the rest of the year in all stations). However, it must be noted that some of the samples indicated extremely high values in specific locations and specific times of the year, such as in Vespasiano with three readings above 290 $\mu g/m^3$ in August, 1991.

10.73 The 1996-97 campaign was initiated in July, 1996, and is still in operation, with the last reported data from December, 1996. It consists of three stations; one in Belo Horizonte, one in Contagem and one in Betim.[7] As in the previous campaign, a number of monthly samples were not significant (only less than 75% of data available). Table 10.10 provides the annual arithmetic means that were found (based on significant samples - more than 75% of the time reporting).

---

6 The three stations in Contagem were at Subestação COPASA, Bairro JK and Metrô Eldorado; and the Belo Horizonte station was at the Terminal Rodoviário.

7 These stations were located respectively in the junction of Viaduto dos Andradas and Avenida dos Andradas, Ave. Babita Camargos and Bairro Petrovale.

Table 10.10: Concentrations Of PM10 And SO_2 In BHMA, In $\mu g/m^3$

Belo Horizonte		Contagem		Betim	
PM10	SO_2	PM10	SO_2	PM10	SO_2
36.9	-	48.1	25.0	39.8	13.4
Jul.95-Feb.96	Jul.95-Feb.96	Jul.95-Dec.97	Jul.95-Jan.96	Jul.95-Nov.95	Jul.95-Nov.95

Expected impacts and costs from air pollution in Belo Horizonte Metropolitan Area

10.74 As can be seen from the results of these campaigns, average pollution levels in all cities and neighborhoods in BHMA are below the legislation standards, although the maximum daily concentrations allowed for PM10 is occasionally violated in the winter months in a few localities. The question is whether there are any significant health effects associated to such relatively low levels of pollution that justify some form of intervention, and also whether other municípios/regions with smaller populations but with higher levels of pollution require more urgent attention. Underlying such questions is an economic rationale: even though it would be possible to do something now to prevent air pollution from increasing, this would probably involve costs which would utilize scarce resources that could be channeled to equally pressing social problems, such as education and health. Why should Belo Horizonte not enjoy its favorable economic and environmental conditions and invest less in pollution control than other cities of similar size and with far more serious air pollution problems?

10.75 To estimate the health effects associated with different levels of air pollution, dose-response curves are used. Such curves have been analyzed in the epidemiological literature in more developed countries, and also in some developing countries, including Brazil. Even though a number of factors are specific to each individual locality and population habits, the overall relationships are quite similar. The Bank has recently consolidated a number of such curves and produced a summary of the major health effects associated with different levels of pollution by the major pollutants.[8] What has become clear is that particulate matter and lead pose the most serious problems, followed at a distance by SO_2. Since lead contamination of the air is not a major problem in Brazil, as gasoline is lead-free, particulate matter becomes the sole relevant problem. Of the total particulate matter, the fine particles PM2.5 – those smaller than 2.5 micra in diameter which can penetrate the lower respiratory tract – are the ones that pose the major problem. Since only PM10 has been monitored even in the more developed countries, the dose response curves have been developed for PM10 readings, or even for the more general measurement of total suspended particles (TSP).

10.76 In the case of PM10, according to Ostro (1994), the expected effect of reducing the average concentration of PM10 by 10 ug/m^3 is a reduction in mortality of 0.1 percent. In terms of morbidity, there are also a number of reduced impacts. In estimating the number of premature mortality and morbidity cases, the difference between the current average concentration levels of PM10 and the legislative standard of 50 $\mu g/m^3$ is considered, assuming that this is the level of pollution at which such effects would no longer occur.[9] In Minas Gerais

8 Bart Ostro: Estimating the Health Effects from Air Pollutants: A Method With an Application to Jakarta. World Bank Policy Research Working Paper 1301, May 1994.

9 The constant elasticity derives from the linear specifications of the dose-response curves. It is expected that for extremely low levels of pollution - for instance, close to the standard - and for very high pollution

the average concentration levels of PM10 meet the standard, and there is uncertainty about the health effects of air pollution at or below the standard. To illustrate the costs that may be involved, however, dose response curves and the proposed elasticities for the current pollution levels are utilized.

10.77 **Application to BHMA.** Assuming a population in BHMA of 3,000,000 inhabitants, of which 1,000,000 are below 17 years of age, and converting the treatment costs of illness from the US to Brazil by the two countries' per capita income ratios (roughly 5), [10] the following monetary benefits would be associated with reductions of 1μg/m^3 of both PM10 and SO_2 in average pollution levels in BHMA:

PM10 morbidity = US$ 225,000 per year

SO_2 morbidity = US$ 40,000 per year

10.78 With regard to the risk of increased premature mortality, using the simplified (and underestimated) human capital approach would lead to estimates of US$ 1.5 million per year for PM10 and US$ 750,000 for SO_2 (statistical life at US$ 70,000). Altogether, reductions of 1μg/m^3 in average PM10 concentrations would expectedly bring about benefits of nearly US$ 1.7 million dollars annually, while equal improvements in SO_2 levels would result in benefits of nearly US$ 800 thousand annually. Since all relations are assumed linear, reductions of pollution levels of 10 μg/m^3 would imply the expected benefits to increase tenfold. The linearity assumption also poses some limitations, particularly the implication of constant elasticity of all effects involved, as indicated earlier (footnote 9): since pollution levels by both PM10 and SO_2 are below the standard, the elasticities are probably lower than the ones just used, which would imply that the numbers presented are likely to be overestimates of the likely costs associated with reducing air pollution in BHMA.

Deciding on air pollution priority interventions: comparisons with other cities

10.79 Belo Horizonte has relatively low levels of air pollution, but is the largest city in Minas Gerais. Other cities, particularly those housing the largest smelters and other industries, such as Sete Lagoas, Barroso, Pedro Leopoldo, Ipatinga, Itaú de Minas and Betim have much smaller populations but (expected) higher levels of pollution. Which of the two problems is more important for authorities to focus on?

10.80 The two problems can be compared based on the total expected health effects associated with different pollution levels in each city. The methodology for estimating such effects has just been described, and can be applied to the other cities, as long as there is data on pollution levels for these other cities. The linearity assumptions on

---

levels, the elasticity should be much lower and much higher, respectively.

[10] The following are the major health effects associated with reductions of 1 μg/m3 in PM10 and SO_2 (Ostro, 1994):
PM10:
Change in mortality per person = 0.001 * crude mortality rate (0.007 in the US) = 0.7 deaths/100,000
-respiratory hospital admissions = 1.2/100,000
-emergency room visits = 23.54/100,000
-restricted activity days per person = 0.0575
-lower respiratory illness in children (per child) = 0.0017
-asthma attacks (per asthmatic) = 0.0326 (5 per cent of the US population)
-respiratory symptoms per adult = 0.183
-chronic bronchitis = 61.2/100,000
SO2:
Change in mortality per person = 0.0005 * crude mortality rate = 0.35 deaths/100,000
-chest discomfort per adult per year = 0.01
-respiratory symptoms per child per year = 0.00018

Table 10.12: PM10 Shares From Industry And Transport: Top 15 Municipios

Ipio	Total PM10	Industrial PM10	Transport PM10	% From Industry
orizonte	9,375	4,441	4,934	47
agoas	4,878	4,544	333	93
o	4,366	4,328	38	99
Leopoldo	3,869	3,806	64	98
Minas	2,842	2,818	24	99
siano	2,646	2,586	60	98
a	2,493	2,057	436	82
s Claros	2,473	1,970	502	80
inhos	2,440	2,391	49	98
gem	2,375	1,422	953	60
	1,781	1,732	49	97
e Fora	1,530	611	918	40
a	1,512	1,414	98	94
ndia	1,508	653	855	43
ba	1,462	999	463	68

the dose-response relations between pollution concentrations and health effects leads to an automatic linear relation between city sizes when comparing the total health effects of each: the effects of reducing 1 $\mu g/m^3$ of PM10 in a city of 1,000 people should be the same as reducing 2 $\mu g/m^3$ of PM10 in a city of 500 inhabitants.

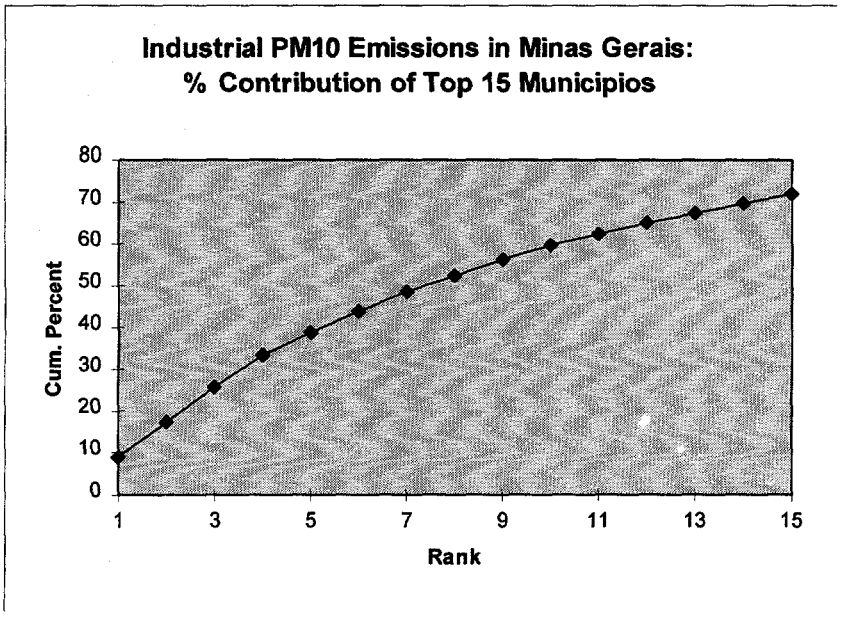
10.81 Comparison of the total costs associated with air pollution levels in different cities reveal where the priority interventions are likely to be but not which interventions (sectors) they should focus on, nor what the desirable level of control is. What is needed, then, is an inventory of emission sources and estimates of the costs of controlling emissions from each different source. The two main sources of PM10 are industrial emissions, concentrated in a few industries, and vehicular emissions. For vehicular emissions, recent estimates from Sao Paulo suggest PM10 emissions intensities (in grams/liter) of 4.8 for gasoline, 1.1 for alcohol, and 7.3 for diesel. It is clear that both gasoline and diesel fuel due to transport are significant sources of PM10.

10.82 Table 10.11 provides information on the industry sectors which are the primary sources of PM10 emissions in Minas Gerais. It is clear that these emissions are highly concentrated by region and sector. As Figure 10.3 indicates, over 70% of total industrial PM10 emissions come from only 15 municipios – less than 3% of the municipios in Minas Gerais. Within these areas, most PM10 emissions come from two sectors: non-metallic minerals (primarily cement) and metals.

10.83 Table 10.12 provides information on the shares of PM10 emissions produced by industry and transport in the top 15 municipios, ranked by total PM10. In only three cases (Belo Horizonte, Juiz de Fora, Uberlandia) is the industry share below 50%. In 10 cases, on the other hand, the industry share is 90% or greater. Except for Belo Horizonte, industry clearly dominates PM10 emissions in municipios with the greatest potential problem (Sete Lagoas, Barroso, Pedro Leopoldo). Since vehicle control is difficult in any case, PM10 control in Minas Gerais outside of Belo Horizonte should focus on large industrial sources. Even in Belo Horizonte, regulation of industrial PM10 emissions would address almost 50% of the problem.

10.84 Which industry sectors would be most cost-effective to regulate? Other things being equal, it would be sensible to focus first on sectors with low abatement costs. The entries in Table 10.13 are sectors which are significant PM10 sources, ac-

Figure 10.3: % Contribution By Top Municipios Of PM10 Emissions



counting for at least 100 tons of estimated emissions per year. Within each município, they are ordered by increasing average cost of abatement. For example, there are four significant source sectors in Contagem. The first (Cement) produces approximately 30% of total PM10 emissions (1,422 tons/year), which can be controlled at an estimated average cost of only $16/ton.[11] The second (Other Non-Metallic Minerals Products) accounts for 11% of emissions and has an average abatement cost of $82/ton. Finally, two metal products sectors account for an additional 28% of emissions and have an average abatement cost of approximately $210/ton. By contrast, heavy PM10 emissions in Pedro Leopoldo (3,806 tons/year) are almost entirely accounted for by Cement ($16/ton), while substantial emissions in Ipatinga (2,057 tons/year) come almost entirely from the metals industry ($210/ton).

[11] Abatement cost estimates include the cost of labor, materials, energy and services as well as the annualized cost of capital (at 10%).

Cost per life saved

10.85 Based on the above analysis, it is possible to identify which sectors should be controlled first based on their different abatement levels, i.e., cost-effectiveness in terms of abatement of 1 ton of PM10. But, of course, controlling one ton of PM10 in Belo Horizonte will produce different environmental benefits (and thus different health benefits) than controlling the same ton of PM10 in, for example, Ipatinga. To obtain equal improvements in environmental (health) conditions at the least possible cost, which source and in which city should be controlled first? To answer this question it is necessary to go from one ton of emitted PM10 to its effects in terms of atmospheric concentrations and from there to the health effects (using the dose-response methodology previously applied to the case of Belo Horizonte).

10.86 The average concentration level of PM10 in Belo Horizonte is 36.5 $\mu g/m^3$. Based on the data of tables 10.11, 10.12 and 10.13, it is evident that industries account for 47% of total PM10 emissions (4,934

tons/year out of a total of 9,375 tons/year). However, the contribution of the industrial sector to air pollution concentrations is not so high. This is because a ton of PM10 emitted by the transport sector is likely to cause a more serious problem (in terms of PM10 concentration in the air) than does the same ton emitted by industries. Even though a detailed air pollution dispersion model is not available for the specific conditions of Belo Horizonte, it is possible to make a first-cut estimate of the effects of the emissions of 1,000 tons of PM10 by industries and by the transport sector in terms of air quality for the city's conditions (area of 330 square kilometers and assuming moderate atmospheric dispersions conditions). Each 1,000 tons emitted by the transport sector lead to a concentration increase of 4.2 $\mu g/m^3$ of PM10 in the air, and the same 1,000 tons emitted by the industrial sector lead to a concentration increase of only 0.25 $\mu g/m^3$ of PM10. In addition to transport and industry, other sources also account for air pollution, and are estimated to represent an additional 25 percent of the emissions. Since these sources are more similar to transport than industries, the same 4.2 factor is attached for these sources. Table 10.14 presents a summary of the assumptions made thus far. It is evident that the estimated total concentration of 31.6 $\mu g/m^3$ compares extremely well with the actual observed average of 36.5 $\mu g/m^3$.

10.87 With this data, it is now possible to estimate how many tons of PM10 emitted by, say, the industry sector, are necessary to be abated to obtain a reduction of 1 $\mu g/m^3$ in the air. The answer is 4,000 tons. In the case of the transport sector, it is only 238 tons (4,934 divided by 20.7). The next step is then to estimate how many lives, or disability days, would be saved by reducing the

Table 10.11: Sources Of Industrial PM10 Emissions: Top 15 Municípios

Município	Total PM10 (tons/yr.)	Sector Description	Sector PM10 (tons/yr.)
Sete Lagoas	4,544	Lime, hydrated lime and plaster	3,167
		Pig iron	1,317
Belo Horizonte	4,441	Cement	2,495
		Iron and steel pipes	1,174
		Iron, steel, iron-alloys	109
Barroso	4,328	Cement	4,165
		Lime, hydrated lime and plaster	142
Pedro Leopoldo	3,806	Cement	3,689
Itau de Minas	2,818	Cement	2,817
Vespasiano	2,586	Cement	2,518
Matozinhos	2,391	Cement	1,641
		Lime, hydrated lime and plaster	539
		Pig iron	144
Ipatinga	2,057	Laminated steel	2,005
Montes Claros	1,970	Cement	1,899
Arcos	1,732	Lime, hydrated lime and plaster	1,136
		Cement	522
Contagem	1,422	Cement	426
		Iron, steel, iron-alloys	284
		Other non-metallic mineral products	163
		Cast steel and iron	116
Formiga	1,414	Lime, hydrated lime and plaster	1,388
São Jose da Lapa	1,167	Lime, hydrated lime and plaster	1,159
Timóteo	1,159	Laminated steel	1,140
Mesquita	1,107	Cement	1,107

average concentration of PM10 in the air by 1 μg/m^3. This is readily obtained from the dose-response curves presented earlier (0.7 deaths/100,000 inhabitants; footnote 10). Concentrating in Belo Horizonte city only (2 million people), 14 lives are expected to be saved. However, in addition to lives (the premature mortality effect of pollution) there are other health benefits associated with diminishing PM10 concentrations in the air by 1 μg/m^3. For simplicity, these additional benefits are not considered here.

10.88 To estimate the cost per life saved, the cost of controlling emissions and thus of reducing the average concentration levels of PM10 must be known. These were also presented above in Table 10.13. Since estimating the control cost in the transport sector is a more complicated exercise (but see Transport Air Quality Management Project Mexico City), the study is limited to the industry case. The marginal control cost (US$ 160/ton) is used since the concern is for 1 μg/m^3 only for the sake of analysis. The result is US$ 45,600 per life saved. If the cement industry is already controlled, the next choice would be to control iron and steel plants, at a cost of US$ 210/ton, leading to a cost per life saved of US$ 60,000.

Brief recommendations for implementing cost-effective air-pollution control strategies

10.89 Existing data in Belo Horizonte Metropolitan Area indicate that there is no severe air pollution problem in the city. Even though effective monitoring is absent in other industrial cities, the preliminary analysis indicates that potential air pollution problems should also not be significant. This does not mean that higher pollution levels are not found in specific localities, and this should perhaps encourage FEAM to monitor these places. Overall, however, Belo Horizonte city should enjoy the favorable prevailing conditions and implement a policy of preventing air pollution from increasing, rather than embrace a major air pollution control program. This is also an

Table 10.13: Abatement Costs For PM10 Source Sectors In Minas Gerais

Municipio	Total PM10	Sector Description	% Mun. PM10	Ab. Cost ($/Ton)
Sete Lagoas	4,544	Lime, hydrated lime and plaster	70	16
		Pig iron	29	210
Belo Horizonte	4,441	Cement	56	16
		Iron and steel tubes	26	210
		Iron, steel and iron-alloys	2	210
Barroso	4,328	Cement	96	16
		Lime, hydrated lime and plaster	3	16
Pedro Leopoldo	3,806	Cement	97	16
Itaú de Minas	2,818	Cement	100	16
Vespasiano	2,586	Cement	97	16
Matozinhos	2,391	Cement	69	16
		Lime, hydrated lime and plaster	23	16
		Pig iron	6	210
Ipatinga	2,057	Laminated steel	98	210
Montes Claros	1,970	Cement	96	16
Arcos	1,732	Lime, hydrated lime and plaster	66	16
		Cement	30	16
Contagem	1,422	Cement	30	16
		Other non-metallic mineral products	11	82
		Iron, steel and iron-alloys	20	210
		Cast steel and iron	8	210

Table 10.14: Contribution By Different Sectors To Air Pollution Concentrations

Source	Tons of PM10 emitted per year	Effect of 1,000 tons emitted on average concentration of PM10 in the air ($\mu g/m^3$)	Contribution to average concentration ($\mu g/m^3$)
Industry	4,441	0.25	1.1
Transport	4,934	4.2	20.7
Others (assumed additional 25%)	2,343	4.2	9.8
TOTAL	**11,718**	--	**31.6**

invitation for attracting business.

10.90 The preliminary analyses confirm that even though not a significant problem, particulates are the most relevant pollutant and should be the focus of any strategy. In order to prevent pollution levels from increasing significantly, the licensing process by COPAM should perhaps incorporate a system of compensations whereby any new polluting plant would either have to entirely control its emissions or would have to offset them by ensuring that some other source would have an equivalent reduction in emissions.

10.91 The contribution of industry to air pollution in Belo Horizonte is far less significant than that of the transport sector. Regulation of industries and enforcement of their emissions, however, is far simpler (less costly) than regulation of emissions from vehicles. In any case, policies aiming to control/reduce emissions of the transport sector seem more promising than the industrial sector. Since inspection and maintenance systems are now mandatory in Brazil, an effective program in Belo Horizonte may ensure a stagnation in the levels of overall emissions, and depending on the fleet increase, perhaps even a small reduction in overall emissions and thus of pollution levels. Concessions to a few specialized private operators have proven the most effective system for inspection and maintenance programs in many developing, as well as industrialized, countries.

10.92 The existing data and coverage of this exercise did not allow for a comparison of the costs (and effectiveness) of controlling emissions by industry relative to the transport sector. The analyses helped indicate what a cost-effective industrial pollution control strategy should focus on first. In fact, a benefit cost-analysis was made with very preliminary estimates. The cost of a life saved is on the order of US$ 50,000 and this is compatible with the estimates in similar contexts. The exercise also clearly indicated the power of real data originating from monitoring and enforcement in allowing for policy oriented analyses. Even with the preliminary indication that the overall problem is not likely to be severe, more systematic monitoring campaigns and perhaps an expanded monitoring network in Belo Horizonte, Contagem and few selected industrial cities in Minas Gerais may be justified.

MAJOR FINDINGS AND SUMMARY RECOMMENDATIONS

10.93 The main objective of this report was to help the government establish an environmental strategy for the State of Minas Gerais. It analyzed the importance, the criteria and the difficult political choices involved in the establishment of priorities, made an analysis of alternative strategies for addressing the major pollution problems in the State, and provided a summary review of institutional issues. The report also provided a fairly detailed economic analysis of the benefits and costs associated with pollution control strategies for selected pollution problems in Minas, illustrating the potential of such analyses for environmental decision making.

10.94 Overall, environmental problems in Minas are not so severe given the diluted location of economic activity and population, as well as ecosystems' diluting capacity, although localized pollution problems (hot spots) may be severe. One of the first recommendations of this report was the need for improving the environmental information system, particularly at FEAM. This involves gathering existing information, putting it in standard formats, disseminating it, and linking it with other databases. The report illustrated how the use of simulation models and GIS coupled with careful analysis and organization of data can provide fundamental support for policy decisions, including the establishment of priorities between hot spots and low pollution concentration problems affecting large populations (such as air pollution in Belo Horizonte).

10.95 The report acknowledges a great openness and climate of cooperation in the government environmental sector. Even though the extremely participatory and consensus building approach by COPAM must be encouraged, it presents two major drawbacks: the potential climate of collusion by the government working "too close" to industries, and the time required for handling each case. The latter precludes attention being given to other sectors/areas and may perhaps explain the relatively large number of polluting activities not having environmental licenses. Greater agility is perhaps necessary.

10.96 The selection of priorities in the case of Minas Gerais involves a critical assessment of the trade-offs (in terms of what is considered more important, such as costs) between the conditions involved in the various problems. Economic analyses can greatly help assess such trade-offs as illustrated in the report. The basis for comparison are benefit-cost or cost-effectiveness analyses which were made for both air and water pollution problems. The preliminary estimates suggest that the investments required to save a statistical life by controlling industrial PM10 emissions are in the order of US$ 50,000. To save a statistical life by providing urban piped water the costs are in the order of US$ 6,000. Even being much lower, however, the willingness to pay to have access to this service is unlikely to be so high, particularly for the poorer population, probably calling for some form of government intervention. For sewerage provision the situation is even worse, since the costs of provision are higher and the willingness to pay for the service is lower.

10.97 With regard to water pollution, the report emphasized that the lack of a clear understanding of the links between effluent discharges - water pollution - and effects on human health forces water pollution policies to address the three problems independently: emissions (domestic and industrial), environmental pollution and human health. The analyses suggest that organic water pollution in Minas Gerais will not be controlled until household sewage is treated. Paradoxically, however, relative abatement costs are so skewed in favor of industrial BOD abatement that it makes sense to begin a program of organic pollution control with targeted regulation of emissions from large factories. Heavy metal pollution originates entirely from industries, while phosphorus loads in the most critical regions probably come primarily from households.

10.98 An attempt was made to estimate the impact of expanding water and sanitation services on infant and child mortality. Lower incomes, poor female education, limited access to piped water and sanitation as well as urbanization all significantly contribute to higher mortality rates. Urban water supply should be the priority action, even though most of this population is already served. Even being the most cost-effective intervention, the capacity to pay, particularly by the beneficiary population who is certainly the poorest segment, is not as high as the costs of service provision. This calls for

government intervention and a more careful analysis of the costs and benefits involved. For sanitation services the conditions are even worse - higher costs and lower willingness to pay.

10.99 A cost-effective pollution control strategy was devised for the case of industrial pollution in the Velhas basin, building upon an existing government program which concentrates on the 32 major polluters. The introduction of the control costs as a variable for prioritizing actions showed very different control costs, even among the 32 major industries. The government should definitely target first those with lower abatement costs. FEAM should perhaps carry out a more detailed exercise to estimate the control costs of each individual pollutant or to use an index to combine all pollutants. In any case, the objective of addressing first the industries with lower abatement cost for the most critical pollutants must be pursued.

10.100 With regard to management of water basins, the experiences of Doce and Paraopeba indicate the need for a bottom-up approach (early involvement of interested municipalities and major stakeholders) coupled with technical assistance/expertise. Because management by river basins introduces significant changes in the environmental management system, it is important that the environmental agencies are involved with the new water basin agencies and consortia, providing information, technical assistance, and ensuring that environmental issues are incorporated into the new agencies' mandates.

10.101 Existing data in Belo Horizonte Metropolitan Area indicate that there is no severe air pollution problem in the city, and preliminary analyses suggest the same for other industrial cities. Belo Horizonte city should implement a policy of preventing air pollution from increasing, rather than embrace a major air pollution control program. To do this, the licensing process by COPAM should perhaps incorporate a system of compensations whereby any new polluting plant would have to offset its emissions by ensuring equivalent reductions by some other source in the city. In the transport sector, since inspection and maintenance programs are now mandatory in Brazil, an effective program in Belo Horizonte may ensure a stagnation in the levels of overall emissions and perhaps even a small reduction in overall emissions. The existing data also allowed for estimates of controlling emissions by industry. The estimated cost of saving a premature death as just indicated was in the order of US$ 50,000, and this is compatible with the estimates in similar contexts.

10.102 With regard to institutional design and performance, the conditions in Minas are quite satisfactory, although some important functions cannot be, or simply are not being, performed routinely by FEAM. The most important missing activity is the regular monitoring of ambient environmental quality and an effective monitoring of industrial emissions, so a carefully planned, comprehensive monitoring network needs to be urgently established. Internally, the major area of concern is the poor coordination between the departments of environmental quality and control. The new proposed environmental law and institutional reorganizations address these problems to a limited extent, but the existing distorted incentives must be addressed in a more direct manner.

10.103 Finally, like the creation of water basin agencies, new instruments, especially economic incentives, information dissemination and direct negotiation with major polluters are also maturing and will soon introduce more effectiveness into the environmental management system. It is important to emphasize that it is environmental quality goals that should dictate the decisions to be taken and instruments to be selected. Basic economic principles such as

cost-effectiveness must be pursued, but they do not exclude the additional consideration of other criteria, such as political and institutional feasibility, and also all aspects related to the process of policy implementation, such as participation, transparency, and negotiations with municipalities, industries and affected communities.

References

Montgomery Watson LTDA/ESSE *Engenharia e Consultoria* LTDA.

Ostro, B 1994. "Estimating the Health Effects of Air Pollutants." World Bank Policy Research Working Paper 1301, Washington, D.C.

PROSAM/Governo do Estado de Minas Gerais, 1996. "Estudo Sobre O Controle de Polucia Industrial," Montgomery Watson LTD and ESSE Engenharia e Consultoria LTDA.

11. POLLUTION MANAGEMENT PRIORITIES IN PERNAMBUCO [1]

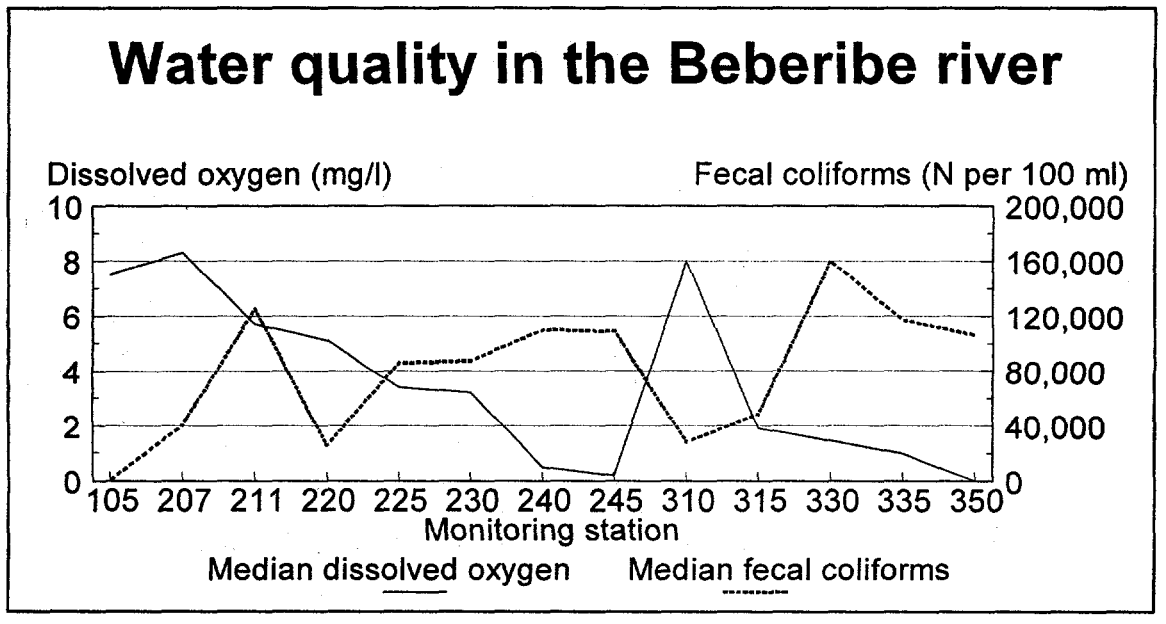
SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND PROBLEMS
The main problem is incomplete coverage of water and sanitation.
The primary ambient environmental problems in Pernambuco concern the poor quality of water in the lower reaches and estuaries of its rivers, especially those which pass through Recife metropolitan area.

STRATEGY AND RECOMMENDATIONS
Absolute priority should be given to ensuring that all urban households have access to piped water supplies. Thereafter, the extension of local sewer networks should have priority. Wastewater disposal should be adjusted to specific local conditions, but will, in most cases, not require secondary or tertiary treatment in the near future.
Under present institutional and financial arrangements, the choice between investing in water and sewerage networks and investing in sewage treatment is unavoidable. However, this choice may be avoided if the State Government were to pursue a different approach to the organization of water and sanitation services. As a very broad indication of what might be necessary for the State Government to adopt such an approach, a simple financial model has been constructed for a private water concession covering the whole of the Recife metropolitan region. The key assumptions include : • service targets of 98% access to piped water supply within 5 years; • 40% coverage of sewers within 5 years, increasing at 20 percentage points each 5 years thereafter up to a maximum of 90% with advanced primary treatment for all sewage that is collected from year 6 onwards; • completion of the Piripama water supply scheme within 5 years; and • construction of a submarine outfall for Recife, Jaboatao, and Olinda within 5 years, and construction/rehabilitation of wastewater treatment plants to provide advanced primary treatment for a sewage flow of 2 m^3/s with the effluent being discharged to the submarine outfall.
The introduction of private finance via the offer of a concession -- or even two concessions if the State wishes to promote some form of yardstick competition -- for water and sanitation services in the metropolitan region of Recife would permit the investments required to meet these goals over a reasonable period of time. Thus, the choice is better seen as one between the costs of changing the State's role in the water and sanitation sector versus the costs of persisting with an entrenched but inefficient institutional structure.

[1] This paper was prepared by Gordon Hughes.

Figure 11.1: Water Quality--Beberibe River



AIR QUALITY

11.1 There is little or no evidence that ambient air quality poses any significant costs in the state. Undoubtedly there are isolated areas where air quality is worse than might be considered desirable, largely as a consequence of emissions from individual sources or from large volumes of traffic. However, the nature of industries in Pernambuco combined with the favorable meteorology of Recife means that this is not an issue that deserves detailed investigation.

WATER QUALITY

Figure 11.2: Water Quality--Capibaribe River

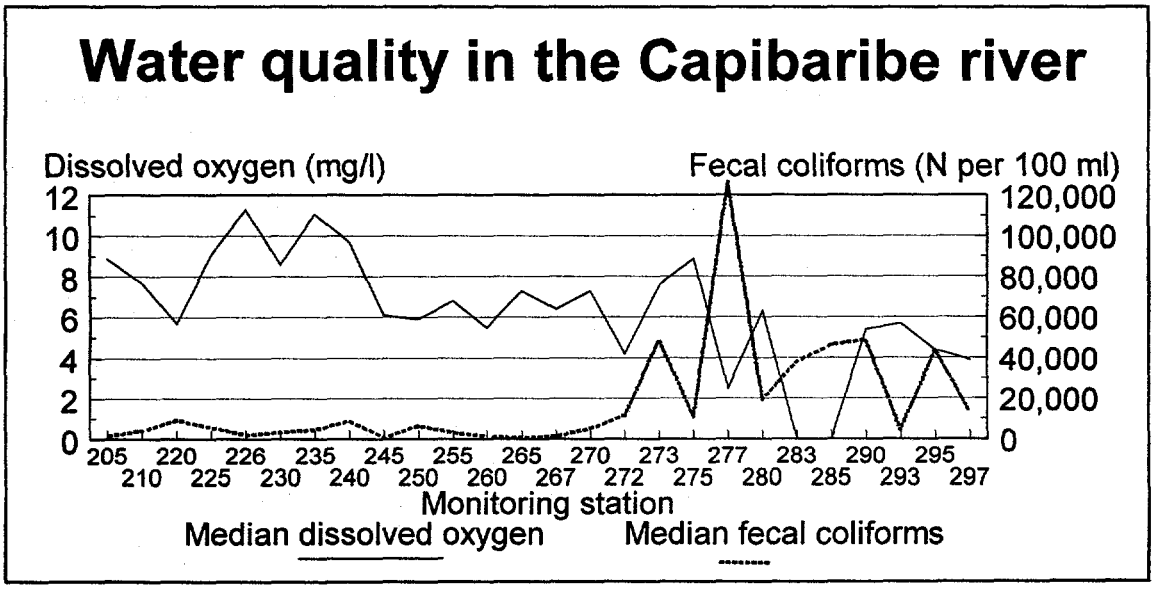
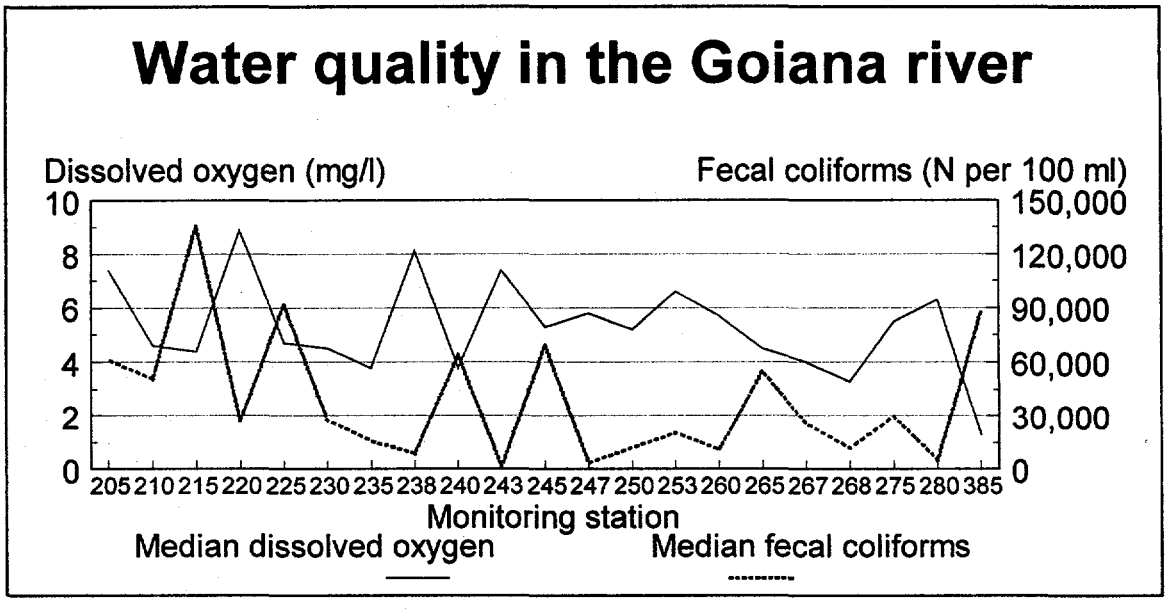


Figure 11.3: Water Quality--Goiana River



11.2 The primary environmental problems in Pernambuco concern the poor quality of water in the lower reaches and estuaries of its rivers, especially those which pass through Recife metropolitan area. Many of the rivers in the coastal zone of the state are grossly polluted at the point where they enter the ocean and, in some cases, for many kilometers upstream. In particular, levels of fecal coliforms are extremely high and dissolved oxygen levels are frequently less than 2 mg/l.

11.3 Figures 11.1-11.6 show the results

Figure 11.4: Water Quality--Ipojuca River

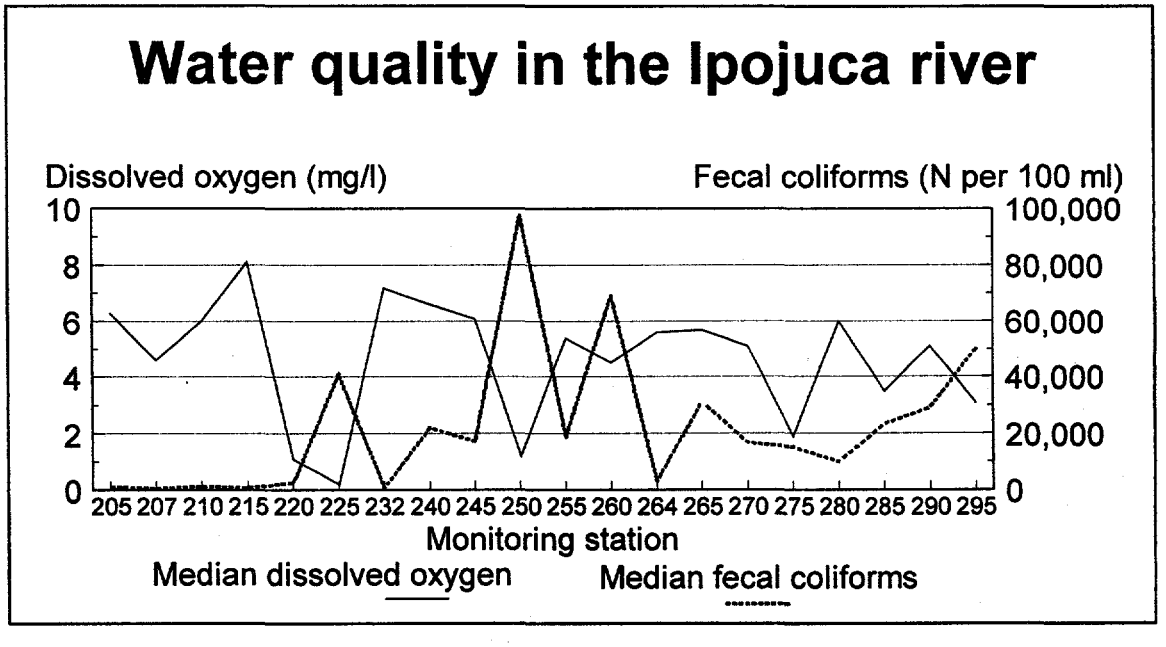
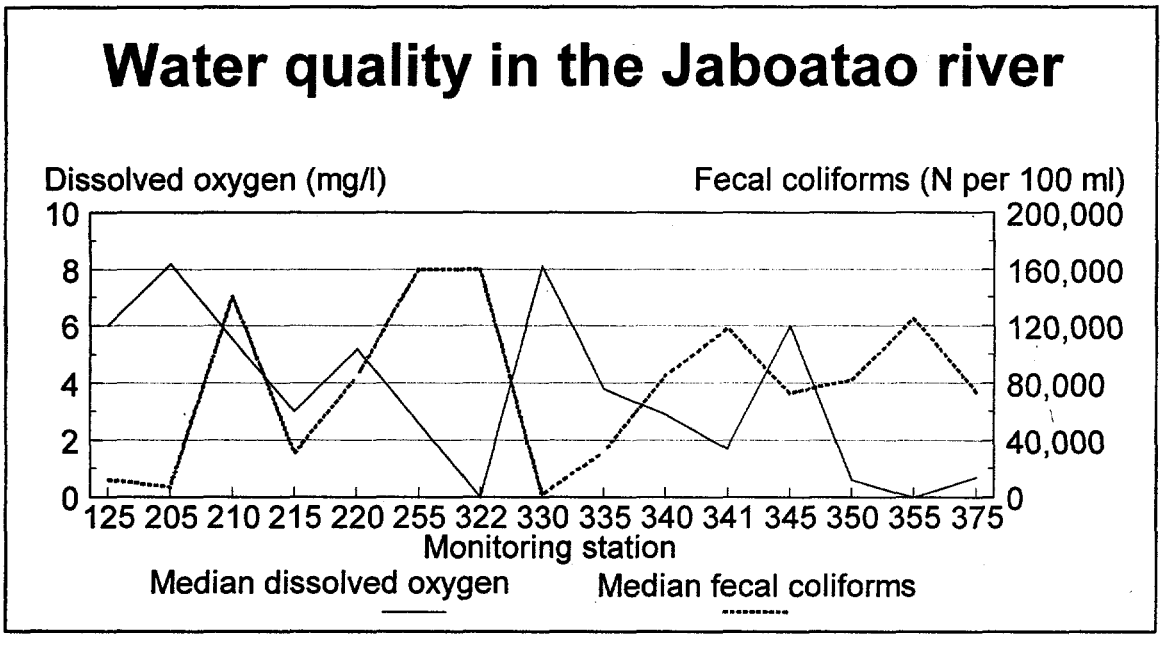


Figure 11.5: Water Quality--Jaboatao River

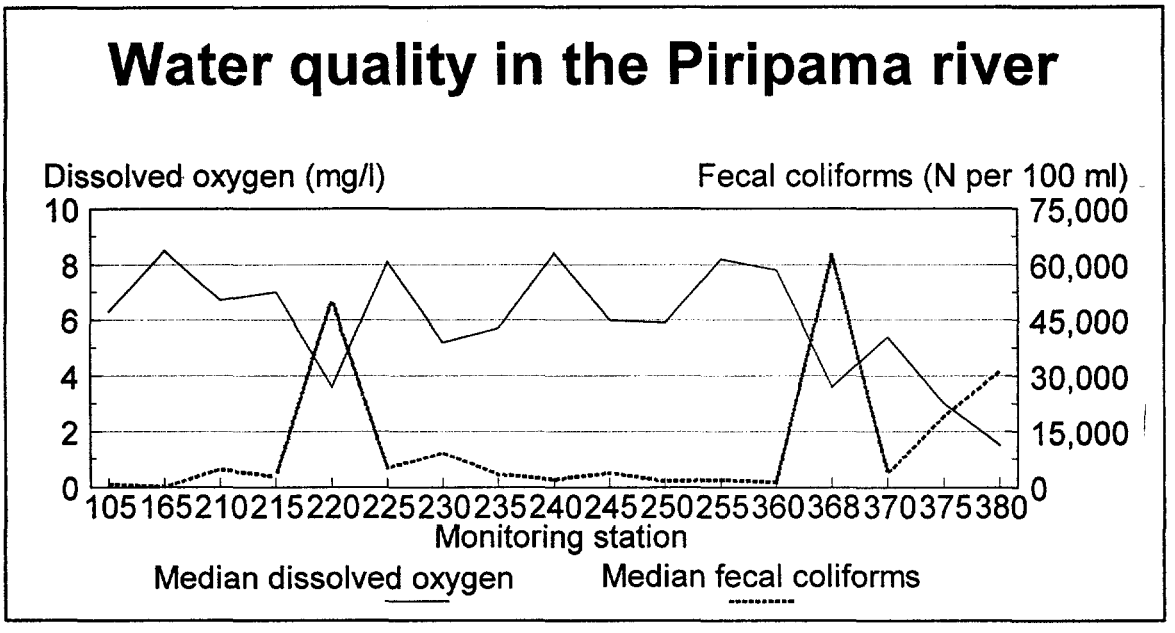


of water quality monitoring for 6 of the most important rivers in the Atlantic littoral region of the state. The Goiana, Capibaribe, and Ipojuca rivers extend a moderate distance inland, whereas the Beberibe, Jaboatao, and Piripama rivers are short coastal rivers. The graphs plot the average of annual median values for 1987-95. Annual median values were used because the annual averages for some monitoring stations are heavily influenced by one or two extreme values. These are usually the result of heavy discharges of BOD from sugar factories during their peak operating season.[2]

11.4 Comparison of the Beberibe and Capibaribe rivers shows the impact of urban discharges of sewage. For most of its length, the Capibaribe river has low levels of fecal coliforms and dissolved oxygen in excess of 6 mg/l. However, as it passes through the Recife metropolitan region -- monitoring stations 277 and higher -- the level of fecal coliforms exceeds 20,000 per 100 ml at most stations and the level of dissolved oxygen falls below 6 mg/l. Indeed, the oxygen demand of discharges is so high that the river becomes completely anoxic for some distance. The same pattern is even more exaggerated for the Beberibe river, most of which lies within the Recife metropolitan region. At 8 out of 13 monitoring stations the level of fecal coliforms exceeds 80,000 per 100 ml, while the level of dissolved oxygen is below 2 mg/l at 5 monitoring stations. For certain periods of the year -- especially between January and May -- the quality of water in some stretches of the Beberibe and Jaboatao rivers is little better than somewhat diluted sewage.

2 Note that the monitored values of fecal coliforms were censored at 160,000 per 100 ml, so that this value means that the actual value was greater than or equal to 160,000 per 100 ml. This censoring only affects a small proportion of the annual median values -- e.g. station 330 on the Beberibe river, and stations 255 and 322 on the Jaboatao river -- so that the downward bias should not be large.

Figure 11.6: Water Quality--Piripama River



11.5 However, the costs of such poor water quality may be quite low :

- With the ocean so near, the amenity value of the rivers for recreational purposes is low. There is a risk that tidal movements and ocean currents may carry the pollution to the main bathing beaches. This question is addressed in more detail below.

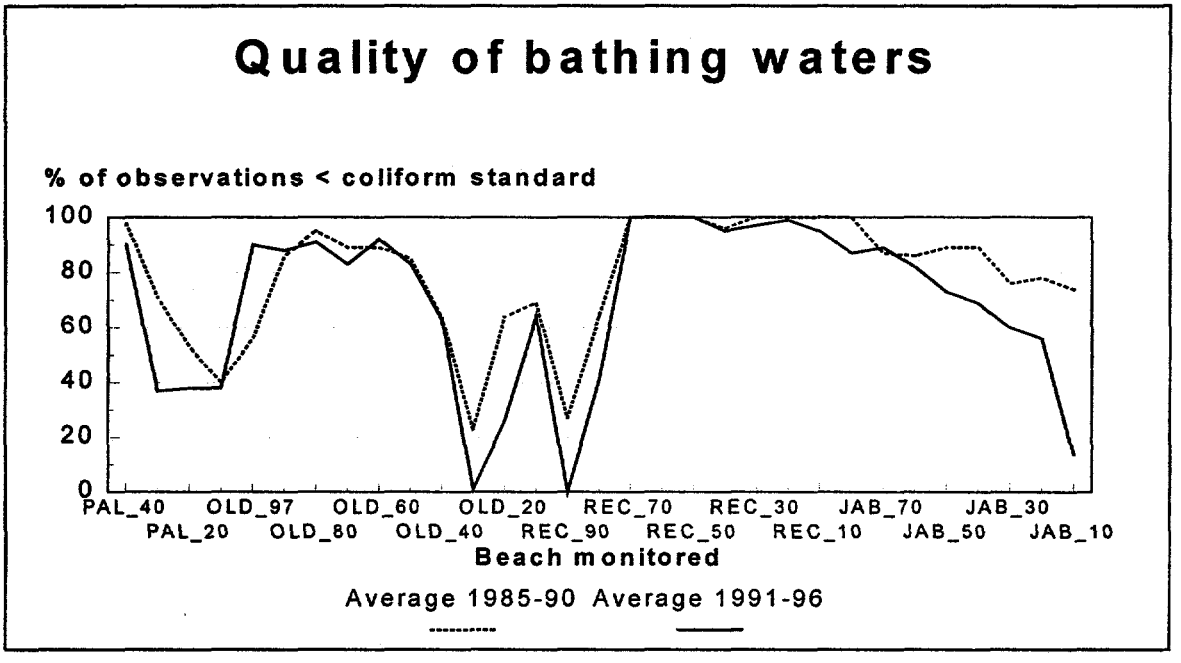
- The productive value of the tidal river basins (Jaboatao, Pina & Teijipio) -- for both fish and shellfish -- is almost zero because of current levels of pollution. This has clearly affected the income of those who have previously relied upon such fisheries, but with ample other fisheries along the coast the economic cost will be modest (relative to the potential costs of cleaning up the basins).

- Since the most polluted sections of the rivers are tidal, there would be no question of using their water for drinking water or industrial consumption. Thus, any losses arising from the need to seek alternative water supplies or to provide more extensive treatment will again be very small.

- What is left is the amenity cost of having rivers and -- even more important -- canals that carry pollution to the rivers which smell and are simply unpleasant to be near. This cost is certainly not zero and could be substantial. Still, more evidence on willingness to pay for this amenity benefit of reducing pollution would be required before it would be reasonable to conclude that such costs can justify extensive programs to improve water quality.

11.6 Evidence from other countries in broadly similar circumstances -- e.g. Philippines -- suggests that willingness to pay to improve the quality of bathing waters and for the general amenity benefits of cleaner rivers is rather low. However, tourism is an important source of income for Recife and neighboring municipalities, so that protecting bathing beaches is a major concern for them.

Figure 11.7: Quality Of Bathing Waters



11.7 Figure 11.7 shows the proportion of weekly samples of bathing waters which meet the standard for coliform levels (less than 1,000 per 100 ml) for beaches in the Recife metropolitan area. The solid line gives the average of annual percentages for 1991-96 and the dotted line the average for 1985-90. The municipalities are identified by the suffixes PAL for Paulista, OLD for Olinda, REC for Recife, and JAB for Jaboatao, while the beaches monitored are listed from North to South. The results show that the quality of the bathing waters along the main tourist beaches from REC_70 to JAB_30 is reasonably high. Olinda's beaches are not so clean, though the worst spots, OLD_30 and OLD_20, are located close to the mouth of the Beberibe river. The influence of heavily polluted rivers can be seen in the poor or very poor quality of bathing waters in Paulista, the northern beaches of Recife close to the port and the Pina basin (REC_90 and REC_80), and in Jaboatao near the mouth of the Jaboatao river (JAB_10).

11.8 Comparing the averages for 1985-90 and 1991-96 suggests that the influence of polluted rivers on the quality of nearby bathing waters has increased. This is particularly marked in Jaboatao for which there has been a statistically significant deterioration in bathing water quality for 5 out of the 8 beaches monitored. The population of the municipality is growing rapidly as a result of industrial and suburban residential development. At the same time, many new hotels have been built or are proposed, so that the municipality's income from tourism is also rising. Clearly, measures to protect the bathing waters used by tourists from further deterioration are required. In the short run, this may involve the separation of tourist facilities from the main sources of pollution. In the longer run, the key to keeping beaches clean lies in the development of sewer networks accompanied by either wastewater treatment or the construction of a satisfactory submarine outfall.

SOURCES OF WATER POLLUTION

11.9 Estimates of total discharges of BOD and suspended solids by municipality and river basin have been prepared. These are based on :

- population data and proportions of households with sewer connections, septic tanks, and no sanitation from the 1991 Census;
- the database of pollution sources maintained by the state environmental agency CPRH; and
- data on industrial employment supplied by IBGE which was used to prepare initial estimates of pollution loads using the IPPS database.

11.10 The information in the CPRH database is limited to estimates of potential and actual emissions of BOD for major plants, but this was sufficient to scale the estimates derived from the IPPS database. The most important adjustment concerned the sugar processing industry. In this case it was necessary to impute values of actual emissions for approximately one-half of the plants in the CPRH database by using the actual to potential pollution ratios for plants of similar capacity. All of the emission estimates are expressed in tons per day, because there are wide variations across industries in the number of days per year that plants operate. For example, most sugar plants only operate 150 days per year. Thus, the figures present a picture of pollution loads when all plants are operating.

11.11 This approach yields an estimate for total emissions of BOD from domestic and industrial sources in the state of about 418 tons per day (TPD), of which 261 TPD (62%) comes from domestic sources and 157 TPD from industrial sources. The sugar industry accounts for 140 TPD or nearly 90% of industrial discharges of BOD. For suspended solids, the comparable figures are 914 TPD in total, of which almost 67% comes from the sugar industry alone with non-sugar industries accounting for another 3% of the total. For practical purposes, controlling water pollution is a matter of dealing with emissions from the sugar industry and from domestic sources.

11.12 Barely one million people -- about 20% of the urban population -- have sewer connections in Pernambuco. The section on the benefits of expanding coverage of water and sanitation showed that investments to ensure that all of the urban population of the state has access to sewers would save over 140,000 DALYs per year at an average annualized cost of about $1100 per DALY saved. Thus, it is worth examining what would be the increase in the amount of pollution discharged into the state's rivers if sewer networks were expanded to cover the entire urban population without any increase in the amount of sewage that is treated.

11.13 Under this scenario, it is assumed that local sewer networks simply discharge into canals or directly into rivers, as is largely the case now. Consequently, there would be a significant increase in the pollution loads which reach rivers. Much of the BOD and suspended solids currently discharged to septic tanks and in the open is effectively treated by soil filtration and soil bacteria. With 100% access to urban sewers, the total loads of BOD and suspended solids would increase to 524 TPD and 1006 TPD respectively, corresponding to increases of 25% and 10% on the current totals. Domestic sources would account for 70% of the total load of BOD but still only 37% of suspended solids.

11.14 Table 11.1 provides a more detailed breakdown of discharges under the two scenarios by river basin. For the purpose of this analysis, the small littoral river basins have been combined with their larger neighbors. The main sources of data are organ-

Table 11.1: BOD Loads By River Basin And Source

River Basin	Discharges of BOD in tons per day				
	Industrial sources			Domestic sources	
	Sugar		Other	Current	100% urban sewers
		Min 90% removal			
Goiana	54.2	32.9	2.3	30.6	41.3
Capibaribe	10.8	3.9	9.9	135.5	196.5
Ipojuca	24.0	17.0	1.7	19.5	29.0
Sirinhaem	34.0	23.7	0.1	5.7	8.3
Una	17.2	17.2	0.1	19.8	27.5
All inland basins	0.2	0.2	2.1	49.9	65.2
Total	141.0	95.1	16.2	261.0	367.8

ized by municipality, so each municipality has been assigned to the river basin which accounts for the largest proportion of the area of the municipality.[3] As a result, Olinda (Beberibe river basin) was combined with the Capibaribe river basin as also were Jaboatao dos Guarapes (Jaboatao river basin), and Sao Lourenco da Mata. This meant that almost all of the Recife metropolitan region -- with the exception of Moreno and Paulista (both in the Goiana river basin) -- was included in the Capibaribe river basin. Hence, the Capibaribe basin accounts for over 50% of domestic BOD discharges under both the domestic scenarios.

11.15 The figures show that the sugar industry is the largest source of water pollution in the Goiana, Ipojuca, and Sirinhaem. This would remain true for the Goiana and Sirinhaem basins even with 100% coverage of urban sewers. Many of the smaller sugar plants remove less than 80% of the BOD in their raw wastewater, whereas the best plants remove 95% of potential BOD emissions, largely by using most of the molasses and bagasse that they generate as fertilizers or fuel, but also by treating their wastewater discharges. To illustrate what would be the level of discharges if all sugar plants came closer to the performance achieved by the better plants, the second column of the table gives the level of emissions from the sugar industry if all plants were required to remove at least 90% of the BOD in their raw wastewater. This would reduce total discharges by a little over 45 TPD without imposing substantial costs on the industry.

11.16 In the Capibaribe basin, as well as inland river basins, at least 90% of the total BOD loads comes from domestic sources. It follows that different kinds of pollution management strategies will be required in the various river basins. Combining the earlier analysis of water quality with the estimates of sources of pollution suggests a broad classification with some initial conclusions for the focus of management policies:

- *Category 1 : Capibaribe and inland river basins.* Water quality is largely determined by pollution from domestic sources. The share of domestic sources will increase as sewer networks are extended. The crucial issue is to evaluate the benefits of treating sewage that is collected, largely in terms of the improvement in amenity and protection of tourist facilities, against the alternative of continuing to rely upon rivers as

3 This assignment was carried out using data on hydrographic basins in the *Annuario Estatistico de Pernambuco 1992*, pp. 33-35.

natural treatment systems. Low cost measures to reduce emissions from industry should be adopted where available, especially with respect to discharges containing heavy metals and/or toxic chemicals. In practice, this implies an emphasis on industrial pretreatment rather than biological treatment. Further, insistence that all sugar plants remove at least 90% of the BOD that they generate would reduce emissions of BOD from this industry in the Capibaribe basin to no more than 3.9 TPD.

- *Category 2 : Goiana, Ipojuca, and Una river basins.* Currently, the sugar industry is responsible for the largest share of BOD loads, but this will be matched or overtaken by domestic sources as sewer networks are extended. Discharges from sugar plants cause high peak levels of pollution, especially when river flows are low during the dry season from October to March. Management strategies for these basins should be selective, focusing on reducing peak levels of BOD and/or coliforms both over the year and along the length of the rivers. Priority should be given to locations where pollution has a clear economic impact, either by increasing treatment costs of water for industrial or municipal use that is abstracted from the river or by jeopardizing the development of tourist or other activities. In the longer term it will be necessary to treat more of the sewage that is collected in the larger urban areas in these basins, though advanced primary treatment will probably be sufficient for the next 20-30 years. Emissions from the sugar industry could also be reduced by about 21 TPD for the Goiana river basin if a standard of at least 90% BOD removal were enforced.

- *Category 3 : Sirinhaem river basin.* In this case, managing water quality is primarily a problem of reducing emissions from the sugar industry. Unfortunately, the improvement from enforcing the minimum 90% BOD removal standard would only reduce emissions from sugar plants in the basin to just under 24 TPD. Thus, the question is whether the cost of relatively expensive controls to reduce emissions from sugar plants yet further can be justified in terms of the benefits generated. Water quality is extremely poor in some stretches of the river -- notably at station SI 2-02 and between stations SI 2-20 and SI 2-25 -- and readings of fecal coliforms are surprisingly high along most of the river. There might be a case for considering some form of wastewater treatment for the town of Ribeirao, and perhaps for Sirinhaem too. However, in general, it is likely that further reductions in both industrial and domestic discharges in this basin beyond those permitted by low cost measures will have a relatively low priority.

11.17 There are a small number of plants in the metallurgy sector -- largely based in the municipalities of Itapissuma, Recife, Jabaotao, and Cabo -- whose potential discharges of toxic heavy metals are a matter for some concern. These plants should also be the focus of specific regulatory and enforcement attention with appropriate monitoring of levels of heavy metals in their discharges and in the receiving waters.

11.18 Table 11.2 shows the costs that would be required to reduce BOD loads in each river basin by 50% for the scenario under which the minimum requirement of 90% BOD removal is applied to all sugar factories, and that all urban households have access to sewers. In most of the river basins, the level of BOD removal exceeds 50% since the cost curves are step functions as it is assumed that wastewater treatment plants are always constructed to treat all of the sewage collected in a municipality. Thus,

Table 11.2: The Costs Of Reducing BOD Loads By 50% In Each River Basin

River Basin	Costs of reducing BOD loads in each river basin by 50%						
	Marginal cost ($ per ton)	Domestic sources			Industrial sources		
		Investment cost ($ million)	Annualized cost ($ million per year)	BOD removed (%)	Invest ment cost ($ mil-lion)	Annualized cost ($ million per year)	BOD re-moved (%)
Goiana	6253	132	29.4	88	1	0.3	6
Capibaribe	1179	202	41.6	51	5	1.1	63
Ipojuca	4719	71	15.3	78	1	0.3	9
Sirinhaem	14745	31	6.7	86	64	37.0	38
Una	6134	86	18.9	82	0	0.0	1
All inland basins	1200-1930	96	20.4	-	2	0.3	-
Total	-	617	132.3	-	73	39.8	-

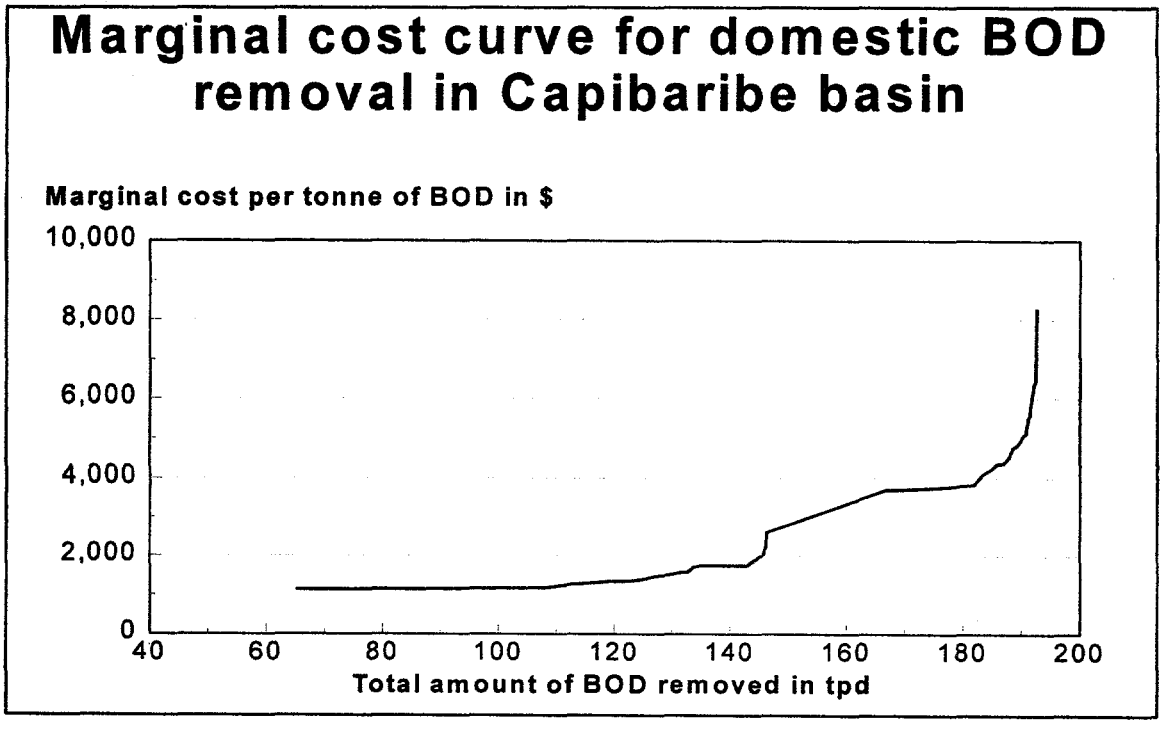
the marginal cost shown in the table represents the marginal cost of removing BOD for which the 50% target is reached or exceeded. Note that these marginal costs are very high for the Goiana, Ipojuca, Una, and (especially) Sirinhaem basins. This is a consequence of the relative balance between industrial and domestic loads in these basins. Moving from 90% BOD removal to 95% or even 98% removal can be very expensive for sugar plants -- for example, in the Sirinhaem basin a total investment by sugar plants of $64 million would be required to meet the target. Thus, it may be more cost-effective to meet the overall target by opting for a higher level of treatment for domestic wastewater. In practice, high marginal costs are a signal that the target of 50% load removal may be unreasonable for these river basins.

11.19 A total investment of about $620 million for the treatment of domestic wastewater would be required as part of an overall strategy to meet the target for each basin. The Capibaribe basin accounts for the largest share of this total, so the costs of reducing BOD discharges from domestic sources in this basin are examined in more detail below. Costs will also be large in the Goiana basin, both because the total BOD load in the basin is large -- over 76 TPD -- and because sugar plants account for nearly 45% of that total. Reducing BOD loads in the inland basin is relatively much easier. Marginal costs differ across basins as a result of wide variations in the urban populations of municipalities which affects average treatment costs because of the economies of scale in building larger treatment plants. By comparison with Goiana for which an investment of $132 million is required to remove 38 TPD, the total investment for the inland basins would be $96 million to remove 34 TPD, which is about 20% lower per TPD.

MUNICIPAL WASTEWATER TREATMENT IN THE CAPIBARIBE BASIN

11.20 In terms of costs and potential impact, the most important questions of environmental management in the state revolve around the level and extent of municipal wastewater treatment in the Recife metropolitan region and, more generally, the Capibaribe river basin. In analyzing this issue, it is appropriate to assume that the investments required to achieve 100% urban coverage of water supply and sewers in the

Figure 11.8: Marginal Cost Curve For Domestic BOD Removal--Capibaribe Basin

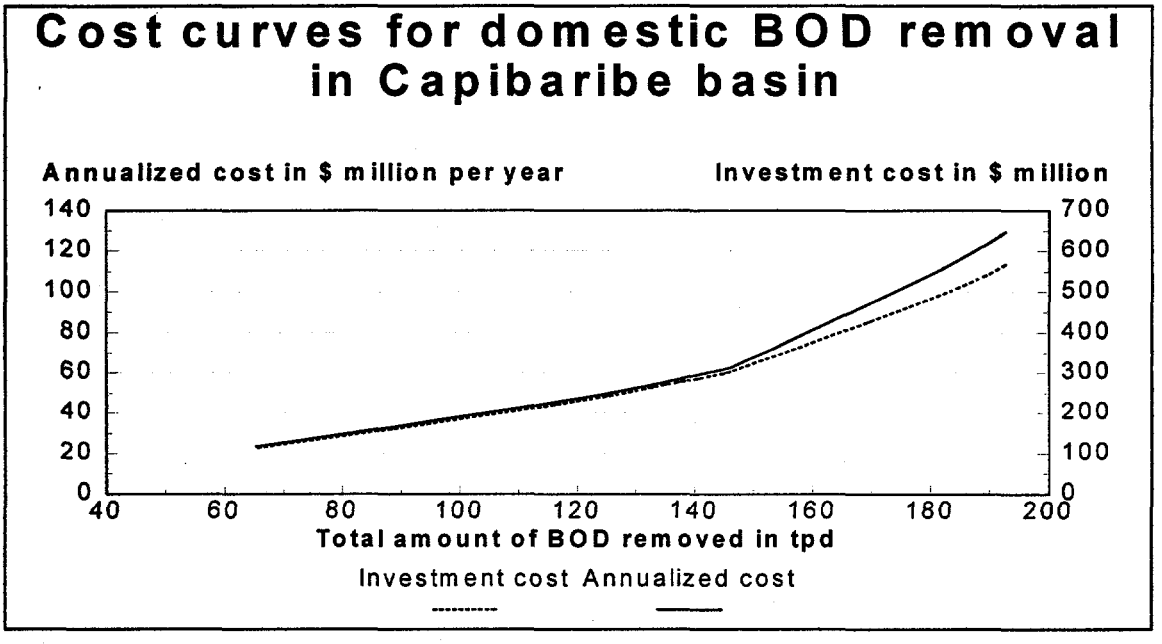


region will be made as rapidly as resources permit. If it is thought that financial constraints imply a real trade-off between spending money on expanding urban water and sewer networks and investing in wastewater treatment, then the choice should be simple. Absolute priority should be given to ensuring that all urban households have access to piped water supplies. Thereafter, the extension of local sewer networks should have priority. Only when these goals have been (almost) met should attention turn to wastewater treatment. As an alternative, if a decision were made to split up COMPESA and to invite proposals for privately financed and operated concessions in the metropolitan region, there should be no such trade-off and network expansion could proceed in parallel with investments in treatment plants.

11.21 Marginal and total cost curves for the removal of BOD from domestic sources in the Capibaribe river basin are shown in Figures 11.8 and 11.9. The marginal cost curve is relatively flat up to the removal of about 135 TPD with marginal costs in the range from $1,100 to $2,000 per ton removed. Thereafter, the marginal cost curve becomes increasingly steep with marginal costs in excess for $4,000 per ton removed if the target were to reduce total discharges in the basin by more than 175 TPD.

11.22 Two options dominate the measures that would be implemented in the lower portion of the marginal cost curve. The main one is advanced primary treatment with relatively high doses of chemicals to remove BOD, suspended solids, and phosphorus. The analysis is based on the assumption that this treatment option would remove 70% of BOD and 90% of suspended solids. In fact, the preliminary results of experiments currently under way in Sao Paulo and Rio de Janeiro suggest a combination of ferric chloride and a polymer at lower dosage rates would produce almost as good results (60-65% BOD removal, > 90% TSS removal) but with lower investment

Figure 11.9: Cost Curves For Domestic BOD Removal--Capibaribe Basin



and operating costs.[4] The higher removal rate for suspended solids would permit disinfection of water discharged from the plants -- by chlorination or ultra-violet treatment. This would deal with the very poor bacteriological quality of water at many points in the basin and improve the quality of bathing waters that are currently affected by pollution loads in various rivers. The implication is that the marginal and total cost curves presented probably overstate the costs associated with advanced primary treatment. If all municipalities with urban populations of 20,000 or more in the basin were to rely upon advanced primary treatment for the sewage that is collected in their urban areas, then this would reduce discharges -- assuming 100% coverage of urban sewers -- by about 125 TPD. Of this total, almost one half would be accounted for by the treatment of all sewage collected in Recife -- rather than the small share that is currently treated.

11.23 The second option that falls in the lower part of the marginal cost curve is the installation of septic tanks in villages and semi-rural communities. Quite apart from the reduction in BOD loads, this may yield significant health benefits, though -- as discussed in Annex 2-- the epidemiological evidence on their size is ambiguous.

11.24 The cost of building advanced primary treatment plants capable of treating all of the sewage that would be collected in municipalities with an urban population of at least 20,000 would be about $270 million with an annualized cost of about $55 million per year (assuming a real interest rate of 12%). Depending on the size of the municipality, this would translate to a cost of $18-25 per person per year. Such a sum is not trivial for a state whose average income per person is about $1800, but it is not totally out of reach. By comparison, the cost per

4 This is because the addition of a polymer to the salt greatly reduces the settling time of solids in the settling basin, which allows for a much higher overflow rate. This translates into a reduction in the number (or size) of settling basins required to treat a given flow of sewage, thus lowering the investment and operating costs of the plant.

person of advanced primary and biological treatment (the only other efficient treatment option in the least cost analysis) would be approximately double that for advanced primary treatment alone for an increase in the amount of BOD removed of about 35%.

11.25 There is one other option which should be considered for the coastal municipalities in the Recife metropolitan region. A submarine outfall could be constructed to discharge all of the sewage collected in the metropolitan region at a sufficient distance away from the shore. Submarine outfalls have often been controversial because they have been poorly located, too short, and badly built or maintained.[5] Nonetheless, an outfall of 6-8 km in length built out from Recife, Jaboatao, or Olinda could be a cost effective option, especially if provision were made for advanced primary treatment and disinfection before discharging the wastewater from the outfall. Careful analysis of tidal and ocean currents is required before a location for an outfall is chosen in order to ensure that these do not carry pollution inshore, either close to the mouth of the outfall or further along the coast. This approach is used in a number of large cities including San Diego and Australia and is planned for the suburban area of Barra de Tijuca in the Rio de Janeiro metropolitan region.

11.26 It is not possible to provide a good estimate of the total cost of building a submarine outfall here since this will depend upon location, sea-bed conditions, and other factors. However, data from detailed studies and/or projects for Fortaleza, Rio, and Santos suggest that an outfall with 6-8 km under the sea, 10 km of trunk sewer, and pumping stations might cost $100-120 million. This would be the additional cost on top of the cost of interceptors and trunk sewers that would be required to transport sewage to treatment plants. This is about 60% of the investment cost of building advanced primary treatment plants for Recife, Jaboatao, and Olinda. Since operating costs would be low, the annualized cost of this option would be about one half of the annualized cost of advanced primary treatment plants.

11.27 If a submarine outfall were to be seriously considered, the project should be designed so as to permit the construction of a primary treatment plant at the point where the interceptors link up with the main trunk sewer carrying the sewage to the submarine portion of the outfall. In this way, it will be possible to add advanced primary treatment at a later date -- either when the necessary resources are available or if there are concerns about the impact of the sewage being discharged from the outfall.

SETTING ENVIRONMENTAL GOALS

11.28 Drawing together the various strands of the analysis it is possible to identify the main options for addressing the problems associated with water pollution from various types of sources in Pernambuco.

Sugar Industry

11.29 All plants should be required to achieve a minimum level of 90% removal of BOD before discharging wastewater. It is estimated that this would reduce total emissions of BOD from the industry by about one third -- equivalent to 45 TPD.

[5] Leakage from the joints between sections of outfalls has been a problem for a number of cities in Brazil including Santos in Sao Paulo and Rio de Janeiro. In part, this is a problem of design because not enough attention was paid to the stresses experienced during storms, but poor maintenance has also meant that problems were not identified and corrected quickly enough.

Other Industrial Sources

11.30 These account for about 4% of total BOD emissions in the state. As far as possible, plants should be encouraged to pretreat their discharges of wastewater, particularly those in the metallurgical and metal finishing industries. The adoption of low cost measures to reduce discharges of BOD by plants in the Recife metropolitan region will make a small contribution to improving water quality in certain locations. Overall, CPRH's relatively low key approach to regulating these sources seems entirely reasonable.

Urban Sewage Outside The Recife Metropolitan Region

11.31 The construction of advanced primary treatment plants in urban areas with populations of more than 20,000 could be considered once sewer networks have been completed. The total investment required to install such plants would be about $200 million with an annualized cost of $40 million per year. However, the benefits of this expenditure are not likely to be large except in places where discharges of sewage are having a substantial localized impact on amenity or on the use of river water for industrial, agricultural, or other purposes. Except in the few cases where earlier measures can be justified, a time period of 10-15 years might be appropriate for meeting a target of advanced primary treatment for sewage collected in medium and large towns.

Urban Sewage In The Recife Metropolitan Region

11.32 Advanced primary treatment for all urban sewage in this region would involve an investment of at least $250 million and an annualized cost of $50 million per year. One alternative would be to rely upon a submarine outfall for sewage from the municipalities of Recife, Jaboatao, and Olinda plus advanced primary treatment for the other municipalities in the region. The immediate saving in investment cost would be about $70-80 million. In the longer term, the combination of a submarine outfall and advanced primary treatment for all sewage would require about $100 million less in investment than advanced primary plus biological treatment for all sewage and should result in better water quality both in river basins and along the coast. For reasons of amenity and tourism, treatment of sewage from Recife, Jaboatao, and Olinda should have priority over other municipalities in the region. Nonetheless, the case for giving equal or even greater priority to treating sewage from these municipalities rather than allocating more resources to the construction of sewers has not been convincingly made. To the extent that resources for sanitation investments are limited, priority should probably be given to sewers and a longer time scale adopted for the construction of facilities to treat the sewage that is being or will be collected.

OPTIONS

11.33 But does a choice have to made between investment in water and sewer networks and in sewage treatment? Under present institutional and financial arrangements, such choices cannot be avoided. The state government is not creditworthy and COMPESA does not generate a sufficient cash flow from its operations to finance the new investments required as well as to service debt incurred in making past investments. A financial projection for the period 1996-2055 envisages a total investment of about $615 million at 1995 prices. Even this is only feasible with a combination of concessional loans and rather optimistic assumptions about operational performance -- given the company's past record. This level of investment would sufficient to :

- complete the Piripama water supply scheme (about $200 million);
- achieve almost 100% access to piped water supplies for the urban population of Recife metropolitan region (about $275 million); and
- increase the number of households in the metropolitan region with sewer connections by 180,000 (about $140 million) -- but with no investment in wastewater treatment.

11.34 However, since the population of the metropolitan region is growing at nearly 3% per year, the investment program implies that the proportion of urban households in the region without sewer connections would be higher in 2005 than it was in 1995. The logic of the situation is inescapable. Without a radical change, the State will have to chose between :

a) meeting the water supply needs of its people, but allow sewers and wastewater treatment to fall further and further behind the growth in its urban population; or

b) investing more in sewer networks to keep up with population growth, while relying upon unspecified finance to expand reservoirs and water treatment plants with a corresponding increase in tariffs to cover the sharp increase in bulk water costs.

11.35 Neither of these options is attractive, nor would they be necessary if the State Government were to adopt a different approach to the organization of water and sanitation services. As a very broad indication of what might be necessary, a simple financial model has been constructed for a private water concession covering the whole of the Recife metropolitan region. The key assumptions include :

- service targets of 98% access to piped water supply within 5 years;
- 40% coverage of sewers within 5 years, increasing at 20 percentage points each 5 years thereafter up to a maximum of 90% with advanced primary treatment for all sewage that is collected from year 6 onwards;
- completion of the Piripama water supply scheme within 5 years; and
- construction of a submarine outfall for Recife, Jaboatao, and Olinda within 5 years, and construction/rehabilitation of wastewater treatment plants to provide advanced primary treatment for a sewage flow of 2 m^3/s with the effluent being discharged to the submarine outfall.

11.36 These assumptions imply a heavy investment obligation for concessionaires. Total investment in years 1 to 5 would be about $920 million at constant prices, with a further $470 million in years 6 to 10. Gross cash flow will be negative for the first 5 years of the concession. Nonetheless, the concession could generate a satisfactory return on capital over a 30 year concession period if tariffs are increased by 10% in real terms from their 1997 level and held constant thereafter -- at the equivalent of R$0.77 per m^3 for water and the same for sewage at 1995 prices.

11.37 The State Government would have to assume the debts of COMPESA relating to projects in the metropolitan region and to fund severance payments to COMPESA employees laid off as a result of the transfer of the company's metropolitan operations to a concession. There would be a small annual lease payment for the concession but this would not be sufficient to cover these debts and transfer costs. Some combination of higher tariffs (e.g. a tariff increase of 20% rather than 10%), a longer time period for investments, or Federal/State guarantees

for concessional loans would enable these costs to be covered by the transaction as well.

11.38 The overall implication of this study is that the Government of Pernambuco does have to make a choice in formulating its goals for the water and sanitation sector with their resulting implications for the quality of life enjoyed by the state's population and their environment. However, this choice need not be one between competing quality of life or environmental goals. The introduction of private finance via the offer of a concession -- or even two concessions if the State wishes to promote some form of yardstick competition -- for water and sanitation services in the metropolitan region of Recife would permit the investments required to meet these goals over a reasonable period of time. Thus, the choice is better seen as one between the costs of changing the State's role in the water and sanitation sector versus the costs of persisting with an entrenched but inefficient institutional structure.

12. LESSONS FOR POLLUTION MANAGEMENT FROM WORLD BANK FINANCED PROJECTS[1]

SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUES AND RECOMMENDATIONS
Financing for industrial pollution control suffers from limited demand and dissipated environmental effects unless linked closely to specific environmental quality targets and enforcement programs.
Sectoral projects (water and sanitation, transport, urban and municipal) can be potent instruments for improved pollution management if clear environmental targets are defined and close collaboration between environmental and sectoral staff in Government and the Bank is assured.
Technical assistance is only effective if objectives are clearly defined and institutions enjoy necessary political support.
Future Bank support would focus on: (a) economic approaches for priority setting and cost effective strategies; (b) modernization of instruments, particularly the use of economic instruments in water basin systems; (c) integration of environmental aspects in sectoral policies and planning; and (d) the participation of the private sector in pollution management.

INTRODUCTION

12.1 A number of World Bank projects in the sanitation, urban transport, and municipal development sectors in Brazil indirectly improve environmental conditions. For example, projects may reduce exposure to polluted water with expanded sewerage coverage and drainage infrastructure, reduce vehicle emissions from improved traffic patterns and maintenance and inspection programs, and improve the collection and disposal of solid waste. While many of these projects also attempt to improve the institutions and policies that govern each sector (transport, water supply and sanitation, municipal finance), few Bank projects have directly targeted the existing policies and tools for pollution management in Brazil. The purpose of this chapter is to present preliminary lessons from two groups of projects that have targeted improved pollution management policies as a central objective: water quality projects and industrial pollution control projects.[2]

12.2 The overall lessons drawn from this chapter are that the Bank has only recently begun to address the brown agenda and that improvements in the policy environment will require a continued dialogue, not only with environmental authorities, but with sectoral agencies that regulate important pollution sources (notably sanitation, transport, and urban management). The challenges facing the Bank include:

[1] This paper was prepared by Laura Tlaiye.

[2] A third group considered was the urban transport projects (Rio Mass Transit; Belo Horizonte Metropolitan Transport, Recife Metropolitan Transport) which include a component related to air quality management (vehicle inspection and maintenance program and traffic studies); however, these projects are not yet approved or the relevant components have not yet been implemented.

- perseverance in promoting the policy instruments already introduced in projects under implementation (e.g., water basin management in water quality projects);

- selectivity in defining areas of assistance in sectors where Bank has strongest leverage to introduce pollution management objectives, or in regions where impact is likely to be greatest and replicated elsewhere in Brazil;

- better integration of disciplines of staff working on infrastructure, municipal finance, and environment to arrive at more comprehensive though realistic objectives and policy recommendations; and

- more critically review the rationale of Bank involvement in projects with unclear objectives and small policy development (e.g., industrial pollution control credit lines).

12.3 The following sections summarize the key lessons learned to date from Bank projects that have attempted to introduce pollution management as a key project objective. The categories of instruments introduced by the projects can be classified in two areas: (i) water basin management in urban areas; and, (ii) directed credit for industrial pollution control, including direct lending to polluters (e.g., CVRD).

LESSONS FROM WATER QUALITY PROJECTS

12.4 This section presents preliminary lessons of the contribution of the Bank's ongoing water quality projects to progress in water pollution management in Brazil (Loans 3503, 3504, and 3505-BR for Sao Paulo, Parana, and the Paraiba do Sul federal component, and Loan 3554 for Minas). The objectives of this section are twofold: (i) stimulate discussion about the contribution made thus far by the projects and, to the extent possible, determine the areas where the Bank can make an even greater contribution; and (ii) to encourage key stakeholders in the current debate concerning the establishment of basin agencies to work towards fruition of the efforts made thus far and initiate integrated basin management. 1997 appears to be a critical year for demonstrating commitment to basin management given that the legal and technical groundwork for basin management is or will be mostly concluded, and that extension of Bank projects is also being considered.

12.5 Appendix 12.1 summarizes the status and lessons of the subcomponents of these projects that are relevant to pollution management. The Appendix and lessons are based on brief discussions with the project team and supervision reports and may not represent complete knowledge of the status of project execution.

Key Lessons

- The projects have helped catalyze the debate about the establishment of basin management in Brazil and have supported preparation of enabling laws at the State level (example of Guarapiranga law developed under the project now used as a model for State "umbrella" law).

- The studies under the projects are contributing to a deeper understanding of water quality dynamics from a more integrated perspective (relative contribution of industry, agricultural run-off, sewage discharges, and other diffuse sources) and are providing decision-making tools previously not available (e.g., flood modeling in Parana).

- The project team has introduced discussion of the economic rationale of water treatment goals which is enabling more rational decisions (e.g., the original das

Velhas project proposed two secondary treatment plants which has been debated and reassessed).

- There is a continued need to incorporate economic analysis in setting long-term water quality objectives as is now being done for the das Velhas basin (e.g., introducing cost-effectiveness in load reduction targets).

- The actual setting of the long-term water quality targets ought to take into consideration the views of users, state and national environmental restoration goals, and affordability of the investments; this exercise was started by projects but should be fostered when the basin agencies are in place.

- Bank lending to the sanitation sector can be an important lever to introduce incentives for improved pollution management when actively managed in that direction (e.g., the Bank is pushing SABESP to connect two large plants to the sewerage network which reduces impact on surface water quality).

- The Bank needs to reassess the interests of stakeholders in each basin to identify how best to channel lending as a catalyst for negotiations about the transfer of power from state to basin agencies. Institutional evolution is likely to exceed the life of these projects: will the Bank remain involved?

12.6 In developing these lessons, it is useful to remember the rationale for the Bank's inclusion of water basin management as an innovation for pollution management within sanitation sector investment projects.[3] The Bank's diagnosis was that past interventions in Brazil failed to reverse the deteriorating water quality trends because government action was fragmented and weak, and failed to address pollution issues from an integrated approach using the natural ecosystem of a basin (or sub-basin) as the management unit. The Bank further indicated that certain local constituencies had expressed interest in organizing their efforts at the basin level and that the Bank had selected those with the apparent highest level of commitment.

12.7 The following three issues deserve further exploration in assessing the progress made on these projects to date:

a) basin management implies a devolution of power to the local level (from federal to state in federal rivers) as well as a coordination of functions; how willing are water companies to devolve that power considering the position of other key stakeholders (on the regulatory side, State Water Resources and Environment authorities; and on the user side, industry and downstream users);

b) can the Bank more effectively leverage influence to facilitate the gradual negotiation of interests among these groups?

c) what are the constraints to a more effective "brokerage" role for the Bank? Will the new Bank structure enhance this role?

12.8 Now that the legal framework for the establishment of basin agencies is in place, or will be developed in 1997 (e.g., framework federal law, umbrella law in Sao Paulo, Minas law under revision, and Parana law reaching at approval stage), political agreement needs to be reached to make basin management a reality. Thus, it may be

[3] The sanitation investments supported under these loans were priority works in drainage, sewerage, resettlement, etc. that justify the projects on their own merits; thus, the attempt here is to assess the synergy of working with the sanitation sector to advance the agenda of pollution management.

appropriate to analyze again the underlying incentives of each stakeholder in each water basin in order to assess the Bank's role. For example, what negotiating position can the municipal consortium in Piracicaba offer in discussions with the more state-led committee? How do they view pricing and how could the political gains be distributed among state and local representatives?

12.9 Finally, it is important to recognize that no major crisis or active constituency yet exists to force the government to accept accountability for water quality improvements. Thus, the process of concentrating accountability in basin agencies will take time (except when a "political champion" assumes leadership, as in Ceara). The Bank should establish interim benchmarks for institutional reforms and remain involved through projects when feasible, sector work, or dissemination activities.

LESSONS FROM INDUSTRIAL POLLUTION CONTROL PROJECTS

Credit Lines

12.10 The main lessons drawn from Bank experience with two loans (loans 1822 and 2831) to Sao Paulo for the *Programa de Controle á Poluição* (PROCOP) as well as the experience to date with a third loan to BNDES for industrial pollution control are as follows:

- credit has tended to be underutilized mainly due to lax enforcement and adverse macroeconomic conditions (high interest rates);
- except for firms with export markets and sophisticated management, most firms in Brazil perceive pollution control as an expense rather than as an investment and will react only when the perceived penalty is greater than the expense;
- credit programs are difficult to administer since unintended uses of funds need to be controlled, which leads to bureaucracy in review and approval;
- bureaucracy in credit administration is clearly highlighted by beneficiaries as a drawback of these programs (both in BNDES's program and PROCOP);
- government administered credit suffered interference/interruption in the flow of funds irrespective of the program execution (PROCOP);
- because of low utilization, open-ended credit programs (state-wide in Sao Paulo, national for BNDES's program) were justified on the basis of increasing the chances of credit utilization and equitably allocating the "benefits" of these programs, although this result has not been directly obtained;
- when pollution control programs were targeted and enforced (Cubatao, 1994 state of Tiete), credit was effectively utilized and helped agencies prove that polluters had "no excuse" but to invest in pollution control;
- long-term credit in Brazil carries financial risk that banks are unwilling to accept for the typical compensation paid (2.5%) except for the most creditworthy firms, for which they sell more profitable products -- this explains why beneficiaries of credit tend to be mostly firms with annual sales above US$15 million; and
- credit programs tend to become ends rather than means for assisting enforcement for environmental quality objectives.

12.11 Despite the above lessons, a targeted credit program or a Fund may be useful when a clearly identified pollution problem is associated with a set of creditworthy firms that could accelerate investments by reducing financing costs with long-term credit. If the objective is to reduce pollution and if important non-industrial sources can be credibly reduced simultaneously (firms are very aware of unfair blaming of industrial sources when the public sector does not do its share in addressing domestic sources for organic loads in water and transport for air pollution), credit may be justified even to large firms. The key is to choose credit only when targeted interventions are needed for specific objectives and when the benefits outweigh the administrative costs to the government. If small and medium firms are important pollution contributors (e.g., when large numbers of small firms dispose of heavy metals and other toxic pollutants), a direct subsidy may be a more effective instrument. An economic justification would be needed in such cases, including the environmental and health benefits of such an intervention.

Loans 1822 and 2831: Sao Paulo Industrial Pollution Control Program - Phases I and II

12.12 Since the early 1980's, the World Bank has supported the State of Sao Paulo Industrial Pollution Control Program (PROCOP--a special project account of the Basic Sanitation State Fund-(FESB) through loans 1822 and 2831). PROCOP is a good example of a program that was originally motivated by priority pollution problems but that later lost its focus in an attempt to improve disbursements performance. The project was also adversely affected by government interruptions in the flow of funds for reasons unrelated to the project.

12.13 The origins of PROCOP date to the late 1970s when the Bank was preparing a

Box 12.1: Bank Experience With Institutional Strengthening Components For State Environment Agencies

While a comprehensive evaluation of institutional strengthening components intended to support State Environment Agencies (SEPAs) in various projects (Water Quality loan for Minas, Espiritu Santo Water, certain components of NEAP, National Industrial Pollution Control Project) is not yet available, preliminary lessons from concluded and ongoing projects indicate the following results:

- the financial support provided by these components represent a significant contribution to the investment budget of these agencies and represent, at times, the only source to build the asset base (both human and capital) of these agencies;
- a typical aspect that is neglected in designing these components is strengthening first the capacity to administer resources, i.e., efficiently spend the allocated resources -- planning, budgeting, and procurement aspects should be addressed during preparation;
- a clear definition of the specific policy objectives and associated functions to be strengthened tend to be missed, as well as the indicators to measure improvement; and
- political support for the component's objectives is highly desirable; however, since priorities shift in political cycles, some portions of the component need to be flexible to respond to changing circumstances.

The important question to ask after the studies have been completed, the computers have been installed, the staff's technical skills have been enhanced, etc. is how have these inputs changed this agency's performance? Some outcomes are easier to evaluate (e.g., faster information processing capabilities provide more reliable and faster issuance of licenses) while others require decisions by policy-makers (e.g., the results of a study leading to changes in regulations). The ultimate outcome of these efforts often depends on the ability of project executors to elevate conclusions to political decision-making levels. This task is often times difficult and is a place where the Bank can make an important contribution.

sanitation project that would finance an early stage of SANEGRAN (the state of Sao Paulo's master plan for sewage collection and treatment). PROCOP was thought to provide the necessary financing for industrial pre-treatment prior to discharge in about 400 companies and treatment at the planned biological treatment plants. In 1977, Brazilian authorities requested that the Bank expand PROCOP's scope to include financing for particulate matter pollution in the rapidly deteriorating Greater Sao Paulo Metropolitan Area (GSPMA). As finally prepared, PROCOP's first phase (PROCOP I) constituted the first program in South America designed to control industrial pollution in a highly urbanized metropolitan area. Based on comprehensive inventories of industrial sources, the project developed 10-year strategy for reducing particulate matter concentration which averaged 130μg/m^3 (geometric mean) during the 1983-85 period to the standard of 80μg/m^3.

12.14 Despite the slightly favorable financial terms of the subloans compared to credit programs for equipment purchases available at the time, the loan encountered very limited demand because of the lengthy review and approval procedures, the severe recession affecting firms' credit-worthiness, and lax enforcement. The water pollution control subprojects never materialized as the SANEGRAN program was significantly scaled down and delayed. For firms, this meant that the establishment of treatment plants was highly uncertain and; if the public sector was not investing in controlling domestic sources of pollution (for Tieté they account for 70% of organic load), why should they invest in pre-treatment facilities.

12.15 In view of the limited disbursements, the project was restructured in 1984 by (i) reducing the loan size, (ii) increasing the share of project costs that the Bank could finance to 50%; (iii) opening the credit to the entire State, including the highly polluted region of Cubatao, and for control of additional pollutants (e.g., SO_2 emissions and toxic solid waste); and, (iv) simplifying procedures for approval and making subloan maturities more flexible. A highly motivated governor prioritized Cubatao as the target of CETESB's control efforts and signed a formal agreement with the 22 most polluting firms. The increased public awareness, enforcement, and improved local economy brought about investment by these firms, which completed PROCOP I's commitments and disbursements.

12.16 The particulate matter emission target for industry for the GSPA was met (although the project only contributed 10% of the reduction), but ambient concentrations failed to improve due to contribution of other sources underestimated in the original project studies (transport sector). The SO_2 target in industrial emissions reductions was also met although the project only contributed 8% of the reduction. In Cubatao, the project was responsible for 80% of the 186 ton/day reduction in dust emissions experienced by the end of 1986 because industries were the main source of pollution. Also, the incidence of emergency concentrations was reduced from 6 to zero during the period 1982-86.

12.17 This phase of the program left a pipeline of subprojects representing about US$77 million in investments, 70% of which were accounted for by the then state-owned entity, COSIPA. The Bank's second loan for Sao Paulo's PROCOP was justified on the basis of this pipeline, although no credit-worthiness analysis had been done for the identified pipeline, and the risk of COSIPA becoming ineligible by debt exposure limits to State banks already under discussion at the time was not fully taken into account. The loan was approved in 1988, but became effective in 1990. It's implementation was problematic from the start. The initial stages did not confirm the demand that had been projected mainly because of

the high recession in the country until 1992, and CETESB's institutional instability which reduced its focus on enforcement. The approval process by both the Bank and CETESB was also lengthy.

12.18 The subsequent phases suffered from interruptions in the flow of funds beyond the control of CETESB and the Bank. As in the first phase, the loan was guaranteed by the federal government and the funds flowed from the World Bank through BNDES (the federal government's intermediary), Sao Paulo's Secretaria da Fazenda, and BANESPA, which disbursed the funds to final borrowers. New regulations restricting state bank exposure to debt from state-owned enterprises eliminated COSIPA as a potential borrower from BANESPA. In addition, Sao Paulo became ineligible for federal transfers in 1991-92 period which meant that BNDES (the federal government intermediary for this loan) interrupted disbursements to BANESPA.

12.19 During these periods, CETESB and BANESPA stopped promoting the program because it was uncertain when the transfers would be resumed. Once the interruption was lifted, commitments had to reach 100% of the loan amount by the end of 1993 which meant that CETESB actively went after loan applicants (not so much enforcement drove them to PROCOP although this did occur for firms in the Tieté basin where enforcement began to be costly). A new difficulty related to the transfer of funds occurred in 1994. The State's liquidity crisis motivated a temporary retention of transfers from BNDES; meanwhile BANESPA was instructed to use PROCOP's own fund to cover the retained funds. The Fund was nearly depleted by the end of 1994. When the new administration took office in 1995, transfers were normalized and the Fund was reimbursed to its original level. However, many subprojects had been canceled either because firms used other financing sources or because they postponed their projects.

12.20 After two one-year extensions of the closing date, the loan was closed on June 30, 1996, with about US$4.1 million undisbursed and was rated unsatisfactory in implementation performance by the Bank. The positive side of PROCOP was the institutional development component for CETESB of US$5.2 million (not so for the Federal government which was canceled in mid-1994). CETESB used these resources to train its personnel, to conduct research projects which led to development of new norms, and to establish a new air quality monitoring network. In addition, the credit program provided CETESB recurrent funds (1% of the outstanding debt) to invest in special projects, including telecommunications and computing equipment. Indirectly, polluters have paid the agency for part of the administrative costs of the program. PROCOP has a balance today of about US$21 million and CETESB is evaluating how to best allocate these resources.

Beneficiary Assessment of PROCOP II Program

12.21 During the months of November and December of 1996, the Bank contracted a consulting firm to interview 60 polluting firms in Sao Paulo and assess the usefulness of the PROCOP II program from the perspective of beneficiaries. In addition, the Bank was interested in drawing conclusions for the effectiveness of directed credit as an instrument for pollution management. The specific goals of the assessment were to conduct a with/without credit comparison of : (a) the main motivations for investing in pollution control; (b) how PROCOP II compared with other financing sources; (c) whether credit made any measurable difference in investment decisions; and (d) how beneficiaries of PROCOP evaluated the implementation of the credit program.

12.22 **Sample Composition.** The sample consisted of two groups of 30 firms each:

PROCOP-participants and non-participants. A participant was defined as a firm that presented a technical project to CETESB,[4] and the sample was arranged so that interviewees could report their opinions about the different stages of approval, including a perspective from firms that applied for credit but did not ultimately obtain approval.

12.23 Thus, the first group of 30 PROCOP-participant firms was comprised of:

- 15 firms that received loans from PROCOP (out of a total of 61 firms);
- 15 firms that were rejected (3 in the technical review and 12 in the financial review stage).

This first group was selected mostly on the basis of availability of firm staff that could recount the firm's experience with the PROCOP II (1988-96).

12.24 The second group of 30 non-participants consisted of:

- 22 firms that did not approach PROCOP at all;
- 8 firms that had some contact with PROCOP (2 requested but did not submit the *Carta Consulta,* 4 passed the *Carta* review by BANESPA but did not present a technical project, 2 were rejected at the *Carta* stage).

This group was selected in part from CETESB's list of polluting firms (from regional control offices) and at random within the same industrial subsectors (namely galvanoplasty/metallurgy, sugar/alcohol, textiles, fertilizers/agroindustry, and chemical). In addition, the entire set of 60 firms were classified into small, medium, and large according to annual sales volume as shown in Table 12.1.

Table 12.1: PROCOP II Assessment Study Participants

Firm's Annual Sales (US$ millions)	Number of PROCOP II Participants	Number of Non-Participants
Large: over 50	20	6
Medium: between 50 and 5	5	18
Small: less than 5	5	6

12.25 The sample of the two main groups did not exactly match the distribution by size. This was not possible primarily because of the difficulty of finding interviewees that knew about the program during the period of the survey, and finding firms that did not participate in PROCOP II willing to take the time for the interview.

12.26 **Main Motivating Factors for Investing in Pollution Control.** The majority of firms in both samples (83% of interviewees) ranked CETESB's enforcement action as the principal motivating actions for investing in pollution control. In particular, a group of firms located within the area of influence of the Tieté clean-up project reported that CETESB's stringent enforcement action required, in their opinion, shorter compliance timetables for industry than it took to obtain a loan from PROCOP. This is an interesting lesson about the disconnect between enforcement actions and the credit instrument, which in part may be

[4] A firm interested in obtaining a loan from PROCOP had to: (a) present a *Carta Consulta* , a brief profile of the project and the firm's financial aptitude to qualify for a loan, (b) once passing this screen, the firm hired consultants or prepared the technical project for presentation to CETESB; (c) with CETESB's approval (judged using best available technology and lowest cost technology criteria), the firm's application was passed to BANESPA for creditworthiness evaluation, (since 1994 this step included compliance with all forms of taxes and social contributions).

explained by the appendix nature of PROCOP II in CETESB's organization (formerly linked to the Presidency, later as dependent on Administration and quite separated from enforcement functions (see implementation feedback below)).

12.27 A secondary motivating factor cited by firms in both samples was the existence of an environmental corporate policy (about 40% of respondents in both samples) although this was more evident in the larger firms.

12.28 **Comparison of PROCOP II with Other Financing Sources.** Firms were asked to compare PROCOP II to four other main financing sources: own resources, other government credit lines, private banks, and export credit from foreign banks linked to equipment purchases. The main advantages of PROCOP II cited were its longer grace and loan repayment periods and the technical assistance provided by CETESB. The main disadvantage cited was the financial guarantees required by PROCOP II (7 firms ranked this aspect as a "minus", compared to only 3 firms that ranked "minus" for the interest rate). Non-participants primarily financed its pollution control resources with own resources (27 firms) and a few (5 firms) also used BNDES's credit program. Interestingly, despite the more favorable financial conditions of the official credit programs compared to private banks or own resources, these firms indicated that bureaucracy and lack of understanding of the credit program by bank agencies discouraged them from using these lines, indicating that the transaction costs for firms is much higher than the financing conditions of long-term credit.

12.29 **Investment Volume in Pollution Control by Firm Size.** Large firms participating in PROCOP II invested higher volumes than large non-participant firms (70%, vs. 33% in each group, respectively). On the lower range of the investment and size scale, small firms participating in PROCOP II (2 of 5) invested more than the $100,000 minimum, whereas all of the small non-participating firms invested below $100,000. Medium firms in both groups appear to be equally distributed by investment scale. Although the sample size is small and further segmentation may render these numbers of even smaller statistical significance, the conclusion that credit facilitated larger investments in larger firms is intuitively consistent. In the absence of credit, small firms prefer to invest the bare minimum when faced with CETESB's enforcement actions.

12.30 **Feedback from Beneficiaries on Implementation Performance.** Overall, 13% of participating firms evaluated PROCOP II as highly satisfactory, 50% as satisfactory, 15% as less than satisfactory, and 20% as not satisfactory. The participation process, from technical review to disbursements, was ranked by these interviewees. Firms representing 49% of respondents (27 firms), indicated that CETESB's technical review process was ranked "reasonable", with the balance indicating that the review process was "unreasonable." (this was a subjective scale left to respondents to judge). As for the credit approval by BANESPA, 54% of respondents (26 firms) indicated that the review process was "bad," 23% indicated it was "normal," and an equal share of respondents indicated the review process was "good." Although these responses indicate relative unhappiness with the efficiency of the program, 93% of all firms indicated that the existence of credit programs like PROCOP II are extremely useful and necessary because, in their opinion, investments in pollution abatement are considered expenses (non-productive investments); thus, using the firm's working capital as a financing source is extremely unfavorable to its financial health. As for suggestions, firms offered the following ideas in order of frequency:

- disseminate the program more widely;

- introduce a large number of financial intermediaries/agents;
- establish differentiated conditions for small and medium firms;
- increase the fee paid to intermediaries;
- devise a more effective program monitoring system;
- expedite review and approval processes;
- make guarantees less onerous;
- train bank agencies and decentralize approval process; and
- give longer compliance periods to permit process modification and not just end-of-pipe solutions.

Loan 3480: National Industrial Pollution Control Project (NIPCP)

12.31 Partly based on the experience with PROCOP, BNDES established its own environment credit program and the Bank agreed to provide a loan for US $50 million with an equivalent amount lent by the Export-Import Bank of Japan for a total of US$100 million. BNDES' overall environment credit program, which uses NIPCP for part of its funding, disburses about US$ 400 million per year.[5] The main difference between PROCOP and NIPCP was that the lead manager was a federal bank (BNDES) and not an environment agency. This proved to have the disadvantage of a greater distance between enforcement strategy and credit. The advantage has been a better disbursements performance (after a slow start) since BNDES has had more flexibility in directing the program to various investment subprojects as explained below.

12.32 Based on a broad assessment of the principal industrial pollution in a number of states, NIPCP was intended to provide financing for the main sources of pollution nation-wide. However, the allocation of the relatively small credit volume was left completely open-ended and no environmental performance indicators were developed at project design. In other words, no measure of the benefits in terms of environmental quality of any other program was developed to evaluate the effectiveness of the program. Therefore, the Bank has made an effort to develop indicators for the specific subprojects being financed (primarily the large steel industry clean-up projects). Another aspect worth noting is the relatively small loan amounts compared to the apparent demand identified in the Bank's appraisal report. In Minas Gerais, the Bank's appraisal

[5] BNDES environmental credit program disbursed about US$422 million in 1995 in various categories of programs which can be broadly grouped into two: direct operations between BNDES and the borrowing firm and indirect operations through another bank. The TJLP (*Taxa de Juros de Longo Prazo)* a long-term interest rate is the BNDES's reference rate for this program which reflects the institution's long-term funding sources (*FAT,* the Worker's Support Fund, *PIS/Pasep,* Social Integration Programs for both private and public sectors) and *FMM* Merchant Marine Fund). Direct operations carry the TJLP + 1.5% for BNDES spread and up to 3% risk rate. BNDES can finance up to 75% of the investment, maturities run up to 8 years, and grace period is up to 6 months. Indirect operation carry TJLP + 0.5% for small firms/1.5% for medium and large firms and a financial intermediary spread of less than 3%. (TJLP for the period ending August 1996 was 15.44% p.a.) Compared to other development programs, these financing conditions are slightly more favorable than those available at BNDES for technological training (BNDES covers 10% less of the total investment) and for installation, expansion, and plant modernization (BNDES spread is 1% higher).

report estimated investment needs of only about US$300 million for air pollution.

12.33 The loan was designed to consist of numerous small loans distributed through financial intermediaries, and State Environment Agencies (SEPAs) were expected to enforce regulations for pollution control. Compared to the intended design, BNDES' environmental credit program targeted environmental "liabilities" of past operations in industrial sectors under modernization (e.g. steel, mining, petrochemicals, etc.) involving little opportunity for process efficiency gains. The more favorable credit terms of the environmental program are intended to provide incentives for pollution control. The bulk of the loan amount (70%) is committed to large investment projects in USIMINAS and COSIPA, which, after privatization in 1992, carried a huge backlog of environmental liabilities. Both subloans are a component of larger modernization loans for substantial plant upgrading and modernization. BNDES has coordinated the evaluation of these projects with State Environment Agencies partly because national legislation on official banks requires them to verify compliance with environmental licensing requirements prior to loan approval, and partly in an attempt to ensure adequate monitoring of the supported investments. However, this task has proved difficult due to capacity constraints faced by many state environment agencies and the relatively little priority given to the specific pollution problems addressed by these investments. BNDES has relied more on the adoption of a "total quality" mentality by large companies, which includes environmental compliance, than the enforcement drive from the environmental agencies.

12.34 In retrospect, the World Bank should have more carefully analyzed the incentives of each stakeholder:

- large polluters in each state could potentially consume a large portion of the entire loan if regulations were strongly enforced;
- for State Environment Agencies to enforce regulations, political incentives had to have been in place (this is now the case in Sao Paulo because the *Ministerio Público* and the public are now after CETESB for not making COSIPA comply with regulations, but this did not happen in the past and certainly not when the project was prepared, since COSIPA was still a public company);
- a very small technical assistance component with grant financing (equivalent to 1% of the loan amount passed on by BNDES to SEPAs and a supplementary Japanese Grant) was an irrelevant incentive for SEPAs to become actively engaged with large polluters; and
- BNDES wanted to concentrate its efforts on high impact projects with direct operations (not through intermediaries) that complemented its ongoing credit program in the steel industry and its main objective (as was the Bank's) was to see those projects implemented.

12.35 The result has been an interesting experiment of how a development bank has taken the place of a broker between SEPAs and large polluters. BNDES was at times in the middle of difficult negotiations of *Termos de Compromiso* in an attempt to improve broken relationships from decades past. The case of COSIPA is an interesting case study. A generally neglectful company when in public hands, COSIPA has since experienced a slow but gradual transformation of the managerial attitude towards CETESB and environmental management in general. The role of BNDES and the World Bank may have helped by adding additional pressure to both CETESB and COSIPA to meet their side of the compliance agreement. The general difficulty has been the pace at which manufacturing facilities neglected for

decades can be brought to compliance. Compliance agreements are constantly being renegotiated with the associated friction and unfulfillment of Bank operational disbursement targets. The challenge is to forcibly apply penalties when targets are not being met and make the most cost-effective use of the limited credit program.

12.36 Further preliminary lessons of the NIPCP include the following:

⇒ the Project has served to strengthen BNDES' technical and negotiating capacity with large polluters, allowing it to foster a new view of environmental management within these companies (e.g., COSIPA's willingness and adoption of recommendations of an environmental audit);

⇒ the Project empowered SEPAs to the extent that BNDES and the Bank were asking them for their "no objection" to investment projects and compliance deadlines in order to disburse and approve subloans;

⇒ the loan's procurement limits and Bank procedures proved a major difficulty because the large steel companies now in private hands had large procurement packages for which commercial practices were used (incompatible with Bank ICB and LCB);

⇒ the incentives for active SEPA participation in the Project (TA grants), both for subproject monitoring and environmental quality evaluation, were insufficient as project design did not analyze in detail the institutional feasibility of the SEPA responsibilities under the Project; and

⇒ the dispersion of the Project on a nationwide basis coupled with the Bank's limited supervision budgets contributed to limited physical supervision of subprojects, relying more on BNDES's supervision efforts.

Environmental Conservation And Rehabilitation Project (CVRD Loan)

12.37 In 1995, the World Bank lent US$50 million to Companhia Vale do Rio Doce (CVRD) to support priority investments in its comprehensive environmental program. The program was intended to reduce the impact of mining, industrial, rail, port and commercial forestry operations of the CVRD conglomerate and to compensate for the social disruptions induced by past and current operations. This project is included in this chapter to draw lessons about the Bank's role regarding pollution control components in the context of the contribution of Bank projects to the development of pollution management policies. The social and natural resource aspects of the project are excluded from this discussion.

12.38 The Bank justified its involvement in this loan on the basis that (i) the planned investments fitted into federal and state priorities given the scale of environmental impacts; (ii) CVRD's environmental management and social policies could serve as a model for other large polluters in the country; (iii) the prevention of further environmental and social degradation in the Carajas Corridor was necessary; and (iv) the project would allow the Bank to gain additional insight into how large industrial and mining concerns should identify and mitigate environmental and impacts of large projects in ecologically sensitive areas. Regarding pollution control, the overarching goal was to help CVRD meet its obligations under compliance agreements with state and federal authorities (*Termos de Compromiso).*

12.39 The loan is under implementation and some unforeseen aspects about the Bank's involvement are emerging, namely:

- the Bank is acting as an honest broker between CVRD and environmental authorities and is facilitating agreements that could have taken much longer; and

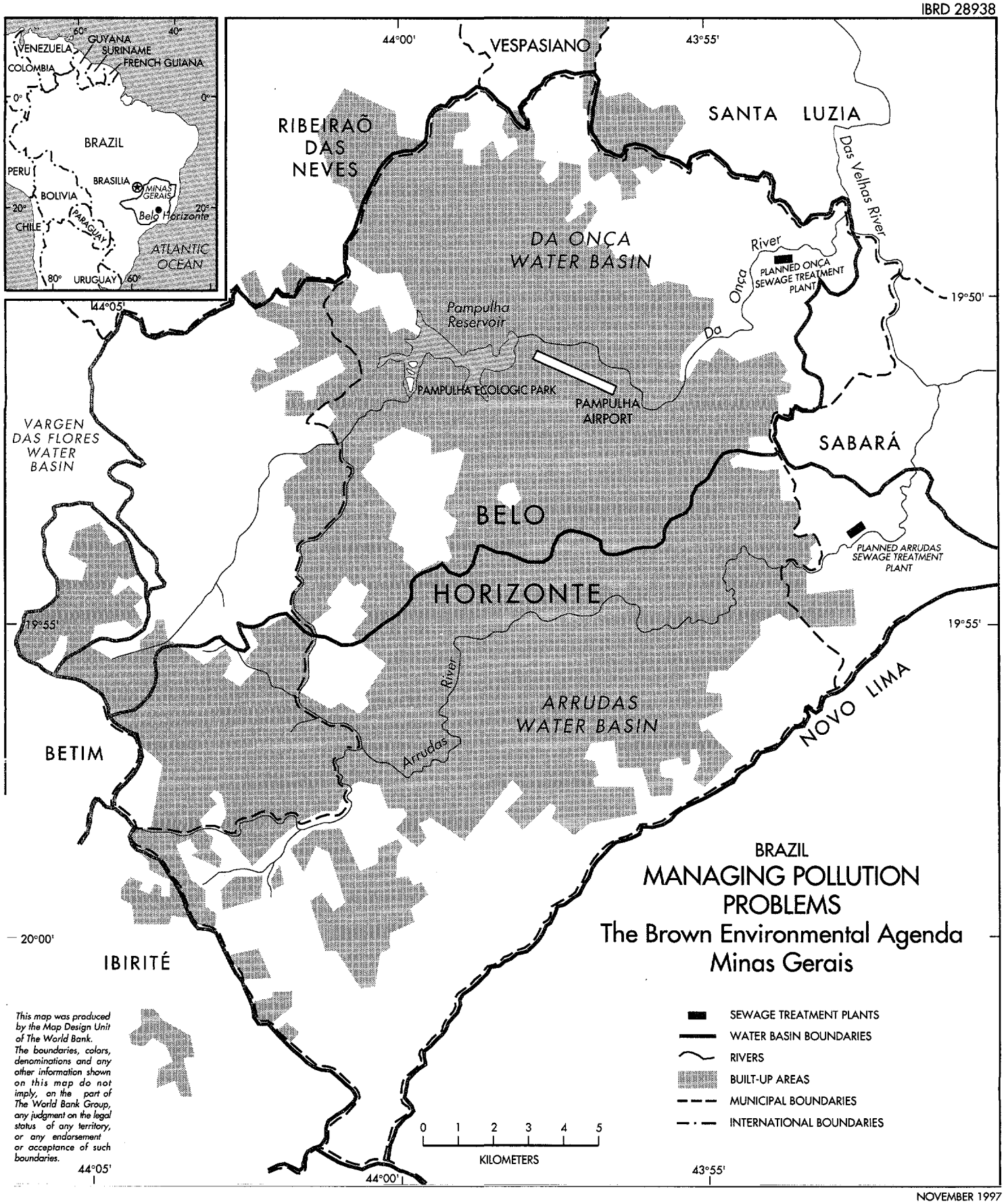
- CVRD, with its US$2.5 billion in annual sales, did not come to the Bank for a US$50 million loan, but for access to international experience, best practice advice, and for a "certifier" to the international community that CVRD's management takes the environmental impacts of its operations seriously.

12.40 The latter point was important to CVRD given the privatization process that would unfold after 1995. On its part, the Bank intended to extract a model of how large polluters should set up and implement environmental and social policies. The project did not, however, include a component to document this model, and thus, remains dependent on the Bank's supervision efforts. While the direct reduction of pollution may have justified the pollution components on their own merit, it is important for the Bank to attain a wider development impact by drawing and disseminating CVRD's successes and failures and by highlighting the regulatory and institutional constraints that slow or prevent faster correction of polluting activities to the government. The project offers fertile ground for learning about how to induce constructive behavior by privatizing enterprises and about how governments should implement policies for correcting large environmental liabilities.

Appendix 12.1: Bank Loans: Status And Lessons

Loan #	Water Basin	Relevant Components and Instruments	Status	Lessons for Pollution Management
3504	Guarapiranga reservoir-SP (sub-basin of Tieté)	- TA leading to creation of water basin agency; pollution inventories, modeling, and charges - improved laws for headwaters protection	- institutional design completed; consultative committee of municipalities formed; state law expected to pass in late 1997 creating basin agency; - basin development plans with quality targets under preparation; - marketing survey of low-polluting users started; - water quality modeling studies well advanced; - water charges law draft under review.	- the most critically affected municipality (SP) is taking the lead in basin coordination; - some water treatment investments being undertaken by SABESP may not be cost-effective - link to urban land use management has proved very important.
3505	Upper Iguazu in Curitiba	- TA leading to creation of water basin agency; state water law; pollution inventories, modeling, and charges	- studies completed but no law has been passed; no committees to date - investment by state water company underway	- too early to tell.
3503	Piracicaba-SP (federal river)	- preparatory studies for investment plan	- basin agency can be created under Jan. 97 Federal law; committee created but consortium of municipalities precedes it; form of funding under Federal law likely to determine final basin agency; - complementary law for water pricing under preparation	- difficulties in agreeing on basin agency structure and membership proves complexity of political process involved. - water quality goals should drive definition of investment proposals using economic analysis to guide the infrastructure plan.
3503	Paraiba do Sul (federal river shared by SP, MG, and RJ)	-basin management leading to integrated resource management and investment program	- CEIVAP created by Decree on 03/96; state management units established; studies underway with results expected fall 1997	- inter-state coordination requires more time than expected
3554	Arrudas and das Velhas-MG	- TA leading to creation of water basin agency; pollution inventories, modeling, and charges - enhancement of state water law and related laws.	-State Counsel exists but no basin agency or committee created yet; -industrial pollution control strategy completed but needs to incorporate cost-effectiveness; -economic evaluation of water quality goals underway; -das Velhas water basin agency and instruments studies to be completed by mid-1997	- producing institutional change and laws has not kept pace with other components - cost-effectiveness has not been an easy concept for project proponents; - quality objectives may need to be revisited when basin agency is in place; - industrial pollution control strategy should prioritize the most cost-effective load reduction sources
3767	Grande Vitoria and Guarapari-ES coastal zone	-institutional strengthening component ($8.7 million): water quality monitoring; hydrological data bases; water resources plan; industrial pollution control program; ecosystems conservation program; env. info. systems program; env. education.	- SEAMA restructured; leadership changed; some studies underway. - tools to be supported include: licensing of polluting sources (industries); industrial effluent standards; manual for small firms; water quality modeling and coastal management plans	- slow start: too early to tell

IBRD 28938



BRAZIL
MANAGING POLLUTION PROBLEMS
The Brown Environmental Agenda
Minas Gerais

This map was produced by the Map Design Unit of The World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.

NOVEMBER 1997


BRAZIL
MANAGING POLLUTION PROBLEMS
National Capital
State Capitals
Selected Towns
State Boundaries
Region Boundaries
International Boundaries
Rivers
KILOMETERS 0 100 200 300 400 500
MILES 0 100 200 300
COLOMBIA
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
PERU
BOLIVIA
PARAGUAY
CHILE
ARGENTINA
URUGUAY
AMAZONAS
PARÁ
AMAPÁ
RORAIMA
ACRE
RONDÔNIA
MATO GROSSO
MATO GROSSO DO SUL
TOCANTINS
GOIÁS
Federal District
MARANHÃO
PIAUÍ
CEARÁ
RIO GRANDE DO NORTE
PARAÍBA
PERNAMBUCO
ALAGOAS
SERGIPE
BAHIA
MINAS GERAIS
ESPÍRITO SANTO
SÃO PAULO
RIO DE JANEIRO
PARANÁ
SANTA CATARINA
RIO GRANDE DO SUL
Boa Vista
Macapá
Marajó Island
Belém
Salinópolis
Manaus
São Luis
Parnaíba
Camocim
Fortaleza
Disputed State Boundary
Teresina
Macau
Natal
João Pessoa
Campina Grande
Olinda
Recife
Porto Velho
Rio Branco
Miracema Do Norte
Maceió
Aracaju
Feira de Santana
Salvador
Jequié
Ipiaú
Ilhéus
Cuiabá
BRASÍLIA
Goiânia
Araguaí
Teófilo Otoni
Governador Valadares
Caravelas
Uberlândia
Uberaba
Campo Grande
Belo Horizonte
Tubarão
Vitória
São José do Rio Prêto
Ribeirão Prêto
Bauru
Juiz de Fora
Campos
Campinas
Sorocaba
São Paulo
Santos
São Sebastião
Cabo Frio
Rio de Janeiro
Ponta Grossa
Curitiba
Jacarezinho
Paranaguá
Lajes
Florianópolis
Vacaria
Tubarão
Santa Maria
Porto Alegre
Tramandaí
Bagé
Pelotas
Rio Grande
SOUTH AMERICA
Brasilia