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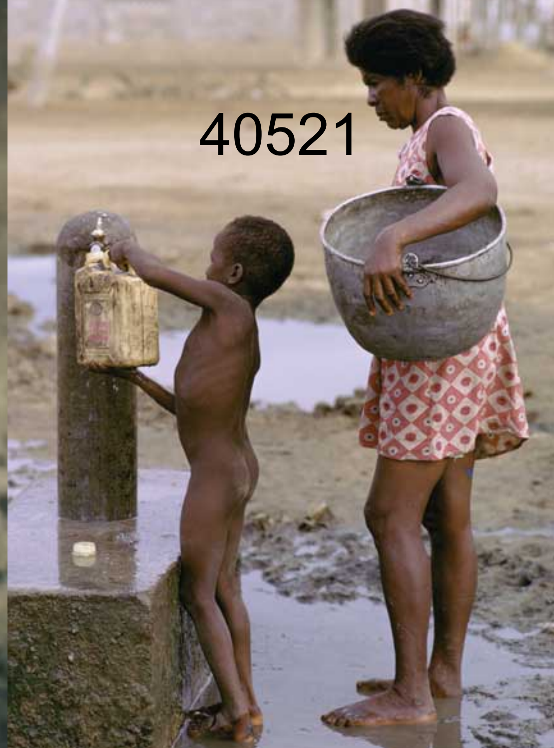

DIRECTIONS IN DEVELOPMENT
Environment and Sustainable Development

Environmental Priorities and Poverty Reduction

A Country Environmental Analysis for Colombia

Ernesto Sánchez-Triana, Kulsum Ahmed, and Yewande Awe, Editors

THE WORLD BANK

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Foreword

Colombia's constitution, known as the "Green Constitution," strives to integrate economic, social, and environmental considerations into national plans and policies. Colombia has achieved a number of milestones in sound environmental policy, including the enactment of the Code of Natural Resources in 1974—the first Code in Latin America—and the Law of the Environment in 1993, and the establishment of a unique and highly decentralized National Environmental System (Sistema Nacional Ambiental).

The government of Colombia recognizes the World Bank's commitment to achieve equitable and sustainable development. *Environmental Priorities and Poverty Reduction: A Country Environmental Analysis for Colombia* is an important testament to the Bank's commitment. The report, which was prepared in response to a request by the government, includes many issues that were brought up during extensive discussion among the World Bank, various national and local agencies, private sector stakeholders, nongovernmental agencies, and other civil society organizations in Colombia.

Environmental Priorities for Poverty Reduction: A Country Environmental Analysis for Colombia is a valuable resource for policy and decision makers. It identifies the environmental issues that are a priority in the national agenda as well as the most cost-effective ways to deal with them. This report was used as a basis in the formulation of Colombia's Vision 2019, which aims at achieving an economy in which all citizens enjoy greater welfare, a more egalitarian and united society, a society with free and responsible citizens, and efficient services.

In addition, some of the studies presented in the report have been the basis for discussions among various stakeholders during the preparation of the 2006–10 National Development Plan, *Estado Comunitario: Desarollo para Todos*, which has the key objectives of promoting the following:

- increased and sustained economic growth
- poverty reduction and equity
- policies for defense and democratic security
- environmental and risk management to promote sustainable development
- an improved national government at the citizen's service.

Furthermore, the Congress, constituencies, and mass media have initiated a public debate based on the findings of technical studies on the environment. Such discussions have had considerable success in raising public awareness of Colombia's primary environmental issues—such as outdoor and indoor air pollution and natural disasters induced by climate change—and the economic burdens that they impose.

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(Minister of Environment, Housing, and Territorial Development)

Preface

The Colombia Country Environmental Analysis, *Environmental Priorities and Poverty Reduction*, is the product of joint work between the World Bank and the government of Colombia. The report highlights the country's principal environmental challenges with a view to facilitate a dialogue that will drive the search for efficient and equitable public policy options. The analysis presented in this document is the first of its kind undertaken by the World Bank in the area of sustainable development and environmental protection in Colombia. The analytical approach serves as an element of a learning process that relates environmental protection and poverty alleviation within a framework that will help the government of Colombia to achieve the Millennium Development Goals, particularly the goal to integrate sustainable development principles in national policies and programs and reverse environmental degradation.

Consistent with the analysis, Colombia's vast wealth of natural resources has not only contributed to economic and social growth, but also to improvements in the quality of life of the population. In the past 50 years, the country has restructured its environmental legal and regulatory framework, undertaking various policy initiatives and broadening and strengthening its institutional capacity to protect and manage natural resources and environmental quality, vital aspects for sustainable growth and poverty reduction. The legal framework has permitted the successful establishment of a decentralized and innovative framework for environmental management that assigns specific responsibilities to the multiple stakeholders involved in environmental management.

Despite significant advances, such as the creation of a system of national parks and forestry reserves that covers almost a quarter of the national territory, as well as the gradual phase-out of leaded gasoline, Colombia must address the great challenge of mitigating and reversing environmental degradation and at the same time strengthen environmental planning and management processes that have been initiated. It is estimated that the cost associated with the principal causes of environmental degradation is equivalent to more than 3.7 percent of Colombia's gross domestic product, due mainly to increased mortality and morbidity and decreased productivity.

The World Bank foresees a continued program of assistance to Colombia in the area of environmental planning and management, making it a central theme in the process of building an equitable, competitive, and sustainable country. Based on the priorities identified by the government of Colombia, the Bank will continue to support, through technical assistance and financing, the design and implementation of sustainable development policies, and thereby strengthen the joint work of the Colombian governmental authorities in the various sectors to benefit the country's most vulnerable groups. We hope that this report serves as a useful instrument for contributing to the achievement of poverty reduction, environmental protection, and sustainable development goals in Colombia.

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The government of Colombia, mainly through the Ministry of Environment, Housing and Territorial Development (MAVDT), the Ministry of Social Protection (MPS), and the National Planning Department (DNP), provided key feedback during the preparation of the study. The following government officials were particularly helpful in providing comments and insights to the task team: Juan Lozano Ramirez (MAVDT); Eduardo José Alvarado (MPS); Alejandro Gaviria (DNP); Astrid Alvarez, Oscar Dario Amaya, Juan P. Bonilla, Pedro Chavarro, Diana Gaviria, Simona Herrera, Lina Patricia Muñoz, Leonardo Muñoz, and Gerardo Viña (MAVDT); Oscar Alvarez (CORNARE); Francisco Zapata (CORANTIOQUIA); Gloria Alvarez (Cundinamarca); Vilma Fabiola Izquierdo (National Health Institute); and Carlos Costa, Gonzalo Arango, Nelsy Verdugo, and Gloria Zapata. Important feedback was also received from members of the Colombian Congress during the workshops in Bogotá. The team is particularly grateful to the Japanese government for its support of some of the studies that underpin this report through Policy and Human Resources Development funds.

This work was supervised by Pamela Cox (Vice President, Latin America and Caribbean Regional Development of the World Bank), Isabel Guerrero (Country Director, Mexico and Colombia's Country Management Unit, Latin America and Caribbean Regional Department of the World Bank), John Redwood (Sector Director, Environmentally and Socially Sustainable Development, Latin America and Caribbean Regional Department of the World Bank), Laura Tuck (Sector Director, Sustainable Development Department, Latin America and Caribbean Regional Department of the World Bank), and Abel Mejia (Environment Sector Manager, Latin America and Caribbean Regional Development Department of the World Bank).

Abbreviations

AAU	Urban Environmental Authority *Autoridad Ambiental Urbana*
ARI	acute respiratory illness
ASOCAR	Colombian Association of Environmental Authorities *Asociación Colombiana de Autoridades Ambientales*
BAMA	Environmental Administration Department of Barranquilla *Departamento Administrativo de Medio Ambiente de Barranquilla*
BOD	biochemical oxygen demand
CAR	Autonomous Regional Corporation (note that CAR is used both generically for all CARs and specifically for the CAR Cundinamarca) *Corporación Autónoma Regional*
CDAV	*Centro de Diagnóstico Automotor del Valle*
CDM	Clean Development Mechanism
CDS	Sustainable Development Corporation *Corporación de Desarrollo Sostenible*
CEA	country environmental analysis

CEPAL	Economic Commission for Latin America and the Caribbean *Comisión Económica para América Latina y el Caribe*
CER	Certified Emission Reduction
CFC	chlorofluorocarbon
CGSM	Great Swamp of Santa Marta *Ciénaga Grande de Santa Marta*
CH_4	methane
CNE	National Emergencies Committee *Comité Nacional de Emergencias*
CNG	compressed natural gas
CNPAD	National Disaster Preparedness and Response Committee *Comité Nacional para la Prevención Renovables y Atención de Desastres*
CNRN	National Code for Renewable Natural Resources and Environmental Protection *Código Nacional de Recursos Naturales Renovables y de Protección al Medio Ambiente*
CO	carbon monoxide
COI	cost of illness
COLPAD	Local Disaster Preparedness and Response Committee *Comité Local para la Prevención y Atención de Desastres*
CONAIRE	National Intersectoral Technical Commission for Prevention and Control of Air Pollution *Comisión Técnica Nacional Intersectorial para la Prevención y el Control de la Contaminación del Aire*
CONPES	National Council on Economic and Social Policy *Consejo Nacional de Política Económica y Social*
COPD	chronic obstructive pulmonary disease
CO_2	carbon dioxide
CREPAD	Regional Disaster Preparedness and Response Committee *Comité Regional para la Prevención y Atención de Desastres*
DALY	disability-adjusted life year
DANE	National Statistical Administration Department *Departamento Administrativo Nacional de Estadísticas*

DARNAR	Administrative Department of Renewable Natural Resources *Departamento Administrativo de Recursos Naturales Renovables*
DGPAD	General Directorate for Disaster Relief and Prevention *Dirección General para la Prevención y Atención de Desastres*
DHS	Demographic and Health Survey
DNP	National Planning Department *Departamento Nacional de Planeación*
dS/m	deciSiemens per meter
EAAB	Bogotá Water and Sewer Company *Empresa de Acueducto y Alcantarillado de Bogotá*
EIA	Environmental Impact Assessment
EMGESA	Bogotá Energy Utility *Empresa de Energía de Bogotá*
ESP	Medellín Public Utilities *Empresas Públicas de Medellín*
FAO	Food and Agriculture Organization
FNC	National Disaster Fund *Fondo Nacional de Calamidades*
FNR	National Royalty Fund *Fondo Nacional de Regalías*
FONAM	National Environmental Fund *Fondo Nacional Ambiental*
Gcf	giga cubic feet
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
ha/yr	hectares per year
HC	hydrocarbon
HCA	human capital approach
H_2SO_4	sulfuric acid
IDB	Inter-American Development Bank
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies *Instituto de Hidrología, Meteorología y Estudios Ambientales*

IGAC	Agustín Codazzi Geographic Institute *Instituto Geográfico Agustín Codazzi*
INDERENA	National Institute of Renewable Natural Resources *Instituto Nacional de los Recursos Naturales Renovables*
INGEOMINAS	Colombian Institute of Geology and Mines *Instituto Colombiano de Geología y Minería*
INS	National Institute of Health *Instituto Nacional de Salud*
INVEMAR	Institute of Marine and Coastal Research *Instituto de Investigaciones Marinas y Costeras*
IUCN	World Conservation Union
JICA	Japan International Cooperation Agency
LPG	liquefied petroleum gas
$l/s/km^2$	liters per second per square kilometer
MAVDT	Ministry of Environment, Housing and Regional Development *Ministerio de Ambiente, Vivienda y Desarrollo Territorial*
MDGs	Millennium Development Goals
$\mu g/m^3$	micrograms per cubic meter
MHCP	Ministry of Finance and Public Credit *Ministerio de Hacienda y Crédito Público*
MMA	Ministry of Environment *Ministerio del Medio Ambiente*
MMcfd	million cubic feet per day
MME	Ministry of Mines and Energy *Ministerio de Minas y Energía*
m^3/s	cubic meters per second
MW	megawatt
NGO	nongovernmental organization
NNPS	National Natural Parks System
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
NPA	National Parks Authority
NPAS	National Protected Areas System

O_3	ozone
OAD	obstructive airways disease
ODS	ozone-depleting substance
OECD	Organisation for Economic Co-operation and Development
ONPAD	National Disaster Preparedness and Response Office *Oficina Nacional para la Prevención y Atención de Desastres*
ORT	oral rehydration therapy
PAT	Three-Year Action Plan *Plan de Acción Trienal*
PCB	polychlorinated biphenyl
PDM	Municipal Development Plan *Programa de Desarrollo Municipal*
PGAR	Regional Environmental Management Plan *Plan de Gestión Ambiental Regional*
PGIR	Municipal Integrated Solid Waste Management Plan *Plan de Gestión Integral de Residuos Sólidos*
PLEC	Local Emergency and Contingency Plan *Plan Local de Emergencia y Contingencia*
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PM_{10}	particulate matter less than 10 microns in diameter
PNPAD	National Disaster Preparedness and Response Plan *Plan Nacional para la Prevención y Atención de Desastres*
POIA	Annual Investment Operating Plan
POMCA	Watershed Administration and Management Plan *Plan de Ordenamiento y Manejo de Cuenca Hidrográfica*
POP	persistent organic pollutant
POT	Land Use Plan *Plan de Ordenamiento Territorial*
ppm	parts per million
Ramsar	The Ramsar Convention on Wetlands
RFF	Resources for the Future
RR	relative risk ratio
SIAC	Colombian Environmental Information System *Sistema de Información Ambiental de Colombia*

SINA	National Environmental System *Sistema Nacional Ambiental*
SINCHI	Amazonian Institute for Scientific Research *Instituto Amazónico de Investigaciones Científicas*
SISAIRE	Air Quality Information System *Sistema de Información sobre Calidad del Aire*
SITM	Integrated System for Mass Transportation *Sistema Integrado de Transporte Masivo*
SNPAD	National Disaster Preparedness and Response System *Sistema Nacional de Prevención y Atención de Desastres*
SO_2	sulfur dioxide
TSP	total suspended particles
TSS	total suspended solids
TVA	Tennessee Valley Authority
UAESPNN	Special Administrative Unit for the National Natural Parks System *Unidad Administrativa Especial del Sistema de Parques Nacionales Naturales*
UESP	*Unidad Ejecutiva de Servicios Públicos del Distrito Capital de Bogotá*
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UPME	Mining and Energy Planning Unit *Unidad de Planeación Minero Energética*
USAID	United States Agency for International Development
UTO	Ozone Technical Unit *Unidad Técnica de Ozono*
VAT	value-added tax
VIS	Social Interest Housing *Vivienda de Interés Social*
VOC	volatile organic compound

VSL	value of statistical life
WHO	World Health Organization

Note:

Currency Unit = Col$ (Colombian peso)

Fiscal Year = January 1 to December 31

Local and Regional Environmental Authorities

Autonomous Regional Corporations	
CAM	Corporación Autónoma Regional del Alto Magdalena
CAR Cundinamarca	Corporación Autónoma Regional de Cundinamarca
CARDER	Corporación Autónoma Regional de Risaralda
CARDIQUE	Corporación Autónoma Regional del Dique
CARSUCRE	Corporación Autónoma Regional de Sucre
CAS	Corporación Autónoma Regional de Santander
CDMB	Corporación Autónoma Regional de Defensa de la Meseta de Bucaramanga
CORANTIOQUIA	Corporación Autónoma Regional del Centro de Antioquía
CORNARE	Corporación Autónoma Regional de las Cuencas de los Ríos Negro y Nare

CORPAMAG	Corporación Autónoma Regional del Magdalena
CORPOBOYACA	Corporación Autónoma Regional de Boyacá
CORPOCALDAS	Corporación Autónoma Regional de Caldas
CORPOCESAR	Corporación Autónoma Regional del Cesar
CORPOCHIVOR	Corporación Autónoma Regional de Chivor
CORPOGUAJIRA	Corporación Autónoma Regional de La Guajira
CORPOGUAVIO	Corporación Autónoma Regional del Guavio
CORPONARIÑO	Corporación Autónoma Regional de Nariño
CORPONOR	Corporación Autónoma Regional de la Frontera Nororiental
CORPORINOQUIA	Corporación Autónoma Regional de la Orinoquía
CORTOLIMA	Corporación Autónoma Regional del Tolima
CRA	Corporación Autónoma Regional del Atlántico
CRC	Corporación Autónoma Regional del Cauca
CRQ	Corporación Autónoma Regional del Quindío
CSB	Corporación Autónoma Regional del Sur de Bolívar
CVC	Corporación Autónoma Regional del Valle del Cauca
CVS	Corporación Autónoma Regional de los Valles del Sinú y San Jorge
Sustainable Development Corporations	
CDA	Corporación para el Desarrollo Sostenible del Norte y Oriente Amazónico
CODECHOCO	Corporación para el Desarrollo Sostenible del Chocó
CORALINA	Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina

CORMACARENA	Corporación para el Desarrollo Sostenible de la Macarena
CORPOAMAZONIA	Corporación para el Desarrollo Sostenible del Sur de la Amazonía
CORPOMOJANA	Corporación para el Desarrollo Sostenible de La Mojana y San Jorge
CORPOURABA	Corporación para el Desarrollo Sostenible del Urabá

Urban Environmental Authorities

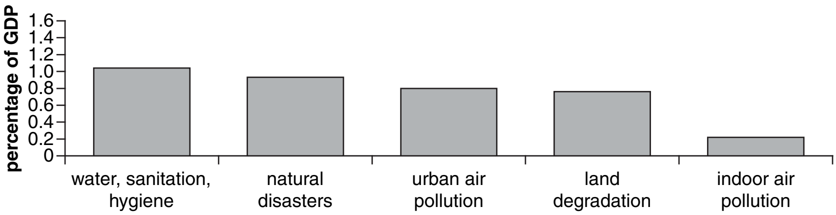
AMVA	Autoridad Ambiental Urbana del Área Metropolitana del Valle de Aburrá
DADMA	Departamento Administrativo de Medio Ambiente Santamarta
DAGMA	Departamento Administrativo para la Gestión del Medio Ambiente, Cali
DAMA	Departamento Administrativo del Medio Ambiente, Bogotá
DAMAB	Departamento Técnico Administrativo del Medio Ambiente de Barranquilla
EPA	Establecimiento Público Ambiental de Cartagena

Executive Summary

Over the past five decades, Colombia has made substantial progress in protecting its environment. Its actions include restructuring its legal and regulatory landscape, undertaking policy initiatives, strengthening its capacity for protecting and managing its natural resources and environmental quality, and establishing a system of national parks and forestry reserves that covers more than a quarter of the country. Colombia's environmental management framework has focused on three main environmental priorities: (a) river basin management and conservation of water resources, (b) reforestation, and (c) conservation of biodiversity. During 1994 to 2005 the total value of investments by Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs) amounted to about US$2 billion. Approximately 60 percent of those investments were directed mainly at water and forestry interventions.

The analysis of the cost of environmental degradation conducted as part of the country environmental analysis (CEA) shows that the most costly problems associated with environmental degradation are urban and indoor air pollution; inadequate water supply, sanitation, and hygiene; natural disasters (such as flooding and landslides); and land degradation (figure 1). The burden of these costs falls most heavily on vulnerable segments of the population, especially poor children under

Figure 1 Annual Cost of Environmental Degradation



Source: Larsen 2004.
Note: GDP = gross domestic product.

age five. The effects of environmental degradation associated with these principal causes are estimated to total more than 3.7 percent of gross domestic product (GDP), mainly because of increased mortality and morbidity and decreased productivity.[1] To identify alternatives aimed at abating the cost of environmental degradation, this CEA examines institutional and policy issues in the functioning of the country's environmental management system and suggests some cost-effective interventions.

The analysis of environmental expenditures shows that current expenditures can be better aligned with the priorities of lower-income groups or with the most pressing problems associated with the cost of environmental degradation (Canal 2004).[2] In 2001, CARs allocated 28 percent of their investment funds to projects involving protection of flora and fauna and only 5 percent to pollution control projects other than wastewater treatment plants (Canal 2004). Although data are limited and must be interpreted cautiously, they suggest that the highest proportion of CAR investments have focused on the construction of wastewater treatment plants, water basin management, reforestation, and conservation (Blackman and others 2005).

The results of a 2004 survey of public perceptions about environmental problems in Colombia, which included a sample of 2,600 individuals from a wide range of regions, sectors, government agencies, civil society organizations, and ethnic groups (CNC 2004), complemented the analysis of the cost of environmental degradation. Approximately 80 percent of respondents identified air pollution as the top environmental problem, but there were significant differences in the perception of priorities among income groups. Whereas low-income groups identified air pollution, noise, and natural disasters as major problems, upper-income groups tended to perceive global environmental impacts (such as global warming and loss of biodiversity) and inappropriate land use in urban areas as high priorities.

Inadequate Water Supply, Sanitation, and Hygiene

Although Colombia has achieved substantial reductions in child mortality from diarrhea and other diseases, the costs associated with diarrheal morbidity from contaminated water and poor hygiene in both children and adults remain high. The poorest groups often lack adequate sanitation and water supply services. About 9 percent of the population does not have access to an improved water source, and the lack of sewerage in 20 percent of urban centers is a serious environmental problem for the country. These results are largely attributable to the absence of explicit cross-sectoral policies to reduce waterborne diseases.[3] The proportion of disability-adjusted life years (DALYs)[4] in Colombia that are attributable to unsafe water is in the 1.0 to 1.9 percent range, the same range as the rest of Latin America, with the exception of Bolivia, Ecuador, Guatemala, Peru, and Nicaragua, where the proportion is higher (WHO 2002).

Larsen (2004) estimates the health benefits of water supply and sanitation service provision based on a cost of diarrheal illness of Col$25,000 per case averted and a cost of US$58,500 per death averted in rural areas.[5] An analysis of alternative interventions to address waterborne diseases shows that the most effective intervention in Colombia would be the design and implementation of a safe water program to promote hygienic behavior through hand washing and improvements in water quality at the point of use (Larsen 2005).

Urban and Indoor Air Pollution

Air pollution is one of the most widespread and serious problems in Colombia's cities and rural areas. Although air pollution levels are moderate in most cities, the fact that close to 50 percent of the population lives in cities with more than 100,000 inhabitants creates substantial aggregate health effects, associated mainly with particulate matter. This results in health impacts such as cardiopulmonary diseases and lung cancers in adult segments of the population, and acute respiratory illness, particularly in children, including death from related diseases such as pneumonia. Analysis reveals that most of the associated cost of urban air pollution is linked to mortality and morbidity. Approximately 6,000 premature deaths occur each year as a result of outdoor air pollution.[6] An estimated 1,100 premature deaths are related to exposure to indoor air pollution, associated with fuelwood, charcoal, and other solid fuels used for cooking.[7]

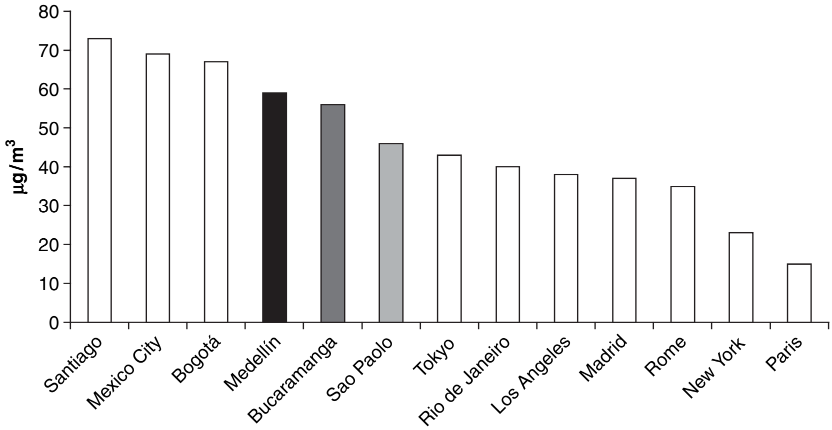
Urban air pollution resulting from transportation and industry has worsened and is most critical in the country's industrial corridors, such as Bogotá-Soacha, Cali-Yumbo, Medellín-Valle de Aburrá, Sogamoso, and Barranquilla. According to MAVDT (2006, p. 2), "particulate matter concentrations affecting public health present the greatest problem in the Puente Aranda, Kennedy, and Fontibón areas of Bogotá." With respect to indoor air pollution, there are no reliable time series data. Nonetheless, indoor air pollution and the health problems associated with it continue to pose challenges. Comparisons between the annual mean concentrations of particulate matter less than 10 microns in diameter (PM_{10}) in Colombia's main cities and those of other urban centers must be made with caution, because of the complexities and challenges associated with the measurement of these pollutants. In many cases, the cities have a monitoring network in which concentrations vary widely from one station to another or from one time period to the next; thus, the mean value may not accurately reflect the severity of air pollution. Yet, a first approximation suggests that PM_{10} concentrations in Bogotá are similar to those of other Latin American cities with severe air pollution, including Mexico City and Santiago (World Bank 2005). The differences in mean PM_{10} concentrations are much more obvious when compared with those of cities outside the region. Cities with larger industrial production and transportation sectors, such as Los Angeles, Tokyo, or Rome, have successfully reduced their ambient concentrations to levels that are lower than those of Medellín and Bucaramanga (figure 2).

The analysis indicates the need to update regulations and issue standards and economic instruments that minimize the concentration of fine particulate matter in the air. Some of the most promising options include reduction in the sulfur content of fuels and control of emissions from stationary and nonpoint sources, including the burning of agricultural residues. Possible options for the reduction of indoor air pollution include the use of cleaner fuels, technical mitigation such as improved cooking stoves, and policies that promote improved housing design. Furthermore, allocations of financial resources need to be increased to effectively address air pollution issues.

Natural Disasters

Colombia is vulnerable to natural disasters such as floods, droughts, and earthquakes, averaging 2.97 natural disasters per year, the third-highest rate among the 19 countries in the Latin American region. The largest

Figure 2 PM_{10} Average Annual Concentrations in Selected Cities



Source: World Bank 2005.
Note: µg/m^3 = micrograms per cubic meter.

number of natural disasters is related to floods and landslides. Insufficient drainage and the disposal of garbage in natural channels in most urban areas are important factors contributing to urban flooding. In the past quarter century, the country experienced six major earthquakes, three volcanic eruptions, three landslides, and three avalanches, with significant human and physical capital costs. It is estimated that more than 4 million Colombians were affected by natural disasters during 1993 to 2000, at an annual cost of approximately US$453 million (Echeverry 2002). In addition, an estimated 30,000 deaths were caused by these natural disasters, the third-largest figure for Latin America. The occurrence of these events has resulted in losses of more than US$4.5 billion, or 11.5 percent of the country's 1995 GDP. The poorest and most susceptible populations have paid the highest costs for these disasters in damages, deaths, and lost assets. To address this problem, comprehensive actions are needed, including the adoption of nonstructural measures to prevent human settlement in areas of high vulnerability to natural disasters.

Urban Environmental Management

Urban environmental issues include problems associated with housing and urban planning and with waste management. The three main actions suggested by the CEA to mainstream environmental considerations in urban planning and housing policies include (a) streamlining environmental issues in Land Use Plans (*Planes de Ordenamiento Territorial*); (b) preventing informal settlement in areas prone to floods, landslides, and other natural disasters; and (c) designing housing subsidy programs to reduce indoor air pollution and other forms of environmental degradation.

More than 700 open-air garbage dumps and inadequate waste disposal sites are located in municipalities throughout Colombia where public waste collection and disposal services are deficient. Very few of the nation's registered landfills operate effectively; in most cases, open-air garbage dumps and uncontrolled landfills threaten surface and groundwater in surrounding areas.[8] Deficiencies in the design and enforcement of environmental regulations and weak interinstitutional mechanisms for ensuring closure of open-air dumps and construction of adequate waste disposal sites have resulted in pervasive poor municipal waste disposal practices in Colombia.[9] Typically, the poorest live closest to open-air dumps and badly designed and operated landfills, which pose both environmental and health risks. Underscoring these challenges is the increase in shantytowns and informal housing in areas most susceptible to risks of natural disasters. This has resulted in increased vulnerability for greater numbers of poor people. Suggested actions to address these issues include the development of policies to operate effective regional waste disposal sites and the establishment and enforcement of regulations to segregate and treat hazardous wastes.

Water Resources Policies

Water resources are abundant in Colombia. The country has a national average freshwater supply of more than 59 liters per second per square kilometer ($l/s/km^2$), a figure nearly three times larger than that of other Latin American countries, where the average is 21 $l/s/km^2$.

In recent years significant progress has occurred in watershed management and recovery of wetlands at the national and local levels. At the national level, the program to rehabilitate the Ciénaga Grande de Santa Marta restored the ecosystem functions of one of Colombia's largest wetlands. At the local level, achievements have likewise been impressive. For example, in the late 1990s the municipal government in Bogotá implemented a comprehensive program to improve the quality of life in the city that included ecological restoration of the Juan Amarillo and El Salitre wetlands, complete with environmentally sensitive pedestrian walkways and bicycle paths, and the building or rebuilding of 1,243 parks that are visited by more than 1.5 million people annually.

Achievements in wastewater treatment include construction of new treatment plants in the cities of Medellín and Bucaramanga. In Medellín, the total cost of the program was about US$440 million, including construction of wastewater treatment plants in San Fernando and Bello. The *Corporación Autónoma Regional de Defensa de la Meseta de Bucaramanga* developed an upflow anaerobic sludge bed treatment plant that removes more than 50 percent of biochemical oxygen demand and total suspended solids. In addition, in the Bogotá Savanna, the Cundinamarca CAR has spent around US$50 million to build wastewater treatment plants for 21 municipalities in the upper Bogotá River watershed.

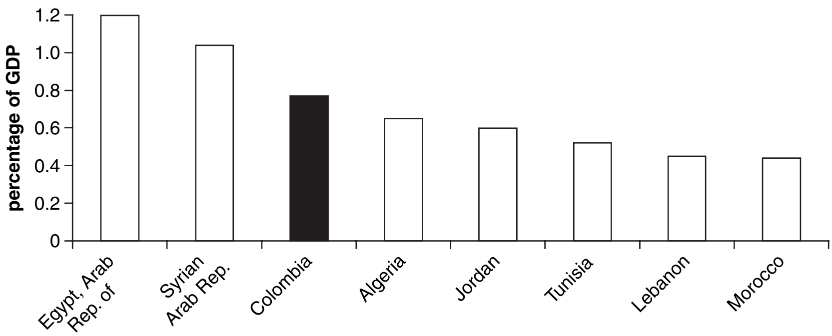
Recommendations to further strengthen the water sector's performance include (a) improving the existing regulations to control water pollution, including water pollution fees; (b) restructuring economic instruments to improve efficiency and equity; and (c) improving water quality standards for human consumption, recreational uses, and irrigation.[10] Likewise, strategies are advisable for the formulation, socialization, and implementation of programs for accountability, transparency, and governance to promote compliance with water quality standards.

Soil Degradation and Deforestation

Although problems associated with land degradation, particularly soil erosion, have worsened over time, they are comparable to those of other countries for which similar analysis has been performed (figure 3). The two most salient components of land degradation in Colombia are (a) erosion and salinization, and (b) deforestation. The need to improve interinstitutional coordination to address the problems of land degradation is evident.

Colombia has evolved rapidly over the past 50 years from being a country with a largely rural economy to one that is highly urbanized and more economically diverse. With a strong tradition of development planning, environmental priorities have focused on conservation of biodiversity and renewable natural resources, with impressive results. For instance, the system of national parks and forestry reserves encompasses nearly one-quarter of the national territory. In addition, deforestation rates, which stood at about 600,000 hectares per year in the 1970s and early 1980s, were reduced to an average of 145,000 hectares per year

Figure 3 Economic Cost of Soil Degradation in Selected Countries



Sources: Algeria: Ministère de l'Aménagement du Territoire et de l'Environnement 2002; Egypt: World Bank 2002; Jordan: METAP 2000; Morocco: World Bank 2003; Syria: Sarraf, Bolt, and Larsen 2004; Tunisia and Lebanon: Sarraf, Larsen, and Owaygen 2004.

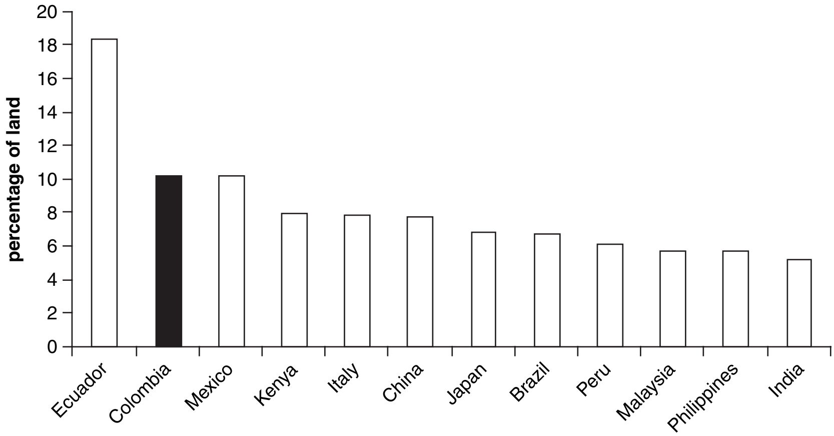
during 1986 to 96 (IDEAM 1998, p. 295). Combined with an increase in secondary forests of nearly 3.5 million hectares, there was actually a net gain in forest cover of 3.3 million hectares in 10 years (IDEAM 1998, p. 295). By 2004, the Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*) estimated a deforestation rate of 91,932 hectares per year (0.18 percent), which is similar to Peru but significantly lower than the average for Latin America and the Caribbean (0.5 percent), and significantly lower than countries such as Ecuador, El Salvador, Panama, and Mexico IDEAM 2004; SIAC 2002; World Bank 2005).

The analysis suggests that reforestation investments by departments, municipalities, environmental authorities, and CARs have minor impacts on erosion control or regulation of water streams.[11] Congress is currently discussing a national forestry law. Several stakeholders have recommended incorporating into the bill provisions to secure the rights of indigenous peoples and small farmers.

Global Environmental Problems

Some of the most salient global environmental problems in Colombia are biodiversity loss, climate change, and ozone depletion. The area covered by the national parks represents close to 10 percent of the national territory. In comparison with four other highly diverse Latin American countries, and countries in other latitudes, the percentage of protected land is considerable (figure 4).

Figure 4 Nationally Protected Areas in Selected Countries



Source: World Bank 2005.

While progress has been achieved in the creation of national parks, there is a need to further their success and guarantee their sustainability. To that end, legislation could be improved by increasing the importance of local economic, cultural, and social realities and expectations to ensure that the rights of local stakeholders are not harmed. Protected areas legislation has in some cases limited the use of traditional production systems and natural resources by local inhabitants. To overcome this the government is considering putting in place institutional mechanisms to prevent and resolve conflicts between conservation interests and other social priorities, such as regional, social, and economic development.

Regarding biodiversity, climate change, and ozone-depleting substances, Colombia has taken advantage of financial mechanisms such as the Global Environment Facility, the Prototype Carbon Fund, and the Montreal Protocol to finance private investments aimed at reducing emissions of greenhouse gas and ozone-depleting substances.

Institutional Strengthening

The Constitution of 1991 and Law 99 of 1993, which created the National Environmental System (*Sistema Nacional Ambiental*, SINA), reinforced the rights of every citizen to a clean and healthy environment. The SINA defines the roles of multiple stakeholders, including a central-level ministry responsible for overall policy formulation and coordination, CARS, and Urban Environmental Authorities (*Autoridades Ambientales Urbanas*) responsible for environmental enforcement and water resources development, and research centers responsible for collecting and disseminating environmental data (figure 5).

The SINA provides for a strong structure of multiple stakeholder involvement, decentralized management, and financial independence. Coordinating such a decentralized system poses significant challenges, including technical capacity, efficient regulations, enforcement, sufficient data, and mechanisms for public participation. The development of a system to identify environmental priorities and a mechanism to increase accountability of CARs are key steps to improving the SINA's effectiveness and efficiency.

The government has begun to address these challenges through a results-based framework to hold CARs accountable for their three-year action plans. Presidential Decree 1200 of 2004 established a system of indicators to measure the impacts and results of environmental investments at the regional level that links the Ten-Year Regional Environmental Management Plans (*Planes de Gestión Ambiental Regional*, PGARs) and Three-Year Action Plans (*Planes de Acción Trienal*, PATs) that each CAR is required to submit to the SINA. The PGARs provide a description of the principal challenges (for example, social, economic, cultural, and physical) facing the region, the CAR's strategy for managing environmental resources, financial requirements and potential sources of financing, and tools for monitoring and evaluating the program.

Conclusions

The highest costs imposed by environmental degradation in Colombia are from, in decreasing order of magnitude, waterborne diseases, urban air pollution, natural disasters, land degradation, and indoor air pollution. Combined, these environmental problems cost Col$7 trillion (US$3 billion), or 3.7 percent of Colombia's GDP (Larsen 2004).[12] The poor and vulnerable populations bear a disproportionately high amount of this cost. To address these problems, this report identifies a number of cost-effective policy interventions that could be adopted in the short and medium terms to support sustainable development goals.

In recent decades, considerable progress has been made in addressing the water and the forestry environmental agendas. The impact of environmental degradation on the most vulnerable groups suggests the need to increase emphasis on environmental health issues.[13] However, the environmental management agenda has yet to catch up with this shift in

Figure 5 Organizations of Colombia's SINA

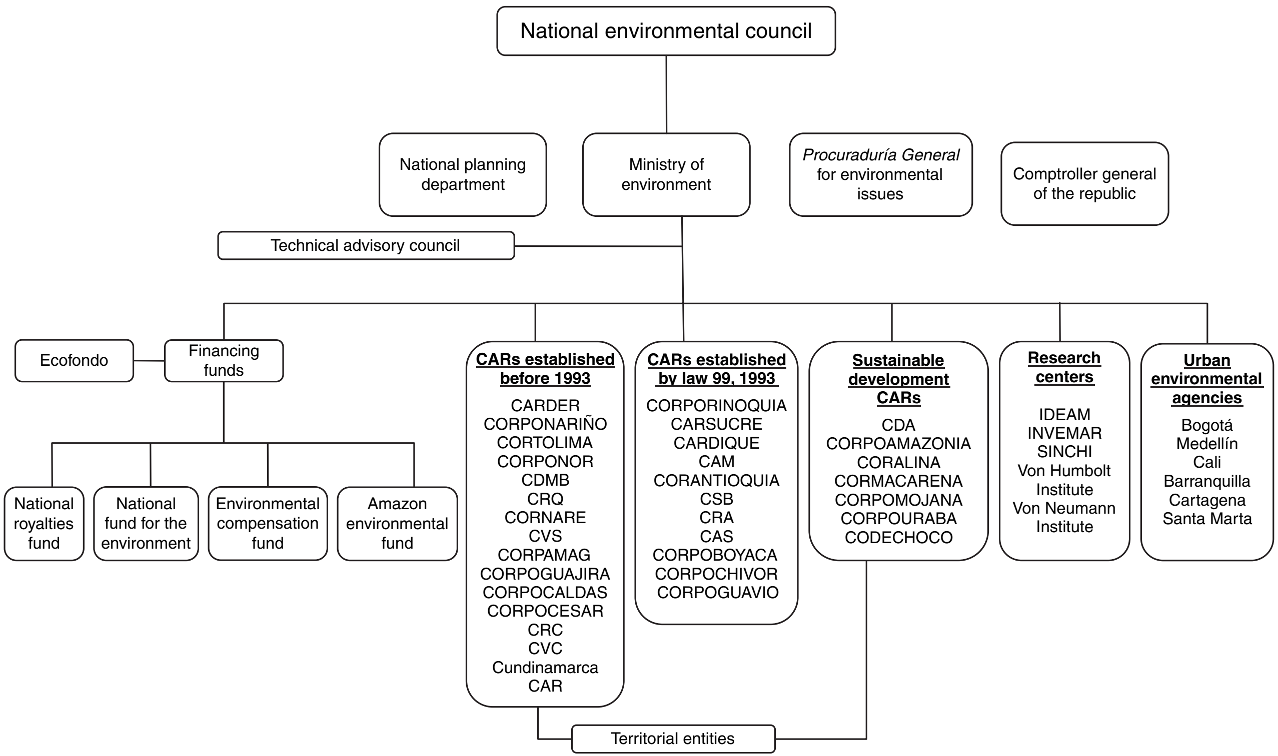


Table 1 Main Policy Options of the Report

Key issue	*Main policy options*
Need for strategic and systematic tools for priority setting	Design and implement a policy (through laws and regulations) to set environmental priorities at the national, regional, and local levels based tools for priority on learning mechanisms to periodically review and learn from the experiences of implementing environmental policies Install and implement systems to monitor and evaluate environmental management and the extent to which the objectives of environmental priorities are efficiently met Periodically evaluate progress on the implementation of policies to tackle environmental priorities with the support of the accumulation of data, results, and experiences achieved through intersectoral coordination and learning
Need for strengthening institutions' capacity to address environmental priorities, particularly in environmental health	Mainstream environmental considerations in policy formulation by strengthening SINA institutions' capacity in priority areas through, for example, strategic environmental assessments in (a) environmental health, (b) vulnerability to natural disasters, and (c) sustainable urban development
High cost of environmental degradation associated with waterborne diseases	Design and implement a safe-water program that includes components dealing with hand washing and point-of-use disinfection of drinking water Facilitate private sector participation in water supply and sanitation Modify water pollution fee system (*tasas retributivas*) to promote the construction of sewerage collection systems Formulate and implement actions to promote compliance with drinking water quality standards Modify laws and regulations on parameters of effluent standards so that pathogens and toxic and hazardous substances are regulated
High cost of environmental degradation associated with air pollution	Revise and establish national standards for $PM_{2.5}$ and PM_{10} in priority urban areas and update major emission standards for mobile and nonpoint sources to reflect new scientific and technological advances Implement air pollution control interventions, such as promoting the improvement of fuel quality in transport and industry sectors; expanding the use of natural gas to replace coal and oil; and establishing emissions control from stationary, mobile, and nonpoint sources Implement an air quality monitoring program to monitor $PM_{2.5}$ and PM_{10} in priority urban areas Implement and enforce regulations (including Resolution 0532 of 2005) to control air pollution emissions and appropriate monitoring methods for "green cut" of sugarcane (green cut refers to using

Table 1 Main Policy Options of the Report (*continued*)

Key issue	*Main policy options*
	manual or mechanical methods to remove sugarcane instead of burning out the fields for planting)
	Reform compliance and enforcement systems to include the adoption of a more severe penalty system
	Introduce more rigorous approaches to vehicle emissions testing
Morbidity and premature deaths associated with indoor air pollution	Promote the use of cleaner fuels in areas that predominantly use fuelwood in an accessible, safe, and cost-effective manner
	Implement a program to promote improved stoves
	Extend the coverage of rural electrification programs
	In subsidy programs for rural low-income housing, include requirements for building codes and housing design in poor communities to allow for improved ventilation and optimal chimney design
Vulnerability to natural disasters	Increase efforts to prevent natural disasters, especially floods and landslides, through activities that focus on incorporating disaster prevention in land use plans, drainage improvements, warning systems, and regulations prohibiting informal settlement in areas prone to risks of natural disasters
	Develop a permanent system of performance indicators for reduction of vulnerability to natural disasters
	Define the specific roles of each national- and regional-level member of the National Disaster Preparedness and Response System and the SINA, particularly CARs
	Create stronger incentives for inclusion of disaster considerations in environmental impact assessments and environmental licensing
	Periodically conduct national, regional, and local risk assessments
	Require all levels of government to use comparative risk assessment to guide allocations of financial, human, and technical resources
	Establish priorities for disaster monitoring and alert systems based on comparative risk assessment
Requirements for improved urban environmental conditions	Devise concrete ways to integrate environmental conditions into urban planning and management tools after reviewing the legal and regulatory framework of environmental and urban legislation
	Define and include environmental criteria in the eligibility criteria of Social Interest Housing projects
	Address structural land supply problems and reduce costs of formality
	Strengthen upstream enforcement of existing regulations and planning documents to prevent occupation of hazardous sites
	Enforce land use plans so that decisions on siting of landfills are consistent with zoning regulations contained in those plans
Need for improved water resource management	Reexamine the roles of government bodies and create more efficient cooperative mechanisms
	Find an economically efficient approach to wastewater treatment, and control discharges of pathogens and hazardous wastes

(*continued*)

Table 1 Main Policy Options of the Report (*continued*)

Key issue	*Main policy options*
	Ensure the collection and public disclosure of information related to water availability and water demands
	Ensure that the economic value of water is adequately reflected in water fees
Land degradation and deforestation	Identify the costs and benefits of alternative interventions to control soil erosion and soil salinization
	Generate alternatives to diversify nontimber forest products and improve the livelihoods of forest-dwelling communities
	Establish the analytical mechanisms to foster the capacity for both indigenous communities and the rural poor to profit from the sustainable and productive uses of forest areas and the implementation of payments for environmental services

Note: $PM_{2.5}$ = Particulate matter less than 2.5 microns in diameter.

priorities from watershed and forestry to environmental health problems because mechanisms in the current institutional structure to signal these changes are not yet in place.[14] Improved monitoring and dissemination of information on environmental outcomes, assignment of accountability for environmental actions and outcomes, and involvement of a broad range of stakeholders are three important mechanisms to allow these signals to be picked up.

The main policy options of the report are summarized in table 1.

Notes

1. Estimates of social and economic costs of environmental damage in Colombia are based on the national estimates presented in Larsen (2004). Although the analysis of the cost of environmental degradation relied extensively on large sets of statistics and data from various ministerial departments, institutions, and institutes in Colombia, the analysis was restricted by data limitations (Larsen 2004). Costs of deforestation and water pollution are only partially and indirectly estimated because of data limitations. Some of the cost of deforestation is captured in the cost of natural disasters (flooding, landslides) and agricultural land degradation insofar as deforestation contributes to natural disasters and soil erosion. Other costs of deforestation, such as impacts on water resources and recreational value, are not estimated. The cost of water pollution is captured only in terms of waterborne (diarrheal) illnesses. Other costs, such as potential impacts of heavy metals and chemicals on health and recreational value, or biodiversity loss are not estimated.
2. Estimates of public environmental expenditure in Colombia are based on a public environmental expenditure review prepared by Canal (2004).

3. According to government information (CONPES 3343 2005, p. 10), "28 percent of municipalities lack potable water services and 40 percent do not possess sewerage connections. Sewerage coverage levels increased between 1980 and 2005." Analysis conducted by the government (MAVDT 2006, p. 2) indicates that "although national budgetary resources have been directed toward addressing these coverage deficiencies, there have been problems in the efficiency and execution of resource expenditures, which is not to say that policies aimed at addressing the problem of basic sanitation in Colombia do not exist."
4. DALYs are a standard measure of the burden of disease. DALYs combine life years lost as a result of illness and disability, with one DALY being equal to the loss of one healthy life year (Murray and López 1996).
5. Data series published by the National Statistical Administration Department (*Departamento Administrativo Nacional de Estadísticas*, DANE) indicate that about 7.3 percent of child mortality is from diarrheal illness. For diarrheal morbidity, however, it is very difficult or practically impossible to identify all cases of diarrhea. The main reason is that many cases are not treated or do not require treatment at health facilities, and are therefore never recorded. A second reason is that cases treated by private doctors or clinics are most often not reported to public health authorities. Therefore, household surveys often provide the most reliable indicator of total cases of diarrheal illness. However, most household surveys contain only information on diarrheal illness in children. Moreover, the surveys only reflect diarrheal prevalence at the time of the survey. Because there is often high variation in diarrheal prevalence across seasons of the year, extrapolation to an annual average will result in either an over- or underestimate of total annual cases. It is often difficult to correct this bias without knowledge of seasonal variations.
6. Morbidity and mortality estimates are based on the risk ratio, or dose response coefficients by Pope and others (2002). Pope and others (2002) found a statistically significant relationship between levels of particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and mortality rates; all-cause mortality increased by 4 to 6 percent for every 10 micrograms per cubic meter increase in $PM_{2.5}$.
7. Smith (2000) provides a review of research studies around the world that have assessed the magnitude of health effects of indoor air pollution from use of solid fuels. The odds ratios for acute respiratory illness and chronic obstructive pulmonary disease used for estimating health risks associated with indoor air pollution in Colombia are based on Smith (2000).
8. According to government information (CONPES 3343 2005, p. 10), the majority of Colombia's municipalities "dispose of their solid waste by discharging wastes in open garbage dumps or in surface waters, or by burying or openly burning waste." The government considers "the primary difficulties in the disposal of solid wastes to include: (i) inadequate municipal planning with respect to the useful life of landfills, the assignment of resources, and the lack

of an organized system to charge users for services; (ii) insufficient knowledge regarding the impacts of inadequate disposal on public health and quality of life (harmful gases, increased illnesses, and polluted water bodies, soils, and ecosystems); and (iii) technical, operating, and planning specifications in the current norms that are inconsistent with the capacity of municipalities" (CONPES 3343 2005, p. 10).

9. Title F of Resolution No. 1096 (Technical Regulations for the Potable Water and Basic Sanitation Sector) establishes technical specifications for the final disposal of waste in sanitary landfills. In addition, Decree 838 of 2005 determines a number of criteria for the location of waste disposal sites.
10. In Colombia, diverse economic instruments have been developed for the provision of potable water and sewerage services and to improve water resources management, including "a tariff system for public water and sanitation services, charges for water usage, and pollution charges" (MAVDT 2006, p. 3). According to MAVDT (2006), to address the weaknesses and needed improvements of current economic instruments aimed at controlling pollution, the proposed Water Law presented to Congress in 2005 includes structural reforms such as the redesign of water usage charges and water pollution charges.
11. According to MAVDT (2006, p. 3), "since 1994 the Ministry, supported by International Bank for Reconstruction and Development and International Development Bank financing, has carried out reforestation programs that have required effective coordination among regional environmental authorities, territorial entities, and civil society. These reforestation programs have centered on protecting watersheds and not on controlling erosion. However, environmental authorities from some regions (Caldas, Antioquía, Cundinamarca) have invested in controlling soil erosion for decades. Although the government has not directed national resources toward preventing erosion, which has been effectively managed at the regional level, this does not imply that coordination does not exist. It should be kept in mind that there are considerable investments in this area, and that budgetary restrictions and the need to attend to other priorities have limited the national government in addressing this area."
12. Although the analysis relied extensively on large sets of statistics and data from various ministerial departments, institutions, and institutes in Colombia, the analysis was restricted by data limitations (Larsen 2004).
13. The recommendation of assigning a higher priority to the environmental management actions that provide the greatest benefits to the most vulnerable segments of the population does not imply that the areas of forestry and water basin management should be removed from the environmental agenda.
14. For MAVDT (2006, p. 3), "the limitations of the analysis conducted and the fact that quantitative assessments of the impact of watershed management and reforestation actions in Colombia are not included in the analysis do not

permit the Ministry to conclude that less priority should be placed on allocating resources to these areas."

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CHAPTER 1

Overview

In the past 50 years, Colombia has succeeded in establishing a decentralized and innovative environmental management framework that includes roles for multiple stakeholders. The National Environmental System (*Sistema Nacional Ambiental*, SINA) defines roles for different stakeholders, including financially independent regional environmental agencies, a central-level ministry responsible for overall policy formulation and coordination, and research institutes responsible for collecting and disseminating environmental data. The SINA also defines a role for nongovernmental organizations (NGOs) through their involvement on the boards of regional agencies, and for the private sector through its significant involvement in a Technical Advisory Council to advise on policy formulation. Intersectoral coordination is promoted through the National Environmental Council, which comprises representatives from 25 organizations including nine ministers (Planning; Agriculture; Health; Mines and Energy; Education; Transport; Defense; Commerce; and Environment, Housing, and Regional Development) and six representatives from business and industry associations (oil and gas, mining, export, manufacturing, forestry, and agriculture).

Environmental degradation in Colombia disproportionately affects the health and productivity of poor people. The impact of human activities on the environment threatens the well-being of current and future generations by creating problems such as (a) localized environmental health problems associated with inadequate household water quality, sanitation, and hygiene and with indoor air pollution; (b) urban and regional air pollution, suboptimal waste management, and contamination of rivers, lakes, and coastal areas; and (c) natural resource degradation and worsening of global environmental problems such as global warming.

In Colombia, lack of access to clean water, poor or nonexistent sanitation services, and indoor air pollution are among the principal causes of illness and death, predominantly for children and women in poor households. The effects of these principal causes of environmental degradation are estimated to cost more than 3.7 percent of Colombia's gross domestic product (GDP), mainly because of increased mortality and morbidity and decreased productivity associated with four causes (Larsen 2004). The first is poor ambient air quality in urban areas caused by industrial, commercial, residential, and vehicle emissions, and poor indoor air quality in rural areas caused by the use of fuelwood for cooking and heating. The second is insufficient water supply, sanitation, and hygiene. The third is natural disasters. The fourth is land erosion and salinization (Larsen 2004).

Over the past five decades, Colombia has restructured its legal and regulatory landscape, undertaken numerous policy initiatives, and dramatically expanded and strengthened its institutional capacity for protecting and managing the natural resources and environmental quality that are vital to sustainable growth and poverty reduction. Although the government made significant advances, such as establishing a system of national parks and forestry reserves that covers nearly a quarter of the national territory and phasing out leaded gasoline, it still faces the serious challenge of slowing and reversing environmental degradation.

Objectives of the Country Environmental Analysis

The objective of the country environmental analysis (CEA) is to present an analytical framework to support the efforts of the government of Colombia toward achieving the Millennium Development Goals (MDGs). Particular focal points are Goal 7, ensuring environmental sustainability, and two of the targets within Goal 7—Target 9, integrating the principles of sustainable development into country policies and programs and reversing the losses of environmental resources, and

Target 11, achieving a significant improvement in the lives of urban slum dwellers.

Through its examination of urban environmental issues such as air pollution and untreated drinking water, which affect the most vulnerable population groups, CEA also provides the analytical underpinnings to design policies aimed at achieving MDG 4, which aims to reduce child mortality, by addressing the causes of respiratory illness, diarrhea, and other principal factors in morbidity and mortality for children under age five.

The findings of CEA are specifically expected to help design and implement policies to (a) improve the effectiveness and efficiency of Colombia's SINA and (b) integrate principles of sustainable development into key sector policies, with an emphasis on protecting the most vulnerable groups. The main elements of CEA include analyses of (a) the institutional capacity for environmental management in Colombia; (b) the cost of environmental degradation; and (c) the effectiveness and efficiency of existing policy, and legislative and regulatory frameworks to address priority environmental concerns.

CEA Process and Summary

Preparation of CEA began in January 2004, in parallel with the preparation of the Programmatic Development Policy Loan for Sustainable Development. The findings of the main studies conducted during CEA were presented to national stakeholders and development partners at an August 2004 workshop in Bogotá. From January to September 2004, a number of smaller workshops and meetings were held to discuss methodology, gather data, and discuss emerging results with smaller stakeholder groups. These groups included representatives from sectoral ministries, Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs), the control agencies, academia, the private sector, Congress, the National Planning Department (*Departamento Nacional de Planeación*, DNP), bilateral agencies active in Colombia, and other development partners.

The report has 14 chapters. Chapter 1 presents an overview of the report. Chapter 2 examines the evolution of Colombia's environmental management framework over the period from 1952 to 2005, including the establishment of CARs; the development of the National Code for Renewable Natural Resources and Environmental Protection, which remains Colombia's most important environmental management regulation; the role of the Ministry of Health in pollution control; the passage and implementation of the National Sanitary Code of 1979; and the establishment in 1993 of the Ministry of Environment and 33 CARs as part of the newly organized SINA. Also discussed is the government of Colombia's 2002 decision to merge the Ministries of Environment and Development and to phase out the Environmental Directorate in the National Planning Department.

Chapters 3 and 4 analyze the performance of various SINA agencies, including the Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT); research centers; environmental financing funds; the control authorities; and CARs. Chapter 4 identifies the major challenges to mitigating environmental degradation and includes a series of suggested actions to tackle identified institutional problems.

Chapter 5 analyzes the cost of environmental degradation in Colombia. The analysis shows that the environment-related problems with the highest costs are urban and indoor air pollution; inadequate water supply, sanitation, and hygiene; natural disasters; and land degradation. The burden of these costs falls most heavily on vulnerable segments of the population, especially poor children under age five. Chapter 5 also presents the results of a 2004 survey of public perceptions about Colombia's environmental problems and reveals that while the vast majority of respondents identified air pollution as the top environmental problem, there were significant differences in priorities among income groups. The analysis supports the notion that the most vulnerable groups, who bear the greatest costs of environmental degradation, traditionally have not been taken into account in policy making and lack an effective voice as a constituency.

Chapter 6 shows that although Colombia has achieved substantial reductions in child mortality, including mortality from diarrheal diseases, the costs of diarrheal morbidity from contaminated water and poor hygiene in both children and adults is still high. The poorest groups often lack adequate sanitation and water supply, largely because of the lack of policies that explicitly address these problems. Alternative interventions are analyzed to address waterborne diseases.

Chapters 7 and 8 show that air pollution is one of the most widespread and serious problems in Colombia's cities and rural areas. Although air pollution levels in most cities are moderate, close to 50 percent of the population is concentrated in large cities (with more than

100,000 inhabitants) where the pollution problems and health effects are the worst, especially from particulate matter. The chapters conclude that there is an urgent need to update regulations and issue standards and economic instruments aimed at reducing airborne particulate matter, and to allocate sufficient financial and human resources to address air pollution, leading to the use of cleaner fuels, improved cook stoves, and better housing design.

Chapter 9 discusses urban environmental management issues and highlights two main sets of problems associated with housing and urban planning and with waste management and disposal. Although few regulations are in place on these issues, environmental authorities have not made them a high priority or allocated sufficient financial resources from the Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs) and the national government to address problems such as how to adequately manage the roughly 27,500 tons of solid waste generated daily in Colombia. The chapter addresses the importance of developing policies to operate effective regional waste disposal sites and establish and enforce regulations to segregate and treat hazardous wastes.

Chapter 10 discusses problems associated with natural disasters, particularly floods and landslides, the management of which falls under the mandate of SINA. More than 4 million Colombians were affected by natural disasters during 1993 to 2000, at an annual cost of approximately US$453 million (Echeverry Garzón 2002). The poorest and most vulnerable have paid the highest costs for these disasters in damages, deaths, and lost assets. A number of actions are recommended to address this issue, particularly nonstructural measures to prevent human settlements in areas that are highly vulnerable to natural disasters.

Chapter 11 discusses problems associated with water resources management, and particularly allocation of water rights and degradation of water bodies. Existing regulations do not efficiently respond to some of the most urgent problems related to the allocation of water rights, such as small farmers' and indigenous peoples' access to water rights. In addition, national regulations often create bottlenecks in managing water resources and processing water permits and are ineffective in controlling the degradation of watersheds and water bodies. The chapter provides recommendations in several areas, including water quality and hazardous pollutants, sources of pollution, water runoff and urban drainage, vulnerability to natural disasters, conservation of important water ecosystems, and clarification of the roles of government agencies involved in water resources management. The chapter also addresses the need to reform water pollution fees and wastewater discharge standards and to increase accountability, transparency, and governance to promote compliance with water quality standards.

Chapter 12 discusses erosion, salinization, and deforestation, and illustrates the need for stronger efforts to address the problems of land degradation. The analysis suggests that the investments made in reforestation by states, municipalities, environmental authorities, and CARs have had little or no impact on erosion control and regulation of water streams. The chapter recommends incorporating provisions into the proposed national forestry bill that would secure the rights of indigenous peoples and small farmers.

Chapter 13 discusses the most salient global environmental problems perceived in Colombia: biodiversity loss, climate change, and ozone depletion. The analysis emphasizes the challenges associated with the National Parks System. It suggests that the creation of national parks by the government could have been more sensitive to the rights of local stakeholders. Protected areas legislation, which is still in effect, has limited the use of traditional production systems and natural resources by local inhabitants and has allowed parks to be created on private lands with unclear compensation measures for land taken. The chapter recommends that institutional mechanisms be established to prevent and resolve conflicts between conservation interests and other social priorities, such as regional, social, and economic development.

Chapter 14 summarizes the main conclusions and finds that the institutional system might need to be strengthened to effectively support government efforts to promote environmentally sustainable development, in particular by allocating human and financial resources to address key environmental priorities that are linked to economic development. The chapter highlights the need for policy and institutional changes to address these priorities and to target complementary investments toward areas that impose high economic costs but that have not been adequately tackled. In particular, increased efforts are needed to improve the quality of life of the growing number of poor people living in and around urban areas in a country where more than 70 percent of the population is urban. The goal of the recommendations is to support the country's efforts to move toward more equitable and sustainable economic growth.

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CHAPTER 2

A Unique Model for Environmental Management

The evolution of Colombia's environmental institutions over the past 50 years has led to a unique decentralized environmental management framework. Over the period from 1952 to 1974, a decentralized water resources development system was established through the creation of Autonomous Regional Corporations (CARs) and the National Institute of Renewable Natural Resources (INDERENA). In 1974, Colombia's most important environmental regulation, the National Code for Renewable Natural Resources and Environmental Protection, was developed. During 1975 to 1993, INDERENA was very effective in establishing a system of national protected areas, and CARs were also effective in developing water resources and other infrastructure projects. The 1991 Constitution and Law 99 of 1993 led to the creation of Colombia's National Environmental System (SINA). During 1994 to 2005, SINA agencies focused their efforts on implementing environmental investment projects in watershed management, reforestation, and construction of wastewater treatment plants. After 2002, the Ministries of Environment and Development merged, opening opportunities for environmental mainstreaming.

This chapter examines the evolution of Colombia's environmental management framework during three periods between 1952 and 2005. The findings of this chapter are based on secondary information and interviews conducted in Colombia in 2004.[1]

In 1952, Colombia created the Division of Renewable Natural Resources within the Ministry of Agriculture. Two years later the first Autonomous Regional Corporation (*Corporación Autónoma Regional*, CAR), the Autonomous Regional Corporation of the Cauca Valley (*Corporación Autónoma Regional del Valle del Cauca*, CVC), was established to promote integrated economic development in the Cauca Valley region. These two organizations were the beginning of what would become an independent environmental ministry, a coordinated national environmental system, and an extensive network of financially autonomous regional environmental authorities.

Environmental regulations approved in the 1960s and 1970s included the 1969 Forestry Law, a 1977 statute creating the National Parks System, and a 1973 statute on flora and fauna. By far the most important new legislation, however, was the 1974 National Code for Renewable Natural Resources and Environmental Protection (*Código Nacional de Recursos Naturales y de Protección al Medio Ambiente*, CNRN), a comprehensive statute that remains Colombia's most important regulation for environmental and natural resources management. The code has 340 articles covering water, air, solid and hazardous waste, soil, flora, and fauna, and it was one of the first environmental protection laws in the world to incorporate pollution fees and environmental impact assessments.

During the 1980s, Colombia designed and implemented air and water pollution control regulations. The 1991 Constitution and Law 99 of 1993 marked the formation of both the National Environmental System (*Sistema Nacional Ambiental*, SINA), which established 37 organizations for environmental management and research in the country, and the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA). In 2003, the Ministry of Environment was merged with the Ministry of Economic Development to form the current Ministry of Environment, Housing, and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT). This study reviews SINA's evolution and presents in chapters 3 and 4 the results of two different institutional assessments of its current functioning.

Institutional and Legal Foundations: 1952–74

Since the early 1950s, the Colombian environmental management framework has been evolving as a decentralized structure based on regional agencies. This section provides a brief overview of the development of Colombia's environmental institutions and capacity through 1974, when the government issued the CNRN. Modern national environmental management in Colombia began in 1952 with the creation of the Division of Natural Resources within the Ministry of Agriculture. The division's mission was to ensure the rational development of natural resources such as forests and fisheries. Administration was centralized and funding was derived exclusively from the national budget, in line with an institutional structure that was virtually universal in Colombia at the time (MMA 2002; Sánchez-Triana 1999). Under the division's leadership, Colombia's first forest conservation regulations were issued and seven sizable protected areas were created (MMA 2002).

Colombia's first regional development corporation was the CVC, created in 1954 to promote integrated regional economic development (MMA 2002). The CVC's geographic boundaries were defined by the Cauca Valley watershed. The CVC's design was strongly influenced by contemporary thinking about development planning in North America and Latin America and was modeled after the U.S. Tennessee Valley Authority (Arboleda and others 1981, 1982).

From 1954 to 1993, the functions of regional development corporations, CARs, were associated with the promotion of regional economic development.[2] This has allowed them to pursue a wide range of activities, including energy generation and transmission projects, road infrastructure, erosion control, and telecommunications. During 1954 to 1993, CARs gave priority to infrastructure and agricultural development projects whose broad mandates allowed them to carry out activities in different areas, including subsidizing some economic sectors through the transfer of financial resources (such as setting up and managing irrigation schemes).

In 1961, the National Congress established the Corporation for the Magdalena Valley and Northern Colombia (*Corporación del Valle del Magdalena y Norte de Colombia*, CVM) and the Corporation for the Bogotá Savanna and the Ubaté and Chiquinquirá Valleys (*Corporación Autónoma Regional de la Sabana de Bogotá y los Valles de Ubaté y Chiquinquirá*, CAR). The mandate of these organizations was to develop water resources and infrastructure linked with agricultural development (Arboleda and others 1981, 1982). The CVM was established to promote economic development in the Magdalena River Valley, but it was soon found that other government agencies had overlapping functions in these areas. Therefore, the CVM specialized in natural resources conservation, establishment and management of national parks, and reforestation (Currie 1988).

In 1965, the city of Bucaramanga established a partnership with two national government entities, the Institute for Territorial Credit and the Institute for Municipal Development. This association was called the Automonous Regional Corporation for the Defense of the Bucaramanga Plateau (*Corporación Autónoma Regional de Defensa de la Meseta de Bucaramanga*, CDMB) and was later converted into the sewerage utility of Bucaramanga (Arboleda and others 1981, 1982). See table 2.1 for some of the characteristics of CARs established during this time.

During 1955 to 1968, CARs were attached to the Ministry of Development, because they were established to promote regional economic development. In 1964, Congress established the Autonomous Regional Corporation of Quindío (*Corporación Autónoma Regional del Quindío*, CRQ) to promote rural electrification in a department of the coffee-growing area, followed in 1968 by the Corporation for the Sustainable Development of the Chocó (*Corporación para el Desarrollo Sostenible del Chocó*, CODECHOCO) to promote economic development in the Pacific region and to build a canal linking the Pacific and the Atlantic oceans using the Atrato River. The Corporation for the Sustainable Development of Urabá (*Corporación para el Desarrollo Sostenible del Urabá*, CORPOURABA) was also established in 1968 to

Table 2.1 Characteristics of Corporations Established during 1954 to 1971

Name	*Created*	*Principal responsibilities*	*Area of jurisdiction*
CVC	1954	Development of water resources	Upper parts of the Cauca River
CVM	1960	Development of water resources	Magdalena River
CAR	1961	Development of water resources, telecommunications, and infrastructure	Bogotá Savanna and the valleys of Ubaté and Chiquinquirá
CRQ	1964	Transmission and distribution of energy	Department of Quindío
CDMB	1965	Soil erosion control and sewerage services	City of Bucaramanga
CODECHOCO	1968	Development of infrastructure	Department of Chocó
CORPOURABA	1968	Rural and agricultural development	Urabá zone in the Department of Antioquía
CRAMSA	1971	Erosion control	Cities of Manizales, Salamina, and Aranzazu

Source: Sánchez-Triana 1999.
Note: CODECHOCO = Corporation for the Sustainable Development of the Chocó (*Corporación para el Desarrollo Sostenible del Chocó*), CORPOURABA = Corporation for the Sustainable Development of Urabá (*Corporación para el Desarrollo Sostenible del Urabá*), CRAMSA = Autonomous Regional Corporation of Manizales, Salamina, and Aranzazu (*Corporación Autónoma Regional de Manizales, Salamina, y Aranzazu*), CRQ = Autonomous Regional Corporation of Quindío (*Corporación Autónoma Regional del Quindío*).

promote improvement in public services, integrate road networks, and promote agricultural activity in the banana-growing areas (Arboleda and others 1981). In 1973, the Autonomous Regional Corporation of the Sinú and San Jorge River Valleys (*Corporación Autónoma Regional de los Valles del Sinú y San Jorge*, CVS) was established to develop water resources projects and promote agricultural development in northeastern Colombia. The original mission of some corporations was to promote reconstruction in areas affected by natural disasters. For example, at the beginning of the 1970s Congress established the CAR for Manizales, Salamina, and Aranzazu (*Corporación Autónoma Regional de Manizales, Salamina, y Aranzazu*, CRAMSA) to control landslides and soil erosion.

By 1961, watersheds ceased to define the geographic boundaries of CARs, in large part because each of Colombia's departments wanted to have its own CAR (Rodríguez Becerra 1998). During this period, national funding accounted for approximately half of CAR budgets. The other half was generated by fees for the provision of sanitation and other services, water pollution fees, and municipal property taxes, among others.

Although the majority of CARs focused their resources on building of infrastructure, land development, and ranching, their functions were quite varied and included electricity generation and transmission, telecommunications, transportation, flood control, sanitation, potable water, and cattle ranching (Sánchez-Triana 1999). Although they were first attached to the Ministry of Economic Development (1960–68) and then to the Ministry of Agriculture (1968–77), they retained responsibility for management of natural resources and economic development (MMA 2002; Sánchez-Triana 1999, 2001).

In 1968, Presidential Decree 2429 transformed the CVM into the National Institute of Renewable Natural Resources (*Instituto Nacional de los Recursos Naturales Renovables*, INDERENA) by fusing it with the Division of Renewable Natural Resources in the Ministry of Agriculture. By this time, the CVM was perceived as an effective and necessary organization for natural resources conservation; at its conversion to INDERENA (Carrizosa y Asociados 1990; Currie 1988) its area of jurisdiction was broadened to cover the entire national territory. INDERENA's principal responsibilities were management of the National Parks System and promotion of investment projects in fisheries and reforestation (Sánchez-Triana 1999).

Under INDERENA's leadership, Colombia made a number of important advances in environmental management, including the 1969 Forestry

Law and the 1974 National Code for Renewable Natural Resources and Environmental Protection (Suárez, Montenegro, and Carrasquilla 2005).[3] The code's first regulatory decrees, issued between 1974 and 1978, dealt with a variety of topics, including management of forestry reserve areas, provision of environmental education, and protection of wild fauna and hydrobiological resources (MMA 2002).

Expansion of Roles and Legal Frameworks: 1975–93

CARs were attached to the Ministry of Agriculture until 1977, and then to the National Planning Department (*Departamento Nacional de Planeación*, DNP) between 1977 and 1993. In 1987, CARs' responsibilities were clarified by transferring functions such as road infrastructure and telecommunications to other specialized entities. CARs kept responsibility for management of natural resources and economic development (Sánchez-Triana 1999).

In the 1980s, Congress established many CARs, including CARDER, CORMAGDALENA, CORNARE, CORPOCESAR, CORPOGUAJIRA, and CORTOLIMA, and gave them responsibility for implementing projects in water resources, natural resources management, environmental sanitation, erosion control, and other infrastructure to promote regional development. Congress also gave CARs responsibility for controlling water pollution. Two other CARs were established in the 1980s, the Corporation of Nariño-Putumayo (C*orporación de Nariño-Putumayo*, CNP) and the Autonomous Regional Corporation of Frontera Nororiental (C*orporación Autónoma Regional de la Frontera Nororiental*, CORPONOR). The mandate of these CARs was economic development in the border areas with Ecuador and República Bolivariana de Venezuela, respectively.

During 1954 to 1993, most of the investments made by the corporations were directed toward energy and infrastructure. Five of these corporations (CAR, CODECHOCO, CORNARE, CRQ, and CVC) focused on electricity transmission and distribution programs, and only one (CVC) focused on electricity generation. The CVC constructed nearly 3,000 kilometers of electricity lines.

The corporations also gave priority to developing the agricultural sector, which traditionally was very important in the portfolio of state investment projects as a way for local politicians to stimulate the agricultural economy. The corporations' investments in this sector included irrigation and drainage districts, training, credit, technical assistance and agricultural extension services, marketing, and animal vaccinations. CARs also initiated integrated watershed management projects, which included reforestation, land use management, erosion control, and aquaculture.

The CVC's Salvajina project, begun in 1979, was the largest and most important civil works project related to hydroelectric power development, flood control, and pollution control that was ever undertaken by a CAR. This project became the source of many environmental regulations enacted in Colombia, such as water pollution charges. Infrastructure projects carried out by CARs, specifically the Autonomous Regional Corporation of Cundinamarca (*Corporacíon Autónoma Regional de Cundinamarca*, CAR), CODECHOCO, CORPOURABA, CORTOLIMA, CRQ, and CVC, include construction of urban and rural roads, bridges, airports, transportation terminals, markets, health centers, schools, and housing. In the area of communications, CAR Cundinamarca, together with the state-owned telecommunications company (Telecom), expanded the rural telephone system in 24 municipalities in the Bogotá Savanna, including construction of 600 kilometers of new lines to create automatic connections among 41 municipalities. At the same time, financing, construction, and operation and maintenance of the water and sewerage systems and the urban trash collection system were a major portion of CARs' investments. The corporations carried out more than 180 water sanitation projects, with one corporation, CDMB, serving as the sewerage utility for the city of Bucaramanga.

The CAR Cundinamarca's 1985 Regional Master Plan for Environmental Quality stands out among the environmental sanitation projects. Under this plan, the CAR Cundinamarca built and put into operation wastewater treatment plants in some municipalities of the Bogotá Savanna, and in 1991, it took a Col$107,500 million (US$50 million) loan from the Inter-American Development Bank for a program that included the construction of 23 municipal wastewater treatment plants, 25 sanitary landfills, and 9 systems for pretreatment and clean production in municipal slaughterhouses.

While the corporations were engaged in a variety of activities, their main priority was building infrastructure for water resources. These projects allowed resources to be transferred from their sources to support development of other sectors such as agriculture. The corporations financed their activities with funding from the national budget, the property tax (particularly CAR Cundinamarca), transfers from the electricity sector (particularly CORNARE), windfalls from mining (particularly CVS), and tariffs on electricity (particularly CVC). Total budget expenditures by the regional corporations during 1970 to 1994 were US$2.58 billion in constant 1975 dollars.

During this time, INDERENA faced three important challenges. First, it had a small budget relative to its responsibilities. By the end of the 1980s, Colombia's 18 CARs covered only a quarter of the national territory; INDERENA was completely responsible for environmental management in the remaining territory. Julio Carrizosa, a former INDERENA director, pointed out that his organization had less than Col$5 pesos to protect each hectare of national territory, whereas CVC had more than Col$17,000 pesos (US$7.91) per hectare (MMA 2002).

Second, like the Division of Natural Resources, INDERENA was limited by its affiliation with the Ministry of Agriculture. INDERENA worked to protect the same natural resources that ministry offices sought to develop. Manuel Rodríguez, the last Director of INDERENA and the first Minister of the Environment, points out that INDERENA was greatly weakened by "the secondary position that it occupied in the Ministry of Agriculture and the conflict inherent in the fact that [the Ministry] was one of the principal users of renewable natural resources" (Rodríguez Becerra 1994).

Third, INDERENA—and environmental management generally—was weakened by the continued dispersion of environmental functions across different national and regional organizations, including the Ministry of Health; the Ministry of Mining and Energy; the Institute of Hydrology, Meteorology, and Land Suitability; the Maritime and Ports Directorate; and the DNP. The creation of INDERENA seems to have done little to rectify this situation. For instance, several responsibilities relating to environmental licensing of mines were transferred from INDERENA to the Ministry of Mining, while fisheries management was transferred to a new National Institute of Fishing. Simultaneously, INDERENA gradually lost jurisdiction in the areas where 16 new CARs were created. According to Rodríguez Becerra, this dispersion amounted to a "slow death through dismemberment," a "process that was never planned" (Rodríguez Becerra 1994).

From 1975 to 1993, the Ministry of Health was the primary government actor in efforts to control pollution, using the authority granted by the 1979 enactment of the National Sanitary Code that covered, in particular, air pollution, waste management, and solid waste disposal. In 1993, responsibility for air pollution control and solid waste management was transferred to the Ministry of Environment.

In the mid-1980s, Colombian environmentalists and concerned stakeholders both within and outside the fledgling environmental management bureaucracy formed an alliance. This development was encouraged by the unprecedented international attention then being devoted to environmental issues in developing countries. It was also spurred by increasing evidence of a rapid deterioration of environmental quality in Colombia (Rodríguez Becerra 1994). This new alliance lobbied for a major restructuring of environmental management in the country. INDERENA encouraged and participated in this effort. An important theme of the debate was whether and how to establish a national environmental authority, which at the time was a trend throughout Latin America (Dillinger and Webb 1999). A 1985 study of environmental management in Colombia, contracted by INDERENA, concluded that such an initiative was in order (MMA 2002) and that administration and management of renewable natural resources could be performed better with the creation of a national administrative department (Rodríguez Becerra 1994).

These currents culminated in INDERENA's proposal to create an independent Administrative Department of Renewable Natural Resources (*Departamento Administrativo de Recursos Naturales Renovables*, DARNAR) that would raise the status of environmental management. However, the proposal was controversial and failed because it threatened the CARs' autonomy (MMA 2002). Yet, the alliance of environmentalists continued to call for the creation of a national entity responsible for coordinating environmental management.

In November 1990, Congress considered a bill to create a new national environmental system, including a national ministry that would coordinate the decentralized management. This coincided with the 1991 constitutional reform, which significantly changed the structure of governance in all sectors (see the next section). The design of the proposed environmental system was adjusted in response to the ratification of the new Constitution. The first important government documents on environmental policy reform—issued by the National Council on Economic and Social Policy (*Consejo Nacional de Política Económica y Social*, CONPES)—were approved in 1991 and paved the way for the creation of SINA in 1993.

The 1991 Constitution and Law 99 of 1993

The two legislative pillars of Colombia's current environmental management system are the Constitution of 1991 and Law 99 of 1993. One of the key purposes of the 1991 constitutional reform was to establish a more decentralized and participatory government. To that end, the

Constitution gives departments, municipalities, and CARs autonomy to plan and administer local policy (in coordination with national planning), pass local decrees and ordinances, and impose taxes that are not transferable to the national level. The Constitution did not abolish a unitary government, but departments, municipalities, and CARs are all part of the executive branch of the national government. Furthermore, governors and mayors are elected by the public, but are agents of the president who can remove them from office.

The governance structure of CARs and their relationship to the national government are similar to that of departments and municipalities. The Constitution gives Congress the power to create and regulate the functioning of CARs, and specifically requires that they be autonomous. The Constitution created one CAR, the *CAR del Río Grande de la Magdalena*, with the specific purpose of developing and managing water resources in the Magdalena River basin.

The 1991 Constitution envisions a government with extensive planning responsibilities, including those related to environmental protection. It creates a National System of Planning and requires the president to draft a National Development Plan and to present the plan to Congress within six months of taking office. This plan, which typically includes environmental provisions, must include long-term goals, medium-term priorities for action, and short-term strategies for implementation. The territorial governments are required to develop plans in consultation with the national government under the advice of territorial planning councils. Law 99 adopted the same general planning structure for CARs.

The Constitution creates a dedicated revenue base for the government's environmental protection activities. Municipalities must transfer a percentage of municipal property taxes to CARs for environmental management. The Constitution also creates a National Royalty Fund from the proceeds of a severance tax on the exploitation of nonrenewable resources. The fund targets investment projects in infrastructure, mining, and ecological preservation. The 1991 Constitution envisions a central role for individual citizens and nongovernmental organizations (NGOs) in formulating and implementing environmental policy. In addition to having a collective right to a clean environment, citizens have the duty to protect natural resources and the environment.

The Constitution creates three causes of action through which citizens can intervene in the Colombian courts to protect the environment. First, any citizen or group of citizens can bring a popular action (*acción popular*) to protect their collective right to a clean environment, even if they cannot demonstrate direct, personal damage. Second, any person can bring a compliance action (*acción de cumplimiento*) to ensure that laws—including environmental laws—are upheld. Finally, the Constitution allows the law to establish cases in which an action requesting injunctive relief (*acción de tutela*) can be brought to prevent violation of fundamental rights. The Constitution also requires that the law establish those cases in which an *acción de tutela* can be brought to protect "the collective interest." The Constitutional Court of Colombia has interpreted the Constitution to allow an *acción de tutela* to protect the right to a clean environment where environmental deterioration threatens human health (Iguarán 2001). This has proved to be an important tool in environmental protection because it provides virtually immediate injunctive relief—courts must issue a decision within 10 days.

Aside from these mechanisms of participation that depend on access to courts, the 1991 Constitution guarantees the communities' participation in decisions that may affect them, and states that an essential purpose of government is to facilitate such participation. It deals specifically with implications of these provisions for the environmental sector. It stipulates that the state has a duty to provide citizens with sufficient understanding about environmental protection to enable them to fulfill their duty to protect the environment. In addition, it specifically requires adoption of statutes that guarantee community participation in decisions that affect the environment.

The Constitution creates several general mechanisms for public participation, including the right to petition public authorities and public hearings, open meetings, referendums, and standard participation in elections. For the most part, the Constitution does not specify precisely how these mechanisms will be implemented. However, in the case of the *Contraloría General de la República*,[4] the Constitution does require adoption of laws that create systems to allow citizens to monitor public fiscal management at all levels of government.

Law 99 creates Colombia's National Environmental System (*Sistema Nacional Ambiental*, SINA), a "set of orientations, norms, activities, resources, programs, and institutions that allow the implementation of general environmental principles." Consistent with the 1991 Constitution, this management system was to be decentralized, democratic, and participatory (box 2.1). As discussed in detail in Blackman and others (2004), for heuristic purposes, the SINA may be thought of as a management system made up of institutional actors, coordination and planning mechanisms,

Box 2.1

Colombia's National Environmental System

Law 99 of 1993 created both the National Environmental System (SINA) and Colombia's Ministry of Environment (now the Ministry of Environment, Housing and Regional Development, MAVDT). The ministry was intended to consolidate key environmental management functions dispersed throughout the national government and serve as the cornerstone of SINA, which would help coordinate environmental management among a range of public and private stakeholders. In keeping with the 1991 Constitution, SINA was to be decentralized, democratic, and participatory. Law 99 defines SINA as a "set of orientations, norms, activities, resources, programs, and institutions that allow the implementation of general environmental principles" around a model of sustainable development. The principal institutional elements of SINA include the following:

Key government environmental authorities
- MAVDT
- National Parks System
- CARs and Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs)

Territorial authorities
- Departments and municipalities
- Territories of Indigenous Peoples

Civil society
- Environmental NGOs
- Universities and private research institutions
- Commercial firms and farms

Other national government institutions with environmental responsibilities
- National Planning Department
- Government oversight institutions
  - *Contraloría*
  - *Procuraduría*
- Ministries other than MAVTD
- Research institutes
- National Environmental Council
- Technical Advisory Council

The guiding principles of SINA are that (a) economic and social development will be guided by the goal of sustainable development laid out in the 1992 Rio Conference; (b) biodiversity must be protected and should be exploited only in a sustainable manner; (c) human consumption is the highest priority for water use; (d) environmental policy will be based on the best available scientific evidence, and action should be taken to prevent possible serious irreversible damage even if that evidence is incomplete; (e) environmental costs will be incorporated into policies and markets to help conserve the environment and renewable natural resources; (f) environmental protection is a coordinated task among the state, communities, NGOs, and the private sector, and to promote this vision, the state will support the development of environmental NGOs and may delegate some government functions to them; and (g) environmental impact studies will be the basic instrument for deciding whether to engage in activities that might significantly affect the environment.

SINA instruments for governance and management include legal norms such as environmental laws, presidential decrees, enforcement actions, environmental licensing, command-and-control regulations, voluntary agreements, and economic instruments such as effluent fees.

Under Law 99, the MAVDT is responsible for planning national environmental policy. The regional authorities, including the CARs and AAUs, are responsible for implementing it. In addition, requirements and regulations adopted by lower levels of government cannot be weaker than, nor weaken, norms established by higher levels of government. However, the CARs are largely autonomous entities that define their own priorities and investment programs.

Source: Adapted from Blackman and others (2004).

public participation mechanisms, legal norms, policy implementation and enforcement mechanisms, and financial resources.

Law 99 created the Ministry of the Environment (*Ministerio del Medio Ambiente*, MMA) to consolidate many of the principal environmental management functions dispersed throughout various branches of the national government, and to provide a means of coordinating environmental management in both the public and the private sectors. The MMA's principal roles in SINA are to establish national policy, develop regulations, control important fiscal resources, and generally plan and coordinate environmental management (Law 99 Art. 2). With these institutional reforms, Colombia became one of the first Latin American countries to establish an independent environmental agency at the ministerial level. In addition, with the creation of the new ministry, INDERENA was subsequently phased out.

Similar efforts were carried out throughout the region during the 1990s, when most countries responded to growing domestic and international concerns about environmental degradation by developing the national agencies that continue to govern their respective environmental sector to this day (table 2.2). Chile's and Peru's environmental agencies never had ministerial status, while Argentina's and Cuba's were clustered into larger ministries. Colombia, Mexico, and Argentina have introduced more recent institutional reforms that have significantly modified the structures of these organizations. In the case of Colombia, the ministry was recently grouped with the housing and regional development sectors, as detailed later.

To fulfill its mandate to develop regulations, the MMA sets national environmental quality standards and criteria to be incorporated into sectoral policies established by agencies and subordinate governments. It is specifically charged with developing regulations to manage endangered species, conservation, trade of genetic material, marine resources, environmental contamination, native forests, the national forest reserves system, and the National Parks System. As coordinator of the SINA system, the MMA is responsible for approving legal rules adopted by CARs and Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs).

In addition to coordinating government activity, the MMA helps to align the environmental activities of nongovernmental actors with national management goals. For example, the MMA establishes links with the private sector and maintains a registry of environmental NGOs (Law 99 Art. 5).

Law 99 also redefined the roles, functions, and jurisdictions of CARs. Although CARs retained some of their economic development functions,

Table 2.2 Creation of Selected National Environmental Organizations in Latin America

Year	*Country and institution*
1978	Venezuela: Ministry of Environment and Natural Resources
1991	Brazil: Ministry of Environment
1992	Argentina: Secretariat of Natural Resources and Human Environment
1993	Colombia: Ministry of Environment
1994	Chile: National Commission for the Environment
	Cuba: Ministry of Science, Technology and Environment
	Mexico: Ministry of Environment, Natural Resources and Fisheries
	Peru: National Council for the Environment
1996	Costa Rica: Ministry of Environment
1998	Panama: National Environmental Authority

Source: Venezuela: http://www.marn.gov.ve; Brazil: http://www.mma.gov.br; Argentina: Decree 2419/91; Cuba: CIGEA (2001); Mexico: SEMARNAP (2000); Chile: ECLAC (2005); Peru: CONAM (2001); Costa Rica and Panama: ANAM (2004).

they were essentially recast as environmental management authorities. Law 99 also established additional CARs, as well as Autonomous Sustainable Development Corporations (*Corporaciónes Autónomas de Desarrollo Sostenible*, CDSs), a similar regional authority in territories reserved for indigenous peoples, and AAUs in cities with more than 1 million inhabitants.[5] Law 768 of 2002 added two more AAUs, for Santa Marta and Cartagena. This proliferation of regional environmental authorities ensured that the entire national territory was under the jurisdiction of a regional environmental authority.

Consolidating Institutions, Regulations, and Planning: 1994–2005

During the period from 1994 to 2005, the government focused on strengthening the environmental agencies within the SINA. This section discusses the salient activities that took place in that period.

Ministry of Environment

The MMA was created in 1993, and from 1994 to 2005 Colombia has had seven ministers of environment and four administrations, each with different priorities. A National Development Plan was adopted in 1995, and during 1994 to 1998 priorities included increasing investments in environmental projects and strengthening the environmental agencies established under SINA. The plan defined seven programs as priority actions for improving environmental management: strategic ecosystem protection, better water, clean seas and coasts, more forests, better cities and villages, viable population policy, and clean production (MMA 2002).

Over the period from 1998 to 2002, the MMA gave special attention to biodiversity, biosafety, and rural environmental issues such as forestry, and to international discussions associated with global environmental problems. The major achievement from this period was the strengthening of Colombia's National Parks System, for which local communities were recruited to help build in selected locations (MMA 2002).

From 2002 to 2005, two of the administration's main actions were to merge most of the functions of the Ministry of Economic Development with the Ministry of Environment to create the new MAVDT, and to phase out, in January 2004, the Environmental Directorate of the National Planning Department.

The National Development Plans cover the environmental sector (among others), and although plans do exist for subsectors within the environmental sector (such as forestry and environmental research), no systematic periodic planning exercise exists to establish priorities across environmental programs and subsectors such as forestry, air pollution, water resources, and water sanitation.[6] This gap has been highlighted in past evaluations of planning in the SINA (Galán 1998; MMA 2002). Planning is generally done sector by sector and, as yet, efforts to break out of sectoral boxes to consider prioritization across programs or sectors have not been successful. Galán (1998) noted that within MMA, efforts had been made to discuss policy documents among subdirectorates, but that, as of five years ago, it had not been possible to arrive at shared concepts that would allow discussion of priorities across program areas.[7] As discussed in chapter 3, a review of the Uribe administration's 2002–06 National Development Plan reveals little discussion of environmental priorities across sectors (Blackman and others 2004).

According to the U.S. Department of Commerce's *Colombia Environmental Export Market Plan* (1999),[8] the industrial associations influenced the design and have had notable influence in opposing the development of strict environmental regulations.[9] The U.S. Department of Commerce document states that these associations have been successful in restricting the development of environmental legislation and the enforcement of pollution prevention and control regulations.[10] According to the Contraloría (2004, p. 159), with respect to environmental management within the business sector "criteria have not been defined to ensure that, in planning processes, common environmental interests take priority over the particular economic interests of businesses."

Environmental Expenditure Review

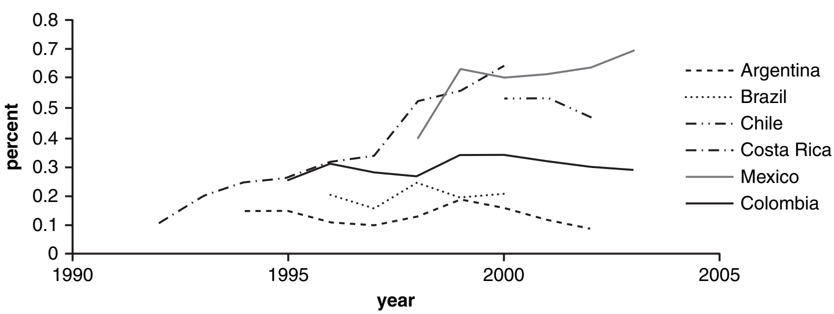
The total budget during 1995–2003 for operation and investments by MAVDT, CARs, the Special Administrative Unit for National Natural Parks (*Unidad Administrativa Especial del Sistema de Parques Nacionales Naturales*, UAESPNN), research institutions, and the Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) is estimated at US$1.98 billion (the equivalent of Col$5,700 billion, in constant 2003 pesos), or an average of US$220 million per year (Col$473,000 million). The average annual environmental expenditure of these organizations (AAUs' expenditures are not included) is estimated at 0.3 percent of

Table 2.3 Annual Environmental Expenditure of CARs, MAVDT, and IDEAM as Percentage of GDP, 1995–2003

Year	*Percentage of real GDP*
1995	0.25
1996	0.31
1997	0.28
1998	0.27
1999	0.34
2000	0.34
2001	0.32
2002	0.30
2003	0.29
Total	0.30

Source: Canal 2004.

Figure 2.1 Public Environmental Expenditure as a Percentage of GDP in Argentina, Brazil, Chile, Costa Rica, Mexico, and Colombia



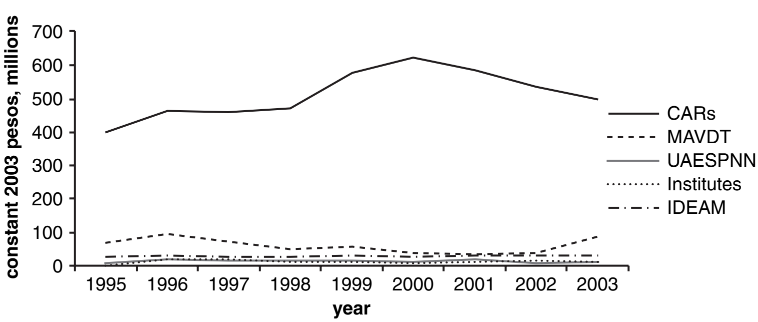
Source: Canal 2004.

GDP (equal to Col$688 billion, US$320 million per year) during 1995 to 2003 (table 2.3 and figure 2.1). From 1995 to 2003, nearly 35 percent of the public environmental expenditures (particularly by CARs) was directed to river basin management, conservation of water bodies, water supply, and wastewater treatment, while another 18 percent went to biodiversity and green markets, global environmental problems, and reforestation.[11] Expenditures on institutional strengthening and enforcement account for the other 40 percent of total expenditures.[12]

CARs account for 81 percent of total estimated environmental expenditures, the MAVDT 10 percent (including some allocations to CARs), IDEAM 5 percent, and the UAESPNN 2 percent. Four research institutions jointly account for the remaining 2 percent of expenditures: the Institute of Marine and Coastal Research, the Institute of Research on Biological Resources, the Amazon Institute for Scientific Research, and the Environmental Research Institute of the Pacific (figure 2.2).

During 1995 to 2003, 71 percent of SINA funding for operational expenditures and 85 percent of its funding for investments was allocated to CARs. Some 78 percent of funding for operational expenditures and 86 percent of funding for investments was self-generated; the balance came from national budget allocations. CARs raise revenue through property taxes, electricity taxes, effluent fees, compensatory fees, water use fees, licenses and permits, fines and sanctions, the sale of goods and services, profits on investments, and interinstitutional agreements. Property taxes account for 35 percent of their total revenues, profits on investments 34 percent, electricity taxes 10 percent, interinstitutional agreements and the sale of goods and services combined 10 percent, and effluent fees less than 2 percent. Revenue generated by CARs grew by 89 percent during 1995 to 2003. These figures mask significant differences among CARs; 82 percent of resources are concentrated in only 8 of the 33 CARs.[13] Total revenues of CARs vary from a low of US$1.35 million (CSB) to a high of US$67.8 million (CVC). Likewise, CAR spending per inhabitant varies greatly, from a low of US$1.50 (CORPOCESAR) to a high of US$42.40 (CORPOGUAVIO). Over 1995 to 2003, the expenditures of CARs were distributed among four main categories: operational expenses, investments in environmental projects, institutional strengthening, and enforcement of environmental regulations. On average, 60 percent of CARs' expenditures, not including

Figure 2.2 Expenditures of SINA Agencies, 1995–2003



Source: Canal 2004.

Table 2.4 Environmental Investments by CARs, 1995–2003

	Expenditures	
Activity or subprogram	*Pesos (millions)*	*Share (%)*
River basin management and conservation of water bodies	619.2	31.3
Wastewater treatment and water supply	518.5	26.1
Forests and reforestation	272.2	13.8
Biodiversity and green markets	184.9	9.3
Global and urban environmental problems	158.3	8.0
Prevention of natural disasters	86.5	4.4
Solid and hazardous waste management	77.5	3.9
Promotion of clean production	56.3	2.8
Land	4.9	0.3
Air quality management	1.3	0.1

Source: Canal 2004.
Note: Col$2,100 = US$1.

operational expenses, were allocated to preinvestment and investment in environmental projects, 26 percent to institutional strengthening, and 14 percent to enforcement of environmental regulations.

The expenditures of the SINA on investment and preinvestment activities are clustered into 10 programs and indicate that priority activities and subprograms for CARs during 1995 to 2003 were investments in the management of river basins and conservation of water bodies, wastewater treatment plants and water supply, reforestation and conservation of forests, biodiversity and green markets, and global and urban environmental issues (table 2.4).

Conclusions

Colombia's environmental management framework evolved gradually. One of the significant milestones reached between 1952 and 1974 was the establishment of CARs, which were intended to promote regional economic development through investments in water resources infrastructure, energy infrastructure, agriculture, and roads. The first of these, the CVC in the Cauca Valley, was created in 1954 on the basis of the U.S. Tennessee Valley Authority model. In addition, in 1961 a CAR was established for the Magdalena River and later transformed into the INDERENA. In 1974, the National Code for Renewable Natural Resources and Environmental Protection was developed. This code is still the most important regulation for environmental management in the country.

Between 1975 and 1993, CARs began to assume their role as environmental regulatory agencies. By 1988 Congress had established 18 CARs. INDERENA was successful in promoting the conservation agenda, as evidenced by advances such as titling of lands belonging to indigenous peoples and establishment of national parks. Furthermore, historical events were influential in focusing the attention of INDERENA and CARs on three main environmental priority areas: river basin management and conservation of water bodies, reforestation, and conservation of biodiversity. The Ministry of Health was the key player in efforts to control pollution, in accordance with Congress's passage in 1979 of the National Sanitary Code, which covers air pollution control, waste management, waste disposal, water quality, and water pollution control.

By 1991, a new constitution was created, leading to passage of Law 99 in 1993, which established the Ministry of Environment and 33 CARs as part of Colombia's National Environmental System, aimed at tackling problems associated with effective environmental management. These problems included degradation of water bodies and the lack of organizations and funds to address environmental priority areas. The area of jurisdiction of these CARs was driven by the interests of several members of Congress. Law 99 also made provisions for revenue generation by CARs so that they could address environmental priorities through investments in environmental projects. By 2002, the government of Colombia decided to merge the Ministries of Environment and Development and to phase out the Environmental Directorate in the National Planning Department.

During 1995 to 2003, the total budget for operation and investments by the MAVDT, CARs, the UAESPNN, research institutions, and IDEAM is estimated to have been US$1.98 billion (the equivalent of Col$5,700 billion, in constant 2003 pesos), or an average of US$220 million per year (Col$473,000 million). The average annual environmental expenditure of these organizations (AAU expenditures are not included) is estimated at 0.3 percent of GDP (Col$688,000 million, US$320 million per year) for the period from 1995 to 2003. Nearly 35 percent of these expenditures were directed at river basin management, conservation of water bodies, water supply, and wastewater treatment, and another 18 percent went to biodiversity and green markets, global environmental problems, and reforestation. Expenditures on institutional strengthening and enforcement account for the other 40 percent of total expenditures.

Notes

1. Ernesto Sánchez-Triana is the author of this chapter, which draws on background documents prepared for this study by Blackman, Morgenstern, and Topping (2004), Universidad de Los Andes (2004), and Canal (2004).
2. Beginning in 1976, the corporations were also responsible for managing renewable natural resources and environmental protection (Arboleda and others 1981).
3. According to MAVDT (2006, p. 4), INDERENA "initiated the process of structuring environmental licenses with important advances in the definition of criteria for evaluating (Environmental Impact Assessment) and the definition of terms of reference for various sectors. Advances were also achieved in the definition of instruments for administering and managing renewable natural resources (water, forest), activities were begun related to environmental education processes for different levels, and activities were initiated related to integrated watershed management and reforestation with community participation. In addition, advances were achieved in the orientation and definition of environmental research."
4. The *Contraloría* is the ranking public entity in charge of oversight of all fiscal matters. It guarantees the correct management of public funds and contributes to the modernization of the state through collaboration with public institutions.
5. At the end of 2005, Colombia had 33 CARs and CDSs. In addition, there are AAUs in six cities: Bogotá (DAMA), Cali (DAGMA), Medellín (AMVA), Barranquilla (DAMAB, formerly DADIMA), Cartegena (EPA), and Santa Marta (DADMA).
6. According to MAVDT (2006, p. 5), "in defining the environment as part of the National Development Plan a joint exercise was carried out among the National Planning Department and technical departments of the Ministry so that policy frameworks prioritize those items included in the Plan. Subsequently, in accordance with Law 152 of 1994 (the Development Plan Law), the Ministry developed the Indicative Sectoral Plan, in which goals for those items included in the National Development Plan are defined."
7. According to MAVDT (2006, p. 5), "a prioritization exercise of the areas linked to the National Development Plan does exist, which is detailed even more at the territorial level in the development of corresponding planning instruments."
8. The plan is accessible online at http://web.ita.doc.gov/ete/eteinfo.nsf/Approved/?Search View&Query=(Colombia)%5D.
9. As MAVDT (2006, p. 5) states, "the development of norms and instruments for policy implementation is carried out through an open, participatory process among the entities involved and the regulated sectors. This is not to say that the development of norms is influenced by business associations."

10. According to the minister of finance and public credit, the director of the National Planning Department, and the minister of environment, housing, and territorial development, “in order to ensure that there is more effective participation of the most vulnerable segments (those affected by environmental degradation), the national government issued a Decree to optimize the Technical Advisory Council for Environmental Policies and Norms of the Ministry of Environment (CTA) to serve as a forum for cross-sectoral coordination and to ensure the participation of the most vulnerable segments (those affected by environmental degradation). The CTA of MAVDT was established under Article 11 of Law 99 (1993) to serve as principal advisor to the Minister of Environment, Housing and Territorial Development in the formulation of policies and the issuance of the country’s environmental rulings. The Council comprises five (5) members, including two (2) representatives from public and private universities, and three (3) representatives from industry, agricultural, and mining and hydrocarbon councils (one representative from each sector). MAVDT has detected a visible imbalance in the level of discussions and recommendations from the Technical Advisory Council for Environmental Policies and Norms of the Ministry of Environment (CTA), given that representation from other key stakeholders who should also be consulted is lacking (in particular those who are most affected by priority environmental problems that are targeted within the rulings issued by MAVDT). For this reason, one of the primary objectives that this new Decree aims to achieve is to guarantee the active participation, at the level of Technical Committees, of representatives of civil society who could be affected by and/or have a valid interest in addressing environmental problems related to the policies and regulations that are submitted to the Council for consideration. In this way, it is intended that the Council will generate a more balanced discussion that considers different stakeholders affected or benefited by the environmental policies and norms that MAVDT issues” (Suárez, Montenegro, and Carrasquilla 2005, p. 73).

11. The review of public environmental expenditures that is summarized in this section was conducted by Francisco Canal of the Association of CARs. The data used in this analysis of public environmental expenditures were taken from publications of the *Contraloría* and of the CARs. MAVDT (2006, p. 5) considers “that it is difficult to make a combined analysis from two different sources of information, in which that of MAVDT is official (public) and that of the CARs has not been validated by the Ministry.”

12. Environmental expenditure, measured as a percentage of GDP, varies significantly from one country to another in the Latin America and the Caribbean region. Whereas countries such as Argentina, Brazil, and Peru have tended to spend a significantly smaller share of GDP to address their environmental challenges, others, including Costa Rica and Mexico, have steadily increased their public environmental expenditure to more than 0.6 percent of their GDP.

13. According to MAVDT (2006, p. 6), the "largest amount of resources are concentrated in a few CARs due to circumstances of a structural nature, related to the development potential of the jurisdictional areas of each one."

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CHAPTER 3

Actors and Institutions

Colombia's National Environmental System includes the Ministry of Environment, the National Environmental Council, regional environmental authorities, urban environmental authorities, research institutes, and control agencies. Challenges that emerge in trying to assess the National Environmental System are the adequacy of data and the lack of indicators on environmental quality and institutional performance; the need to better define sectoral priorities; the efficiency of public sector spending on the environment; management capacity in key agencies; coordination between national and regional agencies and between research institutes and program agencies; suboptimal regulatory instruments and compliance agreements; and low legal and fiscal oversight and auditing capacity.

This chapter examines (a) the distribution of responsibilities among national, regional, and local environmental authorities, (b) checks and balances within and between environmental agencies at various levels, (c) cross-sectoral and interinstitutional coordination mechanisms, (d) monitoring capacity, and (e) ways in which stakeholder interests are balanced in decision making.[1] The effectiveness of an institution is defined as the extent to which it contributes to improved environmental quality by performing the functions assigned to it under Colombia's 1991 Constitution, Law 99 of 1993, and related decrees. As elaborated in the chapter, however, this is difficult to measure because of the lack of available data on environmental quality.

Environmental Information Systems

Law 99 gave the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA) the task of establishing a Colombian Environmental Information System (*Sistema de Información Ambiental de* Colombia, SIAC). SIAC has two main functions: to provide governmental entities in the National Environmental System (*Sistema Nacional Ambiental*, SINA) the information they need for effective environmental management, and to inform Colombians about the state of their environment and thereby facilitate public participation in environmental management. Decrees issued in 1994 gave the Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) responsibility for directing, coordinating, and operating SIAC. The 2003 decree that created the new Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT) assigned coordination of SIAC to the new ministry's General Bureau of Regional Information, Planning and Coordination.

There is wide agreement in Colombia that indicators are indispensable for the formulation of new policies and for overall environmental management. There is also widespread recognition that regulatory authorities still have not developed an adequate system of indicators (Contraloría 2003a; Interinstitutional Committee on Indicators 2002). Efforts to develop environmental indicators have arisen separately at the national and regional levels, and in public and private arenas. These efforts have been mostly independent and uncoordinated. The first concerted national effort was led by the National Planning Department (*Departamento Nacional de Planeación*, DNP), which, in 1994, obtained a loan from the Inter-American Development Bank to design and implement the SIAC. In 1996, the DNP also proposed the creation of an Environmental Management and Planning Indicators System that would include 256 indicators. However, because of the difficulties in the design of this system and the large number and complexity of indicators (detailed methodological standards were developed for 177 of them), the proposals eventually were abandoned (Contraloría 2003b).

In 2001, the MMA, with technical assistance from the Economic Commission for Latin America and the Caribbean (C*omisión Económica* *para América Latina y el Caribe*, CEPAL), undertook a new effort to create environmental sustainability indicators in coordination with national and regional entities and research institutes. In July 2002, these groups published a document describing 32 indicators. At about the same time, IDEAM, MMA, and various research institutes worked together to develop and publish Colombia's first environmental baseline, which included 149 indicators. According to the Contraloría General de la República[2] (2003b), however, this effort had a number of weaknesses mainly related to the fact that participating institutes were not well integrated and the baseline indicators lacked a unified conceptual framework. Information from the diverse entities was based on different scales, coverage, and collection methodologies, making integration of data difficult (Peña 2003). Furthermore, resources had not been assigned to maintain the information flow and acquire the technology needed to continue collecting information for this program.

Efforts are under way to develop indicators at the level of the Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs). According to Decree 1300 of 2002, CARs must establish—in agreement with MAVDT—basic indicators for monitoring and evaluating natural resources and the environment. Some CARs have proposed development baselines in their areas with indicators of both the current state of the environment and the pressures exerted on natural resources and the environment.

To evaluate management performance, most CARs have either developed their own indicators or use those formulated by the ministry. Most of the indicators CARs currently use measure administrative processes (such as expenditures on reforestation) rather than environmental impacts (such as deforestation rates). Unfortunately, the data and models designed by IDEAM are not applicable for CARs (Contraloría General de la República 2003b). MAVDT plans to develop three national indicator systems: (a) environmental sustainability indicators to measure the state of the environment and natural resources, (b) environmental management indicators related to the impact of interventions by environmental management authorities, and (c) sustainable development indicators that allow international comparison.

Although Colombia has tried to develop environmental indicators, it still is a long way from having an integrated system. This is due in part to insufficient data collection infrastructure at the national, regional, and local levels, such as environmental monitoring networks, measurement stations, documentation centers, and basic cartography. Some 40 percent of the country's CARs either have no environmental laboratories or have a data collection and analysis infrastructure that does not work. Some CARs that do have laboratories invest very little in their operation and maintenance and do not operate them effectively. In 2002, less than Col$7 billion (US$3.2 million), or 1.4 percent of total CAR investments, were dedicated to laboratory facilities. The absence and poor quality of basic cartography present another serious challenge. Many CARs either lack basic maps of their jurisdictions or have not updated their cartographic information in more than a decade (Contraloría General de la República 2003b).

The lack of monitoring stations is a problem. For instance, only 20 CARs have any type of monitoring station. Ten of these stations have not registered their networks in the National Catalog of Monitoring Stations, and only four routinely send information to IDEAM. Most stations do not have the budget necessary for proper maintenance, even though 97 percent of the stations have been in service for more than 20 years and have significant maintenance backlogs. Of the activities that the measurement stations are required to perform, only a fraction are actually carried out—25 percent of hydrological measurements and 45 percent of climatological measurements (Contraloría General de la República 2003b).

A review of the SIAC by the Contraloría General de la República (2003b) found that what little data actually were being collected at the CAR level were principally on forestry and had been collected under an agreement with the International Tropical Timber Organization in the mid-1990s. According to the Contraloría General de la República (2003b), the administrative structure of the system lacks clarity. The Contraloría General de la República (2003b, p.75) reported that, overall, Colombia "does not have a satisfactory environmental information system" and identified seven factors that limit the development of SIAC:

- IDEAM performs analyses on a national scale, where as CARs perform analyses on a regional or local scale. As a result, the data and models designed by IDEAM are not applicable for CARs.
- Limited integration among SINA entities and lack of a systematic process for data transfer among institutions prevents the flow of information. Thus, information captured by regional agencies is not generally used to help refine IDEAM's data.
- CARs have limited incentives to develop environmental information, which is reflected in their limited participation at interinstitutional meetings on environmental information planning.
- IDEAM's process of developing an environmental information system has lacked continuity.

- IDEAM and CARs often use incompatible computer platforms. IDEAM should develop network applications that use free software so that CARs and other public and private agencies and stakeholders can use them at low cost.
- SIAC lacks methodological standards or protocols for data collection. Likewise, few advances have been made in generating standards that would allow validation of environmental information.
- Informational planning instruments are not used. The MAVDT, IDEAM, and most CARs lack plans to integrate information.

SINA's Finances

Nearly three-fourths of SINA's self-generated revenue accrues to just eight of Colombia's 33 CARs.[3] As elaborated in chapter 2, most revenue is generated through the mechanisms established under Law 99, principally property taxes, transfers from the sale of electricity, and national contributions. CARs' ability to generate revenue from taxes and fees is critically dependent on the size of their populations, degree of economic activity, and electricity generation. Not surprisingly, CARs in regions with the largest levels of economic activity and the highest population densities generate the most revenue, while those without such resources have historically been more dependent on national funding and have therefore been hardest hit by adjustments in the federal government budget. In addition, 90 percent of environmental investments are originated by the 18 CARs established before Law 99 and only 10 percent by the 15 CARs created by the law itself.

Despite their large budgets, some of the CARs with the largest self-generated income still receive contributions from the national government. Criteria for assigning funds to CARs by the national government are unclear. Mechanisms do exist to even out disparities in CAR revenues. The Environmental Compensation Fund was created in 1996 to redistribute self-generated CAR revenue from the wealthier CARs to the 15 poorest CARs. All CARs, except the Autonomous Sustainable Development Corporations (*Corporaciones Autónomas de Desarrollo Sostenible*, CDSs), must contribute 20 percent of their electricity sector transfers and 10 percent of certain other self-generated resources to the fund. The National Environmental Fund (*Fondo Nacional Ambiental*, FONAM) was also meant to finance investments in poor CARs. Finally, national authorities can direct funds to departments and municipalities through the National Royalty Fund established under the 1991 Constitution.[4]

However, the funds have not been effective. FONAM has not been able to meet its objectives because of poor funding. Among other reasons, Gómez Torres (2003) attributes this failure to the MAVDT's lack of success in obtaining funds for FONAM from outside sources, and demonstrates that FONAM mainly supports older, better-endowed CARs. The National Royalty Fund is subject to wide cyclical swings in availability and has been characterized by excessive partitioning of funds among different local, regional, and departmental projects and by poor overall quality of proposals (Sánchez-Triana 2001).

From 1996 to 1998, the Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs) received funding from three main sources: revenue generated through the mechanisms established under Law 99 (principally property taxes); transfers from municipalities for environmental management support; and national contributions, which were divided between US$20 million in credits from the World Bank for capacity building and ordinary funds from the MAVDT budget. Property tax revenues and World Bank credits were the largest funding sources. After 1998, however, these sources of funding were substantially reduced. The Constitutional Court declared that Article 9 of Decree 1339 of 1994, which had granted AAUs half of the property taxes raised by municipalities, was unconstitutional.[5] From 1995 to 1998, the AAUs' self-generated resources were nearly US$87.8 million, of which 86 percent was generated by the AAU for Bogotá (*Departamento Administrativo del Medio Ambiente, Bogotá* [DAMA]), 11 percent by Cali (*Departamento Administrativo de Gestión del Medio Ambiente, Cali* [DAGMA]), 2 percent by Barranquilla (*Departamento Técnico Administrativo del Medio Ambiente de Barranquilla* [DAMAB]), and 1 percent by the Aburrá Valley (Aburrá Valley Urban Environmental Authority—*Área Metropolitana del Valle de Aburrá* [AMVA]). All of DAMA's funds from property taxes are dedicated exclusively to the Bogotá River decontamination project. DAMAB's and AMVA's low revenues are mainly the result of a recent decision by the cities of Barranquilla and Medellín not to transfer property taxes to the AAUs. After 2000, by decision of the MMA and the DNP, the AAUs stopped receiving environmental fees.

During 1995 to 2002, 13 percent of SINA expenditures for operations and 3 percent for investments were assigned to research institutes. National appropriations provided 100 percent of the funding for operations and 82 percent of funding for investments. Of the national funds allocated to the research institutes, fully three-quarters go to IDEAM. Some of the research institutes have managed to insulate themselves from the fiscal adjustment by seeking outside funding, mainly from international organizations such as the Global Environment Facility. Over the period from 1995 to 1998, national funding financed 83 percent of the research institutes' new investments. However, during 1998 to 2002, as the institutes diversified their funding bases, this contribution dropped to 49 percent. Collectively, research institutes' investments actually grew by 86 percent during 1998 to 2001. Despite this success, the research institutes have considerable difficulty financing operational expenses because international funding sources often place severe restrictions on using financial resources for that purpose.

During 1995 to 2002, 100 percent of the funding for operations and 99 percent of the funding for investments by the National Parks System was provided by national appropriations. Although the National Parks System has some ability to generate its own revenues from ecotourism fees and concessions, these resources are small and are highly sensitive to the impact of public safety issues on the tourism sector. The National Parks System is trying to develop revenue streams to pay the system for the environmental services it provides, including carbon sequestration, biodiversity conservation, and watershed protection. It hopes to generate revenues from carbon sequestration by participating in the Clean Development Mechanism of the Kyoto Protocol. The current law allows parks to charge a tax for water use, but this mechanism requires further legal clarification before it can be implemented. The Parks System has been able to raise significant international funds, primarily for biodiversity conservation. For example, during 1996 to 2000, the Parks System received US$4.1 million (Col$8.8 million) in Dutch donations aimed at developing protection, conservation, and management actions in eight parks in the Pacific region (MMA 2002).

The Ministry of Environment

The Contraloría General de la República (2003a) found that the MAVDT lacks procedures and documentation to clearly define the activities of its staff. In 2002, before the merger of the Ministries of Environment and Economic Development, the MMA had 290 staff members. Table 3.1 presents the staff composition and average salaries. In 1997, three years after the creation of the Ministry of Environment, a study by the consulting firm, Booz Allen Hamilton, recommended better-trained and more technically qualified civil servants (Booz Allen Hamilton 1997b). Seven years later, Blackman, Morgenstern, and Topping (2004) found that despite the

Table 3.1 Ministry of Environment Staffing and Salaries, 2002

Position	*Educational requirements*	*No. of positions*	*Average annual salary per position (Colombian pesos)*
Director	College degree; graduate degree or 2 years' work experience	11	58,741,902
Adviser	College degree; graduate degree or 2 years' work experience	48	42,080,013
Professional	College degree	120	19,937,296
Technical administrative	High school	33	11,722,495
Administrative	n.a.	78	8,902,171
Total	n.a.	290	21,171,340

Source: MAVDT 2004.
Note: n.a. = not applicable. US$1.00 equivalent to Col$2,100.00.

efforts carried out, there were still serious concerns that the MAVDT's environmental management needed strengthening.

The decentralized design of Law 99 affected the MAVDT and CARs. While Law 99 gave CARs a great deal of administrative and fiscal autonomy, it also gave the MMA responsibility for leading the SINA and, in particular, for overseeing and coordinating the activities of CARs. The ministry's coordinating function, however, is not optimal. In 1997, three years after the establishment of the MMA, a study described how "each component of the system conceived of in Law 99 of 1993 is working in an independent and divergent manner—each executes its own Action Plan based on its subjective interpretation of the National Environmental Plan, adapting it according to its own regional needs" (Booz Allen Hamilton 1997b, p. 4). The MAVDT believes there has been significant progress "in the process of articulating actions through planning instruments: PGAR [*Plan de Gestión Ambiental Regional*, Regional Environmental Management Plan] and PAT [*Plan de Acción Trienal*, Three-Year Action Plan]" (MAVDT 2006, p. 6).

Other major evaluations of the SINA generally concur that coordination between the MMA and CARs needs strengthening. One analysis cited that "erratic relations" (particularly in priority setting and resource allocation) between the MMA and CARs had impaired the operation of SINA (Galán 1998). One recommended reform is to increase integration of CARs into the planning and policy formulation carried out by the MAVDT.

Colombia has developed a strong legal framework for decentralization and institutional coordination. However, lack of resources and of information has led to poor implementation. National authorities have a variety of mechanisms at their disposal to ensure that CARs act in accordance with national policies. First, CARs are required to submit 10-year, 3-year, and 1-year action plans that are tied to the National Development Plans drafted by the executive branch. The Contraloría can set in motion procedures to remove CAR general directors from office for failure to comply with these requirements or failure to carry out their plans. In addition, CARs can be sued in court for developing plans that are not in accordance with the National Development Plan. Second, DNP must approve national budget allocations for CAR investment projects.[6] Third, CAR boards of directors include a representative of the MAVDT and a representative of the president's office. Fourth, Colombia's control organizations (*Procuraduría Delegada para Asuntos Ambientales*, *Contraloría General de la República*, *Fiscalia*, and *Veeduria*) can discipline CARs for failure to implement plans or for abuse of office. Fifth, national authorities have some control over the salaries of CAR staff members. Finally, in the past the MMA and other national institutions have contributed investment funds—or have allocated funds contributed by multilateral institutions—and this power of the purse strings has given them some sway over CAR investment projects. Chapter 4 analyzes CARs' performance, their degree of decentralization, their governance structure, and their subordinate relationships with departmental and municipal governments.

Several factors limit the effectiveness of these mechanisms. First, the ministry has poor information about the investment, policy implementation, and regulatory enforcement activities of CARs. The performance indicators that CARs currently use typically reflect regulatory processes rather than impacts. For example, CARs often report on the amounts of money spent rather than on how these investments affected environmental quality. The MAVDT's information about environmental quality at the regional level is limited. Effective coordination is not possible without such basic information. Second, staffing levels in the *Procuraduría Delegada para Asuntos Ambientales*[7] do not allow CARs' performance to be monitored or evaluated, and the *Contraloría General de la República* is severely hampered by lack of data. As for regulations that mandate intensive planning at the regional level, previous evaluations have concluded that even when CARs do fulfill their planning requirements, they often do so simply to fulfill the letter of the law rather than to actually guide resource management. New planning requirements established in 2004 may mitigate this problem somewhat. Finally, current fiscal policy constrains the MAVDT's ability to cofinance investments.

The merger of the Ministries of Environment and Economic Development in 2003 is one outcome of the decision to reduce the national bureaucracy.[8] It is too early to gauge the overall impact of the merger, but it is likely to have both advantages and disadvantages.

One of the perceived disadvantages of the merger is the sense that it lowers the profile, and potentially the influence, of the Ministry of Environment, because Colombia no longer has a Minister of Environment but rather a Vice Minister. Moreover, some issues formerly handled by the Ministry of Economic Development, such as providing housing and water supply infrastructure for the poor, are more urgent than issues associated with environmental pollution control and management of renewable natural resources. There are also concerns that because the Ministry of Economic Development addressed short-term problems, while the Ministry of Environment addressed medium- and long-term problems, attention to environmental issues is likely to be postponed. Another concern is that the merger of the Ministries of Environment and Economic Development is likely to create conflicts of interest, because the MAVDT will be responsible both for investing in infrastructure and for ensuring that the environmental impacts from these investments are minimized.

Conversely, the merger of the ministries may generate a number of benefits. First, it may facilitate better administrative coordination of investments in infrastructure, particularly for water supply and sanitation, which historically have been low. More specifically, large investments in water, and to a lesser degree sanitation, often require environmental impact assessments and permits from authorities at the national level. Second, the merger may help in efforts to integrate or mainstream environmental concerns into planning and decision making in both the infrastructure and the housing sectors. For example, it may help make land use planning an integral component of decisions on housing projects. Third, the merger may help correct two long-standing biases at MMA: the tendencies to focus on the benefits of environmental regulation while ignoring costs, and to pay too little attention to urban issues. Because the MAVDT will be responsible for promoting economic development and environmental regulation, it might be more aware of trade-offs between the benefits and costs of regulation. Similarly, the MAVDT's involvement in housing and infrastructure investments in urban areas may force it to focus more on urban environmental issues.

Evidence shows that the priority of both CARs and the MAVDT is on investments in water basin management, reforestation, and biodiversity conservation. However, because over 70 percent of Colombia's population lives in urban areas, CARs and the MAVDT should also focus on urban

Table 3.2 Ministry of Environment Investment Budget by Issue, 2002

Issue	*Budget (thousand pesos)*	*Share (percent)*
Natural resources management		
Strategic ecoregions	357,300	1
Forests	15,299,700	60
Biodiversity	3,652,000	15
Green markets	368,100	1
Urban quality of life	227,000	1
Endogenous production processes	371,500	1
Cleaner production (voluntary agreements with industry)	4,941,600	19
Water	644,200	2
Total	25,861,400	100

Source: Contraloría General de la República 2003a.

environmental issues such as air quality, natural disasters, sanitation and hygiene, and solid and hazardous waste management. The MMA's investment spending for 2002 in urban environmental management accounted for less than a quarter of the ministry's investment budget (table 3.2).

Regulatory Issues

Although Colombia has extensive environmental regulations, there are many challenges to their effectiveness. For example, the Contraloría has repeatedly documented major regulatory gaps (Contraloría General de la República 2003a), and a recent programmatic audit of the MAVDT found that the ministry still has not established maximum permissible limits of pesticides in foods, formulated economic instruments to motivate reduction in use and management of pesticides, or developed implementing regulations for the *Estatuto Único Forestal* (Statute on Use and Classification of Soils), a critical instrument in land use planning (Contraloría General de la República 2003b).

Some regulations are too general or are subject to a gradual weakening. For example, the Contraloría General de la República (2003a) notes that the lack of regulations regarding the scope and applicability of public hearings has made the use of such hearings ineffective. With respect to the efficiency of the environmental licensing system, the Contraloría General de la República (2004, p. 23) considers that this "area has been subject to a gradual weakening that would lead in the very short term to its elimination. . . . Efficiency in this area cannot reduce the time taken to authorize licenses or eliminate the key requirements to guarantee that licensed actions consider all the environmental impacts that they generate."

Some regulations are prescriptive and of limited applicability for the local economic and social context. For example, command-and-control emissions standards sometimes have been adopted, with little modification, from more developed countries. According to stakeholders interviewed for the report by Blackman, Morgenstern, and Topping (2004), such standards are unrealistic for most firms because they lack the technical information or other resources needed to adopt and operate the abatement technology.

These issues in Colombia's regulations lead to other problems. They contribute to poor coordination between the MAVDT and CARs by making it difficult for CARs to carry out one of their basic functions—implementing national regulations. They also make it difficult for other institutions in the SINA to perform their assigned roles. Incomplete licensing and permitting regulations may lead to inconsistent requirements and enforcement across CARs and may create fertile ground for arbitrary decisions. Amorphous laws and regulations also burden Colombia's judicial system by contributing to the proliferation of *acciónes de tutela* (actions for injunctive relief) brought to protect the environment.

Voluntary Regulation

Since the passage of Law 99 of 1993, both the MMA and some CARs have often used a strategy of developing and enacting regulatory standards and guidelines that are not mandatory. These programs have followed international practices in this area from European countries such as the Netherlands. The international practices are rooted in strong enforcement of command-and-control regulations. In Colombia, however, two types of voluntary regulations are commonly applied. The first is to negotiate with polluters for clean production agreements (*convenios de producción limpia*) that target either specific sectors (for example, transportation or agriculture) or specific regions (Blackman, Morgenstern, and Topping 2004). They typically involve a quid pro quo: polluters pledge to improve environmental performance over a specified period; in exchange, the regulator provides a grace period to allow the polluter to achieve compliance. The purpose of such agreements is to mitigate the problem of chronic noncompliance in certain sectors and regions by "building consensus" among polluters on the need for compliance and giving them guidance on how to comply (Blackman, Morgenstern, and Topping 2004).[9] Many clean production agreements were signed in the mid-1990s. Self-reported data collected by the Colombian Association of Environmental Authorities (*Asociación Colombiana de Autoridades Ambientales*, ASOCAR) indicate that by 2002 CARs had signed a total of 101 clean production agreements (ASOCAR 2002).

The second type of voluntary regulation popular in Colombia is the issuance of environmental guides—manuals that detail options for improving environmental performance in specific sectors. These guides, which typically focus on pollution prevention rather than end-of-pipe abatement strategies, stemmed from the national Cleaner Production Policy issued by the National Environmental Council. The council has published 57 environmental guides that cover approximately 60 percent of all productive sectors. The guides have been written for sectors where licensing is mandatory, and for ones where licensing is not required, such as livestock production. Clean production agreements and environmental guides have both strengths and weaknesses.

The purported strength of clean production agreements is that they build consensus for improved environmental performance in sectors or regions where compliance is a chronic problem. Clean production agreements can have an impact, at least at the regional level, and successes include several agreements negotiated and administered by DAMA in Bogotá.[10] However, voluntary agreements will work only in sectors and regions where environmental regulatory institutions are strong, and only as a complement to conventional command-and-control regulations.

The Colombian environmental guides also have a number of strengths. First, industrial sectors have input into the guides, which therefore might lead to improved environmental performance. Second, the guides fill a significant gap in Colombian regulation: the lack of technical guidance on how emissions standards are to be met. Such gaps imply that emissions standards are unrealistic for most firms, which lack the technical information (or other types of resources) needed to purchase and operate abatement devices or adopt clean technologies. Third, they clarify how polluters can obtain licenses and thereby facilitate consistent and transparent licensing. As discussed later, licensing requirements and processes differ markedly across CARs, and ad hoc licensing is a concern for several firms and farms. In sectors where licensing is required, the guidelines constitute de facto binding (*vinculante*) regulations, and efforts are underway to give them the legal status of regulation—that is, to make them legally binding. Fourth, by improving polluters' technical capacity and establishing uniform standards, environmental guides reduce the transaction costs of permitting for firms, CARs, and the MAVDT. Fifth, in sectors where permits are not required, the guides may help firms improve their environmental performance by lowering the informational costs of pollution prevention and abatement investments. Finally, environmental guides may help firms meet growing demands for cleaner production in the international marketplace. Several sectors require some type of certification that firms are producing in an environmentally friendly manner. The environmental guides facilitate this certification.

Notwithstanding these potential benefits, data suggest that clean production agreements, in general, have not succeeded in improving environmental performance. During the grace period specified in the agreement, polluters do not make any significant new investments. In any case, regulators have no means of assessing environmental performance because the clean production agreements do not include indicators or establish a baseline. Thus, the agreements simply end up legitimizing inaction on the part of both polluters and regulators. Unfortunately, this has been the pattern for most national-level sectoral clean production agreements (Blackman, Morgenstern, and Topping 2004).

An analysis prepared by Esterling Lara Sánchez (2003) of a sample of 13 voluntary clean production agreements, including both single-sector and multisector agreements and agreements at the national and regional levels, found that many of the agreements suffered from weaknesses that rendered them ineffective. For example, commitments made by the signatories to the agreements were typically vague and ill-defined. In addition, the agreements did not identify sources of financing for costly pollution abatement and prevention investments, and the legal status of the agreements was unclear. These conditions created incentives for stakeholders to sign these agreements even if they had no real intention of meeting their commitments, and the resulting compliance with the agreements was quite low. According to Esterling Lara Sánchez (2003), for example, the coal sector's compliance with its voluntary clean production agreement was ranked zero (on a scale of zero to 100) on all components that concerned "incentives and financial resources" and "follow-up and evaluation." Similarly, in evaluating electricity sector agreements, eight of the nine components of the agreement on "clean production promotions strategies," three of the four sections on "legal and technical environmental norms," and three of the five sections on "incentives and financial resources" were ranked as zero (Esterling Lara Sánchez 2003).

Blackman, Morgenstern, and Topping (2004) have also identified a number of weaknesses in Colombia's 57 environmental guides. For example, they are being used for a purpose other than originally envisioned, and as a result they do not serve that new function very well. The guides were conceived as a way of implementing the national Cleaner Production Policy. Specifically, they were to enable facilities to move beyond compliance with existing command-and-control regulations by adopting clean (pollution prevention) technologies. In sectors where licenses are required, however, they have evolved into guides for achieving compliance with existing regulations. Unfortunately, there is often no clear link between existing command-and-control regulations and the information in the environmental guides. Thus, there is no guarantee that a firm that follows the guide's advice will actually meet existing regulatory standards. Moreover, the environmental guides typically provide a limited range of technological alternatives for pollution prevention and pollution control. These alternatives are not always the most appropriate for all scales and types of firms in the sector. For example, they may be appropriate for large firms, but not for the small and medium firms that dominate many sectors.

By law, the MAVDT is responsible for granting environmental licenses and permits to large facilities and those in specified sectors, such as oil and gas exploration and development of energy generation. CARs are responsible for the rest. As a result, CARs grant approximately 70 percent of all environmental licenses and permits. According to Blackman, Morgenstern, and Topping (2004), licensing and permitting present several problems. Both licensing and permitting involve copious red tape and delays that create bottlenecks in the pipeline for urgently needed investments and economic development. Licensing and permitting requirements are not consistent across environmental agencies. For example, in MAVDT and in some CARs, companies building roads are required to reforest cleared areas, but in others there is no such requirement. Moreover, licensing and permitting in some environmental agencies is subject to arbitrary decisions. A root cause of all of these problems is that Colombian environmental licensing regulations are often ambiguous.

Evidence shows that enforcement of a wide variety of environmental regulations in Colombia varies markedly among CARs, sectors, and sizes and types of firms. Contributing factors include several of the problems discussed earlier: behaviors that protect the interests of polluters, low levels of human and technical capacity, poor information systems, reliance on voluntary regulation, and amorphous regulations (Blackman, Morgenstern, and Topping 2004).

Examples illustrating the problems with enforcement abound: inspections are not made, fees are not collected, and institutional deficiencies inhibit enforcement. Other factors exacerbating the problem include the limited quantity and reliability of information, lack of indicators to measure concrete results, lack of adequate systems for the final disposal of waste and limited oversight of compliance with waste disposal norms, and poor-quality laboratories to verify that the values declared or estimated for billing of environmental fees correspond to the real contamination values (Contraloría General de la República 2003a).

National Environmental Council and National Technical Advisory Council

The National Environmental Council is a consultative group attached to MAVDT. Its permanent members are drawn from a wide array of institutions, including MAVDT, the Ministry of Education, DNP, universities, the private sector, nongovernmental organizations (NGOs), and indigenous and Afro-Colombian communities. As envisioned in Law 99, the council's role was to provide a forum to give both public sector and private sector stakeholders a voice in the design of important national environmental policies. It was meant to produce documents that would have an important impact on policy. The council does not have a permanent staff or institutional support and meets on an ad hoc basis.

The National Environmental Council does not appear to be playing its intended role. Council meetings now attract upward of 100 people, often second- or third-tier assistants, and have become simply a formality. The council has produced more than 30 policy documents, all of which were approved with little debate (Blackman, Morgenstern, and Topping 2004). Despite its shortcomings, the council plays the beneficial role of encouraging MAVDT leaders to interact with various stakeholders, including their counterparts in other ministries.

Law 99 created the National Technical Advisory Council to advise MMA on scientific and technical issues related to environmental policy. Unlike the National Environmental Council, it gives advice on decrees that establish regulations subject to approval by the president. This is chaired by the vice minister for environment and has five to eight permanent members, mainly from the private sector. The council includes representatives from universities and the private sector, but seems to be dominated by the private sector (Blackman, Morgenstern, and Topping 2004). The university representatives seldom participate in the council meetings. Historically, all council meetings include elected representatives of industry, agriculture, mining, and the petroleum industry.

National Planning Department

The DNP reviews and approves Colombia's national investment budget and evaluates the impacts of spending. All ministries must submit their budget requests to the DNP for approval. In addition, the DNP coordinates the writing of the multisectoral National Development Plan (*Plan Nacional de Desarrollo*) required of each presidential administration, and serves as technical secretary of the National Council of Economic and Social Policy (*Consejo Nacional de Política Económica y Social*, CONPES). Chaired by the president, CONPES is a high-level multisectoral governance body that includes ministers and private sector representatives. It coordinates economic and social policy, approves loans, and issues policy documents. The DNP also wields power by providing technical support to the president on a wide array of matters, by distributing national funds to municipalities, and by having the authority to negotiate and approve international loans to all Colombian public sector agencies.

The DNP's internal organization virtually mirrors that of the Colombian national government: its designated offices deal with each of the government's various ministries and institutions. Until February 2004, the agency dedicated to the environmental sector was the Environmental Policy Office. This office had two key functions: it helped mainstream environmental functions in a wide array of government institutions and practices by working through the budgeting and planning process and through CONPES, and it monitored and evaluated the impact of investments in the environmental sector. The Environmental Policy Office was also responsible for coordination between the DNP and the MAVDT. In February 2004, the government phased out this office and scattered its functions among other DNP offices (Blackman, Morgenstern, and Topping 2004).

Until February 2004, the principal concern in the DNP's relationship with CARs was monitoring their environmental investments and assessing the impacts of those investments. The DNP's responsibility was to ensure that CARs were spending their funds effectively. However, the DNP had considerable difficulty performing this function because CARs lack adequate indicators of environmental quality. After 2004, the absence of an Environmental Policy Office at the DNP led it to minimize its monitoring of CARs' performance. This has widened the gap in environmental planning (Blackman, Morgenstern, and Topping 2004).

Although plans exist for subsectors within the environmental sector (such as forestry and environmental research), no systematic periodic planning exercise establishes priorities across environmental programs and subsectors such as forestry, biodiversity, air pollution, waste management, water resources, and water sanitation. Planning is generally done sector by sector and, as yet, efforts to break out of sectoral boxes and prioritize across programs or sectors have not been successful. During 1994 to 1998, efforts were made within the MAVDT to discuss policy documents among subdirectorates, but it was not possible to arrive at shared concepts that would allow discussion of priorities across program areas. According to Blackman, Morgenstern, and Topping (2004), this situation has not substantially changed. Sector-by-sector planning is still the norm, and there appears to be little discussion of priority setting across sectors at a national level in the SINA. A review of the most recent National Development Plans reveals little discussion of consideration of priorities across environmental sectors (DNP 2003; Galán 1998).

Investigational Institutes

Law 99 recognizes the critical role that information plays in environmental management. The drafters of Law 99 established investigational institutes to conduct research and collect data needed for public environmental management. Two types of institutes were created by Law 99: (a) those that primarily have research responsibilities (von Humboldt Institute, the Institute of Marine and Coastal Research, the Amazonian Institute for Scientific Research, and the Environmental Research Institute of the Pacific); and (b) one that primarily has data collection responsibilities (IDEAM).

Various reports have found that coordination among the investigational institutes and other SINA entities (particularly the MAVDT and IDEAM) is limited (Contraloría General de la República 2003b; IDEAM 2001). The primary function of IDEAM is to organize and direct environmental data collection in Colombia (Law 99 of 1993, Decrees 1277 and 1600 of 1994). The 2003 annual report of the Contraloría de la República found that the research institutes' work has not supported this function. A key characteristic of the poor coordination between the investigational institutes and other SINA entities is that the former tend to specialize in research that is academic and not especially relevant to policy making. A number of factors contribute to this problem (Blackman, Morgenstern, and Topping 2004).

For example, the MAVDT needs to strengthen its capacity to articulate the SINA's research priorities and to inform agendas of the investigational institutes. However, no provision has been made in recent budgets to provide staff time to consider research priorities or to communicate those priorities to the institutes or other researchers (Contraloría General de la República 2003a). Furthermore, evidence suggests that the MAVDT has not yet created a plan to make effective use of high-quality, policy-relevant research when it is produced. Illustrating this are the five "red list" books that the Humboldt Institute has prepared on threatened species.[11] MAVDT staff and local environmental authorities need the information in these high-quality reports to develop land use plans and issue environmental licenses. These books provide so much information, however, that neither the MAVDT nor local environmental authorities have the time—or sometimes the background—to use them effectively. The SINA needs to develop a mechanism to translate scientific research findings into information that is usable by regulatory staff members with varying levels of professional preparation (Blackman, Morgenstern, and Topping 2004).

Coordination efforts between the research institutes and the SINA can be improved. Apparently IDEAM often is not responsive to requests for specific data, partly because it has no resources dedicated to facilitating coordination and is seen as placing a higher priority on research than on data collection (Blackman, Morgenstern, and Topping 2004).

CARs also contribute to poor coordination between the research institutes and other SINA entities. CARs have critical responsibilities for collecting environmental monitoring data. Facilities are obligated to self-monitor their discharges and then report them to CARs, which in turn are responsible for verifying the data and passing them on to IDEAM. IDEAM is responsible for certifying that CARs' data are accurate and for creating a database. However, IDEAM does not have the human and technical capacity needed to perform these functions. As of late 2003, pilot projects to develop CARs' technical capacity to collect and transmit data to IDEAM have had limited success. This is undoubtedly due in part to the slow progress in developing a consistent set of environmental indicators. For their part, CARs do not see the research institutes as supporting their efforts (Contraloría General de la República 2003a).

Finally, the poor coordination between the researchers at the investigational institutes and policy makers is partly a result of the different time horizons of each group. Scientific researchers tend to focus on long-term problems such as biodiversity loss. Policy makers, by contrast, tend to focus on shorter-term issues, the importance of which changes with each administration (Blackman, Morgenstern, and Topping 2004). National funding for research institutes has declined over the past decade. As a result, some of the institutes have turned to other sources for financing. This reconfiguration is partly responsible for the disconnect between the research agenda of the investigational institutes and the needs of the MAVDT and other entities in the SINA (Gómez Torres 2003). The situation of the Humboldt Institute illustrates how the funding situation contributes to poor coordination between regulators and the research institutes.

Under Law 99, the Humboldt Institute is responsible for conducting research on Colombia's flora and fauna and developing a national biodiversity inventory. The institute is organized around four themes: biodiversity inventory, conservation biology, valuation, and biodiversity policy and legislation. According to its 2004 personnel list, about 70 percent of the institute's 150 staff members are scientists, and the remaining are managers and administrative personnel. The MAVDT contributes 8 percent of the institute's budget as an outright grant, and another 8 percent in the form of contracts for specific services. CARs, NGOs, and international donors such as the German bilateral foreign aid agency GTZ and the Global Environment Facility contribute the remainder of the budget.[12] To support itself financially, the institute must pursue topics deemed important by international funding sources. As a result, even though the institute's board of directors comprises representatives of nearly all the major SINA institutions, the research topics it pursues are not necessarily of central interest to policy makers in the SINA. Although the institute has been the most financially successful of Colombia's research institutes, it still has considerable difficulty generating sufficient funds.[13]

Self-financing of the investigational institutes can affect coordination in more subtle ways. For example, unlike the other four research institutes, IDEAM depends largely on public sector financing. Recent national fiscal policy has led to requirements that IDEAM charge for the data it collects. This may limit IDEAM's ability to influence the direction of nongovernmental research in the SINA. This cost-recovery policy is a problem because IDEAM data have become too expensive for a significant number of researchers to use (Blackman, Morgenstern, and Topping 2004).

It is important that Colombia's research system develop capacity to address ecosystem health and urban environmental issues. None of the four research-oriented institutes focuses primarily on industrial pollution control and human health. The issue of the coverage of research topics aside, an open question is whether the current configuration of four research institutes and one data collection institute is optimal, given chronic funding constraints and Colombia's environmental priority problems (Blackman, Morgenstern, and Topping 2004).

National Parks System

Colombia's National Parks System (*Sistema de Parques Nacionales*) comprises 51 protected areas that fall into four categories: (a) national natural parks, (b) flora and fauna sanctuaries, (c) unique natural areas, and

(d) forestry reserves. These protected areas encompass approximately 10 percent of Colombia's territory and include 30 percent of its headwaters (UAESPNN 2002). Until 1993, a National Institute of Renewable Natural Resources office administered protected areas. Law 99 placed the system under the control of an independent office attached to the MMA. In 2002, the National Parks System employed 364 staff members and 132 contractors.

The greatest challenge facing the National Parks System is lack of rule of law, making it very difficult to enforce regulations that restrict certain land uses in the parks, particularly in areas of social unrest. About 79 percent of the area of the National Parks System is occupied or affected by this unrest.

Most deforestation in the national parks is attributable to land tenure and shifting agriculture. A related problem is that park boundaries often overlap with other legally designated areas. These areas either explicitly or implicitly allow land uses that are inappropriate for protected areas.

Funds for the National Parks System are generated by three sources: fees charged for ecotourism within the parks, the national budget, and international sources, all of which have decreased in recent years. Ecotourism and international aid have decreased as a result of continued social unrest.

The National Parks System is a semiautonomous unit under the MAVDT, but better integration with the MAVDT would enable the ministry to promote the policies of the National Parks System more effectively. Currently, the park system must rely on the MAVDT to enforce land use restrictions, and this process is often inefficient. Conversely, the parks system needs more autonomy so it can raise its own funds and have more control over administration of its more distant parks. In 2005, the government was incorporating nongovernmental and private sector organizations in the management of national parks, and the parks system contracted a large travel agency for the operation and maintenance of two national parks.

Public Participation

The 1991 Constitution envisions a central role for individual citizens and NGOs in formulating and implementing environmental policy. In addition to having a right to a healthy environment, citizens have an express duty to protect natural resources and the environment. The Constitution enables them to do so in three ways: (a) by filing a popular action (*acción* *popular*) to protect the collective right to a clean environment; (b) by filing a compliance action (*acción de cumplimiento*) to assure that laws—including environmental laws—are upheld; and (c) by filing an action requesting injunctive relief (*acción de tutela*) to prevent violation of fundamental rights, including the right to a clean environment where environmental deterioration threatens human health (Iguarán 2001). The 1991 Constitution also specifically requires adoption of statutes that guarantee community participation in decisions that affect the environment through the right to petition public authorities, public hearings, open meetings, referendums, and standard participation in elections, and, in the case of the *Contraloría*, requires adoption of laws that create systems to allow citizens to monitor public fiscal management at all levels of government.

Control Organizations

Within the *Procuraduría General, la Procuraduría Delegada para Asuntos Ambientales* (*Procuraduría Delegada*) is responsible for oversight of all environmental authorities in Colombia. Nine lawyers and three technical people staff the office, a level insufficient to carry out its functions. The *Procuraduría General* hopes that this deficiency can be corrected, in part, by an agreement among the *Fiscalía*,[14] the *Contraloría General de la República* (*Contraloría*) and the *Procuraduría Delegada* to share evidence. The *Procuraduría General* views its central function as preventing abuse of office and failure to implement policy. To be more effective, each year the *Procuraduría Delegada* chooses a specific area on which to focus. In 2003, for example, it focused on solid waste and wastewater treatment plants.

Environmental staff members within the *Contraloría* flagged a number of performance-related concerns. For instance, their capacity to carry out oversight has been constrained by the absence of environmental indicators. This has impeded program evaluation. The *Contraloría* also has difficulty reconciling heterogeneous data from the various agencies involved in environmental policy, including the DNP, the MAVDT, the National Statistical Administration Department (*Departamento Administrativo Nacional de Estadísticas*, DANE), and the *Contraloría* itself.

As a result of the absence of these indicators, the national control offices use administrative indicators of performance, rather than indicators based on environmental quality. Several persons interviewed for the Blackman, Morgenstern, and Topping report (2004) argued that CARs are at least partly responsible for the slow progress in developing indicators. Under current law, the control organizations can set in motion procedures to remove CAR general directors for failure to comply with CAR action plans. This creates a strong incentive for CARs to block implementation of effective indicators. The government issued Decree 1200 of 2004 to establish the framework for environmental indicators.

Judiciary

The Constitution of 1991 and Law 99 of 1993 assign to the judiciary a central role in the SINA. Under the 1991 Constitution, every citizen has the right to file public actions in defense of the Constitution and the law and to petition authorities. As discussed, the Constitution and implementing laws and decrees create three causes of action that citizens can use to demand protection of constitutional rights to a healthy environment and implementation of environmental law.[15] These formal provisions for access to justice to enforce environmental rights are extraordinary.

There is mixed evidence regarding the effectiveness of this access. Based on criteria developed by the Access Initiative, a major international effort to promote public participation in environmental management, a national legal system needs: "(i) constitutional guarantees for access to justice; (ii) impartial administrative, judicial, and alternative venues for resolution of conflicts and remedy; (iii) affordable and timely legal services; and (iv) active education by government on the participation and environmental rights of the public and how they can use the legal system to protect those rights" (Access Initiative 2004). A number of these requirements are still absent in Colombia.

For example, although the 1991 Constitution guarantees access to justice, relatively few Colombians are aware of this right (Seligson 2001). Fewer than 30 percent of respondents to a recent survey knew of *acciónes de tutela*[16] even though this particular action was by far the best known, and less than 1 percent of respondents were aware of the availability of public hearings or other causes of action before the courts.

Notwithstanding these problems, most evaluations of acciónes de tutela are positive. Survey research has indicated that acciónes de tutela are the most widely used causes of action and are viewed as the most effective means of citizen control over government actions (Saez 2003). The Constitutional Court, which hears *acciónes de tutela*, has proved to be a very attractive forum. Through 2001, the number of claims brought as acciónes de tutela in all areas grew at a rate of 130 percent per year. More than 400,000 such actions were brought in 2000 (Saez 2003). Furthermore, petitioners were opting to bring *acciónes de tutela* in the

Constitutional Court instead of through normal jurisdictional channels because decisions there are perceived to be faster and more principled, and with good reason. Between 1992 and 1995, the Constitutional Court granted almost 40 percent of the acciónes de tutela brought before it, while the highest court in the conventional civil court system held for petitioners in less than 7 percent of cases (Seligson 2001).

Conclusions and Recommendations

Principal problems within the SINA include the following: (a) insufficient data on environmental quality and institutional performance; (b) suboptimal priority setting across environmental subsectors and programs; (c) inefficient public environmental spending on the SINA; (d) limited environmental management capacity at the MAVDT; (e) reliance on voluntary regulations and voluntary clean production agreements that perpetuate noncompliance with existing regulations; (f) suboptimal regulations—for example, command-and-control emissions standards adopted from more developed countries with little or no modification; (g) poor coordination among the MAVDT, CARs, and SINA entities; (h) potential adverse impact from the merger of environment and economic development, and weak regulations and control agencies; (i) limited technical capacity in some CARs; and (j) weak enforcement—for example, of the effluent fees that CARs charge to polluters, only one-third are actually collected (Blackman, Morgenstern, and Topping 2004).

One of the main conclusions is that the SINA might benefit from establishing a systematic mechanism for priority setting across environmental programs and subsectors. Planning is generally done sector by sector, and efforts to break out of sectoral boxes and consider prioritization across programs or sectors have not been successful. This is a common problem in environmental regulatory systems around the world and is partly attributable to the fact that, in most environmental regulatory systems, day-to-day work is organized by environmental media or problem areas, such as forestry, water, or air. Lack of cross-sectoral planning contributes to imbalances in budgetary priorities.[17] For example, a recent audit of the MMA found that biodiversity conservation, reforestation, watershed management, and other rural environmental issues accounted for three-quarters of the ministry's investment budget, but over 70 percent of the population lives in urban areas and is exposed to significant health risks. Priority setting across subsectors and programs would be greatly enhanced by improvements in data collection and environmental indicators.

However, even with current information sources, greater attention to setting priorities across environmental subsectors would help improve the effectiveness of environmental management in Colombia. The SINA has spent approximately Col$5 billion without measurable impact indicators to promote linkages between national and regional priorities, or to increase understanding of the impacts of key sectors on the environment. Despite high levels of expenditures, there is no direct correlation between CAR investments and national environmental priorities.[18] The level of funding for the environment in Colombia may be a less important consideration than the efficiency with which funds are spent.

Establish a Mechanism for Setting Priorities Across Environmental Subsectors

Analysis reveals that expenditures on environmental management focus on investments in water basin management, wastewater treatment, and forestry and biodiversity conservation, with much less attention to urban and rural environmental issues affecting the poor, such as air quality, waterborne diseases, and natural disasters. To better align resources with the environmental problems that need to be addressed, coordination and an agreed agenda among the SINA, the DNP, and the MAVDT is necessary, as is a plan to strengthen the design, monitoring, and execution of environmental policies. The areas of SINA that could be strengthened include (a) promotion of environmental health; (b) sustainable urban development; and (c) planning, control, and monitoring of environmental management. Specific actions include: control of air pollution; promotion of hygienic practices; management of hazardous waste; strategic planning; improvement of urban life quality; strengthening of urban development management; and development of instruments for planning, monitoring, and evaluation of environmental management.

Colombia's regional diversity implies that CARs may set very different goals and may use very different strategies to achieve them.[19] Nevertheless, a regular priority-setting mechanism that accommodates this diversity—and the consequent need for policy flexibility—is likely to generate considerable benefits by helping to rationalize and coordinate environmental protection activities across subsectors, regions, administrative levels, and institutions. In the setting of environmental priorities, it would be advisable to promote legitimacy and "buy-in" through participatory processes.

One option is for the MAVDT to require that each CAR periodically perform an assessment of the relative importance of various risks to human health and the environment in the CAR's territory. Furthermore, the MAVDT can require that CARs use this comparative risk assessment to guide the allocation of financial, human, and technical resources (see chapter 4).

Initiate a Long-Term Program to Review and Rationalize Regulations

In the short term, it would be advisable to commission an independent study, or use existing studies, to identify and prioritize challenges posed by regulations for implementation of environmental statutes, including gaps, inconsistencies, and inappropriate levels of specificity, and technical requirements that are not appropriate to current local conditions in Colombia. The results of this analytical effort might help to initiate a long-term program of rationalizing and reforming environmental regulations. To design and implement policies to tackle environmental problems that represent the largest share of the cost of environmental degradation, it would be advisable to undertake strategic environmental assessments relating to environmental health, vulnerability to natural disasters, and urban environmental management.

Evaluate and Rationalize Voluntary Regulation

A paucity of evidence supports the contention that national-level voluntary clean production agreements have been reasonably successful at promoting compliance with existing regulations—or even at furthering improved environmental performance. This conclusion is in line with international experiences in voluntary regulatory compacts, in both industrial and developing countries. Thus, further efforts to promote clean production agreements in lieu of mandatory regulation should be undertaken cautiously, if at all. At a minimum, any future voluntary agreements should shift the burden of proof of intent to comply onto polluting firms by establishing clear periodic performance milestones (focusing on easily monitored activities) that would need to be met for the agreement to continue in force.

The argument for continued reliance on voluntary environmental guides is stronger. These guides appear to fill a need for user-friendly official guidance information on how firms and farms can improve their environmental performance and how they can comply with regulations that, as discussed above, are often incomplete and unclear. Nevertheless, as discussed, the guides themselves have created confusion. For this reason, efforts might be considered to modify them and to clarify the role they play within the SINA. In general, the guides could be revised to ensure they are consistent with existing command-and-control regulations.

Improve the Collection, Management, Dissemination, and Use of Environmental Data

Because information is the cornerstone of improved environmental management within the SINA, the MAVDT could consider improving data collection and management at the CAR level and to collate and integrate these data nationally. Toward this end, the MAVDT might establish a system of indicators of both environmental quality and of CAR performance. The indicators could be sufficiently limited in number and sufficiently simple so that it is possible to implement the system despite the modest data collection and management capacity expected to prevail in CARs in the medium term. It is also very important that the system be consistent across CARs to ensure that data from different CARs can be compared and aggregated at the national level.[20]

Strengthen Advance Notice of Significant Environmental Policy Actions and Provide Opportunities for Public Input

Public participation in environmental policy making in Colombia could be strengthened by establishing formal procedures to facilitate informing the public when new policies are being considered, providing opportunities to comment on proposed new policies, and having comments taken into consideration, at all levels of government. This would entail (a) establishing clear procedures for national and regional regulatory agencies to provide early notification of the government's intent to draft new regulations or make major changes in policy (for example, requiring drafts of proposed regulations to be published in the *Diario Legal* and on publicly accessible Web sites) and for enabling the public to comment on these notices; (b) building into environmental assessment regulations (Decree 1220 of 2005) the opportunity for public comment on investment projects and government programs, plans, and policies; and (c) developing the agencies' internal capacity to consider comments in writing regulations and making policy, and to report back to the public on how public comments were taken into consideration.

Improve Coordination between the MAVDT and CARs and Build Management Capacity in CARs

The MAVDT might explore new strategies for improving coordination between the MAVDT and CARs and building management capacity in CARs. A necessary condition is to establish a system for collecting credible data on the institutional performance of CARs. These data are needed for planning coordinated activities, monitoring compliance with such plans, and monitoring overall institutional performance. Actively disseminating such data—or even publicly disclosing it—can create strong incentives for compliance with coordinated plans and for improved institutional performance. Other potentially complementary mechanisms include strengthening the capacity and authority of the SINA's control organizations, which, in theory, are responsible for ensuring that CARs' activities are in line with the law.

Appoint an Independent Commission to Evaluate the Impacts of the Merger of the Ministries of Environment and Economic Development

The government might consider appointing an independent, nonpartisan commission to evaluate the impacts of the merger on the MAVDT's ability to play its role as the SINA's *rector* and to regulate the provision of national-scale infrastructure. (For a definition of such projects, see Law 99 of 1993, Art. 52.) The commission's report could be disclosed to the public. Ideally, the commission would serve a dual function: it would provide the data that policy makers need to assess the impacts of the merger of the ministries, and to take any remedial action; and it would create incentives for national policy makers to be proactive in ensuring that potential damages from the merger are minimized.

See table 3.3 for a summary of these recommendations.

Table 3.3 Recommendations

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Participating organizations*
Establish a mechanism for setting priorities across environmental subsectors	S	Congress, MHCP, DNP, MAVDT, CARs
Initiate a long-term program to review and rationalize regulations through strategic environmental assessments relating to (a) environmental health, (b) vulnerability to natural disasters, and (c) urban environmental management	S	DNP, MAVDT
Evaluate and rationalize voluntary regulation	S–M	MAVDT
Improve the collection, management, dissemination, and use of environmental data	S	MAVDT, IDEAM, CARs

Table 3.3 Recommendations (*continued*)

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Participating organizations*
Strengthen advance notice of significant environmental policy actions and provide opportunities for public input	S	MAVDT
Improve coordination between the MAVDT and CARs and build management capacity in CARs	S	MAVDT, CARs, FNR, FONAM
Appoint an independent commission to evaluate the impacts of the merger of the Environment and Economic Development Ministries	M	DNP, MAVDT, IDEAM

Source: Authors.
Note: FNR = *Fondo Nacional de Regalías*; MHCP = *Ministerio de Hacienda y Crédito Público*.

Notes

1. Allen Blackman, Richard Morgenstern, Elizabeth Topping, Sandra Hoffman, and Ernesto Sánchez-Triana are the authors of this chapter, which draws heavily from a background document prepared for this study by Blackman, Morgenstern, Topping, and Hoffman (2004).
2. The Contraloría is responsible for fiscal oversight including financial auditing and broader evaluation of the cost-effectiveness of government programs. Each year the Contraloría must present Congress with a report on the state of the environment and natural resources in Colombia (Const. Art. 268).
3. These eight CARs are CAR Cundinamarca, CDMB, CORANTIOQUIA, CORNARE, CORTOLIMA, CRA, CRC, and CVC.
4. In Colombia, royalty payments to departments and municipal governments correspond to a percentage of the production of nonrenewable natural resources, mainly oil and gas, coal, and nickel. Laws 141 of 1994 and 756 of 2002 establish the royalties to be paid for the production of oil and gas and minerals. The royalty law established a system of variable royalty payments of 8 to 25 percent for the oil and gas sector, based on the level of production. Royalties for minerals except petroleum range from 1 to 12 percent. For coal, the royalty rate is 10 percent for mining companies that produce more than 3 million metric tons per year and 5 percent for those that produce below that level. The highest levels of royalties are for nickel and salt (12 percent). Most of this compensation is distributed directly to producing departments and municipalities. A smaller portion is distributed to all departments and municipalities through the National Royalties Fund (*Fondo Nacional de Regalías*). Revenues accrued from royalties amounted to 1 percent of Colombia's gross domestic product in 2002.

5. The decision held that these resources must be invested in the urban perimeter, but the CARs—not the AAUs—are responsible for this investment.
6. According to the MAVDT, "in the process of assigning resources to CAR projects, DNP is only responsible for approving resources for projects financed with national budget resources, which are assigned to those CARs that have less potential to collect resources" (MAVDT 2006, p. 6).
7. The *Procuraduría Delegada para Asuntos Ambientales* is an autonomous entity in charge of upholding universal human rights and the correct functioning of public institutions protecting citizens' interests.
8. The 2002–06 administration initially planned to merge the Ministries of Environment and Agriculture. However, this plan was ultimately changed because of the belief that merging the Ministries of Environment and Economic Development could help improve the administration of infrastructure investments (primarily in sanitation and water), because responsibility for such investments had historically been split between these two ministries.
9. According to the MAVDT (2006, p. 6), under "clean production agreements it has never been agreed that the Environmental Authority stops exercising its command and control functions in order to promote compliance with norms and standards."
10. One such program focused on small and medium enterprises in Bogotá. A second successful voluntary program called *Programa Excelencia* is not a conventional clean production agreement. It involves rating the environmental performance of polluting facilities, and then publicizing the ratings.
11. The red list and red data books are products of a World Conservation Union program designed to list and develop data needed for management to protect threatened and endangered species.
12. The Humboldt Institute has 27 permanent staff members whose salaries are paid by national government contributions; salaries for researchers and all other project-specific staff members are covered by other sources.
13. The Humboldt Institute does have a very direct tie to MAVDT policy makers. The MAVDT contracts out several specific functions to the institute, including implementation of the National Biodiversity Policy. Some 27 members of the institute's staff are currently on contract with the MAVDT.
14. The *Fiscalía* is an entity of the judicial branch with broad administrative and budgetary autonomy, the function of which is to provide citizens with due and efficient administration of justice.
15. See Constitutional Articles 77, 86, 87, 88; Law 393/97; Law 472/98; Law 99/93 Art. 77; Decree 306/92; Decree 2591/92.
16. *Acciónes de tutela* are actions requesting injunctive relief—legal procedures for the immediate protection of fundamental rights from threats by authorities or

individuals. *Tutelas* protect citizens from arbitrary acts of authority and from actions by individuals in cases in which a subordinating relation exists.

17. According to the MAVDT (2006, p. 6), "the resource potential of Corporations does not depend on whether the Corporation operated prior to Law 99 of 1993 or if it was created by the law, but rather on the development conditions of its jurisdiction. Taking into account that the most important sources are the percentage of municipal property taxes transferred for environmental management and electricity sector transfers, it is clear that in less developed territories collection of the first source is limited and that electricity generation projects do not benefit all Corporations."
18. According to the MAVDT (2006, p. 6), regional and national priorities coincide, given that "in the National Development Plan general areas are identified that should be defined at the regional level in accordance with their importance at that level."
19. According to the MAVDT (2006, p. 6), the "objectives of the Corporations and their functions are defined under Law 99 of 1993. What adjusts to their characteristics is the development of actions within the framework of national policies. In developing the planning instruments of the Corporations, advances are being made in the definition of regional action priorities that originate from participatory processes."
20. According to the MAVDT (2006, p. 6), it "should be recognized that an effort is being made to consolidate an information system and an indicators system. The document poses a recommendation that is already underway with the application of Decree 1200 of 2004 and Resolution 643."

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CHAPTER 4

Decentralization: A Balancing Act

Environmental management in Colombia has been decentralized to the Autonomous Regional Corporations (CARs). This unique feature of Colombia's environmental management system has several strengths, including financial autonomy and involvement of local stakeholders in environmental governance. The 33 CARs display marked heterogeneity. Analysis of their performance indicates that they do not always adequately prioritize environmental issues. Other concerns are financial and jurisdictional conflicts among CARs, and suboptimal coordination between the Ministry of Environment, Housing and Regional Development and CARs. There are also challenges to improving CARs' transparency and accountability mechanisms, and to improving guidance from the national government. Solutions include (a) improving priority setting by CARs, (b) reconstructing CARs' governance structure, (c) resolving conflicts between CARs and Urban Environmental Authorities, and (d) eliminating those CARs that chronically perform poorly.

Although Law 99 assigns the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA) the role of leading and coordinating environmental management in Colombia, arguably one group of the most important institutional actors of the National Environmental System (*Sistema Nacional Ambiental*, SINA) is the Autonomous Regional Corporations

(*Corporaciones Autónomas Regionales*, CARs), which are assigned the role of implementing environmental policy.[1] This chapter looks at the performance of CARs by examining (a) the sources of CARs' financial resources, (b) the allocation of CAR resources and priority setting, (c) proposed reforms to CAR governance, (d) conflicts of interest related to sanitation infrastructure, and (e) the relationships between CARs and other SINA agencies.

Colombia's 33 CARs display marked heterogeneity across a wide variety of institutional characteristics including performance, priorities, resource allocation, finances, and human and technical resources. CARs' basic geographical, historical, and socioeconomic characteristics also vary widely. In size, CARs range from 51 square kilometers (CORALINA) to 226,000 square kilometers (CORPOAMAZONIA), and in number of municipalities from 2 (CORALINA) to 87 (CORPOBOYACA). Eight CARs border on five Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs). Sixteen CARs were established before enactment of Law 99 of 1993. Population varies from 81,000 (CORALINA) to over 4 million (CVC), and urbanization from 22 percent (CORPOGUAVIO) to 94 percent (CRA). Gross domestic product (GDP) varies from Col$100 billion (US$46.5 million) (CORPOGUAVIO) to Col$21,509 billion (US$10 billion) (CVC). Literacy varies from just 68 percent (CODECHOCO) to 95 percent (CORALINA). Perhaps most striking of all, poverty, measured as the percentage of municipalities where basic needs are not met for more than 53 percent of the population, varies from 0 percent (CVC and CRQ) to 100 percent (CDA). Many of these socioeconomic characteristics (for example, poverty and literacy) are highly correlated (annex 4.1).

Overall Performance of CARs

Since 1993, CARs' principal responsibility has been environmental protection. Therefore, the ideal means of measuring how well individual CARs are carrying out this responsibility is to assess their impact on environmental quality over time using data on, for example, hectares reforested and water pollution reduced by year. Unfortunately, the quality of environmental data in Colombia is poor—although some credible environmental quality data exist for selected natural resources and geographical subregions, very little complete and reliable data exist at the CAR level. A recurring finding of research on CARs is a paucity of data on environmental quality and institutional performance at the CAR level. The importance of this deficiency is impossible to overstate. It hamstrings environmental decision making at the regional, national, and even at the international levels. A more immediate implication is that it has placed important limitations on the present analysis of CARs.

Because of this problem, past studies of CARs' performance have supplemented existing CAR-level data on environmental quality with process-related proxy data, that is, information about whether and to what extent CARs carry out functions associated with environmental protection. Although clearly second best, such data do provide some useful information about performance. More specifically, they provide an indication of whether necessary (but insufficient) conditions exist for a CAR to have a positive impact on environmental quality. Therefore, proxy data help to identify CARs that are unlikely to have a positive impact on the environment, as opposed to CARs that actually do have a positive impact.

The only repository of extensive CAR-level performance data is maintained by the Colombian Association of Environmental Authorities (*Asociación Colombiana de Autoridades Ambientales*, ASOCAR). Most of the data are self-reported by CARs in response to an annual ASOCAR survey. The ASOCAR data set comprises hundreds of variables, but much of it is only tangentially related to performance, or is incomplete. Of the complete and consistent variables in the ASOCAR data, there are 14 that best measure performance. These variables are presented in table 4.1. Four of the 14 performance variables are direct measures of performance. The remaining 10 performance variables are measures of processes related to environmental management.

The dependent variable was constructed with two indexes: GRADE 1 and GRADE 2. GRADE 1 is based on all 14 variables, including direct measures of performance and process-related proxies, and GRADE 2 is based only on the four direct measures of performance. The two indexes were constructed as follows: First, to be able to compare and aggregate variables measured in different units (for example, RAIDS, the number of raids per hectare per year, with REDUCE_H20_PLN, the reduction in basic oxygen demand per year), each of the 14 variables was scaled using the following formula:

$$\text{Score}_i = (X_i - \text{minimum value of } X) \times 100 / (\text{maximum value of } X - \text{minimum value of } X)$$

where *i* indexes each of the 33 CARs, and *X* is the performance variable in question. This formula produces a score on a scale of 1 to 100 where 1 corresponds to the minimum value of the performance variable and

Table 4.1 ASOCAR Data Variables with Direct Measures of Performance

Variable	*Indicator*
Variables with direct measures of performance	
REFOREST	Percentage of hectares reforested out of total susceptible land
SOLID WASTE	Percentage of municipalities with legal solid waste disposal by 2002
REDUCE_H20_ PLN	Reductions in total suspended solids + biochemical oxygen demand per Col$ of GDP by 2002
CLEAN_PDN GOALS	Percentage of clean production goals achieved by 2002
Variables with measures of processes related to environmental management	
ENVIRO_PDM	Percentage of municipalities with environmental section of Municipal Development Plan
ENVIRO_POT	Percentage of municipalities with environmental component in Land Use Plan
WATER_MGMT _PLAN	Percentage of CAR area under watershed management plan
RAIDS	Number of raids per hectare per year
SEIZURES	Seizures of logs, flora, and fauna in 2002
VALUE_FINES	Value of fines by 2002
EFF_PERMIT	Percentage of effluent sources permitted in 2002
DIS_PREV_PLAN	Percentage of municipalities with disaster prevention plans
ENV_ED_PLAN	Percentage of municipalities with environmental education plans
SOIL_ZONING	Percentage of municipalities with land zoning plans

Source: Blackman, Morgenstern, and Topping 2004.

100 corresponds to the maximum value. After the variables were scaled, they were summed. GRADE 1 is the sum of all 14 scores, and GRADE 2 is the sum of four scores derived from the direct-measures variables. Finally, GRADE 1 and GRADE 2 were used to rank CARs.

Results from the econometric analysis of these variables by Blackman, Morgenstern, and Topping (2004) indicate that three socioeconomic characteristics are correlated with overall performance: (a) whether the CAR was established before Law 99 of 1993[2]; (b) the percentage of municipalities in the CAR where the basic needs of more than 50 percent of the population are not met (poverty); and (c) the natural log of geographic area in square kilometers. CARs established before Law 99 are considered to be more effective because they have stronger institutions and more political and popular support. At least two factors may explain the poverty result. First, considerable research suggests a link between poverty and environmental degradation (Duraiappah 1998). Therefore, CARs with higher rates of poverty may face more significant challenges in mitigating environmental problems. Second, poorer CARs may generate lower tax revenues and have a limited supply of environmental professionals in both the public and the private sectors. As a result, such CARs may have to make do with relatively low levels of financial and human resources. The explanation for those CARs that have geographically smaller jurisdictions and that perform relatively well is fairly obvious—such CARs presumably have more financial, managerial, and technical resources to devote to each hectare. The econometric analysis also shows a very low correlation with some characteristics such as revenues (normalized as total spending per CAR inhabitant) and number of staff members, among others.

Allocation of CAR Resources and Priority Setting

Collectively, CARs invested Col$331,418,152,500 (about US$15.4 million) in 524 projects in 2001. The number of investment projects per CAR ranged from 4 (CVS) to 84 (CAM) while the size of the investment projects ranged from Col$200,000,000 (US$65,000) to Col$93,184,000,000 (US$51.4 million). The size of the average investment project was Col$632,477,000 (US$295,175). To determine how CARs allocated their investment funds across environmental subsectors, each investment project can be placed into one of 22 different categories, which are then aggregated into 4 meta-categories (table 4.2).

According to Blackman, Morgenstern, and Topping (2004), an analysis of the distribution of investment funds and projects among the 4 meta-categories and 22 categories for each CAR reflects two important trends. First, CARs allocated a relatively large percentage of funds—11 percent, the third-largest percentage outside of flora and fauna conservation and construction of municipal wastewater treatment plants—to projects in the operations-related general activities category (category 20). This category includes projects that, as judged by their titles, would be more accurately classified as operations expenditures than investment expenditures. Examples include projects titled Legal Advice on the Defense of Institutional Interests, Strengthening of Monitoring and Control Activities, and Participation in Environmental and Natural Resources Associations and Events. Blackman, Morgenstern, and Topping (2004) offer a hypothesis for the classification of these as investment projects, explaining that some CARs intentionally mask operational expenditures as investment expenditures in response to legal and institutional pressures to limit operational expenditures.[3]

The CARs' aggregate investment data suggest that, like the Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT), their investment

Table 4.2 Categorization of CAR Investment Projects

Flora and fauna conservation

1. Forest and ecosystem conservation
2. Protected areas
3. Green markets

Pollution

4. Air pollution control
5. Solid and hazardous waste management
6. Clean technologies
7. Industrial pollution control projects covering multiple or unspecified media, particularly construction of municipal wastewater treatment plants
8. Wastewater infrastructure
9. Water quality control other than wastewater infrastructure

Water quantity

10. Drinking water supply
11. Water quantity, general
12. Irrigation

Other

13. Water, general or unspecified
14. Soil conservation
15. Coastal and marine resources management
16. Natural disaster prevention (including flood control)
17. Mosquito control
18. Research and information gathering
19. Environmental education
20. Operations-related general activities (including planning, legal actions, monitoring and control, and institutional strengthening where environmental media are not specified)
21. Community and territorial entity activities (including joint activities with departments, municipalities, nongovernmental organizations, and indigenous and Afro-Colombian communities where nature of activity is not specific)
22. Other or undetermined activity

Source: Blackman, Morgenstern, and Topping 2004.

allocations reflect a bias against air pollution control, control of waterborne diseases, and reduction of vulnerability to natural disasters. The greatest percentage of investment funds—35 percent—appears to have been devoted to construction of wastewater treatment plants. In fact, the lion's share of this investment was in just one category, "wastewater infrastructure," which accounted for 30 percent of total investment. Moreover, investments in wastewater infrastructure constituted a small number of very expensive wastewater treatment plants. In 2001, all 33 CARs funded only 11 projects in this category, but the average cost of each project was Col$9,078,200,454 (about US$4 million). Municipalities and departments already make sizable investments in sanitation infrastructure. Leaving aside "wastewater infrastructure," investments in all of the remaining categories within "industrial pollution control"—including "solid and hazardous waste management," "clean technologies," "industrial pollution control other," and "water quality other"—accounted for only 5 percent of total funds invested by CARs, and only 12 percent of the total number of investment projects.

Therefore, the analysis suggests that CARs devote a large percentage of their investment funds to pollution control, when in actuality the majority of these funds were spent on building a small number of very expensive wastewater treatment plants, and relatively few funds were spent on any other pollution projects.[4] By contrast, CARs devoted fully 28 percent of their investment funds to projects in the "flora and fauna conservation" meta-category, including those falling under "forest and ecosystem conservation" (category 1), "protected areas" (category 2), and "green markets" (category 3).

Allocation of CAR Resources to the Most Pressing Environmental Problems

A different question is whether individual CARs allocate their investment funds to their most pressing environmental problems. Factors for this determination include (a) the severity of different types of environmental risks in the area under a CAR's jurisdiction, and (b) the extent to which CARs focus their investment funds on these risks. If CARs are allocating investment spending in a rational manner, that is, based on an assessment of the severity of different risks, there should be a correlation between (a) and (b). For example, CARs in which deforestation rates are relatively high should be spending a relatively high percentage of their investment funds on flora and fauna conservation.

Unfortunately, the unavailability of appropriate data limits such an analysis. For example, data on environmental risks that exactly match these categories of investment spending are not available. Instead, data on environmental risks associated with some of these categories of investment spending must be used. Some categories of spending rely on questionable and imperfect proxies for the severity of environmental risks, such as those for water pollution and air pollution. The proxy used for air pollution is the percentage of deaths from respiratory illness, but it is widely known that a broad range of factors unrelated to outdoor or indoor air pollution affect the incidence of respiratory illness, including smoking. Similarly, wastewater treatment is not correlated with gastrointestinal illness, including basic sanitation. A second data limitation is that some of the environmental risk data are quite imprecise. In particular, some data were collected at the department level and converted to the CAR level using population- or land area–based weights. Moreover, as noted, the categorization of spending is imprecise. Because of these data limitations, analysis of whether CAR spending is allocated rationally is inexact. Nonetheless, an analysis can shed light on the question of whether there are gross imbalances in the allocation of investment spending across categories.

To compare the severity of different types of environmental risks in each CAR with the extent to which CARs focus their investment funds on these risks, the severity of the risk posed by a certain type of environmental risk in each CAR can be ranked as high, medium, or low, depending on whether the CAR ranks in the top, middle, or bottom third of the distribution of the appropriate measure of environmental risk across all 33 CARs. For instance, the risk to flora and fauna in each CAR is ranked as high when the deforestation rate in that CAR is in the top third of the distribution of deforestation rates across all 33 CARs. A similar method is used for ranking the extent to which CARs focus their investment funds on a certain risk. The percentage of investment funds allocated to addressing a certain risk in each CAR is ranked as high, medium, or low, depending on whether the percentage of investment funds spent on that risk ranks in the top, middle, or bottom third of the distribution of these percentages across all 33 CARs. The purpose of choosing coarse (high, medium, low) categories of risk is to match the precision of the ranking with the precision of the data on environmental risks.

After the severity of different types of environmental risks and the extent to which CARs focus their investment funds on these risks have been ranked, these two rankings can be compared to determine whether CARs have overinvested or underinvested in certain types of risks. A CAR is said to have underinvested in a given type of risk when the risk is ranked as either high or medium but the CAR investment spending is ranked as low. A CAR is said to have overinvested in a certain type of risk when the risk is ranked as low but the CAR investment spending is ranked as medium or high. For example, *Corporación Autónoma Regional del Magdalena* (CORPAMAG) has underinvested in flora and fauna if deforestation rates in CORPAMAG are in the top or middle third of rates for all CARs, but CORPAMAG's spending on flora and fauna preservation is in the bottom third.

The data presented in tables 4.3A through 4.3F suggest that CARs' allocations of investment spending across different risks do not align

Table 4.3A Severity of Risk versus Percentage of 2001 Total Investment by CAR: Soil Degradation

CAR	*Cost of soil degradation (pesos)*	*Percentage of total investment in soil conservation*
CAM	High	Low
CAR Cundinamarca	High	Low
CARDER	Low	Low
CARDIQUE	Low	Low
CARSUCRE	Low	Low
CAS	High	Low
CDA	n.a.	Low
CDMB	Medium	High
CODECHOCO	n.a.	Low
CORALINA	n.a.	Low
CORANTIOQUIA	High	High
CORMACARENA	High	Low
CORNARE	High	Low
CORPAMAG	Medium	Low
CORPOAMAZONIA	n.a.	Low
CORPOBOYACA	High	High
CORPOCALDAS	Medium	Low
CORPOCESAR	Low	Low
CORPOCHIVOR	Medium	Low
CORPOGUAJIRA	Low	Low
CORPOGUAVIO	Medium	Low
CORPOMOJANA	Low	Low
CORPONARIÑO	Medium	Low
CORPONOR	n.a.	Low
CORPORINOQUIA	n.a.	Low
CORPOURABA	Medium	Low
CORTOLIMA	High	Low
CRA	n.a.	Low
CRC	Medium	Low
CRQ	Low	Low
CSB	Low	Low
CVC	High	High
CVS	n.a.	Low
Percentage of CARs that underinvest		54
Percentage of CARs that overinvest		0

Source: Blackman, Morgenstern, and Topping 2004.
Note: n.a. = not applicable.

Table 4.3B Severity of Risk versus Percentage of 2001 Total Investment by CAR: Flora and Fauna Degradation

CAR	*Annual average percentage change in forest cover, 1986–96*	*Percentage of total investment in flora and fauna conservation*
CAM	Low	Medium
CAR Cundinamarca	Low	Low
CARDER	Low	Medium
CARDIQUE	High	Low
CARSUCRE	High	Low
CAS	Low	Low
CDA	Medium	High
CDMB	Low	Low
CODECHOCO	Medium	High
CORALINA	n.a.	Medium
CORANTIOQUIA	Low	High
CORMACARENA	Medium	High
CORNARE	Medium	Low
CORPAMAG	High	Medium
CORPOAMAZONIA	Medium	Low
CORPOBOYACA	Medium	Low
CORPOCALDAS	High	High
CORPOCESAR	Low	Medium
CORPOCHIVOR	Medium	Low
CORPOGUAJIRA	Medium	Low
CORPOGUAVIO	Low	High
CORPOMOJANA	High	Low
CORPONARIÑO	Low	Medium
CORPONOR	Low	High
CORPORINOQUIA	High	Medium
CORPOURABA	Medium	High
CORTOLIMA	High	High
CRA	High	Medium
CRC	Medium	Medium
CRQ	High	Medium
CSB	High	High
CVC	Low	High
CVS	High	Medium
Percentage of CARs that underinvest		24
Percentage of CARs that overinvest		24

Source: Blackman, Morgenstern, and Topping 2004.
Note: n.a. = not applicable.

Table 4.3C Severity of Risk versus Percentage of 2001 Total Investment by CAR: Natural Disaster Prevention

CAR	*Average percentage of population affected by natural disasters, 1997–2003*	*Percentage of investment in natural disaster prevention*
CAM	Medium	Low
CAR Cundinamarca	Low	Low
CARDER	Medium	Low
CARDIQUE	High	Low
CARSUCRE	High	Low
CAS	Low	Low
CDA	High	Low
CDMB	Low	Low
CODECHOCO	High	Low
CORALINA	Low	Low
CORANTIOQUIA	Low	Low
CORMACARENA	Medium	Low
CORNARE	Low	Low
CORPAMAG	High	Low
CORPOAMAZONIA	High	Low
CORPOBOYACA	Medium	Low
CORPOCALDAS	Low	Low
CORPOCESAR	High	Low
CORPOCHIVOR	Medium	Low
CORPOGUAJIRA	Medium	Low
CORPOGUAVIO	Low	High
CORPOMOJANA	High	Low
CORPONARIÑO	Medium	Low
CORPONOR	Low	Low
CORPORINOQUIA	High	Low
CORPOURABA	Low	Low
CORTOLIMA	Medium	Low
CRA	Low	Low
CRC	Medium	Low
CRQ	Medium	Low
CSB	High	Low
CVC	Low	Low
CVS	High	High
Percentage of CARs that underinvest		61
Percentage of CARs that overinvest		3

Source: Blackman, Morgenstern, and Topping 2004.

Table 4.3D Severity of Risk versus Percentage of 2001 Total Investment by CAR: Water Pollution

CAR	*Percentage of deaths from gastrointestinal disease*	*Percentage of investment in water supply and sanitation (conservative estimate)*	*Percentage of investment in water supply and sanitation (liberal estimate)*
CAM	Medium	High	High
CAR Cundinamarca	Medium	High	High
CARDER	Medium	Low	High
CARDIQUE	Medium	Low	Medium
CARSUCRE	Medium	Medium	Medium
CAS	High	High	Medium
CDA	High	Low	Low
CDMB	High	High	High
CODECHOCO	Low	High	High
CORALINA	High	Low	High
CORANTIOQUIA	Medium	Low	Low
CORMACARENA	Low	High	Medium
CORNARE	Medium	Low	Low
CORPAMAG	Low	Medium	High
CORPOAMAZONIA	Low	Low	Low
CORPOBOYACA	Low	High	Medium
CORPOCALDAS	High	Low	Low
CORPOCESAR	High	High	Medium
CORPOCHIVOR	Low	Low	Low
CORPOGUAJIRA	Low	Low	Low
CORPOGUAVIO	High	Low	Medium
CORPOMOJANA	Low	Low	Low
CORPONARIÑO	Medium	Low	Low
CORPONOR	High	Low	Medium
CORPORINOQUIA	Medium	Medium	Medium
CORPOURABA	Low	Low	Low
CORTOLIMA	Medium	High	High
CRA	High	Low	High
CRC	Low	High	High
CRQ	High	Medium	Medium
CSB	High	High	High
CVC	Medium	Medium	Medium
CVS	Low	Low	Low
Percentage of CARs that underinvest		33	15
Percentage of CARs that overinvest		15	15

Source: Blackman, Morgenstern, and Topping 2004.

Table 4.3E Relative Severity of Risk versus Relative Intensity of 2001 Investment by CAR: Air Pollution

CAR	*Percentage of deaths from respiratory illness*	*Percentage of investment in air pollution management (conservative estimate)*	*Percentage of investment in air pollution management (liberal estimate)*
CAM	High	Low	Medium
CAR Cundinamarca	High	High	Medium
CARDER	High	Low	Low
CARDIQUE	Medium	Low	High
CARSUCRE	Low	Low	Low
CAS	Low	Low	Medium
CDA	High	Low	Low
CDMB	Medium	High	Medium
CODECHOCO	Low	Low	Low
CORALINA	Medium	Low	Low
CORANTIOQUIA	High	High	High
CORMACARENA	Medium	Low	Low
CORNARE	High	Low	Low
CORPAMAG	Medium	Low	Low
CORPOAMAZONIA	Medium	Low	High
CORPOBOYACA	Low	High	High
CORPOCALDAS	Medium	Low	High
CORPOCESAR	High	Low	Low
CORPOCHIVOR	Low	Low	Low
CORPOGUAJIRA	Medium	Low	High
CORPOGUAVIO	High	Low	Medium
CORPOMOJANA	Low	Low	Low
CORPONARIÑO	Low	Low	High
CORPONOR	Low	Low	High
CORPORINOQUIA	High	Low	High
CORPOURABA	Low	Low	Low
CORTOLIMA	Medium	Low	Low
CRA	Medium	Low	Low
CRC	Medium	Low	Low
CRQ	High	Low	Low
CSB	Low	Low	High
CVC	High	High	High
CVS	Low	Low	Low
Percentage of CARs that underinvest		55	33
Percentage of CARs that overinvest		3	15

Source: Blackman, Morgenstern, and Topping 2004.

Table 4.3F Relative Severity of Risk versus Relative Intensity of 2001 Investment by CAR: Solid Waste

CAR	*Percentage of solid waste disposed of legally*	*Percentage of total investment in solid waste management (conservative estimate)*	*Percentage of total investment in solid waste management (liberal estimate)*
CAM	Medium	High	High
CAR Cundinamarca	Low	High	Medium
CARDER	High	Low	Low
CARDIQUE	Low	High	High
CARSUCRE	High	Low	Low
CAS	Medium	Low	Medium
CDA	Low	Low	Low
CDMB	High	High	Medium
CODECHOCO	Low	Low	Low
CORALINA	Low	Low	Low
CORANTIOQUIA	Medium	Low	Medium
CORMACARENA	Medium	Low	Low
CORNARE	Medium	Low	Low
CORPAMAG	High	Low	Low
CORPOAMAZONIA	Low	Low	Medium
CORPOBOYACA	Medium	High	High
CORPOCALDAS	High	Low	High
CORPOCESAR	High	Low	Low
CORPOCHIVOR	Low	High	High
CORPOGUAJIRA	Medium	Low	High
CORPOGUAVIO	Low	Low	Medium
CORPOMOJANA	Low	Low	Low
CORPONARIÑO	High	Low	Medium
CORPONOR	High	Low	High
CORPORINOQUIA	High	Low	High
CORPOURABA	Low	Low	Low
CORTOLIMA	Medium	Low	Low
CRA	Low	High	High
CRC	High	Low	Low
CRQ	Medium	High	High
CSB	Low	High	High
CVC	Low	High	Medium
CVS	Low	Low	Low
Percentage of CARs that underinvest		45	24
Percentage of CARs that overinvest		18	24

Source: Blackman, Morgenstern, and Topping 2004.

particularly well with the severity of these risks. For all but one type of risk—flora and fauna loss—CARs underinvested in the risk far more than they overinvested. For soil degradation, 54 percent of CARs underinvested in this risk, while no CARs overinvested. For natural disasters, 61 percent of CARs underinvested, while only 3 percent overinvested. For water pollution, up to 33 percent of CARs underinvested (depending on what measure of spending is used) while up to 15 percent overinvested. For air pollution, 33 to 55 percent of CARs underinvested. Finally, for solid waste management, 24 to 45 percent of CARs underinvested while 18 to 24 percent seem to be overinvesting.

Allocation of CAR Investment Spending to Priorities Established in Three-Year Action Plans

Law 99 places considerable emphasis on planning. CARs are required to draft a 10-year Regional Environmental Management Plan (*Plan de Gestión Ambiental Regional*, PGAR), a Three-Year Action Plan (*Plan de Acción Trienal*, PAT), and Annual Investment Operating Plans (*Planes Operativos de Inversíon Anual*, POIAs). All of these plans are required to align with the National Development Plans drafted by every newly elected president of Colombia. Presumably, then, to the extent the various plans establish priorities for investment, the planning process provides a possible mechanism for priority setting. Obviously, however, a necessary condition for planning to serve this end is that CARs must actually comply with their plans. By comparing investment plans and actual investment spending for four case-study CARs (CAR Cundinamarca, CORANTIOQUIA, CRA, and CARDIQUE), conclusions can be drawn about how effectively CARs comply with their plans. The results of the analysis are presented in tables 4.4A through 4.4D.

As illustrated in table 4.4A, CAR Cundinamarca's planned investment spending did not align well with actual investment. Even though actual investment spending (Col$93,184 million, US$43 million) exceeded planned spending (Col$70,543 million, US$32 million) by over Col$20 billion, CAR Cundinamarca does not appear to have invested in a good number of the projects listed in its PAT for 2001, and, conversely, it appears to have invested in a good number of projects that were *not* listed in its 2001 PAT. For example, in the "Industrial pollution" meta-category, CAR Cundinamarca did not invest in a Col$31 billion (US$14 million) water quality project that was listed in its PAT, and it did invest in a Col$70 billion (US$32 million) wastewater infrastructure project, and several other urban pollution control projects, that

Table 4.4A Investment Spending: Planned (PAT) versus Actual for CAR Cundinamarca, 2001

	Spending (thousand pesos)		*Spending (%)*		*Number of projects*	
Category	*PAT*	*Actual*	*PAT*	*Actual*	*PAT*	*Actual*
Flora and fauna (sums 1–3)	1,369,000	5,035,000	2	5	1	6
1. Forest and ecosystem management	0	1,133,000	0	1	0	2
2. Protected areas	1,369,000	3,902,000	2	4	1	4
3. Green markets	0	0	0	0	0	0
Industrial pollution (sums 4–9)	30,671,000	70,907,000	43	76	1	5
4. Air pollution control	0	410,000	0	0	0	1
5. Solid and hazardous waste management	0	600,000	0	1	0	1
6. Clean technologies	0	99,000	0	0	0	1
7. Industrial pollution other, general	0	0	0	0	0	0
8. Wastewater infrastructure	0	69,798,000	0	75	0	2
9. Water quality other	30,671,000	0	43	0	1	0
Water quantity (sums 10–12)	20,500,000	3,226,000	29	3	4	4
10. Drinking water supply	0	0	0	0	0	0
11. Water quantity	20,500,000	1,526,000	29	2	4	3
12. Irrigation	0	1,700,000	0	2	0	1
Other (sums 13–22)	17,994,088	14,016,000	26	15	8	21
13. Water other, general	0	6,030,000	0	6	0	3
14. Soil conservation	2,656,000	0	4	0	1	0
15. Coastal and marine management	0	0	0	0	0	0
16. Natural disaster prevention	0	0	0	0	0	0
17. Mosquito control	0	0	0	0	0	0
18. Research information	88	3,734,000	0	4	0	6
19. Environmental education	978,000	964,000	1	1	1	3
20. Operations-related general activities	7,878,000	3,088,000	11	3	2	8
21. Joint community and territorial entity activities	6,482,000	200,000	9	0	4	1
22. Other or undetermined	0	0	0	0	0	0
Total	70,534,088	93,184,000	100	100	14	36

Source: Blackman, Morgenstern, and Topping 2004.
Note: US$1 = Col$2,150.

were not listed in its PAT. In the "Water quantity" meta-category, CAR Cundinamarca invested only approximately one-sixth of the total amount listed in its PAT. Finally, in the "Other" meta-category, although CAR invested around Col$4 million less than the planned amount, the distribution of projects within this meta-category did not match planned spending.

Table 4.4B Investment Spending: Planned (PAT) versus Actual for CORANTIOQUIA, 2001

	Spending (thousand pesos)		Spending (%)		Number of projects	
Category	*PAT*	*Actual*	*PAT*	*Actual*	*PAT*	*Actual*
Flora and fauna (sums 1–3)	14,307,000	10,637,600	35	32	5	10
1. Forest and ecosystem management	11,217,000	7,457,600	28	22	4	8
2. Protected areas	3,090,000	3,090,000	8	9	1	1
3. Green markets	0	90,000	0	0	0	1
Industrial pollution (sums 4–9)	844,000	3,134,902	2	9	1	4
4. Air pollution control	0	1,939,902	0	6	0	1
5. Solid and hazardous waste management	0	0	0	0	0	0
6. Clean technologies	0	0	0	0	0	0
7. Industrial pollution other, general	844,000	1,195,000	2	4	1	3
8. Wastewater infrastructure	0	0	0	0	0	0
9. Water quality other	0	0	0	0	0	0
Water quantity (sums 10–12)	6,820,000	257,260	17	1	1	1
10. Drinking water supply	0	0	0	0	0	0
11. Water quantity	6,820,000	257,260	17	1	1	1
12. Irrigation	0	0	0	0	0	0
Other (sums 13–22)	18,389,000	19,219,238	46	58	14	22
13. Water other, general	0	820,000	0	2	0	1
14. Soil conservation	1,360,000	1,060,000	3	3	1	1
15. Coastal and marine management	0	0	0	0	0	0
16. Natural disaster prevention	0	0	0	0	0	0
17. Mosquito control	0	0	0	0	0	0
18. Research information	4,520,000	4,145,806	11	12	4	10
19. Environmental education	2,260,000	810,000	6	2	1	2
20. Operations-related general activities	1,219,000	8,533,432	3	26	4	3
21. Joint community and territorial entity activities	9,030,000	730,000	22	2	4	3
22. Other or undetermined	0	3,120,000	0	9	0	2
Total	40,360,000	33,249,000	100	100	21	37

Source: Blackman, Morgenstern, and Topping 2004.
Note: US$1 = Col$2,150.

Compared to CAR Cundinamarca, CORANTIOQUIA's planned investment spending matches its actual spending fairly well (see table 4.4B). Nevertheless, some significant discrepancies exist between actual and planned spending. Actual total investment spending (Col$33.0 billion, US$15.7 million) fell 18 percent below planned total spending

Table 4.4C Investment Spending: Planned (PAT) versus Actual for CRA, 2001

	Spending (thousand pesos)		*Spending (%)*		*Number of projects*	
Category	*PAT*	*Actual*	*PAT*	*Actual*	*PAT*	*Actual*
Flora and fauna (sums 1–3)	1,159,867	2,162,856	17	28	2	3
1. Forest and ecosystem management	1,159,867	2,162,856	17	28	2	3
2. Protected areas	0	0	0	0	0	0
3. Green markets	0	0	0	0	0	0
Industrial pollution (sums 4–9)	900,000	900,000	13	12	1	1
4. Air pollution control	0	0	0	0	0	0
5. Solid and hazardous waste management	0	900,000	0	12	0	1
6. Clean technologies	0	0	0	0	0	0
7. Industrial pollution other, general	900,000	0	13	0	1	0
8. Wastewater infrastructure	0	0	0	0	0	0
9. Water quality other	0	0	0	0	0	0
Water quantity (sums 10–12)	0	0	0	0	0	0
10. Drinking water supply	0	0	0	0	0	0
11. Water quantity	0	0	0	0	0	0
12. Irrigation	0	0	0	0	0	0
Other (sums 13–22)	4,636,144	4,636,144	69	60	4	6
13. Water other, general	2,574,000	2,574,000	38	33	1	2
14. Soil conservation	0	0	0	0	0	0
15. Coastal and marine management	790,000	790,000	12	10	1	1
16. Natural disaster prevention	0	0	0	0	0	0
17. Mosquito control	0	0	0	0	0	0
18. Research information	272,144	0	4	0	1	0
19. Environmental education	0	272,144	0	4	0	1
20. Operations-related general activities	1,000,000	900,000	15	12	1	1
21. Joint community and territorial entity activities	0	100,000	0	1	0	1
22. Other or undetermined	0	0	0	0	0	0
Total	6,696,011	7,699,000	100	100	7	10

Source: Blackman, Morgenstern, and Topping 2004.
Note: US$1 = Col$2,150.

(Col$40 billion, US$19 million). In the "Flora and fauna" meta-category, CORANTIOQUIA spent almost Col$4.0 billion (US$1.9 million) less than planned on "Forest and ecosystem management" and approximately Col$90.0 million (US$0.04 million) more than planned on "Green markets." In the "Industrial pollution" meta-category, CORANTIOQUIA evidently

Table 4.4D Investment Spending: Planned (PAT) versus Actual for CARDIQUE, 2001

	Spending (thousand pesos)		*Spending (%)*		*Number of projects*	
Category	*PAT*	*Actual*	*PAT*	*Actual*	*PAT*	*Actual*
Flora and fauna (sums 1–3)	761,877	761,876	13	13	4	3
1. Forest and ecosystem management	650,000	761,876	11	13	3	3
2. Protected areas	0	0	0	0	0	0
3. Green markets	111,877	0	2	0	1	0
Industrial pollution (sums 4–9)	293,000	743,000	5	13	1	3
4. Air pollution control	0	0	0	0	0	0
5. Solid and hazardous waste management	293,000	293,000	5	5	1	1
6. Clean technologies	0	0	0	0	0	0
7. Industrial pollution other, general	0	450,000	0	8	0	2
8. Wastewater infrastructure	0	0	0	0	0	0
9. Water quality other	0	0	0	0	0	0
Water quantity (sums 10–12)	900,000	900,000	16	16	3	3
10. Drinking water supply	0	0	0	0	0	0
11. Water quantity	900,000	900,000	16	16	3	3
12. Irrigation	0	0	0	0	0	0
Other (sums 13–22)	3,700,000	3,250,000	65	57	15	13
13. Water other, general	550,000	550,000	10	10	2	2
14. Soil conservation	0	0	0	0	0	0
15. Coastal and marine management	950,000	950,000	17	17	3	3
16. Natural disaster prevention	0	0	0	0	0	0
17. Mosquito control	0	0	0	0	0	0
18. Research information	600,000	300,000	11	5	2	1
19. Environmental education	200,000	200,000	4	4	1	1
20. Operations-related general activities	600,000	600,000	11	11	2	2
21. Joint community and territorial entity activities	550,000	400,000	10	7	4	3
22. Other or undetermined	250,000	250,000	4	4	1	1
Total	5,654,877	5,654,876	100	100	23	22

Source: Blackman, Morgenstern, and Topping 2004.
Note: US$1 = Col$2,150.

spent approximately Col$2 billion (US$1 million) more than planned in this area. In the "Water quantity" meta-category, CORANTIOQUIA spent 4 percent of the amount planned on a water quantity project. Finally, in the "Other" category, CORANTIOQUIA spent approximately the planned amounts in each subcategory.

CRA's planned investment spending matches its actual spending quite well. Actual total investment spending (Col$7.7 billion, US$3.58 million) exceeded planned total spending (Col$6.7 billion, US$3.12 million) by Col$1 billion (US$470,000). The Col$1 billion discrepancy appears to be attributable to the fact that CRA spent Col$2.2 billion (US$1.1 million) on "Forest and ecosystem management" instead of the Col$1.2 billion (US$560,000) planned. Otherwise, actual spending more or less aligns with planned spending.

Finally, CARDIQUE's actual investment spending also matches its planned spending quite well. Actual total investment spending (Col$5.7 billion, US$2.71 million) and planned total investment spending (Col$5.7 billion, US$2.71 million) match almost exactly. The only significant discrepancies between planned and actual spending arise from the fact that CARDIQUE appears to have cancelled a planned Col$112 million (US$52,000) project in the "Green markets" category and to have developed an unplanned Col$450 million (US$209,000) industrial pollution project.

In sum, actual investment spending aligns well with planned investment spending for two of the four case study CARs—CRA and CARDIQUE. The match between planned and actual spending is poorer for CORANTIOQUIA, and poorer still for Cundinamarca CAR. Conclusive evidence on the extent to which CARs abide by the plans laid out in their PATs would require additional analysis of planned and actual investment spending by several more CARs over several more years, and would require an effort to track spending on a project-by-project basis, instead of a category-by-category basis. Nevertheless, the limited evidence suggests that for some CARs, there may be a significant gap between their PATs and their actual investment spending.

Sources of CARs' Financial Resources

As the frontline environmental management institutions in Colombia, CARs generate and use the majority of the SINA's financial resources. Nationwide, during 1995 to 2002, 71 percent of total SINA funding for operations and 86 percent of total SINA funding for investment was allocated to CARs. Fully 78 percent of the funding for operations and 86 percent of the funding for investment is generated by CARs on the basis of the mandates established by Law 99 of 1993 (Gómez Torres 2003).

Distribution of Financial Resources among CARs, 2003

Table 4.5 displays the financial resources available to CARs in 2003. Separate entries indicate the funds available from national contributions

Table 4.5 CAR Resources, 2003
million pesos

	Operations			*Investment*			*Debt*		*Total*		
CAR	*National contribution*	*Self-generated revenue*	*Total*	*National contribution*	*Self-generated revenue*	*Total*	*Self-generated revenue*	*Percentage of resources expended on operations*	*National contribution*	*Self-generated revenue*	*Total resources*
CAM	1,180	1,394	2,574	0	5,152	5,152	0	33.3	1,180	6,545	7,725
CAR Cundinamarca	0	28,312	28,312	0	46,124	46,124	7,487	34.6	0	81,924	81,924
CARDER	1,262	2,772	4,033	11	6,499	6,510	151	37.7	1,273	9,421	10,694
CARDIQUE	1,160	836	1,996	0	6,692	6,692	0	23.0	1,160	7,528	8,688
CARSUCRE	1,201	354	1,555	597	203	800	0	66.0	1,798	557	2,355
CAS	1,131	1,538	2,668	150	4,175	4,325	0	38.2	1,281	5,713	6,994
CDA	1,423	128	1,551	983	86	1,069	0	59.2	2,407	214	2,620
CDMB	0	5,738	5,738	0	43,334	43,334	1,021	11.5	0	50,093	50,093
CODECHOCO	924	1,809	2,733	367	628	996	0	73.3	1,292	2,437	3,729
CORALINA	1,301	48	1,350	434	1,401	1,835	0	42.4	1,736	1,449	3,185
CORANTIOQUIA	1,168	3,968	5,136	0	41,330	41,330	0	11.1	1,168	45,299	46,467
CORMACARENA	1,195	191	1,386	1,157	573	1,730	0	44.5	2,352	764	3,116
CORNARE	0	4,358	4,358	0	16,479	16,479	1,121	19.8	0	21,958	21,958
CORPAMAG	1,954	913	2,866	713	1,929	2,642	0	52.0	2,666	2,842	5,508
CORPOAMAZONIA	1,254	1,319	2,573	711	5,020	5,731	0	31.0	1,965	6,339	8,304
CORPOBOYACA	1,038	1,198	2,235	0	5,303	5,303	0	29.7	1,038	6,501	7,538
CORPOCALDAS	1,706	1,143	2,850	6	9,418	9,424	0	23.2	1,712	10,562	12,274
CORPOCESAR	1,531	541	2,071	0	1,027	1,027	0	66.8	1,531	1,568	3,099
CORPOCHIVOR	1,139	1,164	2,303	0	3,149	3,149	377	39.5	1,139	4,690	5,829

(*continued*)

Table 4.5 CAR Resources, 2003 (*continued*)
million pesos

	Operations			*Investment*			*Debt*		*Total*		
CAR	*National contribution*	*Self-generated revenue*	*Total*	*National contribution*	*Self-generated revenue*	*Total*	*Self-generated revenue*	*Percentage of resources expended on operations*	*National contribution*	*Self-generated revenue*	*Total resources*
CAM	1,180	1,394	2,574	0	5,152	5,152	0	33.3	1,180	6,545	7,725
CORPOGUAJIRA	0	3,530	3,530	0	27,775	27,775	0	11.3	0	31,305	31,305
CORPOGUAVIO	0	3,064	3,064	0	4,975	4,975	0	38.1	0	8,038	8,038
CORPOMOJANA	1,277	23	1,300	664	100	764	0	63.0	1,941	123	2,064
CORPONARIÑO	959	1,817	2,777	614	2,077	2,691	0	50.8	1,573	3,894	5,468
CORPONOR	1,326	1,493	2,819	0	4,948	4,948	0	36.3	1,326	6,441	7,768
CORPORINOQUIA	1,082	2,278	3,360	200	4,265	4,465	0	42.9	1,282	6,543	7,824
CORPOURABA	1,999	436	2,435	740	2,613	3,353	0	42.1	2,739	3,049	5,788
CORTOLIMA	1,023	2,264	3,287	41	11,302	11,344	126	22.3	1,064	13,693	14,758
CRA	927	1,408	2,334	0	10,795	10,795	595	17.0	927	12,798	13,725
CRC	2,764	4,125	6,889	0	14,324	14,324	0	32.5	2,764	18,448	21,212
CRQ	2,516	970	3,486	316	4,431	4,747	0	42.3	2,831	5,401	8,232
CSB	1,347	140	1,486	1,040	191	1,231	0	54.7	2,387	331	2,717
CVC	0	28,484	28,484	0	107,265	107,265	0	21.0	0	135,749	135,749
CVS	104	2,771	2,875	0	12,537	12,537	1,089	17.4	104	16,397	16,501
Total	35,890	110,524	146,414	8,743	406,122	414,865	11,968	25.5	44,634	528,614	573,248

Source: Blackman, Morgenstern, and Topping 2004.
Note: US$1 = Col$2,150.

and self-generated revenues, including debt. Separate entries also indicate the resources used for CAR operations and for investments. Some 92 percent of total resources were self-generated and the remaining 8 percent were derived from national contributions. Although the data in the table do not identify the trend, national contributions have declined significantly in recent years. The 8 percent figure in 2003 represents a reduction of slightly more than 50 percent compared with the period from 1995 to 2002 (Blackman, Morgenstern, and Topping 2004).

An analysis of the financial resources available to CARs in 2003 also shows that the distribution of funds across CARs is highly unequal. Total revenues of CARs vary by approximately two orders of magnitude, from a low of Col$2.06 billion (US$958,000) (CORPOMOJANA) to a high of Col$135.7 billion (US$63.1 million) (CVC). Two-thirds of the total resources for all 33 of Colombia's CARs accrue to just seven CARs (in rank order): CVC, CAR Cundinamarca, CDMB, CORANTIOQUIA, CORPOGUAJIRA, CORNARE, and CRC. As expected, the variation in self-generated (as opposed to total) revenues is even larger: self-generated revenues in CVC are a full three orders of magnitude greater than those in CORPOMOJANA. Even adjusting for population, rather wide differences persist among CARs. CAR spending ranges from a low of Col$3,040 (US$1.40) per person (CORPOCESAR) to a high of Col$84,660 (US$39.40) per person (CORPOGUAVIO).

It appears that, on average, about one-fourth of CAR revenues are devoted to operations and the remaining three-fourths to investments. However, these proportions also vary widely across the 33 CARs. Despite the requirements of Law 617, which established that a maximum of 30 percent of the total funds can be used for salaries and administration, many CARs' operational expenses far exceed 30 percent, especially CARs with relatively modest levels of self-generated funds and, correspondingly, small budgets. For instance, operations account for as much as 73.3 percent of the total 2003 budget in a low-income CAR such as CODECHOCO, and as little as 11.1 percent in a relatively high-income CAR such as CORANTIOQUIA. For funds provided by national contributions, the situation is quite different than for total funds: an average of four-fifths of national contributions support operations, and only one-fifth are devoted to capital investments. Only eight CARs report debt-related revenue, which amounted to about 2 percent of total spending across all 33 CARs in 2003.

Sources of Self-Generated Revenues by CARs

Self-generated CAR revenues consist of 12 different categories of taxes, fees, and other types of revenue that are mandated by Law 99. For example, Law 99 stipulates that 15 to 26 percent of municipal property taxes are to be used to fund CARs' environmental management activities. Law 99 also requires that electricity generators must pay a gross revenues tax (*transferencia*) to CARs based on their power sales.[5] Other sources of revenue mentioned in Law 99 include monies from the National Royalty Fund, fines, a percentage of damages awarded by courts in *acciónes populares*, a percentage of fines imposed by territorial authorities for violations of environmental laws, appropriations from the national budgets, fees, licenses, permits, authorizations, and concessions.

The largest source of self-generated revenues is capital. However, 60 percent of those revenues accrue to a single CAR, CVC. The next largest recipients are CRC and CORANTIOQUIA, with 9.4 and 8.7 percent, respectively. Five CARs report negligible or no revenues from capital. Following revenues generated from capital, property taxes represent the next largest source category. These are somewhat more evenly distributed than capital revenues, although even here a single entity, CAR Cundinamarca, accounts for 42.1 percent of total property tax revenues. Other important sources of self-generated revenues are contributions, electricity taxes, and revenues from the sale of goods and services. Water fees are a relatively small source of revenues, although as in the case of property taxes, a very large proportion of total revenues are accounted for by CAR Cundinamarca, in this case 76.9 percent. Other small revenue sources include redistribution fees, contractor revenues, penalties, forest fees, and licensing fees.

Changes in Financial Resources, 2002–03

An additional perspective on CARs' finances may be gleaned by examining year-to-year changes in revenues. Such a perspective enables one to gauge a number of issues, for example, whether the growth in self-generated or national contributions is more focused on rich or poor CARs. In considering the changes over the most recent two-year period (2002–03), total CAR spending for 2003 rose by 14.5 percent over 2002 levels. However, the major revenue components displayed quite different patterns. For example, national contributions declined by 1.3 percent while self-generated revenues rose by 16 percent.

Total spending on operations declined in 2003 by 8.3 percent while investment spending increased by 26.8 percent. National contributions for operations increased by a negligible amount, while national contributions for investments declined by 8.4 percent. The opposite pattern applies to self-generated revenues, which declined by 10.9 percent for operations while increasing 27.8 percent for investments. Self-generated funds from debt declined by 13.7 percent.

What are the possible causes of these year-to-year budget changes? Of particular interest is whether the CARs with larger budgets are growing more rapidly compared with the ones with smaller budgets. The findings on year-to-year changes over 2002–03 reflect some reallocation of revenues for both investment and operations. In general, these results can be interpreted as demonstrating a more activist reallocation of funds. While there is a small "Robin Hood" effect involving the reallocation of investment funds from CARs with high spending levels the previous year to those with lower spending levels, this does not extend to national contributions for operations.[6] Here it can be argued that richer CARs (richer based on expenditures per CAR inhabitant and per hectare) fared better in 2003 than in 2002.

Adequacy of Human and Technical Resources

This section addresses a number of issues relevant to the adequacy of human and technical resources of the CARs. Some basic data on the numbers of direct employees and contractors for each CAR are presented. Possible explanations for the large observed differences in CAR-wide hiring patterns are discussed. Finally, available information on computers and other technical resources available across the CARs is presented.

Human Resources

Environmental management capacity varies markedly across CARs. Shortages of human resources are partly to blame. Several studies on the institutions found a general scarcity of highly qualified human resources in CARs with poor governance (Booz Allen Hamilton 1997b) and a direct relationship between overall efficiency of CARs and their staff members' levels of professionalism (Vargas 2003). A key issue is the staffing patterns in CARs, including the use of contractors. Filling staff needs with contractors as opposed to permanent employees is common, as is high turnover among staff members (and contractors), and what is generally described as favoritism in hiring both staff and contractors. The inadequate technical qualifications of employees and contractors is also a concern (Blackman, Morgenstern, and Topping 2004).

The average staff size across all CARs was 112.6 in 2002. Not surprisingly, there are large differences in staff size across the CARs. Some CARs operated with quite small staffs in 2002: 26 in CRA; 27 in CORPOGUAVIO; and 31 each in CARDIQUE, CORALINA, and CORPOBOYACA.

Others have much larger staffs: 817 in CAR Cundinamarca; 331 in CORANTIOQUIA; and 262 in CRC. The number of contractors also varied considerably across the various CARs in 2002. While the average CAR engaged 66.9 contractors, some had as few as 7 (CORPOMOJANA, CORPONOR). At the high end, CDMB had a total of 301 contractors in 2002. On average, contractors make up 37.3 percent of total staff, ranging from a low of 2.7 percent (CAR) to a high of 83.3 percent (CRA). On the ratio of inhabitants in each CAR to the number of employees and contractors, the extremes across CARs are slightly higher than the extremes in total employees. In the case of contractors, the variation on a per capita basis is many times greater than the variation in total employees.

Education levels also seem to vary considerably across CARs, with some employing a high proportion of college-educated people, and others relying disproportionately on those with only a high school education. An average of 60.7 percent of the CAR staff members and 63.5 percent of contractors in 2002 completed four years of college (or more). Six of the CARs report that 100 percent of their staff members held at least a college degree, while six others reported that less than 50 percent of their staff members had that status. In the case of contractors, 13 CARs reported that 100 percent held at least a college degree, while 9 others reported that less than 50 percent had such a degree.

A first order question is how the numbers of staff members and contractors vary with the operating and investment budgets available to the CARs. Because a high proportion of total budgets are paid out in the form of staffing costs, it would be surprising if there was not a clear connection between staff size and both operating and investment budgets. For contractors, the situation is less clear, because contractors often carry out daily tasks that typically should be assigned to staff members, such as making periodic inspections of permitted facilities to monitor compliance or completing those tasks focused primarily on investment projects.

To understand differences in employment and contractor levels across CARs, it may be argued that causality runs from budgets to staff (and contractor) size when holding constant GDP and other income and demographic variables. For permanent employees, operational spending enters the equation with a positive and highly significant coefficient, indicating that the number of employees is highly dependent on the size of CARs' operational budgets. However, the coefficient on investment spending is not statistically different from zero, suggesting that such spending is not a key factor in determining employment across CARs. Also of interest is a strong likelihood that older, more established CARs have relatively higher staffing levels. Overall, a high percentage of the variation in staff size is largely explained by the operating budget.

According to analysis by Blackman, Morgenstern, and Topping (2004) for contractors, neither the operations nor the investment budgets are statistically significant, although CARs with smaller operating budgets may tend to hire more contractors while CARs with large investment budgets may tend to hire fewer contractors.

Technical Resources

Technical weaknesses in the CARs have been cited as one of the leading problems inhibiting environmental investment projects (González, Barona, and Galindo Caballero 2002). However, the term *technical resources* as applied to the operations of CARs is not very precise. Of course, technical capacity shortages are not surprising given the highly unequal distribution of financial resources across CARs, and technical and administrative capacity varies significantly across CARs. Some CARs are excellent; others are minimally functional. One approach to analysis of CARs' efficiency would be to compare the number of computers and computers per employee available in the CARs in 2002. Although the average is about 104 computers per CAR, the variation is considerable. On the high end, CAR Cundinamarca reports a total of 358 computers. On the low end, CARSUCRE reports a total of 16 computers, roughly 5 percent the number in CAR Cundinamarca. Computers per employee also vary considerably. Although the average is 0.9 computers per employee, on the high end CORPOCALDAS reports 3.33 computers per employee while CORPOGUAVIO reports 2.96 and CRA reports 2.62. On the low end, CVS reports 0.32 computers per employee and CARSUCRE reports 0.39 per employee, a full order of magnitude lower than CORPOCALDAS. Even though some CARs may provide computers for contractors or other relevant groups, it is nonetheless difficult to explain why the number of computers in some CARs exceeds the number of employees by such a wide margin. It is likely that the overall availability and use of computers in CARs are closely related to the social conditions in the jurisdiction (Blackman, Morgenstern, and Topping 2004).

Sanitation Infrastructure

The original mission of CARs was to promote integrated regional development by, among other things, building sanitation infrastructure including wastewater treatment, drinking water, and irrigation facilities. Although

Law 99 redefines CARs as regional environmental regulatory authorities and assigns primary responsibility for sanitation infrastructure to municipalities, it also mandates that CARs retain certain responsibilities for developing infrastructure, a dictate that clearly has the potential to create conflicts of interest. In particular, in cases where CARs finance, plan, own, or operate sanitation infrastructure, their incentives to strictly enforce environmental regulations governing this infrastructure are compromised.

MAVDT data on CARs' investments in sanitation infrastructure indicate that CARs collectively devoted 30 percent of all money spent on investment to wastewater treatment plants, a higher percentage than in any of the other categories (or meta-categories) of investment. Superficially, this statistic suggests that sanitation infrastructure is a major focus of CAR investment. However, further examination of the CARs-level data indicates that this investment comprised a relatively small number of very expensive treatment plants. In 2001, all 33 CARs funded 11 plants, with an average cost of Col$9,078,200,454 (about US$4 million).

Several political, economic, and legal factors are driving CARs' continued investments in sanitation infrastructure. Perhaps most important, the government has explicitly mandated such investments. The 2002–06 National Development Plan directs CARs to help finance sanitation infrastructure using their self-generated revenue. According to the president of ASOCAR, the national association of regional environmental authorities, CARs oppose this provision of the National Development Plan on the grounds that it creates conflicts of interest. A closely related factor is that, given the sources of revenues assigned to CARs by Law 99, some CARs have significant fiscal resources. Thus, in the view of some policy makers, given the current fiscal policy, CARs are the logical institutions to finance municipal sanitation infrastructure. Presumably, this view informed the provision of the current National Development Plan cited earlier (Blackman, Morgenstern, and Topping 2004).

Local political considerations evidently provide significant incentives for CARs to develop sanitation infrastructure. Large municipalities typically provide the bulk of CARs' self-generated revenues through property taxes and also wield considerable influence over CARs' decision making. It is felt that CARs focus on municipal sanitation infrastructure as a means of funneling investment funds to these large municipalities (Blackman, Morgenstern, and Topping 2004).

According to Blackman, Morgenstern, and Topping (2004), to the extent that CARs' infrastructure investments contribute to conflicts of interest, a number of strategies have been proposed to mitigate them. One option is to restrict CARs' role in developing sanitation infrastructure to planning and financing, that is, to prohibit CARs from owning or operating such infrastructure. Presumably, given this limited role, CARs' incentives for strict enforcement of environmental regulations would not be compromised, or at least not to the degree they would be if CARs played a more important role. This strategy is problematic, however. Although most CARs prefer to restrict their roles to planning and financing wastewater treatment plants, a number of practical considerations tend to push them into owning and operating them. Specifically, in many cases, CARs finance or build (or both) such plants with the intention of turning over responsibility for the plants to municipalities. However, municipalities are reluctant to assume this responsibility because the plants are not profitable—user fees are not sufficient to cover expenses or the plants are not adequate to meet environmental guidelines and, therefore, leave the owner liable for fines and retributive fees. One example is wastewater treatment plants on the Bogotá River built by CAR under a loan financed by the Inter-American Development Bank. Municipalities have refused to assume ownership of these plants. A potential solution to the problem is for CARs to require municipalities to demonstrate a clear commitment to ownership before undertaking any infrastructure investments. CORANTIOQUIA, for example, requires municipalities to provide 50 percent cofinancing before it finances infrastructure.

A second option to mitigate potential conflicts of interest inherent in developing infrastructure is to simply prohibit CARs from playing any role in infrastructure development. Given the fiscal realities described above, this does not seem a realistic strategy. Were this option to be pursued, CARs could be stripped of responsibility for infrastructure development and of a portion of the property tax revenue now used for this purpose (Blackman, Morgenstern, and Topping 2004).

A third option is for CARs to create separate internal divisions for building infrastructure and for regulating that infrastructure. However, many CARs already have separate divisions for investment and regulatory oversight, and as long as conflicts of interest exist, this institutional structure may continue to be ineffective at mitigating them (Blackman, Morgenstern, and Topping 2004).

Relationships between CARs and Other SINA Entities

This section highlights some of the strengths and shortcomings of decentralized environmental management in Colombia.

National-Regional Coordination

The decentralized design of Law 99 creates tension between the MAVDT and CARs, because the law gave CARs a great deal of administrative and fiscal autonomy. It also gave the Ministry of Environment the role of leading SINA, overseeing and coordinating the activities of CARs. However, evidence suggests that national-regional coordination has been less than optimal. An evaluation of the SINA presents what may be the most frank critical assessment of this relationship:

> Currently, each component of the system conceived in Law 99 of 1993 is working in an independent and divergent manner—each executes its own Action Plan based on its subjective interpretation of the National Environmental Plan, adapting it according to its own regional needs . . . The problem arises principally from the absence of leadership on the part of the central axis of the system, in particular, a failure to coordinate actions, assign work, process information, and evaluate results in accordance with national intentions . . . [this failure] results in duplication of efforts and an increase in operational costs (4) . . . with the lack of a system leader, [each CAR] interprets its function as an individual entity, and not . . . as part of the system (5) . . . Management of relations between MMA and CARs, territorial entities, research institutes and urban environmental authorities are dispersed. This dispersion generates, on the one hand, inconsistency in decisions on environmental matters, and, on the other hand, ambiguous and contradictory administrative action, and what's worse, the absence of a unique sectoral policy (Booz Allen Hamilton 1997b).

In general, MAVDT is not able to exert sufficient control over the planning and functioning of CARs. In some cases, the general directors of certain CARs are extremely powerful, perhaps too powerful relative to the other players in the environmental management system. Many CARs have strong links to the Congress, which in turn can exert influence on the MAVDT.

Several fundamental arguments can be made for continued decentralized environmental administration—presumably the same arguments that motivated the decentralization embodied in the 1991 Constitution and in Law 99. They are: (a) autonomy enables CARs to operate independently of local political pressures at the municipality and department levels; (b) autonomy insulates CARs from bad governance at the national level; (c) decentralization encourages public participation and social control at the regional level; and (d) given Colombia's size and diversity, central administration of the environment is inefficient or impractical. Perhaps decentralization is the principal reason that Colombia's environmental regulatory system functions as well as it does. Before decentralization, most of the country lacked environmental regulation altogether. This remains the situation in Latin American countries where environmental regulation is more centralized (Blackman, Morgenstern, and Topping 2004).

It is perceived that the ministry has insufficient information about the investment, policy implementation, and regulatory enforcement activities of CARs. The performance indicators CARs currently use typically reflect regulatory processes rather than impacts. For example, CARs often report on the amounts of money spent rather than on how these investments affect environmental quality. The MAVDT's information about environmental quality at the regional level is also insufficient. Effective coordination is not possible without such basic information (Blackman, Morgenstern, and Topping 2004).

To overcome the coordination problems among CARs and national and regional agencies, Presidential Decree 1200 of 2004 establishes six sustainable development objectives and 15 impact indicators aimed at promoting a better linkage between national and regional priorities and strengthening the focus on results and impacts linked to the environment, and at evaluating environmental management by CARs.[7] These are to be addressed at the regional level through PGARs and PATs. The PGARs outline the principal social, economic, cultural, physical, and other challenges facing the region, and CARs' strategy for managing environmental resources, investment priorities, financing requirements, potential sources of financing, and tools for monitoring and evaluating the program. The PATs, prepared in consultation with CARs, municipalities, civil society representatives, and other stakeholders, detail each CAR's short-term strategy for achieving the goals set forth in the PGAR. Decree 1200 requires the MAVDT to review progress toward achieving the goals set forth in the PATs and PGARs. The directors of CARs that do not meet the goals set forth in their own PATs are at risk of being removed by the CAR's Board of Directors. By June 2005, the MAVDT, the Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM), and CARs had not started gathering data to establish a monitoring baseline with respect to the six sustainable development objectives. Since the MAVDT has not started implementation of this decree, it is too early to evaluate the decree's effectiveness.

CARs, AAUs, and Municipalities

Significant financial and jurisdictional battles are taking place between CARs and Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs) and between CARs and municipalities, all institutions that need to—and by law are supposed to—cooperate to facilitate environmental management. Furthermore, the precise roles and jurisdictions of the different agencies, particularly the AAUs and CARs, are confused and sometimes in conflict. Some regulated firms report being inspected by multiple authorities, sometimes based on different criteria. Several court cases are pending, although interim cooperative agreements have been reached pending resolution of these cases (Blackman, Morgenstern, and Topping 2004).

According to Blackman, Morgenstern, and Topping (2004), actual and potential conflicts of jurisdiction among CARs, municipalities, and the AAUs occur, such as cases in which multiple permits are mandated by different agencies, sometimes with conflicting requirements. Financial conflicts among CARs, municipalities, and AAUs are particularly contentious. Regarding relationships between CARs and municipalities, in principal, CARs receive at least 15 percent of the revenues from property taxes collected in their jurisdictions. Administratively, these revenues are collected by the municipalities. However, many CARs claim that they do not receive their full allocations because of artificially low valuations and because the mayors often retain some of the funds for investments in their municipalities. Two principal mechanisms are cited by which the mayors retain funds: (a) the use of intricate accounting procedures and (b) the use of in-kind, rather than cash, payments to CARs. In the latter case, the mayors sometimes argue that certain investment projects undertaken within their jurisdictions should have been financed by CARs. Therefore, the municipalities (unilaterally) net out the costs of these projects before allocating revenues to CARs. For a variety of reasons, the CARs' general directors tend not to fight these actions. How do the mayors exert such influence? They are members of the boards of directors of the CARs, and although they are supposed to represent all the mayors in the CARs, they often focus on their own interests; and the mayors tend to form coalitions with other board members (Blackman, Morgenstern, and Topping 2004).

Financial conflicts between the CARs and the AAUs can be equally contentious. A number of CARs, including CARDIQUE and CRA, are battling with the AAUs over the disposition of the property taxes collected within the jurisdictions of the AAUs in their areas (Cartagena and Barranquilla, respectively). In the case of CRA, for instance, interviews carried out by Resources for the Future revealed that a recent judicial decision awarded the full 15 percent of the property taxes collected in Barranquilla to the AAU (Environmental Administration Department of Barranquilla). While many observers believe this case will not stand up on appeal, final resolution may take many years. In the meantime, the parties have reached an agreement to split the revenues equally (Blackman, Morgenstern, and Topping 2004).

Conclusions and Recommendations

The main conclusions are these:

- detailed, albeit limited, data suggest that CARs do not prioritize environmental risks adequately;
- CARs' overall performance varies significantly and appears to be correlated with the age of the CAR, and with levels of poverty and geographic jurisdictions;
- although the distribution of financial resources across the CARs is highly unequal, opportunities might exist to mitigate inequities by encouraging CARs to take advantage of unexploited prospects for revenue generation;
- human and technical resources vary markedly across CARs, and human resources difficulties are exacerbated by conflicting national-level polices;
- the participation of CARs in financing, owning, and operating sanitation infrastructure weakens their incentives to stringently regulate that infrastructure;
- coordination between the MAVDT and CARs is suboptimal, partly as a result of tensions inherent in the design of the SINA; and
- jurisdictional conflicts arise among CARs and AAUs.

To meet the institutional challenges discussed, Blackman, Morgenstern, and Topping (2004) propose a series of recommendations (see summary in table 4.6).

Improve Priority Setting by Mandating CARs to Undertake Analysis of Cost of Environmental Degradation and Comparative Risk Assessments

To improve CAR priority setting, the MAVDT might consider (in addition to enforcement of Decree 1200 of 2004) requesting that each

Table 4.6 Recommendations

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Participating institutions*
Improve priority setting by mandating that CARs undertake analysis of cost of environmental degradation and comparative risk assessments	S	Congress, MAVDT, DNP
Strengthen the participation of representatives of civil society on CAR boards of directors	M	Congress, MAVDT, DNP
Require top CARs managers and members of boards of directors to meet minimum professional criteria and financial disclosure requirements	M	*Departamento Administrativo de la Función Pública,* MAVDT
Hold an annual public meeting of CAR and MAVDT representatives	M	MAVDT, CARs
Improve national-regional coordination	S	MAVDT, DNP, MHCP
Develop guidelines to minimize conflicts of interest arising from CARs' involvement in developing sanitation infrastructure	S	Congress, MAVDT, DNP
Take action at the national level to resolve jurisdictional and financial disputes between AAUs and CARs	S	Congress, MAVDT, DNP
Eliminate CARs that chronically perform poorly	M	Congress, MAVDT, DNP

Source: Authors.
Note: DNP = *Departamento Nacional de Planeación*; MHCP = *Ministerio Hacienda y Crédito Público*.

CAR periodically assess the relative importance of various risks to human health and the environment in the CAR's territory. The MAVDT can also require that CARs use this comparative risk assessment to guide its allocation of financial, human, and technical resources. The specific steps the MAVDT can take to make these requirements feasible include improving data collection and management at the CAR level; developing a standard methodology for comparative risk assessments that is practical, given current capacity for data collection and analysis among CARs; providing technical assistance and training in comparative risk assessment by, among other things, developing user-friendly training manuals and holding workshops; developing means of certifying third parties to assist CARs in carrying out risk assessments; and developing regulations requiring CARs to link the results of comparative risk assessments to the resource allocations included in their PATs.

Strengthen the Participation of Civil Society Representatives on CAR Boards of Directors

To balance the influence of private sector interests, the government might consider strengthening the participation of the members of CAR boards of directors who represent civil society, the MAVDT, departments, and the president. CARs and the MAVDT can strengthen civil society participation by funding projects and programs to build capacity of nongovernmental organizations (NGOs) at the local level, creating networks and associations among NGOs and between Colombian and international civil society, and involving civil society in CAR activities. Measures that can help to strengthen civil society include continuing to promote environmental education and ensuring free availability of environmental data. Steps can also be taken to professionalize the representatives of public sector institutions on the boards of directors, including representatives of the MAVDT, the departments, and the president.

Require Top CAR Managers and Members of Boards of Directors to Meet Minimum Professional Criteria and Financial Disclosure Requirements

A number of steps can be taken to professionalize and enhance transparency of CAR management and oversight. For example, in accordance with recent reforms of the election process for general directors (Decree 3345 of 2003), the government might consider establishing national minimum professional criteria for other top positions in CARs. Individual CARs would be allowed to establish stricter criteria, but not weaker ones. The principal aim of this effort would be to assure that key CAR staff members and most members of boards of directors possess the technical qualifications and professional experience needed to perform their jobs effectively. The professional criteria should take into account that regional diversity implies that different qualifications may be appropriate in different CARs. Independent third parties such as universities and professional associations should be responsible for assessing the extent to which candidates meet these criteria. Professional experience and education could substitute for each other in meeting the criteria. Even if the criteria are not legally binding, a voluntary system of evaluation and public disclosure might have a positive impact, and might serve as a first step toward a more comprehensive system.

In addition, the government might consider efforts to establish financial disclosure requirements for CAR senior management—including general directors and most public sector board members—and regulations governing what types of conflicts of interest disqualify candidates from service. Financial disclosures would need to be vetted by a credible, independent, qualified party.

Hold an Annual Public Meeting of CAR and MAVDT Representatives

An annual meeting of MAVDT and CAR general directors that is fully open to the public could serve a number of purposes including improving CAR-MAVDT coordination, disseminating best practices among CARs to raise average levels of regulatory capacity, and increasing transparency and information sharing. In addition, such an annual meeting would enable CARs to publicly report on their activities, thereby creating incentives for improved institutional performance.

Improve National-Regional Coordination

The MAVDT could aggressively explore new strategies for improving coordination between the MAVDT and CARs. A number of more specific coordination mechanisms are available that fall into two categories: "carrots"—that is, rewards for cooperative behavior; and "sticks"—sanctions for noncooperative behavior. Rewards are likely to be more effective for resource-poor CARs and sanctions are more likely to be effective for resource-rich CARs. First, strengthening the capacity and authority of the MAVDT to supervise the performance of SINA organizations would help it apply sanctions.

A second stick is to enhance MAVDT authority over CAR management and spending decisions. For example, standards and processes might be developed that allow the MAVDT to undertake a periodic formal evaluation of CAR general directors and to remove them for blatant violations of MAVDT policy directives. The MAVDT might also be endowed with the authority to approve certain CAR budget or investment decisions on the basis of clear standards. To minimize the potential for bureaucratic sluggishness, the MAVDT would be given a limited amount of time to approve or reject budgets. In addition, a formal dispute resolution mechanism could be established to facilitate the overall process.

Possible coordination incentives include enhancing the MAVDT's ability to cofinance investment projects at the regional level. In countries with a decentralized environmental structure, cofinancing is often the most important tool national authorities have to ensure national-regional coordination. One disadvantage of this approach is that it would be less effective in CARs with relatively large amounts of self-generated funds.

National environmental funds are likely the most efficient and transparent means of enhancing cofinancing. The MAVDT could rely on existing mechanisms—the National Royalty Fund, the Environmental Compensation Fund, the National Environmental Fund, and the National Fund for Environmental Action. However, each of these funds has significant structural characteristics that render them less than ideal for the purpose at hand: each fund alone has resources that might not be sufficient to have the desired impact; several of the funds have goals other than coordinating national-regional environmental management or that entail legal restrictions that would leave the MAVDT with limited discretion in deciding how and where to disburse funds; some of the funds have been plagued by poor management; and some of the funds have limited resources outside of national appropriations. Given these constraints, the government might consider efforts to consolidate and restructure the existing funds.

Ideally, the fund used to improve national-regional coordination—whether a modification of an existing mechanism or a new one—would have the following features: CARs would submit proposals for cofinancing to the MAVDT, and the MAVDT would evaluate and select proposals using clear and transparent criteria. In establishing these criteria, the MAVDT's broad aim would be to maximize net benefits (benefits to human health and the environment net of total costs) but also to further national-regional coordination and to reduce disparities across CARs in both regulatory capacity and access to environmental services. Thus, the proposal selection criteria would include such factors as the degree to which the project aligns with national and regional environmental plans, the capacity of the particular CAR to implement the project, the level of environmental infrastructure in the particular CAR relative to other CARs, the need for capacity building in the particular CAR relative to other CARs, and the magnitude of the potential net benefits to human health and the environment from the proposed projects.

Conventional mechanisms would be used to ensure that project funds are well spent. To ensure that a CAR is fully committed to the project, it would be required to supply a significant percentage of capital from its own coffers. CARs would also be required to collect clear, transparent, baseline data; establish performance milestones based on specific monitorable criteria; and provide periodic progress reports on the extent to which these milestones have been met. Clear failure to meet milestones would disqualify CARs from future cofinancing. These mechanisms would help to bolster the MAVDT's ability to monitor CAR activities.

Finally, the annual meeting constitutes a mechanism for enhancing CAR-MAVDT coordination that involves both carrots and sticks.

Develop Guidelines to Minimize Conflicts of Interest Arising from CARs' Involvement in Developing Sanitation Infrastructure

A number of measures can be taken to minimize potential conflicts of interest arising from CAR involvement in developing sanitation infrastructure. The most effective means would be to simply prohibit CARs from having any involvement in developing sanitation infrastructure. Although not unreasonable as a long-term policy goal, in the medium term, given the paucity of other sources of funds for sanitation infrastructure and consequent national pressures to use CARs' self-generated funds for this purpose, this drastic measure may not be politically feasible.

A more practical approach in the short term might be to prohibit CARs from operating or owning sanitation infrastructure, and to strictly limit their role to providing cofinancing. Although unlikely to completely eliminate conflicts of interest, this prohibition would probably dampen them. Similarly, conflicts of interest could be dampened by requiring CARs to create independent administrative divisions to finance sanitation infrastructure.

Take Action at the National Level to Resolve Jurisdictional and Financial Disputes between AAUs and CARs

Continuing jurisdictional and financial disputes between CARs and AAUs—including numerous court cases—have needlessly drained scarce resources; precluded cooperation between the two sets of institutions; and sowed uncertainty, confusion, and mistrust in the regulated community. National-level authorities, including the Congress, might consider clarifying lines of authority and finance relationships between AAUs and CARs, and might develop workable and efficient dispute resolution mechanisms.

Eliminate CARs that Chronically Perform Poorly

One option for improving the functioning of the regional environmental management systems in Colombia is to eliminate CARs that chronically perform poorly by consolidating them with contiguous, well-functioning CARs. Until information management systems are improved, however, evaluating the performance of individual CARs will remain a difficult, subjective, and extremely contentious exercise. Once indicators and management systems are in place, rules could be established mandating that CARs meet minimum performance standards.

Development of these standards could be closely tied to efforts (that are presumably underway) to require CARs to set specific quantifiable goals in their PATs, and to systematically monitor their progress toward achieving these goals. Ideally, this performance evaluation system would measure CARs' direct impacts on environmental quality, such as reduction in waterborne diseases or in concentrations of particulate matter less than 2.5 microns in size ($PM_{2.5}$) for outdoor or indoor environments.[8] In addition, the new system could take stock of process-related proxies for CARs' environmental impacts that have to do with the extent to which they carry out functions associated with environmental protection, such as completing planning activities, collecting environmental quality data, and carrying out monitoring actions.

CARs that chronically fail to meet minimum performance standards, and that cannot show good cause for this failure, would be subject to elimination by consolidation. Procedures to carry out these activities would need to be established, possibly including some form of legislative approval. Even if never carried out, this threat could be a strong incentive to improve performance.

A performance-evaluation system involving such severe sanctions would create strong incentives for poorly performing CARs to block improvements in information management systems. To prevent this, the two policy initiatives could be staggered—the evaluation system could be initiated after information systems have been upgraded. Thus, this system would appear to be more practical in the medium or long term than in the short term.

Notes

1. Allen Blackman, Richard Morgenstern, Elizabeth Topping, and Ernesto Sánchez-Triana are the authors of this chapter, which draws heavily from a background document prepared for this study by a team from Resources for the Future (Blackman, Morgenstern, and Topping 2004).
2. According to the MAVDT (2006, p. 7) the "Corporations' resources are associated with the structural conditions of development and not with their seniority. Some of the Corporations created prior to Law 99 are CORPOCESAR, CORPAMAG, and CORPONARIÑO, which are among the 15 with the fewest resources, and Corporations such as CORANTIOQUIA, which was created by Law 99 and is one of those with the most resources."

3. According to the MAVDT (2006, p. 7) it is "clear that all projects bear operating costs inherent to their objectives."
4. To deal with organic discharges, wastewater treatment plant construction has grown significantly in recent years. In 1990, less than 1 percent of the urban population had wastewater treatment coverage (Contraloría 2002). None of those wastewater treatment plants removed pathogens or toxic pollutants.
5. According to the MAVDT (2006, p. 7) "electricity sector transfers are not taxes or charges."
6. According to the MAVDT (2006, p. 7), the "increases in the investment budgets of the Corporations do not follow a distribution. They originate from the circumstances of their own available resources given, as has been stated, their potential to collect resources. On this basis, the increases correspond to resource management and to the Environmental Compensation Fund."
7. These indicators include deforestation rates and forest conservation efforts, development of green markets, rationalization and optimization of consumption of renewable natural resources, reduction in health impacts associated with environmental factors, and reduction in vulnerability to risks associated with natural disasters.
8. According to the MAVDT (2006, p. 7) "general goals cannot be deemed (in the sense that they are for all CARs) as environmental goals (air pollution) that are not a generalized problem, as in this case it is suggested to measure the performance in achieving PM 2.5 reductions that at the global level still lack norms in industrialized countries."

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Annex 4.1 Colombia: Regions Managed by Local and Regional Environmental Authorities

CHAPTER 5

Setting Environmental Priorities: Top Down and Bottom Up

As assessment of the social and economic costs of environmental damage in Colombia shows that the highest costs of environmental degradation (representing approximately 3.7 percent of gross domestic product) are associated with insufficient water supply, sanitation, and hygiene; and ambient and indoor air pollution; followed by natural disasters and land degradation. Ambient and indoor air pollution account for approximately 7,000 premature deaths annually, while 1,450 to 1,820 children die each year from diarrheal illness related to insufficient water, sanitation, and hygiene. A survey of Colombian societal perceptions of environmental priorities showed that the environmental problems that carry the highest costs of environmental degradation are also of great concern to the Colombian population. It also indicated that these environmental problems affect the poor most directly—low-income groups identified air pollution as the most serious environmental concern for the country (74 percent), and environmental health (70 percent) as the top priority for their household.

This chapter provides estimates of social and economic costs of environmental damage in Colombia based on the national estimates presented in Larsen (2004b), and describes results from a survey administered in 2004 to determine perceptions of different stakeholders on priority environmental concerns (CNC 2004).[1] Costs are presented for five environmental categories: water, sanitation, and hygiene; urban air pollution;

indoor air pollution; agricultural land degradation; and natural disasters.[2] Cost estimates were also undertaken in the preparation of this report for insufficient household solid waste collection, and for vector-borne illnesses (malaria, dengue, and leishmaniasis). While the costs of these two categories are significant in some departments and localities, the cost estimates indicate that at the aggregate national level they are only a fraction of the national costs of the five previous categories. They are therefore not presented in this chapter (annex 5.1).

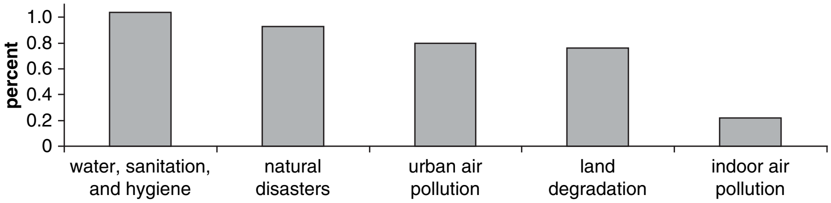
Chapters 11, 12, and 13 discuss degradation at the national level for water resources, wetlands, biodiversity, and protected areas. Estimates of the costs related to these environmental issues are very low compared with those associated with water, sanitation, and hygiene; land degradation; and indoor and urban air pollution.

This chapter discusses the annual cost of environmental damage in Colombia, presents estimates of the cost of environmental degradation associated with the earlier mentioned environmental categories, presents the results of a survey administered in 2004 to determine perceptions of different stakeholders on priority environmental concerns, and draws conclusions.

Annual Cost of Environmental Damage

The mean estimated annual costs of environmental damage for five categories—insufficient water, sanitation, and hygiene; urban air pollution; indoor air pollution; agricultural land degradation; and natural disasters—amounts to approximately 3.75 percent of gross domestic product (GDP)[3] per year (figure 5.1). The highest-cost categories are insufficient water supply, natural disasters, and urban air pollution, followed by agricultural land degradation and indoor air pollution (Larsen 2004b).

Figure 5.1 Annual Cost of Environmental Damage
(% GDP)



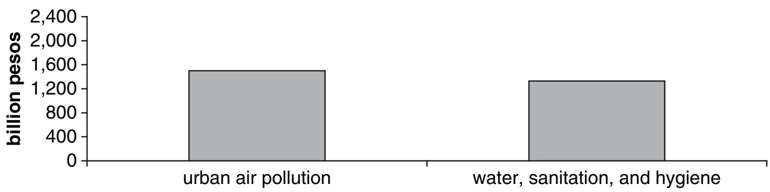
Source: Larsen 2004b.
Note: Cost of land degradation is erosion and salinity of cultivated land and does not include pasture and rangeland.

Table 5.1 Annual Costs of Environmental Damage, Low and High Estimates

	Billion pesos per year		
Environmental categories	*Low*	*Mean estimate*	*High*
Water, sanitation, and hygiene	1,700	1,960	2,220
Natural disasters	1,330	1,750	2,175
Urban air pollution	720	1,500	2,285
Agricultural soil degradation[a]	1,310	1,440	1,570
Indoor air pollution	230	415	600
Total annual cost	5,290	7,065	8,850

Source: Larsen 2004b.
Note: US$1 = Col$2,150.
a. Cost is erosion and salinity of cultivated land (not including pasture or rangeland).

Figure 5.2 Estimated Annual Urban Costs



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

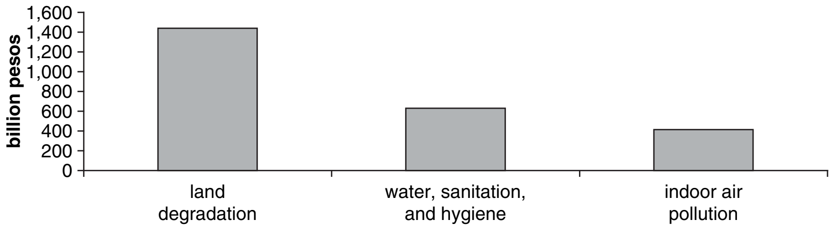
Low and high estimates of annual costs are presented in table 5.1. The largest range is associated with urban air pollution, mainly because two valuation techniques for estimating the social cost of mortality have been applied, as explained in the Urban Air Pollution section of this chapter. The large range for indoor air pollution results mainly from uncertainty about the level of exposure to indoor smoke from the use of fuelwood; thus, a range has been applied for the level of health risk.

Costs by Environmental Category

In urban areas, the cost of urban ambient air pollution is slightly higher than the cost of inadequate water, sanitation, and hygiene (figure 5.2). In rural areas, the cost of land degradation (not including pasture) is estimated to be more than twice as high as the cost of inadequate water, sanitation, and hygiene (figure 5.3), while the cost of indoor air pollution is almost as high as that of water, sanitation, and hygiene.[4]

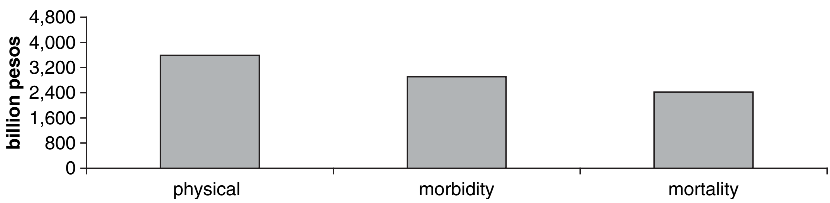
Physical damage, such as land degradation and damage to buildings and infrastructure from natural disasters, has the highest share of total environmental damage costs. This is followed by an almost equal cost share

Figure 5.3 Estimated Annual Rural Costs



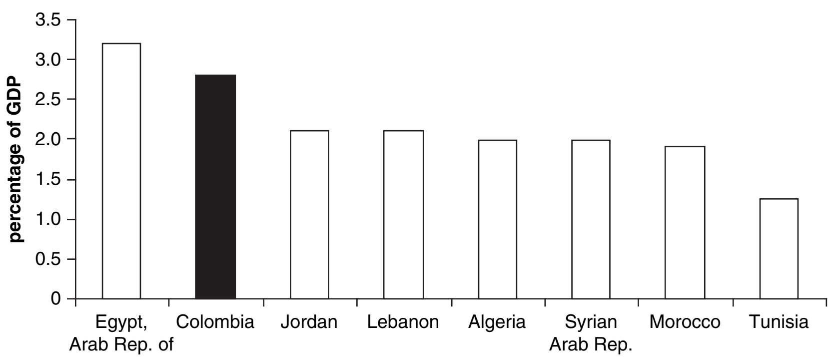
Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Figure 5.4 Costs by Category



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

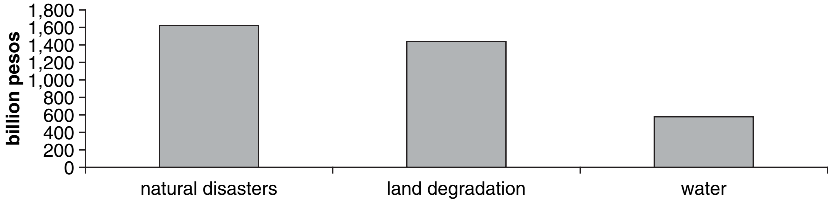
Figure 5.5 Costs of Environmental Degradation (Health and Quality of Life)



Sources: Tunisia and Lebanon: Sarraf, Larsen, and Owaygen 2004; Algeria: Ministère de l'Aménagement du Territoire et de l'Environnement 2002; Egypt: World Bank 2002; Morocco: World Bank 2003; Syria: Sarraf, Bolt, and Larsen 2004; Jordan: METAP 2000.

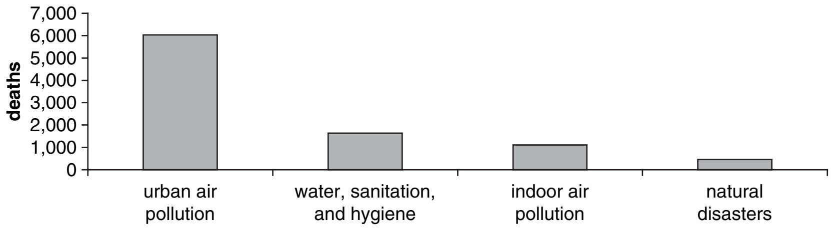
for morbidity and mortality (figure 5.4). The negative health impacts associated with environmental degradation in Colombia are higher than in other countries with similar income levels. Studies conducted in several lower-middle-income countries and Lebanon (an upper-middle-income country) in the Middle East and North Africa region show that in most cases the monetary value of increased morbidity and mortality remains

Figure 5.6 Physical Costs by Category



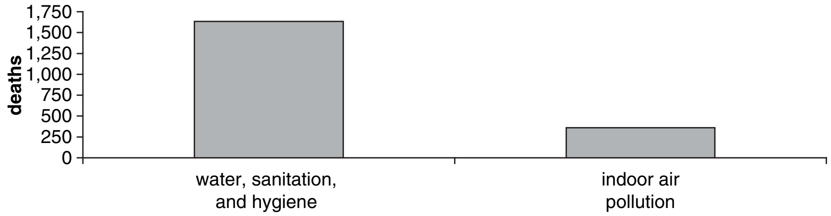
Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Figure 5.7 Number of Deaths by Category



Source: Larsen 2004b.

Figure 5.8 Deaths among Children, by Category



Source: Larsen 2004b.

below 2 percent of GDP, while these costs are about 2.8 percent of GDP in Colombia (figure 5.5). Of the physical costs, the categories with the highest cost shares are natural disasters and land degradation (figure 5.6). The costs associated with water are for expenditures on bottled water, household water purification, and boiling of drinking water associated with perceived health risks of water supply sources.

The estimated number of annual deaths from urban air pollution is several times higher than in the other categories (figure 5.7). However, the situation is different for children. Insufficient water, sanitation, and hygiene represent the largest mortality risk for children, followed by indoor air pollution (figure 5.8).

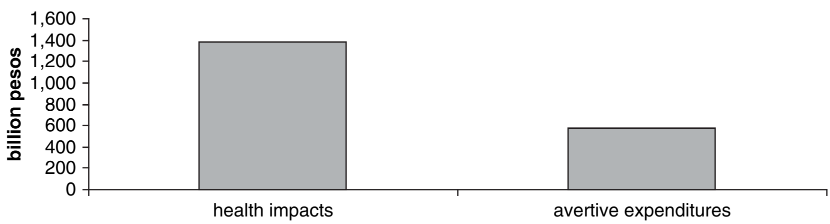
Water, Sanitation, and Hygiene

The mean estimated annual cost associated with insufficient water supply, sanitation, and hygiene ranges from Col$1,700 billion to Col$2,220 billion (US$790 million to US$1 billion) per year, with a mean of Col$1,960 billion (US$911 million). The cost of health impacts represents an estimated 70 percent of total mean cost, and avertive expenditures about 30 percent (figure 5.9). Health impacts include both mortality and morbidity, and avertive expenditures include bottled water consumption, household water filtering, and household boiling of drinking water (figure 5.10). This section discusses the linkages among health and water, sanitation, and hygiene; the environmental health situation in Colombia; the methodologies used to estimate health impacts; and the socioeconomic valuation of these health impacts.

Diarrheal Illness

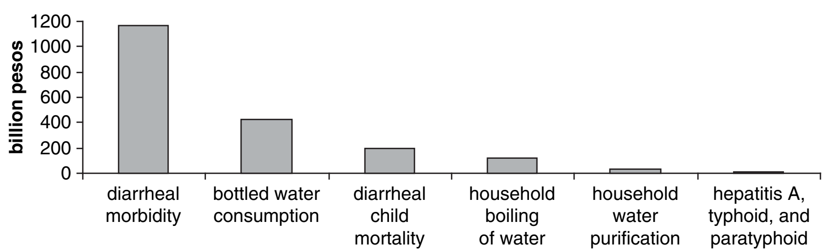
Insufficient potable water supply, sanitation facilities and practices, and hygiene conditions are associated with various illnesses in both adults and children. Esrey and others (1991) provide a comprehensive review of studies documenting this relationship for diseases such as schistosomiasis

Figure 5.9 Annual Costs of Insufficient Water, Sanitation, and Hygiene



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Figure 5.10 Annual Costs by Category



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

(bilharzia), intestinal worms, diarrhea, and others. From a review of studies, Curtis (2002) reports a mean reduction of 44 percent in cases of severe diarrhea from good handwashing practices. While diarrheal illness is generally not as serious as some other waterborne illnesses, it is more common and affects a larger number of people.

Water, sanitation, and hygiene factors also influence child mortality. Esrey and others (1991) find in their review of studies that the median reduction in child mortality from improved water and sanitation was 55 percent. Shi (1999) provides econometric estimates of the impact of potable water and sewerage connection on child mortality using data for about 90 cities around the world. Literacy and education level is also found to be important for parental protection of child health against environmental risk factors. Esrey and Habicht (1988) report from a study in Malaysia that maternal literacy reduces child mortality by about 50 percent in the absence of adequate sanitation, but only by 5 percent in the presence of good sanitation facilities. Literacy is also found to reduce child mortality by 40 percent if piped water is present, suggesting that literate mothers take better advantage of water availability for hygiene purposes to protect child health.

Findings from the Demographic and Health Survey (DHS) seem to further confirm the role of literacy in child mortality reduction. Rutstein (2000) provides a multivariate regression analysis of infant and child mortality in developing countries using DHS data from 56 countries for the period from 1986 to 1998. The study finds a significant relationship between infant and child mortality rates and piped water supply, flush toilets, maternal education, access to electricity, medical services, oral rehydration therapy (ORT), vaccination, presence of a dirt floor in household dwelling, fertility rates, and malnutrition. Similarly, Larsen (2003) provides a regression analysis of child mortality using national data for 2000 from 84 developing countries representing 95 percent of the total population in the developing world. A statistically significant relationship between child mortality and access to improved water supply, safe sanitation, and female literacy is confirmed.

Baseline Health Data

Colombia has achieved substantial reductions in child mortality and diarrheal child mortality. Child mortality is now about one-third lower than in the Latin America and the Caribbean region, and almost 50 percent lower than the average for lower-middle-income countries. Baseline health data for estimating the health impacts of insufficient water supply,

Table 5.2 Baseline Data for Estimating Health Impacts

Parameters	*Baseline*	*Source*
Diarrheal mortality in children under age 5 (% of child mortality)	7.3	Based on data from DANE
Total annual diarrheal mortality in children under age 5	1,450–1,820	Estimated from DANE
Diarrheal two-week prevalence in children under age 5	13.9%	DHS 2000
Estimated annual diarrheal cases per child under age 5	2.9	Estimated from DHS 2000
Estimated annual diarrheal cases per person age 5 and over	0.40–0.57	Estimated from a combination of INS data and DHS 2000
Hospitalization rate (% of all diarrhea cases)—under age 5	0.75	Adjusted to Colombia based on evidence from
Hospitalization rate (% of all diarrhea cases)—under age 5	0.5	Egypt (Larsen 2004a). No data available for Colombia
Percentage of diarrheal cases and hospitalizations attributable to water, sanitation, and hygiene	90	WHO 2002
DALYs per 100,000 cases of diarrhea in children under age 5	30–40	Estimated from WHO tables
DALYs per 100,000 cases of diarrhea in people age 5 and over	100–130	Estimated from WHO tables
DALYs per case of diarrheal mortality in children under age 5	34	Estimated from WHO tables

Source: Larsen 2004b.
Note: DALY = disability-adjusted life year; DANE = *Departamento Administrativo Nacional de Estadísticas;* INS = *Instituto Nacional de Salud.*

sanitation, and hygiene are presented in table 5.2. Data from the National Statistical Administration Department (*Departamento Administrativo Nacional de Estadísticas*, DANE) indicate that about 7.3 percent of child mortality is from diarrheal illness. The lower bound for diarrheal mortality (1,450 deaths) is based on 7.3 percent of official death records, while the upper bound (1,820 deaths) is based on 7.3 percent of total estimated child mortality published by DANE.[5]

For diarrheal morbidity, however, it is practically impossible to identify all cases of diarrhea. The main reason is that a substantial share of cases are not treated or do not require treatment at health facilities, and are therefore never recorded. A second reason is that cases treated by private doctors or clinics are most often not reported to public health authorities. Therefore, household surveys often provide the most reliable indicator of total cases of diarrheal illness. Most household surveys, however, contain only information on diarrheal illness in children. Moreover, the surveys reflect diarrheal prevalence only at the time of the survey. Because there is often high variation in diarrheal prevalence across seasons of the year, extrapolation to an annual average will result in either an over- or an underestimate of total annual cases. Correcting this bias is often difficult without knowledge of seasonal variations.

The Colombia Demographic and Health Survey 2000 (DHS 2000) provides data on diarrheal prevalence in children under age five. It reports that diarrheal prevalence (in the preceding two weeks) was 13.9 percent. This rate was used to estimate annual cases per child under 5, and then total annual cases in all children under 5 (table 5.2). The procedure applied is to multiply the two-week prevalence rate by 52/2.5 to arrive at an approximation of the annual cases per child. The prevalence rate was not multiplied by 26 two-week periods (that is, 52/2), but multiplied by 52/2.5 for the following reason: the average duration of diarrheal illness is assumed to be three to four days, which implies that the two-week prevalence captures a quarter of the diarrheal prevalence in the week before and a quarter in the week after the two-week prevalence period.

The DHS household survey does not (nor does any other household survey in Colombia) provide information on diarrheal illness in the population age 5 and over. However, the Colombia National Institute of Health (*Instituto Nacional de Salud*, INS) has a large database on cases of diarrheal illness for several years reported by each department on the basis of information from health care facilities. While this database is not complete, it provides an indication of the annual incidence of diarrhea per child relative to annual incidence for the rest of the population.[6] An analysis of the database suggests that diarrheal incidence in children under age 5 is up to seven times higher than the incidence in the population age 5 and over. It should be noted, however, that the database contains information on cases of diarrhea treated at health facilities. In general, the percentage of cases of diarrhea that are treated at health facilities is higher among young children than among older children and adults. For instance, according to the DHS 2000, the percentage of cases of diarrhea among 4-year-old children is 28 percent lower than among children ages 0 to 4. Thus, the incidence ratio of 7, as suggested from the INS database, is likely an overestimate. The annual number of cases of diarrhea per person among the population above age 5, presented in table 5.2, is therefore estimated at 1/7 to (1/0.72) × 1/7 of the annual cases per child under age 5.

Table 5.2 also presents disability-adjusted life years (DALYs)[7] per case of diarrheal illness, which are used to estimate the number of DALYs lost because of insufficient water supply, sanitation, and hygiene. While the disability weight for diarrheal morbidity is similar for children and adults

(0.119 for children under age 5 and 0.086 for the rest of the population), and the duration of illness is assumed to be the same (three to four days), the DALYs per 100,000 cases of diarrheal illness are much higher for adults. This is because DALY calculations involve age weighting that attaches a low weight to young children, and a higher weight to adults, corresponding to physical and mental development stages.[8] For diarrheal child mortality, the number of DALYs lost is 34. This reflects an annual discount rate of 3 percent of life years lost.

Estimated Impacts on Health from Insufficient Water, Sanitation, and Hygiene

Table 5.3 presents the estimated impacts on health from insufficient water, sanitation, and hygiene. The estimates are based on the data in table 5.2, taking into account the World Health Organization (WHO) estimate that 90 percent of diarrheal illness is attributable to water, sanitation, and hygiene. DALYs lost to diarrheal illness (mortality and morbidity) are presented in table 5.4. More than 60 percent of the DALYs are from diarrheal child mortality.

Table 5.3 Estimated Annual Impacts on Health from Insufficient Water, Sanitation, and Hygiene

	Annual estimates	
Parameters	*Low*	*High*
Cases of diarrheal illness		
Children (under age 5)—increased mortality	1,305	1,635
Children (under age 5)—increased morbidity	12.4 million	12.4 million
Population age 5 and over—increased morbidity	14.5 million	20.0 million
Cases of diarrheal hospitalization		
Children (under age 5)	90,000	95,000
Population age 5 and over	75,000	100,000
Total DALYs—mortality and morbidity	64,000	91,000

Source: Larsen 2004b.

Table 5.4 Estimated DALYs Lost to Diarrheal Mortality and Morbidity

	Estimated annual DALYs		
Parameters	*Low*	*High*	*% total DALYs*
Children (under age 5)—increased mortality	44,000	55,500	62–69
Children (under age 5)—increased morbidity	4,000	5,500	6
Population age 5 and over—increased morbidity	16,000	29,000	25–32
Total DALYs	64,000	90,000	

Source: Larsen 2004b.

Estimated Cost of Health Impacts

Total annual cost of health impacts associated with insufficient water, sanitation, and hygiene is estimated at Col$1,210 billion to Col$1,525 billion (US$563 million to US$709 million) (table 5.5). The cost of diarrheal child mortality is based on the human capital approach. The cost of morbidity includes the cost of illness (medical treatment, medicines, and value of lost time) and DALYs from morbidity valued at GDP per capita to reflect the cost of reduced well-being associated with illness.

Total annual cost of illness is presented in table 5.6 for diarrheal morbidity. About 40 to 50 percent of these costs is associated with the value of time lost to illness (including care giving), and 50 to 60 percent is from cost of treatment and medicines.

Baseline data for the cost estimates of morbidity in tables 5.5 and 5.6 are presented in table 5.7. Percentage of diarrheal cases in the age group older than 5 years treated at medical facilities is estimated from percentage of treated cases among children (DHS 2000) and the ratio of treated cases among children under age 5 to treated cases among the population

Table 5.5 Estimated Annual Cost of Diarrheal Illness

	Estimated annual cost (billion pesos)	
Parameters	*Low*	*High*
Mortality		
Children under age 5	178	224
Morbidity		
Children under age 5	432	480
Population age 5 and over	493	704
Hospitalization—children under age 5	54	54
Hospitalization—population age 5 and over	53	53
Total annual cost	1,210	1,515

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Table 5.6 Estimated Annual Cost of Illness (Morbidity) by Category

	Estimated annual cost (billion pesos)	
Categories	*Low*	*High*
Medical treatments (doctors, hospitals, and clinics)	351	351
Medicines	232	232
Time lost to illness	361	567
Total annual cost	944	1,150

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Table 5.7 Baseline Data for Cost Estimation

Parameters	*Baseline*	*Source*
Percentage of diarrheal cases treated at medical facilities (children under age 5) and with medicines	29	DHS 2000
Percentage of diarrheal cases treated with oral rehydration salts (children under age 5)	36	DHS 2000
Percentage of diarrheal cases treated at medical facilities (population age 5 and over) and with medicines	18–25	Estimated from a combination of INS data and DHS 2000
Average cost of doctor visits (urban and rural) (pesos)	35,000	Based on consultations with pharmacies, medical service providers, and health authorities
Average cost of medicines for treatment of diarrhea (pesos)	30,000	
Average cost of ORT per diarrheal case in children (pesos)	3,850	
Average duration of diarrheal illness in days (children and adults)	3–4	Assumption
Hours per day of care giving per case of diarrhea in children	2	Assumption
Hours per day lost to illness per case of diarrhea in adults	2	Assumption
Value of time for adults (care giving and ill adults) (pesos/hour)	2,100	Based on urban and rural wages in Colombia
Hospitalization rate (% of all diarrhea cases)—under 5 years old	0.75	Adjusted based on evidence from Egypt, Arab Rep. of (Larsen 2004a).
Hospitalization rate (% of all diarrhea cases)—under 5 years old	0.50	No data available for Colombia
Average length of hospitalization (days)	2	Adjusted from Egypt, Arab Rep. of (Larsen 2004a)
Time spent on visitation (hours per day)	4	Assumption
Average cost of hospitalization (pesos per day)	280,000	Based on consultations with hospitals
Diarrhea cases and hospitalizations caused by inadequate water, sanitation, and hygiene (%)	90	WHO 2002

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

age 5 and over. The latter ratio is from the INS database discussed in the Baseline Health Data section.

The value of time for adults is based on national average wages. Economists commonly apply a range of 50 to 100 percent of wage rates to reflect the value of time. The hourly rate of Col$2,100 (about US$1), or Col$17,000 (US$7.90) per day reflects around 75 percent of average wages in Colombia.[9] These rates for value of time have been applied to both working and nonworking individuals. There are two reasons for applying the rates to nonworking individuals: most of those adult individuals provide a household function that has a value; and there is an opportunity cost to the time of nonworking individuals, because they could choose to join the paid labor force.[10]

Hepatitis A, Typhoid, and Paratyphoid

Recorded annual cases of hepatitis A and typhoid and paratyphoid in Colombia for 2000–03 are presented in table 5.8. The data for 2003 report cases by age. Close to 20 percent of cases of hepatitis A and close to 10 percent of cases of typhoid and paratyphoid were among children under age 5.

Estimated annual cost of these illnesses is presented in table 5.9 based on annual average cases during 2000–03. About 55 percent of estimated cost is from hospitalization and 40 percent is from time losses for the ill individuals and their caregivers during illness. More than 70 percent of the cost of time losses is associated with ill individuals and almost 30 percent with care giving.

Table 5.10 presents the baseline data for estimating the costs of hepatitis A, typhoid, and paratyphoid. It is assumed that all people with cases of hepatitis A and typhoid and paratyphoid are hospitalized. The estimated cost of hospitalization in table 5.9 is therefore an upper bound. The value of time lost to illness and care giving is around 75 percent of average wage rates. Average duration of illness is estimated to be 30 days,

Table 5.8 Annual Cases of Hepatitis A and Typhoid and Paratyphoid, 2000–03

Year	*Hepatitis A*	*Typhoid and paratyphoid*
2000	4,438	99
2001	6,405	373
2002	11,236	256
2003	6,513	1,503
Annual average	7,148	558

Source: National Institute of Health, Colombia 2004.

Table 5.9 Estimated Annual Cost of Hepatitis A, Typhoid, and Paratyphoid

Categories	*Estimated total annual cost (billion pesos)*
Hospitalization	6.5
Medication	0.4
Time losses	4.9
Total annual cost	11.8

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Table 5.10 Baseline Data for Cost Estimation of Hepatitis A, Typhoid, and Paratyphoid

Parameters	*Baseline*	*Source*
Percentage of cases hospitalized	100	Assumption
Average length of hospitalization (days)	3	Estimate
Average cost of hospitalization (pesos per day)	280,000	Based on consultation with health care providers and health care authorities
Average cost of medication (pesos per case)	50,000	
Average duration of illness (days)	30	Estimate
Value of time lost to illness and care giving (pesos per day)	17,000	Based on average wages
Care giving at home per day of illness (hours per day)	3	Estimate

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

and the cost estimate in table 5.9 assumes that 30 days are lost to illness, valued at Col$17,000 (US$7.90) per day.[11] This is likely to be an upper bound because some individuals recover faster and part of the day during recovery may be of productive use. Even with baseline data that are likely to be upper bounds, the total annual estimated cost of hepatitis A and typhoid and paratyphoid is only a small fraction of the cost of diarrheal illness.

Avertive Expenditures

In the presence of perceived health risks, individuals often take avertive measures to avoid these risks. Economists usually consider these measures a cost of health risks. If consumers perceive there is a risk of illness from the municipal water supply, or from other sources of water supply they rely on, some are likely to purchase bottled water for drinking purposes, or boil their water, or install water purification filters. The estimated cost of these measures is presented in this section.

Bottled water. Approximately 775 million liters of bottled water were sold in Colombia in 2001 according to the Annual Manufacturer Survey (DANE 2003). The average factory price was about Col$275 (US$0.13) per liter. According to observations in stores in Bogotá, the average retail price ranged from Col$200 (US$0.09) per liter for five-gallon containers to Col$1,000 (US$0.47) per liter for one-liter bottles.

To estimate the total annual retail cost of bottled water consumption in Colombia, a retail price range of Col$480 to Col$625 (US$0.22 to

US$0.29) per liter was applied. The lower bound represents a 75 percent markup of average factory price. The upper bound represents an arithmetic average of retail prices for the most commonly sold quantities of bottles (and containers). On this basis, the total annual cost of bottled water consumption is estimated at Col$375 billion to Col$485 billion (US$174 million to US$226 million).

Boiling of water. According to the Quality of Life Survey 2003 (DANE 2003), 48 percent of households in Colombia boil their drinking water, either all the time or sometimes. Table 5.11 presents the estimated annual cost of boiling water for those households, totaling Col$75 billion to Col$160 billion (US$35 million to US$74 million) per year.

Table 5.12 presents the data used to estimate the annual cost of boiling drinking water. It is assumed that the average daily consumption of drinking water per person is 0.5 to 1.0 liters among households boiling water. The residential cost of energy is estimated based on data from the Mining and Energy Planning Unit (*Unidad de Planeación Minero Energética*, UPME). The average stove efficiency is for electric, natural gas, and propane stoves.

Water purification. The Quality of Life Survey 2003 (DANE 2003) reports that 4.2 percent of households have drinking water purification filters installed in their homes. The annual cost of household water purification is estimated at Col$30 billion to Col$35 billion (US$14 million to US$16 million). This is estimated by annualizing the cost of purification equipment and filters over their expected useful life, using a discount rate of 10 percent, an average useful life of equipment of 15 years, and

Table 5.11 Estimated Annual Cost of Boiling Drinking Water

	Estimated annual cost (billion pesos)	
Categories	*Low*	*High*
Cost of bringing water to boiling point		
Households using electricity	35	70
Households using natural gas	10	20
Households using propane	18	35
Households using other types of energy (mainly fuelwood)	6	24
Cost of boiling water for 10 minutes		
All households boiling water	6	11
Total annual cost	75	160

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Table 5.12 Baseline Data for Cost Estimation for Boiling Drinking Water

Parameters	*Data*	*References and measurements*
Percentage of households that boil their drinking water	48	DANE 2003 survey
Average daily consumption of drinking water	0.5–1.0	Liters per person per day
Percentage of households using electricity	14	DHS 2000 and data from
Percentage of households using natural gas	34	UPME
Percentage of households using propane	31	UPME
Percentage of households using other types of energy	21	UPME
Energy requirement for heating of water (100% efficiency)	4,200	Joules/liter/1 degree Celsius
Average stove efficiency for heating of water	50%	Varies by type of stove
Cost of residential electricity (economic cost)	350	Pesos/kilowatt hour
Cost of residential natural gas	406	Pesos per cubic meter
Average cost of bottled propane	39,000	Pesos (per 17.7 gallons)

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Table 5.13 Unit Costs of Water Purification

Parameters	*Low*	*High*
Percentage of households using water purification equipment and filters	4.2	4.2
Cost of water purification equipment (most commonly used) (pesos)	295,000	270,000
Cost of replacement filter (pesos)	95,000	22,500
Average useful life of filters (years)	6.0	0.6
Average useful life of equipment (years)	15	15

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

an average lifetime of filters of 0.6 to 6.0 years. These useful lives represent averages for the most common equipment and filters used in Colombia. Unit costs for equipment and filters are presented in table 5.13. These figures, and the useful life of equipment and filters, were obtained from stores in Bogotá.

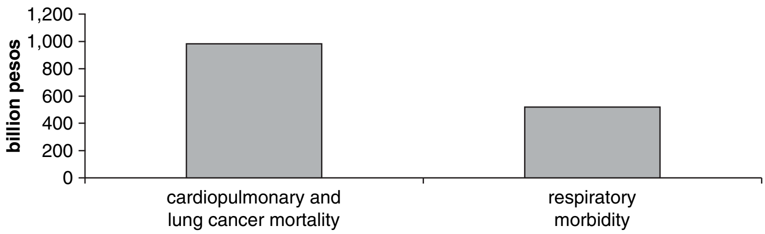
Table 5.14 presents a summary of the cost of avertive expenditures, amounting to a total of Col$480 billion to Col$680 billion (US$223 million to US$316 million) per year. This represents 30 percent of the total estimated annual cost of insufficient water supply, sanitation, and hygiene.

Table 5.14 Estimated Total Annual Household Costs of Avertive Expenditures

	Total annual cost (billion pesos)	
Parameters	*Low*	*High*
Cost of bottled water consumption	375	485
Cost of household boiling of drinking water	75	160
Cost of household water purification	30	35
Total cost	480	680

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Figure 5.11 Annual Costs of Urban Air Pollution



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Urban Air Pollution

The mean estimated annual cost of urban air pollution amounts to Col$1,500 billion (US$698 million) (figure 5.11). About 65 percent of the cost is associated with mortality, and 35 percent with morbidity. Measured in DALYs, mortality represents 50 percent and morbidity 50 percent. This section discusses the scientific evidence for the impacts of urban air pollution on health, the methodologies used to estimate health impacts in Colombian cities, and the socioeconomic valuation of these health impacts.

There is substantial research evidence that outdoor urban air pollution has significant negative impacts on public health and results in premature deaths, chronic bronchitis, and respiratory disorders (Ostro 1994). The air pollutant that has shown the strongest association with these health endpoints is particulate matter (PM), and especially particulates of less than 10 microns in diameter (PM_{10}) or smaller. Pope and others (2002) provide strong evidence that it is even smaller particulates, particulates of less than 2.5 microns in diameter ($PM_{2.5}$), that have the largest health effects. The gaseous pollutants (sulfur dioxide [SO_2], nitrogen oxide [NO_x], carbon monoxide [CO], and ozone [O_3]) are generally not thought to be as damaging as fine particulates. However, SO_2 may have important health consequences because it can react with other substances in the atmosphere to form particulates (Krupnick 2005). Colombia is highly urbanized, with 72 percent of the population living in urban areas (DANE 2002). Close to 50 percent of the population live in cities with more than 100,000 inhabitants, and close to 30 percent live in cities with more than 1 million inhabitants. Only some cities in Colombia have PM_{10} monitoring data (tables 5.15 and 5.16). Their total population is 12.5 million.[12]

Based on the current status of worldwide research, the risk ratios or dose response coefficients from Pope and others (2002) are likely to be the best available evidence for the mortality effects of ambient particulate pollution ($PM_{2.5}$). Pope and others (2002) found a statistically significant relationship between levels of $PM_{2.5}$ and mortality rates; all-cause mortality increased by 4 to 6 percent for every 10 micrograms per cubic meter

Table 5.15 Baseline Data for Cities with PM Monitoring Data

Key parameters	*Bogotá*	*Bucaramanga*[a]	*AMVA*[b]	*Cali*
Population, 2002 (millions)	6.68	0.74	2.80	2.26
Adult population ≥ 15 years (millions)	4.67	0.49	1.79	1.60
Children population ≤ 14 years (millions)	2.01	0.25	1.01	0.66
Annual average PM_{10} ($\mu g/m^3$)[c]	62	56	52	46
Annual average $PM_{2.5}$ ($\mu g/m^3$)[d]	37	34	31	27

Source: Population figures are based on estimates by DANE.
Note: $\mu g/m^3$ = micrograms per cubic meter.
a. Includes Floridablanca and Girón.
b. The AMVA (*Área Metropolitana del Valle de Aburrá*) includes MedellÍn, Bello, Envigado, Itagui, and so on.
c. PM_{10} figures are population weighted by PM_{10} levels in four zones in each city.
d. $PM_{2.5}$ is calculated based on a $PM_{2.5}/PM_{10}$ ratio of 0.6.

Table 5.16 Baseline Data for Cities without PM Monitoring Data

	City size (inhabitants)		
Key parameters	*Over 1 million*[a]	*500,000–1 million*[b]	*100,000–500,000*[c]
Total population, 2002	1.30	1.64	5.98
Adult population ≥ 15 years	0.89	1.11	4.03
Child population ≤ 14 years	0.41	0.53	1.95
Annual average PM_{10} ($\mu g/m^3$)[d]	50	45	40
Annual average $PM_{2.5}$ ($\mu g/m^3$)[e]	30	27	24

Source: Population figures are based on city-specific estimates by DANE.
Note: $\mu g/m^3$ = micrograms per cubic meter.
a. Barranquilla.
b. Cartagena (0.95 million) and Cúcuta (0.69 million).
c. Twenty-four cities with an average population of 250,000 per city.
d. PM_{10} figures are approximations based on population size in relation to cities with PM_{10} data.
e. $PM_{2.5}$ is calculated based on a $PM_{2.5}/PM_{10}$ ratio of 0.6.

($\mu g/m^3$) increase in $PM_{2.5}$. The increase in cardiopulmonary mortality was 6 to 9 percent, and 8 to 14 percent for lung cancer. No statistically significant relationship was found between levels of $PM_{2.5}$ and all other causes of mortality. The impacts on health attributable to air pollution were converted to DALYs to facilitate a comparison with health effects from other environmental risk factors (table 5.17).

It is estimated that urban air particulate pollution causes around 6,000 premature deaths and about 7,400 new cases of chronic bronchitis annually. Annual hospitalizations as a result of pollution are estimated at close to 13,000, and emergency room visits and outpatient hospitalizations at 255,000 per year. In terms of annual DALYs lost, mortality accounts for an estimated 51 percent, chronic bronchitis around 18 percent, restricted activity days 14 percent, and respiratory symptoms 11 percent.

More than one-third of all health effects are in Bogotá. This is significantly higher than in relation to the population of Bogotá and stems from the higher PM levels in the city than in most other cities. More than 20 percent of estimated health effects are in the cities with populations of less than half a million (table 5.18). However, their share of estimated health effects is significantly lower than their population share, because of the lower pollution levels expected in these cities.

As presented in table 5.19, cost of mortality is based on both the human capital approach and the value of statistical life, thus the large range in cost. A measure of the welfare cost of morbidity is often based on the willingness to pay to avoid or reduce the risk of illness. This measure is often found to be several times higher than the cost of medical treatment and the value of time losses (Cropper and Oates 1992), and reflects the value that individuals place on avoiding pain and discomfort. However, there are not a sufficient number of willingness-to-pay studies

Table 5.17 Estimated Impacts on Health from Urban Air Pollution

Health categories	*Total cases*	*Total DALYs*
Premature mortality	6,040	45,300
Chronic bronchitis	7,410	16,300
Hospital admissions	12,970	210
Emergency room visits and outpatient hospital visits	255,000	1,150
Restricted activity days	42,000,000	12,640
Lower respiratory illness in children	585,000	3,800
Respiratory symptoms	135,000,000	10,100
Total	n.a.	89,500

Source: Larsen 2004b.
Note: n.a. = not applicable.

Table 5.18 Estimated Health Impact by City

Parameters	*Percentage of total exposed population*[a]	*Percentage of total cases*[b]
Cities with PM monitoring		
Bogotá	31	38
Ciudad de Bucaramanga	3	4
AMVA	13	13
Cali	10	10
Cities without PM monitoring		
Over 1 million inhabitants	6	7
500,000–1 million inhabitants	8	7
100,000–500,000 inhabitants	28	21

Source: Larsen 2004b.
Note: AMVA = Área Metropolitana del Valle de Aburrá.
a. Exposed population is reported in tables 5.15 and 5.16.
b. Total cases are reported in table 5.17.

Table 5.19 Estimated Annual Costs of Health Impacts

	Total annual cost	
Health categories	*Billion pesos*	*Percent (mean)*
Mortality	200–1,765	65
Morbidity		
Chronic bronchitis	90	6
Hospital admissions	25	2
Emergency room visits and outpatient hospital visits	40	3
Restricted activity days (adults)	270	18
Lower respiratory illness in children	50	3
Respiratory symptoms (adults)	45	3
Total cost of morbidity	520	35
Total cost (mortality and morbidity)	720–2,285	100

Source: Larsen 2004b.
Note: Annual cost is rounded to nearest 5 billion pesos, and percentages are rounded to nearest percent. US$1 = Col$2,150.

in Colombia. For this reason, the cost-of-illness approach (mainly medical cost and value of time losses) has been supplemented in this report by a proxy for the cost of pain and discomfort. The proxy applied is valuation of DALYs at GDP per capita. The value-of-time losses represent almost 50 percent of total cost, and the cost of pain and discomfort (proxied by DALYs valued at GDP per capita) represents somewhat more than one-third.

The value of time for adults is based on urban wages. Economists commonly apply a range of 50 to 100 percent of wage rates to reflect the value of time. The rate of Col$20,000 (US$9.30) per day is about

Table 5.20 Estimated Annual Costs of Morbidity from Urban Air Pollution

	Annual cost	
Categories	*Billion pesos*	*Percentage*
Cost of medical treatments (doctors, hospitals, and clinics)	80	16
Cost of time lost to illness	245	47
DALYs (valued at GDP per capita)	195	37
Total	520	100

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

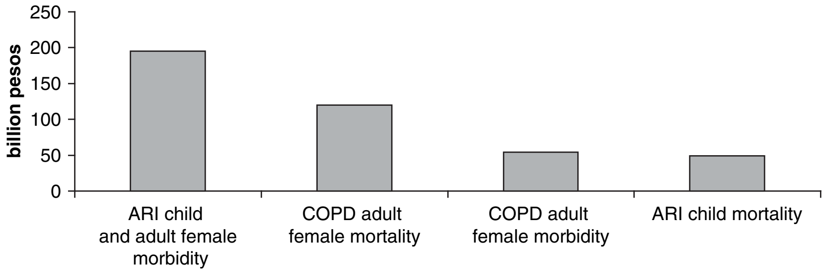
75 percent of average urban wages in Colombia. This rate for value of time has been applied to both working and nonworking individuals. There are two reasons for applying the rates to nonworking individuals: most of those adult individuals provide a household function that has a value, and there is an opportunity cost to the time of nonworking individuals, because they could choose to join the paid labor force.[13] Estimated lost workdays per year are based on frequency of estimated medical treatment plus an additional seven days for each hospitalization and one extra day for each doctor and emergency visit. These days are added to reflect time needed for recovery from illness. To estimate the cost of a new case of chronic bronchitis, the medical cost and value of time losses have been discounted over a 20-year duration of illness. An annual real increase of 2 percent in medical costs and value of time has been applied to reflect an average expected increase in annual labor productivity and real wages. The costs are discounted at 3 percent per year, a rate commonly applied by the WHO for health effects (table 5.20).

Indoor Air Pollution

The mean estimated annual cost of health impacts from indoor air pollution associated with the use of traditional fuels (mainly fuelwood) is Col$415 billion (US$193 million). As presented in figure 5.12, adult female chronic obstructive pulmonary disease (COPD) mortality represents 28 percent of this cost. Acute respiratory illness (ARI) in children and adult females represents 47 percent of the cost, and respiratory child mortality about 12 percent. COPD morbidity in adult females represents 13 percent of the total cost.

The WHO (2002) estimates that 1.6 million people die each year globally from indoor smoke from the use of traditional fuels in the home. The most common of such fuels are wood, agricultural residues, animal

Figure 5.12 Annual Costs of Indoor Air Pollution



Source: Larsen 2004b.
Note: US$1 = Col$2,150. ARI = acute respiratory illness.

dung, charcoal, and, in some countries, coal. The strongest links between indoor smoke and health are for lower respiratory infections, COPD, and cancer of the respiratory system, with indoor smoke causing an estimated 37.5 percent, 22.0 percent, and 1.5 percent, respectively, of these illnesses globally (WHO 2002).

There are two main steps in quantifying the health effects. First, the number of people or households exposed to pollution from solid fuels needs to be calculated, and the extent of pollution, or concentration, should ideally be measured. Second, the health impacts from this exposure should be estimated on the basis of epidemiological assessments. Once the health impacts are quantified, the value of this damage can be estimated.

Traditional Fuel Use

The DHS in 1995 and 2000, conducted among urban and rural households throughout Colombia, contain information on household use of traditional fuels for cooking. The data from the DHSs are presented in table 5.21, indicating that about 60 percent of rural households and less than 3 percent of urban households used fuelwood or charcoal or coal products in 2000. Nationally, this represents around 18 percent of all households.

Table 5.21 also indicates that liquefied petroleum gas or natural gas made rapid inroads among both rural and urban households from 1995 to 2000, replacing both traditional fuels and electricity for cooking. The number of rural households using traditional fuel declined by more than a percentage point per year from 1995 to 2000. Nevertheless, the share of rural households using traditional fuels remains substantial, and can be suspected of being associated with significant respiratory health impacts.

An estimate of the percentage of households using traditional fuels can also be provided from the UPME energy balances. These figures are presented in table 5.22 on the basis of total fuelwood consumption and a

Table 5.21 Fuels Used for Cooking in Colombia

	Percentage of households					
	Rural		*Urban*		*National total*	
Fuel	*2000*	*1995*	*2000*	*1995*	*2000*	*1995*
Fuelwood	57.4	63.7	2.1	2.9	17.0	21.0
Charcoal, coal, lignite	3.2	2.5	0.3	0.7	1.1	1.2
Subtotal	60.6	66.2	2.4	3.6	18.1	22.2
Liquefied petroleum gas and natural gas	32.0	18.0	76.6	56.2	64.6	44.8
Electricity	5.0	9.9	17.0	32.3	13.8	25.6
Kerosene	0.6	2.0	0.8	1.8	0.8	1.8
Other	1.8	3.9	3.2	6.1	2.7	5.6
Subtotal	39.4	33.8	97.6	96.4	81.9	77.8

Source: DHS 2000.

Table 5.22 Household Fuelwood Use

Parameters	*1988*	*1995*	*2000*	*2003*
Fuelwood consumption (million tons/year)	8.97	5.62	4.92	4.64
Average household consumption (tons/year)[a]	3.15	3.15	3.15	3.15
Percentage of households using fuelwood (national level)	42	23	18	17

Source: Fuelwood consumption is from UPME energy balances.
a. Average household consumption is a broad estimate, and is for households using fuelwood.

broad estimate of fuelwood use per household (among households using fuelwood). The trend from 1988 to 2003 shows a substantial decline in the percentage of total households using fuelwood, and the estimates for 1995 and 2000 are quite consistent with the data from the DHSs.

Health Risk Assessment

Smith (2000) provides a review of research studies around the world that have assessed the magnitude of health effects from indoor air pollution from solid fuel use. The odds ratios for ARI and COPD are presented in table 5.23. The odds ratios represent the risk of illness for those who are exposed to indoor air pollution compared with the risk for those who are not exposed. The exact odds ratio depends on several factors, such as the concentration level of pollution in the indoor environment and the amount of time individuals are exposed to the pollution. A range of low to high ratios is therefore presented in table 5.23, which reflects the review by Smith (2000).

The odds ratios in table 5.23 have been applied in this chapter to children under age 5 (for ARI) and adult females (for ARI and COPD) to estimate the increase in mortality and morbidity associated with

Table 5.23 Health Risks of Indoor Air Pollution

	Odds ratios	
Risks	*Low*	*High*
ARI	2	3
COPD	2	4

Source: Smith 2000.

indoor air pollution.[14] These population groups suffer the most from indoor air pollution because they spend much more of their time at home, and more time cooking than older children and adult males.

Dennis and others (1996) present estimates of impacts of indoor air pollution on obstructive airways disease (OAD) among a sample of women in Bogotá. A sample of case subjects with OAD and control subjects without OAD was drawn from hospitals in the city. Information was collected from the subjects on their life history of fuelwood use and other variables known to be associated with OAD. The average age of the subjects was 63 years. The study found an odds ratio of 3.9 (controlling for tobacco smoking, passive smoking, age, and socioeconomic variables), that is, the risk of developing OAD was found to be 3.9 times higher among the women who had a life history of fuelwood use compared with women from households not using fuelwood. The average number of years of fuelwood use was 33 among the subjects with OAD, and 18 among the subjects without OAD.

Studies around the world have also found linkages between indoor air pollution from traditional fuels and increased prevalence of tuberculosis and asthma. It is also likely that indoor air pollution from such fuels can cause an increase in ischemic heart disease and other cardiopulmonary disorders. As discussed in the section on urban air pollution, Pope and others (2002) found that the largest effect of urban fine particulate pollution on mortality is for the cardiopulmonary disease group. Because indoor smoke from traditional fuels is high in fine particulates, the effect on these diseases might be substantial. However, more research is required to draw a definite conclusion about the linkage and magnitude of effect.

Baseline Health Data

To estimate the effects on health from indoor air pollution from the odds ratios in table 5.23, one must establish baseline data for ARI and COPD. These data are presented in table 5.24, with unit figures for DALYs lost to illness and mortality. Data on COPD mortality, and especially morbidity incidence, according to international disease classification, are not readily

Table 5.24 Baseline Data for Estimating Health Impacts

Parameters	*Baseline*	*Source*
Adult female COPD mortality rate (% of total female deaths)	3.1	WHO (2001); Shibuya, Mathers, and López (2001)
Adult female COPD incidence rate (per 100,000)	80	
ARI 2-week prevalence in children under age 5 (%)	12.6	DHS 2000
Estimated annual cases of ARI per child under age 5	2.2	Estimated from DHS 2000
Estimated annual cases of ARI per adult female (over age 15)	0.36–0.41	Estimated from a combination of INS data and DHS 2000
ARI mortality in children under age 5 (% of child mortality)	7.5	Based on data from DANE
ARI mortality in children under age 5 (cases per year)	1,510–1,890	
DALYs per 100,000 cases of ARI in children under age 5	165	Estimated from WHO tables
DALYs per 100,000 cases of ARI in adult females (over age 15)	700	
DALYs per case of ARI mortality in children under age 5	34	
DALYs per case of COPD morbidity in adult females (over age 15)	2.25	
DALYs per case of COPD mortality in adult females (over age 15)	6	

Source: Larsen 2004b.

available for Colombia. Regional estimates from WHO (2001) and Shibuya, Mathers, and López (2001) have therefore been applied.

The national average two-week prevalence rate of ARI in children under age 5 from the Colombia DHS 2000 is used to estimate total annual cases of ARI in children under age 5 and annual cases per child under age 5. The procedure applied is to multiply the two-week prevalence rate by 52/3 to arrive at an approximation of the annual cases of ARI per child. The prevalence rate was not multiplied by 26 two-week periods (that is, 52/2), but multiplied by 52/3 because the average duration of ARI is assumed to be about seven days. This implies that the two-week prevalence captures half of the ARI prevalence in the week before and the week after the two-week prevalence period.

The DHS household survey does not (nor does any other household survey in Colombia) provide information on ARI in adults. However, the INS has a large database on cases of ARI reported for several years by each department in Colombia on the basis of health care facilities. While this database is not complete, it provides an indication of the annual incidence of ARI per child relative to annual incidence per adult.[15] An analysis of the database suggests that ARI incidence in children under age 5 is up to six times higher than the incidence in the population age 5 and over. It should be noted, however, that the database contains information on cases of ARI treated at health facilities. In general, the percentage of cases of ARI that are treated at health facilities is higher among young children than among older children and adults. For instance, according to the DHS 2000, the percentage of cases of ARI among 4-year-old children is 10 percent lower than among children ages 0 to 4. Thus the incidence ratio of 6, as suggested from the INS database, is likely an overestimate. The annual cases of ARI per adult female (age 15 and over) presented in table 5.24 is therefore estimated at 1/6 to (1/0.9) × 1/6 of the annual cases per child under age 5.

ARI mortality in children under age 5, as presented in table 5.24, is based on data from DANE on child mortality rates and estimated percentage of child mortality attributed to ARI. The lower bound for ARI mortality (1,510 deaths) is based on official death records, while the upper bound (1,890 deaths) is based on 7.5 percent of total estimated child mortality published by DANE.[16]

Table 5.24 also presents DALYs per cases of ARI and COPD, which are used to estimate the number of DALYs lost because of indoor air pollution. While the disability weight for ARI morbidity is the same for children and adults (0.28), and the duration of illness is assumed to be the same (seven days), the DALYs per 100,000 cases of ARI are much higher for adults. This is because DALY calculations involve age weighting that attaches a low weight to young children, and a higher weight to adults, corresponding to physical and mental development stages.[17] For ARI child mortality, the number of DALYs lost is 34. This reflects an annual discount rate of 3 percent of life years lost.

DALYs lost per case of COPD morbidity and mortality are based on life tables and age-specific incidence of onset of COPD reported by Shibuya, Mathers, and López (2001). A disability weight of 0.2 has been applied to COPD morbidity, as published by the U.S. National Institutes of Health for the Latin American region.[18] A discount rate of 3 percent is applied to COPD morbidity and mortality.

Estimated Health Impacts

Annual new cases of ARI and COPD morbidity and mortality (D_i) from fuelwood smoke was estimated using the following equation:

$$D_i = PAR \times D_i^B \tag{5.1}$$

where D_i^B is baseline cases of illness or mortality, i (estimated from the baseline data in table 5.2), and PAR is given by

$$PAR = PP \times (OR - 1)/(PP \times (OR - 1) + 1) \qquad (5.2)$$

where PP is the percentage of population exposed to fuelwood smoke (18 percent of the population for 2000 according to table 5.22), and OR is the odds ratio (or relative risk ratio) shown in table 5.23.

The results are presented in table 5.25. Estimated cases of ARI child mortality and ARI morbidity (children and female adults) from indoor air pollution represent about 16 to 25 percent of total ARI in Colombia. Similarly, the estimated cases of COPD mortality and morbidity represent about 15 to 35 percent of total estimated female COPD from all causes. In contrast, Dennis and others (1996) found that indoor air pollution was the cause of 50 percent of COPD in the sample of women in Bogotá. This high number is largely a result of the fact that most of those women had been using fuelwood during part of their lives, and that the odds ratio estimated by Dennis and others is close to the upper bound used in this report.

Table 5.26 presents the estimated health impacts in terms of DALYs. An estimated 27,000 to 52,000 DALYs are lost each year from indoor air pollution. About 40 to 45 percent is from mortality, and about 55 to 60 percent from morbidity.

Estimated Cost of Health Impacts

Total annual cost of indoor air pollution is estimated at Col$240 billion (US$111.6 million) to Col$630 billion (US$293 million), with a mean estimate of Col$415 billion (US$193 million) (table 5.27). The cost of

Table 5.25 Estimated Annual Impacts on Health from Indoor Air Pollution

	Estimated annual cases	
Parameters	*Low*	*High*
ARI		
Children (under age 5)—increased mortality	265	455
Children (under age 5)—increased morbidity	1,600,000	2,800,000
Adult females (age 15 and older)—increased morbidity	900,000	1,500,000
COPD		
Adult females—increased mortality	455	1,040
Adult females—increased morbidity	2,800	6,400
Total DALYs—mortality and morbidity	27,000	51,700

Source: Larsen 2004b.

Table 5.26 Estimated DALYs Lost to Indoor Air Pollution

Parameters	*Estimated annual DALYs* Low	*Estimated annual DALYs* High	*% total DALYs from indoor air pollution*
ARI			
Children (under age 5)—increased mortality	9,000	15,600	30–33
Children (under age 5)—increased morbidity	2,700	4,600	9–10
Females (age 15 and older)—increased morbidity	6,300	10,900	21–23
COPD			
Adult females—increased mortality	2,700	6,200	10–12
Adult females—increased morbidity	6,300	14,400	23–28

Source: Larsen 2004b.

Table 5.27 Estimated Annual Cost of Indoor Air Pollution

Parameters	*Estimated annual cost (billion pesos)* Low	*Estimated annual cost (billion pesos)* High
ARI		
Children (under age 5)—increased mortality	35	62
Children (under age 5)—increased morbidity	70	122
Adult females—increased morbidity	72	124
COPD		
Adult females—increased mortality	20	218
Adult females—increased morbidity	33	74
Total cost	230	600

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

mortality is based on the value of statistical life for adults and on the human capital approach for children. The cost of morbidity includes the cost of illness (medical treatment, value of lost time, and so forth) and DALYs from morbidity valued at GDP per capita to reflect the cost of reduced well-being associated with illness. About 42 percent of this cost is associated with COPD and 58 percent with ARI.[19] COPD and ARI mortality represent about 40 percent of the total cost, and morbidity about 60 percent.

Cost of illness is presented in table 5.28 for ARI and COPD morbidity.[20] About 60 percent of these costs are associated with the value of time lost to illness (including care giving), and 40 percent are from cost of treatment and medicines.

Baseline data for the cost estimates of morbidity in table 5.28 are presented in table 5.29. The percentage of adult ARI cases treated at

Table 5.28 Estimated Cost of Illness by Category for ARI and COPD Morbidity

	Estimated annual cost (billion pesos)	
Category	*Low*	*High*
Cost of medical treatments (doctors, hospitals, and clinics)	21	38
Cost of medicines	22	39
Cost of time lost to illness	65	113
Total	108	190

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

medical facilities is estimated from the percentage of treated cases among children (DHS 2000) and the ratio of treated cases among children under age 5 to treated cases among the population age 5 and over. The latter ratio is from the INS database discussed in the Baseline Health Data section.

The value of time for adults is based on rural wages. Economists commonly apply a range of 50 to 100 percent of wage rates to reflect the value of time. The hourly rate of Col$1,500 (US$0.70), or Col$12,000 (US$5.58) per day, reflects around 75 percent of rural wages in Colombia.[21] These rates for value of time have been applied to both working and nonworking individuals. The rates are applied to nonworking individuals because most of them provide a household function that has a value, and there is an opportunity cost to the time of nonworking individuals who could choose to join the paid labor force.[22]

There is very little information about the frequency of doctor visits, emergency visits, and hospitalization for COPD patients in any country in the world. Schulman, Ronca, and Bucuvalas Inc. (2001) and Niederman and others (1999) provide some information on this from the United States and Europe. Figures derived from these studies have been applied to Colombia. Estimated lost workdays per year are based on frequency of estimated medical treatment plus an additional seven days for each hospitalization and one extra day for each doctor and emergency visit. These days are added to reflect time needed for recovery from illness.

To estimate the cost of a new case of COPD, the medical cost and value of time losses have been discounted over a 20-year duration of illness. An annual real increase of 2 percent in medical costs and value of time has been applied to reflect an average expected increase in annual labor productivity and real wages. The costs are discounted at 3 percent per year, a rate commonly applied by the WHO for health effects.

Table 5.29 Baseline Data for Cost Estimation of Morbidity

Parameters	*Baseline*	*Source*
ARI		
Percentage of ARI cases treated at medical facilities (children under age 5)	35	DHS 2000 (rural children)
Percentage of ARI cases treated at medical facilities (adults age 15 and over)	32	Estimate based on a combination of INS data and DHS 2000
Average cost of doctor visits in rural areas (mainly primary health care centers) (pesos)	20,000	Consultations with pharmacies, medical
Cost of medicines for treatment of ARI (pesos)	16,000–21,000	service providers, and health authorities
Percentage of ARI cases treated with medicines	50	DHS 2000
Average duration of ARI for children and adults (days)	7	Assumption
Hours per day of care giving per case of ARI in children	2	Assumption
Hours per day lost to illness per case of ARI in adults	3	Assumption
Value of time (care giving and ill adults) (pesos/hour)	1,500	Based on rural wages in Colombia
COPD		
Average duration of illness (years)	20	Based on Shibuya, Mathers, and López (2001)
Percentage of COPD patients hospitalized per year	1.5	From Schulman, Ronca,
Average length of hospitalization (days)	10	and Bucuvalas Inc.
Average number of doctor visits per COPD patient per year	1	(2001) and Niederman
Percentage of COPD patients with an emergency doctor or hospital outpatient visit per year	15	and others (1999)
Estimated lost work days (including household work days) per year per COPD patient	2.6	Estimated on the basis of the frequency of doctor visits, emergency visits, and hospitalization
Cost of hospitalization (pesos per day)	280,000	Consultations with
Cost of emergency visit, rural (pesos)	25,000	medical service
Cost of doctor visit, rural (mainly primary health clinic) (pesos)	20,000	providers and health authorities
Value of time lost to illness (pesos per day)	12,000	Based on rural wages in Colombia
Annual real increases in economic cost of health services and value of time (%)	2	Estimate
Annual discount rate (%)	3	Applied by WHO for health effects

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

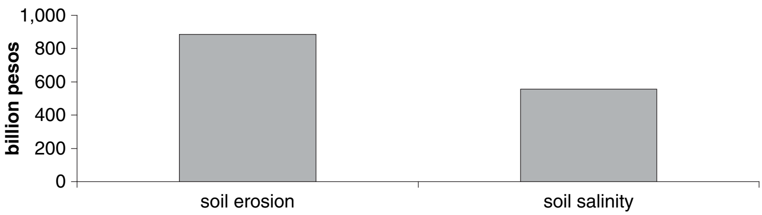
Agricultural Land Degradation

The mean estimated annual cost of land degradation is Col$1,440 billion (US$670 million), of which soil erosion represents about 60 percent and soil salinity about 40 percent (figure 5.13). These costs are the value of crop yield reductions associated with salinity and erosion. Data limitations have precluded an estimate of the cost of pasture (rangeland) degradation. The estimated costs of land degradation in Colombia are also higher than those of countries with a similar income. When compared with a group of Middle East and North African countries, the magnitude of the damages of increased erosion and salinity in Colombia is only lower than those of the Arab Republic of Egypt and the Syrian Arab Republic (figure 5.14).

An estimated 4.25 million hectares are under cultivation in Colombia, of which 0.9 million hectares are irrigated. Permanent pasture constitutes close to 42 million hectares, according to Food and Agriculture Organization (FAO) statistics for 2001.

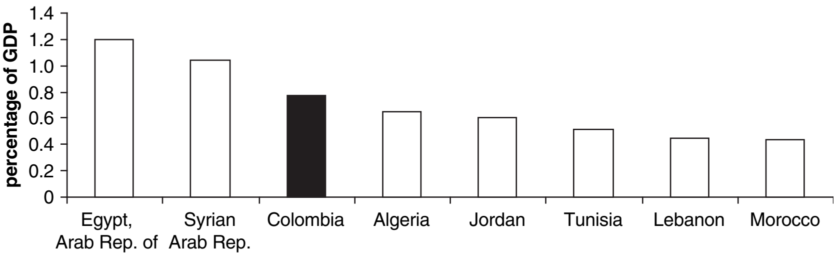
There is a general perception that pasture (rangeland) is overextended in Colombia, that crop cultivation in many instances is marginalized to

Figure 5.13 Annual Costs of Agricultural Land Degradation



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Figure 5.14 Costs of Environmental Degradation (Erosion and Salinity)



Sources: Tunisia and Lebanon: Sarraf, Larsen, and Owaygen 2004; Algeria: Ministére de l'Aménagement du Territoire et de l'Environmental 2002; Egypt: World Bank 2002; Morocco: World Bank 2003; Syria: Sarraf, Bolt, and Larsen 2004; Jordan: METAP 2000.

erosion-prone hillsides (Heath and Binswanger 1998; World Bank 1996), and that the Atlantic Region in the northern part of Colombia suffers from soil salinity.

There are very few studies of the extent of land degradation in Colombia, and of the effect of degradation on agricultural productivity. No systematic and comprehensive studies have been undertaken of soil salinity levels in the Atlantic Region. A recent study of salinity in the Cauca Valley, however, found that about 7 percent of a study area of 192,000 hectares has soil salinity exceeding 3.0 deciSiemens per meter (dS/m). About 55 percent has salinity in the range of 0.7 to 3.0 dS/m, and 38 percent of the area has salinity of less than 0.7 dS/m (CVC 2002). While soil salinity levels below 3 dS/m are generally considered moderate, yields of many vegetables are affected by salinity exceeding 1 to 2 dS/m.

Corpoica (Baquero Haeberlin and others 2003) recently studied the cost of soil erosion in select sites in four departments—Caqueta, Meta, Santander, and Tolima. Several methodologies were employed, including hedonic price and productivity models. The results indicate that the cost of erosion, measured by impacts on agricultural yields, is substantial in erosion-prone areas.

Land Area Affected by Erosion and Salinity

While the study by Corpoica is a very important contribution to understanding the cost of erosion in Colombia, it is difficult to extrapolate the findings to the national level. In the absence of nationwide studies of erosion and salinity, it is necessary to rely on data published by the Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) that provide some broad perspectives on land degradation in each department in Colombia. These data are presented in table 5.30. They indicate that around 10 percent of the land area in the country is subject to moderate to high levels of soil salinity, and 23 percent is subject to high or very high levels of erosion. The data are consistent with the general view that the Northern Region of Colombia is particularly affected by soil salinity, with moderate to high saline conditions in 45 to 85 percent of the land area in the northern departments. According to table 5.30, high or very high erosion is present in 50 percent or more of the land area in seven departments.

Based on the above data, a regression analysis was undertaken with the following equation:

$$q_i = \alpha + \beta_E E_i + \beta_S S_i + \beta_t t_i + \varepsilon_i \tag{5.3}$$

Table 5.30 Indicators of Land Degradation

Department	*Total area (km²)*	*High or very high erosion (% total area)*	*Moderate or high soil salinity (% total area)*
Amazonas	110,213	0	0
Antioquía	63,307	12	10
Arauca	23,784	48	0
Atlántico	3,324	73	74
Bogotá, DC	1,642	8	0
Bolívar	26,644	17	45
Boyacá	23,076	29	5
Caldas	7,444	6	13
Caquetá	89,645	13	0
Casanare	44,435	66	0
Cauca	29,883	16	2
Cesar	22,614	50	63
Chocó	47,321	1	2
Córdoba	25,061	55	44
Cundinamarca	22,490	32	16
Guainía	70,679	1	0
Guaviare	55,080	5	0
Huila	19,240	32	20
La Guajira	20,506	81	79
Magdalena	23,076	33	84
Meta	86,047	50	0
Nariño	30,832	9	3
Norte de Santander	21,995	15	6
Putumayo	26,011	4	0
Quindío	1,948	3	0
Risaralda	3,599	7	5
Santander	30,475	20	8
Sucre	10,719	54	80
Tolima	24,061	24	32
Valle del Cauca	21,277	23	18
Vaupés	53,546	1	0
Vichada	99,874	41	0
All Colombia		23	10

Source: Based on data from IDEAM 2004.
Note: km² = square kilometer.

where q is the index of relative crop yields, E is percentage of land area that is eroded, S is the percentage of land area that is saline, t is farm technology, and i represents departments.

The data provided by DANE and the Ministry of Agriculture and Rural Development were not sufficient to construct a relative yield index for all departments, and the econometric estimation of equation (5.3)

Table 5.31 Estimated Regression Coefficients for Land Degradation

Parameter	β	*t-statistic*
Erosion (*E*)	–0.36	–2.61
Salinity (*S*)	–0.31	–3.64

Source: Larsen 2005.
$R^2 = 0.79$; n = 20.

Table 5.32 Simulated Relative Yields

Parameter	*National average relative yield*[a]
Yield at current levels of soil erosion and salinity	0.82
Predicted yield if NO very high and high erosion	0.92
Predicted yield if NO high and moderate salinity	0.90
Predicted yield if NO erosion and salinity (high–very high and moderate–high)	1.00

Source: Larsen 2005.
a. Arithmetic average of the departments in the regression analysis.

was therefore limited to 19 departments and an aggregate of other departments, that is, 20 observations. Department-specific data on farm technology was limited to share of cultivated land under irrigation. However, no statistical significance was found, and the technology variable was therefore left out of the final estimation of equation (5.3).[23]

The estimated coefficients for erosion and salinity are presented in table 5.31, based on the relative yield index that was constructed from the arithmetic average crop yields.[24] The coefficients suggest that department crop yields decline by about 0.30 to 0.35 percentage points (relative to the national average yield) for every 1 percentage point increase in saline or eroded land area.[25]

The coefficients in table 5.31 were then applied to equation (5.3) to provide predicted yields for each department based on the departmental soil erosion and salinity data. A simulation was then undertaken whereby the salinity and erosion variables were set at zero, to estimate expected yields in the absence of salinity and erosion. The difference in yields is the estimated reduction in yields associated with erosion and salinity. The national average statistics of this simulation are presented in table 5.32.

The results of the simulation discussed were then applied to the gross output value in each department to estimate the cost of erosion and

Table 5.33 Estimated Annual Cost of Land Degradation

	Estimated annual cost (billion pesos)	
Parameter	*Low*	*High*
Soil erosion	805	965
Soil salinity	505	605
Total cost	1,310	1,570

Source: Authors' calculations.
Note: US$1 = Col$2,150.

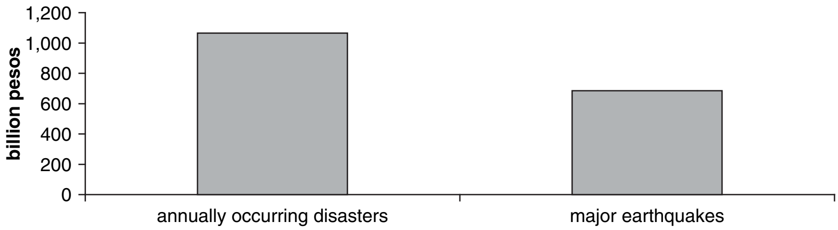
salinity. The gross output value was calculated based on producer prices in Colombia reported by FAO.

Aggregate national estimates of land degradation costs are presented in table 5.33. The cost of erosion relative to salinity is much higher than the statistics in table 5.33 indicate because table 5.32 is based on arithmetic averages of percentage effects on yields of land degradation, while the estimated costs in table 5.33 are based on crop composition and total hectares under cultivation in each department.

An alternative approach to estimating the cost of soil salinity was also undertaken in this study for the seven departments in the Atlantic Region most affected by salinity. Crop-specific soil salinity thresholds and salinity yield coefficients from the empirical international literature were applied to estimate the cost of soil salinity (Allen and others 1998; DeHayr, Diatloff, and Gordon 1997; Kotuby-Amacher, Koenig, and Kitchen 1997). Costs were estimated for a plausible range of soil salinity levels ranging from 3 to 5 dS/m. A plausible range was used because there are no systematic salinity measurements from the Atlantic Region.[26] Estimated cost of soil salinity was found to be in the same range as the estimate from the regression analysis presented in table 5.33. A salinity level of 4 dS/m is associated with a loss close to the mean econometric estimate in table 5.33.

The cost of pasture degradation is an important issue that was not estimated in this report because of lack of data. However, the Corpoica study by Baquero Haeberlin and others (2003) includes an estimate of Col$58,000 (US$30) per hectare per year for such degradation in Caqueta. If 25 to 50 percent of pasture in Colombia is experiencing a similar level of degradation, total annual cost at the national level would be Col$600 billion to Col$1,200 billion (US$279 million to US$558 million). An amount of this magnitude might warrant further assessment in other departments to gain a better sense of the scope and cost of pasture degradation nationwide.

Figure 5.15 Estimated Annual Costs of Natural Disasters



Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Natural Disasters

Colombia is annually afflicted by natural disasters such as floods, landslides, avalanches, and storms; severe earthquakes occur periodically. The total mean annual cost of natural disasters is estimated at Col$1,750 billion (US$814 million), as presented in figure 5.15.

The Department for Disaster Prevention and Response at the Ministry of Interior and Justice maintains a large database on disasters. The database contains information on fatalities and number of individuals and houses affected by disasters up to 1998. For the period from 1999 to 2003, the database also contains information on the number of people injured and public buildings affected, and distinguishes between destroyed and damaged houses. The number of people and units affected by natural disasters is presented in table 5.34. To facilitate comparison from year to year, the table includes only disasters that occur annually, and does not include the large Armenia earthquake in 1999. The impacts of disasters were particularly high in 1999, mainly as a result of severe floods.

Table 5.35 provides average annual impacts for three periods over the past decade. There does not seem to be any detectable trend in impacts over these periods. To test for any time trends, a regression analysis was undertaken for total number of people affected by disasters, but the time trend was statistically insignificant.

Table 5.36 presents the distribution of disaster impacts across types of disasters. The distribution is based on data for the five most recent years (1999–2003). Earthquakes and landslides caused the most deaths. Storms were among the leading causes of damage to houses, but not destruction of houses. Floods and earthquakes had the largest impact, measured by total number of people killed, injured, or affected and houses destroyed and damaged.

Table 5.34 Number of People and Units Affected by Natural Disasters

Impacts	*2003*	*2002*	*2001*	*2000*	*1999*[a]
Deaths	122	142	74	96	276
Injured persons	420	39	379	111	351
Missing persons	18	52	28	15	60
Number of people affected	436,000	343,000	205,000	468,000	1,214,000
Families affected	88,000	67,000	40,000	94,000	240,000
Houses destroyed	2,100	1,300	1,600	2,500	5,500
Houses damaged	16,800	10,200	14,500	10,900	26,200
Roads damaged	31	83	66	135	375
Bridges damaged	8	13	14	61	123
Pedestrian overpasses and bridges damaged	10	22	20	57	126
Water supply systems affected	6	119	21	91	136
Sewerage systems affected	1	1	1	5	30
Health centers affected	6	8	8	11	7
Schools and education centers affected	45	65	64	76	89
Community centers affected	31	62	40	31	62

Source: From the disaster database at Department for Disaster Prevention and Response, Ministry of Interior and Justice.
a. Data for 1999 do not include the Armenia earthquake.

Table 5.35 Annual Average Impacts of Natural Disasters for Three Periods

Impacts	*2000–03*	*1999–2003*[a]	*1993–97*
Deaths	109	142	196
Number of people affected (thousands)	363	533	372
Houses affected (thousands)	15	18	22

Source: Larsen 2004b.
a. The period does not include the Armenia earthquake.

Table 5.36 Disaster Impacts by Type of Disaster, 1999–2003
(percent)

	People			*Houses*	
Event	*Killed*	*Injured*	*Affected*	*Destroyed*	*Damaged*
Landslides	18	6	3	6	5
Floods	8	3	71	21	35
Storms	0	5	7	5	25
Droughts	0	0	3	0	0
Fires/(buildings)	1	2	0	8	0
Fires/(forest)	0	0	1	0	0
Avalanches	3	1	1	4	2
Earthquakes	64	77	13	56	32
Contamination	0	4	0	0	0
Other	6	2	1	0	1
Total	100	100	100	100	100

Source: Larsen 2004b.
Note: The data include the Armenia earthquake.

Table 5.37 presents the total number of people affected by natural disasters in each department, reflecting an annual average for 1997–2003. The Armenia earthquake is not included to provide a perspective on the geographic distribution of frequently or annually occurring disasters.

Table 5.37 Annual Average Number of People Affected, 1997–2003

	People affected		
Department	*Number*	*Percentage of national total*	*Percentage of department population*
Chocó	63,523	14	15
Bolívar	52,619	12	3
Cesar	42,494	10	4
Magdalena	36,393	8	3
Antioquía	29,031	7	1
Sucre	26,459	6	3
Córdoba	20,289	5	2
Nariño	19,563	4	1
Boyacá	14,327	3	1
Atlántico	13,830	3	1
Santander	13,135	3	1
Cauca	12,331	3	1
Valle del Cauca	11,196	3	0
Tolima	8,823	2	1
Huila	7,974	2	1
Amazonas	7,711	2	10
Putumayo	7,194	2	2
Risaralda	6,743	2	1
Arauca	6,158	1	2
Meta	6,125	1	1
La Guajira	4,820	1	1
Quindío	4,800	1	1
Norte de Santander	4,278	1	0
Caquetá	4,264	1	1
Cundinamarca	3,306	1	0
Caldas	3,237	1	0
Casanare	3,084	1	1
Guaviare	2,426	1	2
Guainía	2,324	1	6
Vichada	1,124	0	1
Vaupés	109	0	0
San Andrés y Prov.	19	0	0
All Colombia	439,709	100	1

Source: Larsen 2004b.
Note: The data do not include the Armenia earthquake.

About 62 percent of all people affected are concentrated in seven departments in the northern and northeast Pacific parts of Colombia, where only 29 percent of the population lives. In these departments, an average of 4 percent of the population is affected annually by disasters, in contrast to well below 1 percent in the rest of the country. As much as 15 percent of the population was affected annually in Chocó.

There are no systematic and comprehensive estimates of the cost of damages from natural disasters, with the exception of the Armenia earthquake in 1999. According to the Economic Commission for Latin America and the Caribbean (Comisión Económica para América Latina y el Caribe, CEPAL), the earthquake inflicted a cost of Col$2,800 billion (US$1.8 billion at the 1999 exchange rate), of which more than 70 percent was housing and building damages.[27]

In this report, the cost categories presented by CEPAL have been adapted and applied to provide an order of magnitude of the annual cost of natural disasters.[28] The cost of annually occurring disasters is based on annual averages for 1999–2003. This period was selected because more detailed and comprehensive data were available from the Department for Disaster Prevention and Response at the Ministry of Interior and Justice.

The total estimated annual cost of natural disasters is presented in table 5.38. The cost of frequently or annually occurring disasters is presented in table 5.40. The highest cost is associated with damages to

Table 5.38 Estimated Annual Cost of Natural Disasters (Except Major Earthquakes)

	Estimated annual cost (billion pesos)	
Impacts	*Low*	*High*
Deaths	25	35
Injured persons	4	5
Missing persons	6	10
Houses destroyed	85	85
Houses damaged	265	265
Lost and damaged furniture, equipment, and other losses per house	150	150
Roads and bridges damaged	180	360
Water supply and sewerage systems affected	55	105
Health centers affected	55	110
Schools, education centers, and community centers affected	60	120
Total cost	885	1,245

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

housing, infrastructure, and public buildings. A range has been used for infrastructure and public buildings because of uncertainties of the exact cost of damages. Table 5.39 presents the estimated annualized cost of major earthquakes. The cost estimates are based on the costs of the Armenia earthquake. The frequency of such an earthquake is highly uncertain. A 5- to 10-year frequency range was applied in this report, and the total cost of a major earthquake is annualized. The low estimate represents a frequency of 10 years, and the high estimate a frequency of 5 years. In total, the annual cost of frequently occurring disasters and major earthquakes is estimated at Col$1,330 billion to Col$2,175 billion (US$619 million to US$1 billion).

Unit costs of disaster impacts are presented in table 5.40. These estimates are derived from the cost estimates of the Armenia earthquake presented by the National Planning Department (Echeverry 2002), as discussed earlier. However, it should be recognized that there is uncertainty about the accuracy of applying these unit costs to disasters such as floods, storms, and landslides. An improvement in the estimates would require a comprehensive assessment of the cost of damages across Colombia.

Table 5.39 Estimated Annual Cost of Major Earthquakes

	Estimated annual cost (billion pesos)	
Impacts	*Low*	*High*
Deaths	20	60
Injured persons	10	35
Missing persons	12	33
Houses destroyed	70	140
Houses damaged	45	85
Public buildings damaged or destroyed	115	230
Lost and damaged furniture, equipment, and other losses per house	50	100
Other losses related to housing and buildings	15	30
Roads and bridges damaged	10	20
Water supply and sewerage systems affected	5	10
Health centers affected	10	20
Schools, education centers, and community centers affected	30	60
Energy sector	5	10
Commerce, industry, and services	45	90
Miscellaneous	3	7
Total cost	445	930

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Table 5.40 Unit Costs Applied to Frequently Occurring Disasters

Impacts	*Estimated unit cost in 2003 (million pesos)*
Destruction of houses	33
Damages to houses	17
Lost/damaged furniture, equipment, and other losses per house	8
Roads and bridges damaged	1,990
Water supply and sewerage systems affected	1,300
Health centers affected	13,650
Schools, education centers, and community centers affected	1,065

Source: Larsen 2004b.
Note: US$1 = Col$2,150.

Perceptions of the Priority of Environmental Problems

To determine priority environmental concerns from the perspective of specific groups of stakeholders and the population in general, a survey was administered in 2004 to a random sample representative of Colombian society (including more than 2,600 citizens from the public and private sectors, industry, academia, and civil society). The aim of the survey was to gather data on priority environmental concerns in Colombia. The *Compañia Nacional de Consultoría* administered the survey door-to-door to a random sample of 616 citizens representing the general public. In addition, 2,024 individuals were interviewed, representing the following stakeholder groups: populations living in high-risk areas, central and local government officials, environmental agency officials, environmental nongovernmental organizations, manufacturing industry executives, agricultural workers, livestock workers, academia, civil society, energy sector executives, water utility and water company officials, and executives of transportation businesses.

In the survey, respondents were asked to rank the environmental problems they considered most serious for themselves and their families, in addition to how well the government at both the national and the local levels was addressing these problems. The environmental problems ranked included air quality both inside and outside the home, water quality in the home, trash collection, sanitation services, natural disasters, lack of green areas and parks surrounding the home, neighborhood road quality, traffic accidents, and land degradation. Those surveyed were also asked to rank broader environmental problems affecting their communities and the country, such as air pollution, loss of global resources (for example, biodiversity loss and global warming), and deforestation. Environmental health priorities were also examined by asking respondents if there were children in their households, what types of illnesses the children suffered most from, their hygiene habits, what type of cooking fuel was used in the home, if their homes were ventilated during cooking, and if the water used for cooking was treated before consumption. To evaluate differences in priorities among the country's income groups, the survey also asked respondents to identify their income-level range.

The survey results reflect the Colombian population's great concern regarding the country's environmental problems, which affect the poor most directly. The population perceived air pollution (79 percent) as the most serious environmental concern for the country. However, as shown in table 5.41, the results revealed significant differences among income groups: whereas low-income groups identify air pollution, noise pollution, and vulnerability to natural disasters as major problems, upper-income groups perceive the loss of global environmental resources and inappropriate land use in urban areas as principal problems. Poor income groups tended to link national environmental concerns to their immediate surroundings, indicating a direct relationship between poverty and environmental degradation.

With respect to the environmental problems perceived as affecting the respondents personally, the following were viewed as the most serious: lack of parks and public green spaces, poor ambient air quality, noise pollution, insufficient trash collection, neighborhood safety, and poor sanitation services. Among the general population, higher-income groups considered safety and lack of public green spaces as the greatest priorities, whereas middle-income groups perceived safety, ambient air quality, noise pollution, and lack of green spaces and parks among the greatest

Table 5.41 Environmental Concerns

Environmental problem	*Perceived as major concern (% respondents)*
Low-income groups	
Air pollution	74
Natural disasters	64
Noise pollution	64
High-income groups	
Poor management of global resources	78
Biodiversity loss	75
Poor land management	64

Source: Centro Nacional de Consultoría 2004.

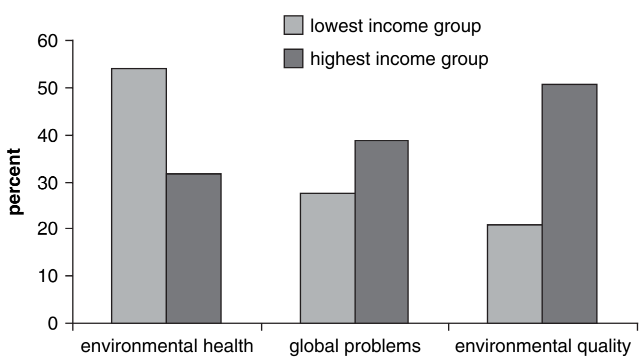
environmental priorities for themselves and their families. Lower-income groups indicated the same environmental concerns as middle-income groups with one exception—they also noted indoor air pollution as a personal environmental concern.

National environmental priorities also varied among stakeholder groups. In addition to being the top priority for the general population, air pollution was also a key environmental concern among four stakeholder groups—the manufacturing industry, energy firms, transportation firms, and trade agencies. For three of the stakeholder groups, poor management of global environmental resources and deforestation were consistent priorities.

Finally, respondents were asked to rank the following environmental issues in order of importance for both the country and their household: environmental health; global environmental problems; biodiversity conservation; and environmental quality of water, air, and other natural resources. Of these issues, 53 percent of the general population perceived environmental health to be the top priority for the country, with global environmental problems a distant second (22 percent), environmental quality third (18 percent), and biodiversity conservation fourth (7 percent). However, figures 5.16 and 5.17 indicate that these priorities varied significantly between the lowest and highest income segments of the population. Environmental health was a key concern for low-income segments, particularly in relation to these respondents' own households.

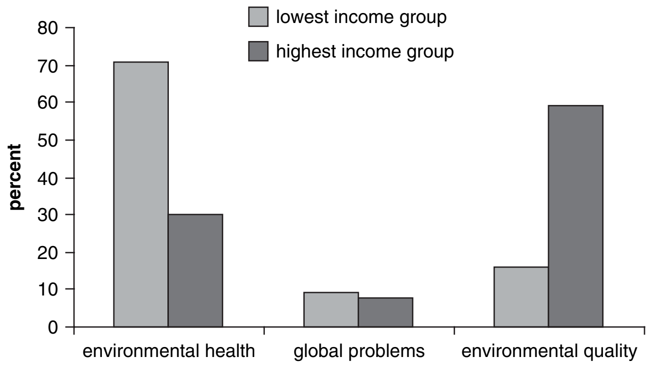
Survey responses regarding household conditions also reflected environmental health as an important priority for poorer families, although only 51 percent of those in the lowest income group reported washing their

Figure 5.16 Top Priorities for Colombia According to Lowest and Highest Income Groups



Source: Centro Nacional de Consultoría 2004.

Figure 5.17 Top Priorities for Households According to Lowest and Highest Income Groups



Source: Centro Nacional de Consultoría 2004.

hands at critical times (for example, before preparing and eating dinner) compared to 100 percent in the highest income group, making the poorer segments more vulnerable to hygiene-related illnesses. Similarly, only the lowest income groups (17 percent of those surveyed in this low-income segment) relied on traditional fuels, such as fuelwood, for cooking and heating in their homes, whereas the higher income groups used natural gas (51 percent) and propane (49 percent). Because burning traditional fuels produces large amounts of smoke and other air pollutants in confined spaces of the home, it poses a dangerous health risk to this segment of the population. Also consistent with these environmental health responses was the survey finding that only the poorest income segments, with children under age 5, reported that their children were frequently sick.

Conclusions

The mean estimated annual costs of environmental damage for five categories—water, sanitation, and hygiene; urban air pollution; indoor air pollution; agricultural land degradation; and natural disasters—amounts to more than 3.7 percent of GDP per year. The highest-cost categories are insufficient water supply and outdoor and indoor pollution, followed by natural disasters and agricultural land degradation.

In urban areas, the cost of air pollution is significantly higher than for inadequate water, sanitation, and hygiene in contrast to the national estimate. In rural areas, the cost of land degradation (not including pasture) is estimated at more than twice as high as the cost of insufficient water, sanitation, and hygiene. Moreover, in contrast to the national estimate, the cost of indoor air pollution in rural areas is almost as high as for inadequate water, sanitation, and hygiene.

Results from a survey of priority environmental problems reflect that urban air pollution (79 percent) is perceived as the most serious environmental concern for the country. Survey results revealed significant differences between income groups: whereas low-income groups identify air pollution, noise pollution, and vulnerability to natural disasters as major problems, upper-income groups perceive the loss of global environmental resources and inappropriate land use in urban areas as principal problems. Poor income groups tended to link national environmental concerns to their immediate surroundings, indicating a direct relationship between poverty and environmental degradation.

Notes

1. Bjorn Larsen, Ernesto Sánchez-Triana, and Yewande Awe authored this chapter, which draws heavily from a background document prepared by Larsen (2004b) for the Ministry of Environment, Housing and Regional Development.
2. Costs of deforestation and water pollution are only partially and indirectly estimated because of data limitations. Some of the cost of deforestation is captured in the cost of natural disasters (flooding and landslides) and agricultural land degradation insofar as deforestation contributes to natural disasters and soil erosion. Other costs of deforestation, such as impacts on water resources and recreational value, are not estimated. The cost of water pollution is captured only in terms of waterborne illnesses (diarrheal illness). Other costs, such as potential impacts on health from heavy metals and chemicals, and on recreational value, are not estimated.
3. In addition to these categories, Larsen (2004b) estimated the cost of road accidents as Col$2.8 billion (US$1.3 million), equivalent to 1.5 percent of GDP.
4. Rural cost of inadequate water supply, sanitation, and hygiene is based on rural-urban population share and rural-urban diarrheal incidence. No adjustments are made to land degradation and indoor air pollution costs, because these are already rural costs.
5. Official death records represent a significant understatement of actual deaths in most developing countries because of underreporting by households. DANE therefore publishes estimated mortality in addition to official records.
6. The database is not complete because not all health facilities have reported diarrhea-related illnesses to the public health authorities.

7. The DALY is a standard metric of the burden of disease that combines life years lost as a result of illness and disability, with one DALY being equal to the loss of one healthy life year (Murray and López 1996).
8. Some researchers elect not to use age weighting, or report DALYs with and without age weighting.
9. This corresponds to a daily national average wage rate of about Col$22,000 to Col$23,000 (US$10.23 to US$10.70).
10. Some may argue that the value of time based on wage rates should be adjusted by the unemployment rate to reflect the probability of obtaining paid work.
11. The cost of time losses for children under age 5 is assumed to be zero.
12. To calculate population-weighted PM_{10} levels, each city or metropolitan area was partitioned into four zones (residential, industrial, downtown, and commercial areas). PM_{10} concentrations from monitoring stations in each zone were then weighted by the zone's population share to obtain population-weighted PM_{10} levels.
13. Some may argue that the value of time based on wage rates should be adjusted by the unemployment rate to reflect the probability of obtaining paid work.
14. Although Smith (2000) presents odds ratios for lung cancer, that effect of pollution is not estimated in this report because the incidence of lung cancer among rural women is generally very low. The number of cases in rural Colombia associated with indoor air pollution is therefore likely to be minimal.
15. The database is not complete because not all health facilities have reported ARI to the public health authorities.
16. Official death records represent a significant understatement of actual deaths in most developing countries because of underreporting by households. DANE, therefore, publishes estimated mortality in addition to official records.
17. Some researchers elect not to use age weighting, or report DALYs with and without age weighting.
18. See http://www.fic.nih.gov/.
19. The cost of morbidity is based on the mean estimated annual cost.
20. These costs do not include the valuation of DALYs.
21. This corresponds to a daily rural wage rate of Col$16,000 (US$7.60). In contrast, average wages in major cities in Colombia are around Col$25,000 (US$11.60).
22. Some may argue that the value of time based on wage rates should be adjusted by the unemployment rate to reflect the probability of obtaining paid work.
23. The irrigation variable may be too outdated to reflect currently irrigated areas.
24. Equation (5.3) was also estimated using the weighted yield index. The erosion and salinity coefficients were quite similar to the estimates in table 5.31, but R^2 was lower.

25. Equation (5.3) was estimated in levels. Log and semi-log forms provided very poor results.
26. Salinity measurements are available for the Cauca Valley, but the total losses are not very large because of relatively low average levels.
27. A presentation by Juan Carlos Echeverry (formerly at the National Planning Department) provides a summary of these estimates.
28. Figures have also been adjusted for inflation to 2003.

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Annex 5.1


IBRD 34821
Caribbean Sea
PACIFIC OCEAN
PANAMA
R.B. DE VENEZUELA
ECUADOR
PERU
BRAZIL
COLOMBIA
BOGOTÁ
Barranquilla
Cartagena
Medellín
Cali
Bucaramanga
Cúcuta
Santa Marta
Riohacha
Valledupar
Montería
Sincelejo
Manizales
Pereira
Armenia
Ibagué
Neiva
Popayán
Pasto
Villavicencio
Tunja
Yopal
Leticia
Puerto Carreño
Puerto Inírida
Mitú
San José del Guaviare
Florencia
Mocoa
Quibdó
COLOMBIA
MITIGATING ENVIRONMENTAL DEGRADATION TO FOSTER GROWTH AND REDUCE INEQUALITY
URBAN AREA POPULATION:
5,000,000 OR MORE
2,000,000-4,999,999
1,000,000-1,999,999
500,000-999,999
100,000-499,999
SELECTED CITIES AND TOWNS
DEPARTMENT CAPITALS
NATIONAL CAPITAL
DEPARTMENT BOUNDARIES
INTERNATIONAL BOUNDARIES
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JUNE 2006

CHAPTER 6

Waterborne Diseases Remain Widespread

Waterborne bacterial diseases pose one of the highest costs of environmental degradation to Colombia, particularly with respect to child morbidity and mortality. Diarrhea, which accounts for approximately 7.3 percent of child mortality, is the most common and widespread waterborne disease and most prevalent in rural zones populated by the poorest segments of the population. Although Colombia has promoted increased water supply coverage over the past 10 years, with investments in water supply and sewerage valued at about 1 percent of gross domestic product, these efforts only provide a partial response to reducing the incidence of disease. A recent meta-analysis of water, sanitation, and hygiene interventions highlights the importance of incorporating hygiene interventions—which can reduce diarrheal illness by up to 45 percent—into programs for reducing waterborne diseases. To address regulatory gaps pertaining to environmental impact assessments and wastewater discharge tariffs, which constrain the provision of water supply and sanitation, it would be advisable to amend the country's regulatory framework to promote private sector investment.

One of the largest costs of environmental degradation in Colombia is associated with morbidity and mortality from waterborne bacterial diseases.[1] Waterborne bacteria are transmitted by means of contaminated surface water sources and large, poorly functioning water distribution systems, resulting in a range of syndromes including cholera, typhoid fever, dysentery, and chronic diarrhea (lasting more than two weeks). While diarrheal illness is generally not as serious as some other waterborne illnesses, it is more common and affects more people.[2]

In Colombia, approximately 7.3 percent of child mortality is attributed to diarrheal illness (1,450 to 1,820 deaths per year) according to the Colombia National Administrative Department of Statistics (*Departamento Administrativo Nacional de Estadísticas*, DANE).[3] Two-week diarrheal prevalence in children under age 5 is 2.9 percent. Approximately 90 percent of diarrheal cases and hospitalizations can be attributed to water, sanitation, and hygiene. Diarrheal illness is most prevalent in rural zones populated by the poorest segments of the population (for example, those living in the departments of Chocó, Cauca, Valle del Cauca, and Nariño). See table 6.1.

Diarrheal morbidity is more difficult to quantify than diarrheal mortality. Many diarrhea cases are not treated or do not require treatment at health facilities, and therefore are not recorded. In addition, cases treated by private doctors or clinics are usually not reported to public health authorities. Therefore, household surveys often provide the most reliable indicator of total cases of diarrheal illness. Most household surveys, however, include information on diarrheal illness in children only, and reflect diarrheal prevalence at the time of the survey. Because diarrheal prevalence often varies across seasons of the year, extrapolating survey data to

Table 6.1 Diarrhea in Children under Age 5

Department	*Percentage of children under age 5 with diarrhea in the preceding two weeks*
Cali	10.8
Bogotá	10.9
Bolívar, Sucre, Córdoba	11.3
Altántico, Bolívar Norte	11.6
La Guajira, Cesar, Magdalena	11.9
Valle del Caucá	12.5
Tolima, Huila, Caquetá	13.5
Boyacá, Cundinamarca, Meta	14.9
Santanderes	15.2
Medellín	15.8
Antioquía	16.2
Caldas, Risaraldo, Quindío	17.6
Cauca, Nariño	18.8
Chocó	22.0

Source: DHS 2000.

create an annual average will result in either an over- or underestimate of total annual cases.

From a global perspective, lack of access to safe water continues to exert a significant burden on the health of millions of people, particularly vulnerable groups. According to the World Health Organization (WHO) (2002a), approximately 3.1 percent of deaths (1.7 million people) and 3.7 percent of disability-adjusted life years (DALYs)[4] (54.2 million) worldwide are attributable to unsafe water, sanitation, and hygiene. Fully 99.8 percent of deaths associated with this risk factor are in developing countries, and 90 percent are deaths of children. In Colombia, the proportion of DALYs attributable to unsafe water ranges between 1.0 percent and 1.9 percent, similar to that of the rest of Latin America, with the exception of Bolivia, Ecuador, Guatemala, Peru, and Nicaragua where the proportion is higher (figure 6.1).

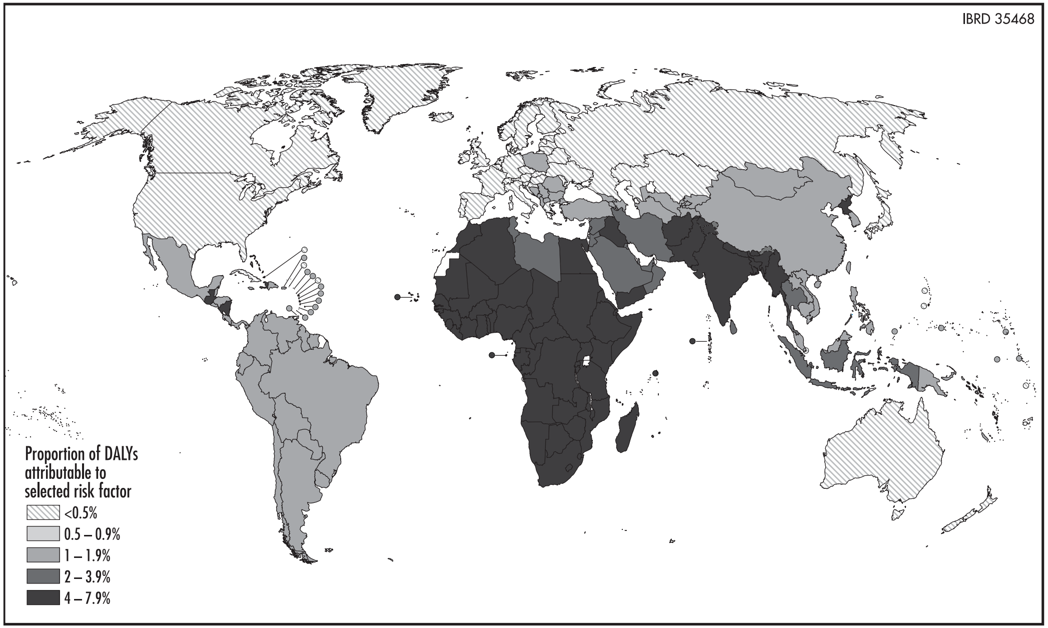
Assessment of Policy Design, Efficiency, and Effectiveness

One intervention to prevent waterborne diseases that the government of Colombia has fostered since the early 1990s aims at increasing access to drinking water and sanitation. Although the current program to increase water and sanitation coverage will help reduce the incidence of waterborne diseases in Colombia and benefit the poorest segments within the country, it provides only a partial response to the problem of waterborne disease.

According to a meta-analysis of water, sanitation, and hygiene interventions on diarrheal illness, improvements in water supply and sanitation provide a 30 percent expected reduction in diarrheal disease (Fewtrell and Colford 2004). In addition, this analysis indicates that although multiple interventions consisting of water supply, sanitation provision, and hygiene education reduce diarrheal illness, they are not more effective than individual interventions (table 6.2). The reasons for this are not clear. Furthermore, these results highlight the importance of determining which package of measures combining all the main intervention areas will maximize health benefits to each community. They also highlight the importance of incorporating hygiene interventions in programs aimed at reducing waterborne diseases. Thus, for a strategy to target waterborne diseases comprehensively, it should support hygiene improvements, which significantly contribute to reducing diarrheal disease, as shown later.

The main results of the 2004 study by Fewtrell and Colford are presented in table 6.2 for developing countries. The relative risk ratio

Figure 6.1 Proportion of DALYs Attributable to Unsafe Water Ranges



Source: WHO 2002b.
Note: DALYs = Disability-adjusted life years.

Table 6.2 Summary of Meta-Analysis by Fewtrell and Colford (2004)

Intervention	*Relative risk*	*Confidence interval (95%)*
Hygiene (hand washing)	0.556	0.334–0.925
Sanitation	0.678	0.529–0.868
Water supply	0.749	0.618–0.907
Water quality (source)	0.891	0.418–1.899
Water quality (point of use, rural)	0.534	0.392–0.727
Water quality (point of use, urban)	0.771	0.725–0.819
Water quality (point of use, chemical)	0.605	0.443–0.828
Water quality (point of use, nonchemical)	0.534	0.379–0.752

Source: Summarized from Table 22 in Fewtrell and Colford (2004).

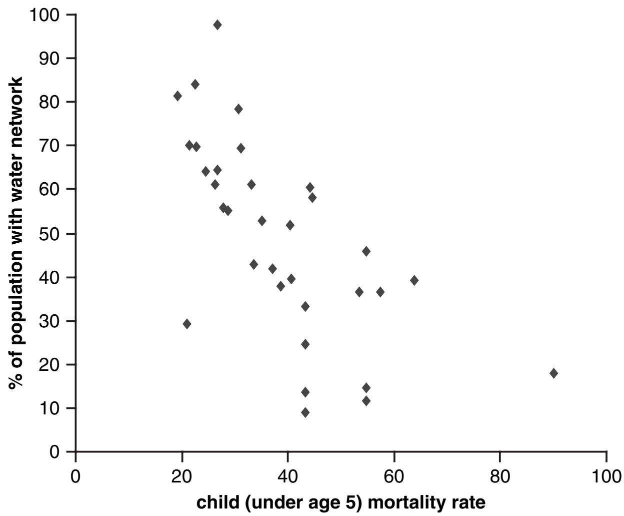
expresses the risk of diarrheal illness occurring as a health outcome in an intervention situation in relation to a nonintervention situation. The percentage reduction in diarrheal illness from intervention is therefore 1.0 minus relative risk. The relative risk ratio for handwashing intervention in table 6.2 is very similar to the results from other related studies (Curtis and Cairncross 2003; Esrey and others 1991).

The most effective hygiene intervention is handwashing after defecation, before preparing meals, and before eating. Improved sanitation consists of facilities for safe and hygienic removal of excreta, such as flush toilets; pour-flush latrines; ventilated, improved pit latrines; and simple pit latrines. Unimproved sanitation refers to open pit latrines, public latrines, service or bucket latrines, and the absence of any facilities. Improved water supply refers to house connection, standpipes, boreholes, protected wells or springs, and collected rainwater. Unimproved water supply includes unprotected wells or springs, open-surface water and rivers, and water provided by vendors or tanker trucks. With regard to water quality improvement, the studies reviewed by Fewtrell and Colford (2004) that assessed reduction in diarrheal illness from source water treatment are not conclusive. The pooled study results suggest a mean reduction in diarrheal incidence of 10 percent, but with no statistical significance. In contrast, point-of-use drinking water treatment (that is, household drinking water treatment) appears very effective in reducing diarrheal illness. Point-of-use treatment includes both nonchemical (for example, boiling of water) and chemical (for example, chlorination) treatment and appears to be most effective in rural areas.

Water Supply and Sanitation Programs

Child mortality is clearly lower in departments with high water network coverage, high literacy rates, and high urban population share. Figure 6.2

Figure 6.2 Child Mortality and Water Network Coverage, by Department, 2002



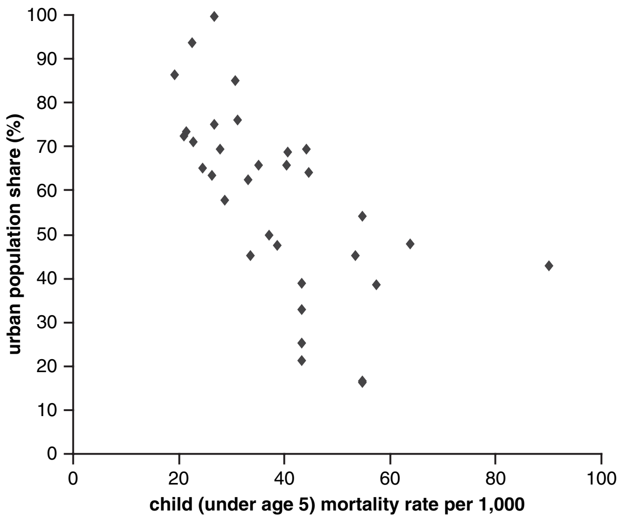
Source: Child mortality rate is from DANE. Water network coverage is from the Ministry of Environment, Housing and Regional Development.

presents child mortality rates in relation to rates of water supply network coverage by department.

Because the main actions undertaken by the government of Colombia to prevent waterborne diseases are aimed at increasing access to drinking water and sanitation, the remainder of this section discusses the water supply and sanitation program that the government is currently implementing. Rural water supply and sewerage coverage is especially poor (52 percent and 15 percent, respectively, when restricting the definition of coverage to household water and sewerage connections only), and at historic levels of effort in service expansion, universal access goals (taking into account demographic growth) would not be reached for another 30 years (World Bank 2004). Figure 6.3 shows a correlation between child mortality and urban population share by department.

The government estimates that, in addition to current investments in water supply and sanitation valued at 1 percent of gross domestic product (GDP), US$1.2 billion is needed to meet the Millennium Development Goals of regional and urban-rural service coverage over the next five years, and a further US$1.0 billion to address investments in maintenance and rehabilitation of the networks and expansion of sewerage systems and wastewater treatment. Affordability issues and deficiencies in the design and functionality of the current system of fiscal

Figure 6.3 Child Mortality and Urbanization, by Department, 2002



Source: Based on data from DANE.

transfers from the national government to municipalities make such a challenge daunting. Although recent reforms in allocation of fiscal transfers to support the sector through Law 715 would theoretically ensure sector financial sustainability in the medium term, the current political and social climate and the relatively recent nature of these reforms mean that the benefits of these changes will take some time to materialize.

Since 2001, the government has been implementing a Water Supply and Sanitation Reform program whose objectives include expanding the coverage of water and sewerage services in participating municipalities, and facilitating the access of populations in low-income areas of participating municipalities to water and sewerage services.[5] The program attempts to overcome service deficiencies, characterized by insufficient potable water and sanitation coverage, rationing and intermittent water supply, noncompliance with water quality standards by most utilities, and inadequate sewerage facilities in poor areas. In rural areas, historic rates of coverage expansion are extremely low compared with requirements to meet universal access. To achieve universal access within the 2010–20 window, the average annual rate of coverage expansion in rural areas would need to increase by 50 percent for rural water and 100 percent for sanitation.

To meet urgent investment needs and ensure achievement of the Millennium Development Goals, the government is aiming to consolidate the reforms undertaken to date and to ensure financial sustainability in the medium term. The government's medium-term strategy to improve access and the quality of services has three key elements:

- *A major investment program with clear and transparent subsidies.* In accordance with its 2002–06 National Development Plan, the government has identified a medium-term investment program to expand coverage and improve quality of service in urban and rural areas.
- *A deepened and broadened approach to improving utility performance.* Private sector participation remains at the core of the government's approach in large and medium urban centers. The strategy also includes improvements in the financial and technical performance of publicly run utilities in areas where private sector participation is not likely to be adopted in the short term.
- *Clear and transparent "rules of the game" for investment*. The development of a harmonized and publicly disseminated set of procedures for the medium-term program is essential to mitigate the unstable regulatory framework because legal uncertainties often make private investors reluctant to enter into business ventures.

Constraints to Water Supply and Sanitation Posed by the Environmental Regulatory Framework

Despite Colombia's efforts since the late 1960s to develop a consistent environmental regulatory framework, regulatory gaps abound. The existing environmental regulatory and legal frameworks do not provide sufficient comfort to potential private investors, and constitute an obstacle to the efforts to consolidate reforms in the water supply and sanitation sector. Currently, three main regulations pose serious obstacles for water supply and sanitation coverage expansion: (a) the Environmental Impact Assessment (EIA) requirements included in the environmental licenses system; (b) the effluent charge system known as the *tasas retributivas*; and (c) the wastewater discharge standards regulations established in Decree 1594 of 1983 (World Bank 2001).

Law 99 of 1993 established the EIA system as a requisite for infrastructure works, establishment of industries, and the development of any economic activity with potential significant environmental impacts. This law was further developed in Presidential Decree 1220 of 2005. The elaboration of an EIA was one of the requirements for the request of an environmental license; EIA regulations became a hurdle for water supply and sanitation projects and added little value to the environmental planning and management processes. According to Challa (2003), Libhaber and Foster (2003), and the World Bank (2001), the main problems with EIA regulations include the following:

- Lack of a screening procedure[6] meant that an EIA was needed for any project, regardless of the intensity and magnitude of its potential impacts, its location, the sensitivity of the surrounding area, or public opinion regarding the project.
- Absence of standards or guidelines resulted in discretionary application of requirements for the preparation and evaluation of environmental studies.
- Responsibility for the elaboration of the EIA fell on the project's proponent, generating conflicts of interest.
- The need for vast numbers of EIAs coupled with an absence of primary environmental data resulted in mass production of EIAs of poor quality and little value.
- Public participation was limited, and provisions to encourage it were lacking.
- Regulations delineating the procedures for public participation in the EIA process were absent.
- Environmental agencies took advantage of these deficiencies to exercise a seemingly boundless authority, which excluded the public from participating in the EIA decision-making process.

In fact, environmental licenses often became pro forma regulations tailored and applied arbitrarily by the environmental agencies to projects. In certain instances, environmental agencies imposed obligations, standards, and compensation schemes—of their choice—with which the projects were required to comply. This highly discretionary application of procedures generated legal uncertainty because project proponents could not adequately evaluate the resources and time required to comply with the environmental licensing requirements (Challa 2003; Libhaber and Foster 2003).

Water Pollution Charges

Water pollution charges have been used in Colombia at least since the late 1970s, when they were introduced in the Code of Natural Resources to control water pollution and were established by the Cauca Valley Corporation. Law 99 of 1993 updated the provisions for the use of similar charges that were further developed by Decree 901 of 1997, Decree

3100 of 2003, and Resolution 372 of 1998. Application and enforcement of environmental regulations are the responsibility of Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs). Thus, on the basis of methodology defined by the decrees and resolution, CARs were required to

- update their discharge registries and define a baseline for discharges of two parameters: biochemical oxygen demand (BOD) and total suspended solids
- negotiate with stakeholders a five-year discharge reduction goal for each stretch of watershed
- charge a fee for every kilogram of the selected parameters that registered point sources discharged into superficial waters within the legal standards
- increase the fee annually until the reduction goal was reached.

According to Challa (2003), Enríquez (2004), Libhaber and Foster (2003), and the World Bank (2001), the design of the water effluent charge, as described above, posed serious obstacles to private sector participation in water supply and sanitation, principally because of the provision for revising environmental goals semiannually. The implication of this scheme was that water utilities had no way of knowing how the charge would ultimately affect their finances. Financing and developing wastewater treatment plants and sewer networks in Colombia is an admittedly difficult task. Considerable evidence suggests that the design and introduction of discharge fees may have aggravated the situation. A study conducted by Colorado State University (2004) reported that municipalities are currently reluctant to develop treatment plants or to assume ownership of existing plants because the discharge fees associated with such plants would make their operation nonremunerative. According to this report, "The fee structure for wastewater permits, while meant to be an incentive to provide treatment, has actually created a disincentive to construct treatment facilities or to apply for a permit. . . . [T]he increase in fees every six months . . . has resulted in many municipalities incurring fee debts that are so high, they have no hope of paying them let alone financing water treatment facilities" (Colorado State University 2004, p. 78).

Unfortunately, a similar rationale applies to municipalities' incentives to build new sewer lines. For Colombia's many municipalities without adequate wastewater treatment facilities, building sewer lines that connect new pollution sources to the system increases the system's total pollution load and, therefore, increases total fees charged to the municipality. Thus, the discharge fees act as a financial disincentive to invest in new sewer networks (Blackman and others 2005).

The reasons for the inability of many municipal sewerage authorities to pay discharge fees or invest in treatment plants that would reduce their discharges have generated widely publicized controversies. The professed inability of the municipalities to reduce their waste loads prevents dischargers in water basins from meeting five-year total pollution load reduction targets established by boards of directors of the CARs, in accordance with Decree 901 of 1997 and Decree 3100 of 2003. The design of the pollution charge system has led to continual increases in fee rates. Table 6.3 shows the dramatic increase in fee rates mandated by regulations for a water basin that fails to comply with its targets for reducing water pollution loads.

In addition, fees charged to municipal wastewater authorities have led them to increase the fees that they charge to their customers. This problem has been especially severe in smaller cities, where the utilities are unable to spread the new costs over a large number of customers. In 1999, the costs to customers increased by 31 percent in municipalities with fewer than 2,500 people, and by 21 percent in municipalities with 2,500 to 12,000 people. Because discharge fees have been passed on to the customers in the form of higher sewerage fees, and these fees do not vary significantly across income groups within cities, the incidence of discharge

Table 6.3 Tariff Increases for Failure to Achieve Water Quality Targets

	Discharge tariff (pesos/kilogram)	
Regional factor[a]	*Biochemical oxygen demand*	*Total suspended solids*
1.0 (min. tariff)	74.24	31.75
1.5	111.36	47.62
2.0	148.48	63.50
2.5	185.60	79.37
3.0	222.72	95.25
3.5	259.84	111.12
4.0	296.96	127.00
4.5	334.08	142.87
5.0	371.20	158.75
5.5	408.32	174.62

Source: Blackman and others 2005.
Note: US$1 = Col$2,150.
a. The regional factor for each pollutant in each water body begins at 1.0. The applicable tariff for discharges into the water body equals the minimum tariff times the regional factor. The regional factor is increased by 0.5 every six months until reduction targets are met.

fees is in fact regressive, that is, the discharge fees consume a larger portion of the income of poorer customers than of richer ones (Enríquez 2004). Furthermore, according to Enríquez (2004), this undesirable effect has been magnified by recent regulatory changes that reduce subsidies to water utilities and allow them to charge user fees that enable them to fully recover costs. Challa (2003), Enríquez (2004), and Libhaber and Foster (2003), have suggested modifications to Law 99 of 1993, Decree 3100 of 2003, and Resolution 372 of 1998 to rectify these problems.

One additional problem stems from the wastewater discharge standards set by Decree 1594 of 1984. As discussed in chapter 11 of this report, these standards are designed to address ecological and aesthetic benefits and require 80 percent removal efficiency for BOD and suspended solids. These standards created disincentives to promoting investments in water supply and sewerage because compliance with them required municipal investments in secondary wastewater treatment plants that could be financed only with increases of over 100 percent in tariffs, which did not necessarily generate environmental benefits. Furthermore, Decree 1594 became a bottleneck for private investment in the sector because compliance with it implied extremely high costs. To complicate matters further, this decree is incompatible with the system of water effluent charge, thus generating uncertainty about the environmental responsibilities of water users.

Analysis of Policy Implementation

Despite improvements achieved to date under the 2001 Water Supply and Sanitation Reform Program, water, sanitation, and sewerage coverage continues to face significant challenges. In 2001, approximately 75 percent of the population living in urban areas (31,339,130 inhabitants) had access to sewerage systems, implying that 7,803,000 people lacked access (table 6.4). However, rural coverage was much lower (53 percent for water and 57 percent for sanitation), shrinking to 52 percent and 15 percent for water and sanitation, respectively, when the definition is restricted to household water and sewerage connections.

The increase in coverage rates masks shortcomings in the quality of service. Although the overall performance indicators for the 59 largest utilities show reasonable levels of efficiency and service, water rationing and intermittent supplies are common in most water supply systems in smaller municipalities. Only slightly less than 50 percent of all drinking water outside the major urban centers is properly treated. As a result, the

Table 6.4 Urban Sewerage System Coverage, 2001

Department	*Number of municipalities*	*Number of municipalities by rate of sewerage system coverage*			*Avg. coverage (%)*
		<70%	*70–80%*	*>80%*	
Antioquía	125	26	22	77	87.9
Atlántico	23	21	2	0	61.7
Bogotá	1	0	0	1	80.0
Bolívar	45	40	2	3	48.9
Boyacá	123	12	11	100	88.4
Caldas	27	2	2	23	90.6
Caquetá	16	7	3	6	50.7
Cauca	41	17	7	17	81.6
Cesar	25	14	7	4	71.0
Córdoba	28	25	0	3	48.0
Cundinamarca	116	58	8	50	62.1
Chocó	26	25	0	1	20.4
Huila	37	1	9	27	82.2
La Guajira	14	9	2	3	52.5
Magdalena	26	24	1	1	48.1
Meta	29	8	3	18	74.7
Nariño	63	30	12	21	76.5
Norte de Santander	40	6	4	30	78.8
Quindío	12	1	7	4	83.6
Risaralda	14	0	0	14	86.1
Santander	87	10	4	73	89.3
Sucre	24	19	3	2	50.4
Tolima	47	26	4	17	76.3
Valle del Cauca	42	6	1	35	82.3
Arauca	7	6	1	0	50.7
Casanare	19	10	0	9	76.3
Putumayo	13	12	1	0	50.1
San Andrés y Prov.	2	2	0	0	48.9
Amazonas	2	1	1	0	68.7
Guainía	1	1	0	0	25.0
Guaviare	4	2	1	1	57.1
Vaupés	3	3	0	0	35.9
Vichada	4	4	0	0	7.6
Total	1,086	428	118	540	75.1

Source: Universidad de los Andes and Ministry of Environment 2002, reported in Garay 2002.

drinking water quality in many systems is substandard. One of the main reasons is that almost a third of the smaller municipalities, although equipped with water treatment plants, do not make the necessary purchases of chlorine for water disinfection because of their weak technical capacity and cash flow problems that restrict the availability of resources to purchase basic production inputs. In addition, sufficient pressure in the water supply systems is often lacking, adding to the risk of bacterial contamination. Added to this, sewerage collection systems do not have sufficient hydraulic capacity to handle wastewater flows, especially in poor neighborhoods, resulting in overflow problems with direct health and environmental impacts.

As highlighted in the earlier section, for Colombia's sectoral policies to target waterborne diseases efficiently and effectively, the authorities might consider promoting safe water programs and hygiene interventions in addition to water supply and sewerage, particularly in those rural zones where the population is at greatest risk of diarrheal disease (see table 6.1). In addition, the policies might include efforts aimed at promoting increased water supply and sanitation coverage by modifying current policies and instruments (EIA framework, Decree 1594 of 1984, and wastewater effluent fees) that discourage private participation in the sector. For example, with respect to wastewater effluent fees, it would be necessary to phase out charges associated with organic and total suspended solid loads for which dischargers currently have to pay, and focus instead on parameters that have a more direct and significant bearing on public health.

Analysis of Alternative Interventions

For an analysis of potential alternative interventions in table 6.2, it is important to distinguish between those that involve changes in household behavior and those that involve infrastructure or hardware improvements. Interventions that involve changes in household behavior are improved hygiene and water treatment at point of use. Although public authorities can promote these behaviors, changes in behavior by individuals and households are beyond their control. This behavioral component must therefore be explicitly accounted for in a benefit-cost analysis. With respect to infrastructure or hardware (water supply and sanitation facilities), improvements are predominantly functions of provision and are likely to be used by households if design and service delivery reflect demand and provide convenience. Therefore, uncertainties regarding behavioral change in relation to water supply and sanitation tend to be less important in a benefit-cost analysis than for hygiene improvement and point-of-use treatment of drinking water.

Pruss and others (2002) provide a framework for estimating the burden of disease from inadequate water, sanitation, and hygiene, presented in table 6.5. Although Pruss and others (2002) applied the

Table 6.5 Selected Exposure Scenarios

Scenario	*Description*	*Pathogen load*	*Relative risk*
VI	NO IMPROVED WATER SUPPLY AND NO BASIC SANITATION in a country that is not extensively covered by those services, and where water supply is not routinely controlled	Very high	11.0
Vb	IMPROVED WATER SUPPLY but no basic sanitation in a country that is not extensively covered by those services, and where water supply is not routinely controlled	Very high	8.7
Va	BASIC SANITATION but no improved water supply in a country that is not extensively covered by those services, and where water supply is not routinely controlled	High	6.9
IV	IMPROVED WATER SUPPLY AND BASIC SANITATION in a country that is not extensively covered by those services, and where water supply is not routinely controlled	High	6.9
IIIc	IV and improved access to drinking water (generally piped to household)	High	—
IIIb	IV and improved personal hygiene	High	4.5
IIIa	IV and drinking water disinfected at point of use	High	3.8
II	Regulated water supply and full sanitation coverage, with partial treatment for sewerage, corresponding to a situation typically found in developed countries	Medium to low	2.5
I	Ideal situation, corresponding to the absence of transmission of diarrheal disease through water, sanitation, and hygiene	Low	1.0

Source: Based on Pruss and others (2002).
Note: — = not available.

framework to estimate the global burden of diarrheal disease, it can also be effectively applied to estimate the benefits and costs of improved water supply and sanitation.

The relative risks in table 6.5 can be interpreted as follows: The risk of diarrheal illness in a situation of no improved water supply and no basic sanitation (scenario VI) is almost 60 percent ({[11.0 – 6.9]/6.9} × 100) higher than or 1.60 times as high (11.0/6.9) as in a situation with improved water supply and basic sanitation (scenario IV). The risk of diarrheal illness in a situation with improved water supply and basic sanitation (scenario IV) is 2.75 times as high (6.9/2.5) as in a situation with regulated water supply and full sanitation coverage and partial treatment for sewerage (scenario II). The risk of diarrheal illness in a situation of no improved water supply and no basic sanitation (scenario VI) is 4.4 times higher (11.0/2.5) than in a situation with regulated water supply and full sanitation coverage and partial treatment for sewerage (scenario II).[7] According to the WHO, diarrheal incidence (cases per person per year) in most developing regions of the world is three to five times higher than in North America and high-income countries in Europe, and as much as six times higher in Sub-Saharan Africa (WHO 2002a). These statistics are relatively consistent with the figures reported in table 6.5, suggesting that most developing countries lie somewhere in the range of scenario IV to scenario VI. These figures represent averages; larger variations exist within specific developing countries, and some segments of their populations lie closer to scenario II.

Pruss and others (2002) derived the relative risks of diarrheal illness from the international literature (table 6.6). The expected reductions in diarrheal illness from provision of improved water supply, basic sanitation facilities, or both water supply and basic sanitation are from Esrey (1996) and are supported by the results in Esrey and others (1991). Pruss and others (2002) identify the risk transition between scenarios IV and II as the most data-scarce transition among the scenarios in table 6.5. According to Pruss and others (2002), no intervention studies fully describe this transition. The authors therefore rely on

Table 6.6 Rates of Reduction in Diarrheal Illness Used in Pruss and Others (2002)

Scenario progression	*Description of improvement*	*Reduction in illness rate (%)*	*Source*
From VI to Vb	Providing improved water supply	20.8	Esrey (1996)
From VI to Va	Providing basic sanitation facilities	37.5	Esrey (1996)
From VI to IV	Providing improved water supply and basic sanitation facilities	37.5	Esrey (1996)
From IV to IIIb	Improved personal hygiene	35.0	Huttly, Morris, and Pisani (1997)
From IV to IIIa	Disinfection of drinking water at point of use	45.0	Quick and others (1999)
From IV to II	Regulated water supply and full sanitation coverage, with partial treatment of sewerage	65.0	Huttly, Morris, and Pisani (1997); Quick and others (1999)
From II to I	Absence of transmission of diarrheal disease through water, sanitation, and hygiene	60.0	Using results from Mead and others (1999)

Source: Pruss and others 2002.

a staged approach by applying results from the international literature that describe selected characteristics of the difference between scenarios IV and II, such as improved personal hygiene (scenario IIIb) and improved water quality (scenario IIIa). Of all personal hygiene improvements, handwashing is often found to be the most effective intervention to reduce disease transmission. Pruss and others (2002) therefore apply the results from a review of studies of handwashing by Huttly, Morris, and Pisani (1997) to estimate the reduction in diarrheal illness from scenario IV to IIIb. For water quality improvements, Pruss and others (2002) apply the results from Quick and others (1999), who found a 45 percent reduction in diarrheal illness from point-of-use water disinfection. The combined results of Huttly, Morris, and Pisani (1997) and Quick and others (1999) were subsequently used to arrive at the expected reduction in diarrheal illness from scenario IV to scenario II.[8] To assess the magnitude of the difference—in diarrheal illness that is transmitted through water, sanitation, and hygiene—between scenario II (typically found in developed countries) and scenario I (typically ideal situation with absence of diarrheal disease), Pruss and others (2002) deduct the share of diarrheal illness that is found to be foodborne in the United States from a likely share that might be transmitted through aerosols.[9] This approach suggests that 60 percent of diarrheal illness in a scenario II situation is related to water, sanitation, and hygiene, and is therefore the expected reduction in diarrheal illness from scenario II to scenario I.

The percentage reductions in diarrheal illness in table 6.6 correspond to the relative risks presented in table 6.5. For instance, the difference in relative risk between scenarios IV (6.9) and II (2.5) corresponds to about a 65 percent reduction $\{[(6.9 - 2.5)/6.9] \times 100$ percent$\}$ from scenario IV to II.

The rest of this section discusses how the framework by Pruss and others (2002) is applied to estimate the benefits and costs of interventions to reduce diarrheal illness and diarrheal mortality in Colombia. The exposure scenarios applied for Colombia are presented in table 6.7. Two aspects of the framework are modified to accommodate various combinations of the scenarios and to minimize limitations imposed by the sequence of pathogen load reductions used by Pruss and others (2002). The relative risks, or reductions in diarrheal illness, are also modified to reflect the more recent findings of relative risks in the meta-analysis study by Fewtrell and Colford (2004) and the meta-analysis study of handwashing by Curtis and Cairncross (2003).

Table 6.7 Exposure Scenario Application to Colombia

Scenario	*Description*	*Relative risk, with and without point-of-use disinfection* *With*	*Without*
VI	No improved water supply and no basic sanitation	11.0	5.8
Vb	Improved water supply but no basic sanitation	8.2	4.4
Va	Basic sanitation but no improved water supply	7.5	4.0
IV	Improved water supply and basic sanitation	7.5	4.0
IIIb	IV and water supply piped to household (no source treatment)	6.7	3.6
IIIc	IV and water supply piped to household (source treatment)	5.9	3.6

Source: Modified from Pruss and others (2002).
Note: Relative risk is for diarrheal disease.

The first modification to the framework presented by Pruss and others (2002) is to distinguish between households that disinfect their drinking water at point of use and those households that do not do so. This distinction is made for each of the scenarios III through VI. The second modification is to distinguish between households with piped water supply that is treated at source (water treatment plant) and those with piped water that is not treated at source.

To allow for a comparison with table 6.5, the relative risk for scenario VI without point-of-use disinfection is also 11.0 in table 6.7. The relative risks in scenarios Vb and Va are derived by multiplying the relative risk in scenario VI by the relevant relative risk ratios in table 6.2. Consistent with the findings of Pruss and others (2002), there is no difference between scenarios Va and IV. The difference between scenarios IV and IIIb is a relative risk ratio of 0.904, reported in Fewtrell and Colford (2004) for household water supply connection. The difference between scenarios IIIb and IIIc is the relative risk ratio of 0.891 presented in table 6.2.

In scenarios VI through IIIb, the ratio of the relative risk with point-of-use disinfection to the relative risk without point-of-use disinfection is 0.53. This corresponds to the relative risk ratio for rural water supply in table 6.2, which may be considered more appropriate to apply than the urban relative risk ratio because scenarios IV through VI are typically found in rural areas (see table 6.8) and water quality in scenarios IIIb through VI is on average likely to involve higher disease risk than urban treated piped water supply. The relative risk for scenarios IIIc and IIIb is assumed to be the same (3.6) if drinking water is disinfected at point of use.

Scenario II, the situation typically found in developed countries, is not included in table 6.7. Providing this level of service (including partial sewerage treatment) to the entire urban and rural population in developing countries is likely to be very costly. The benefit-cost analysis in this report therefore focuses on improved water supply and basic sanitation to those segments of the population without these services.

To estimate the health benefits of water and sanitation interventions, an estimate of the share of the Colombian population in each of the scenarios is needed. Three sources of data from Colombia are used for this purpose—the 2000 Colombia DHS household survey with data on the water and sanitation situation in urban and rural areas; data from the Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT) on piped water network and water treatment plants; and the 2003 DANE Colombia Quality of Life Survey with data on household drinking water disinfection (DANE 2003).

The water supply and sanitation situation according to the 2000 Colombia DHS is presented in table 6.8. As discussed in relation to table 6.2, unimproved or no basic sanitation mainly refers to households with no sanitation facilities or with open-pit latrines. The Colombia DHS tables do not distinguish between types of pit latrines. It is therefore necessary to use high and low bounds for the population share without improved or basic sanitation. Similarly, no improved water supply refers mainly to surface water, tanker trucks, and unprotected well or spring water. However, the DHS tables do not distinguish between protected and unprotected well water. Again, it is necessary to apply high and low bounds.

Table 6.8 Water Supply and Sanitation in Colombia

% households

Water supply and sanitation situation	*Urban*	*Rural*
Sanitation		
No sanitation facilities	1.4	28.7
Pit toilet latrine	2.4	13.0
Flush toilet	96.2	58.2
Water		
Piped water supply	98.0	50.3
Well water	1.3	18.7
Surface water	0.0	24.6
Rain water	0.4	4.1
Tanker truck	0.1	1.2
Other	0.2	1.0

Source: DHS 2000.

For the data in table 6.7 to be used to estimate the population shares in each of the scenarios in table 6.6, a set of allocation rules were applied. These rules are presented in table 6.9, and their application is presented in tables 6.10 and 6.11. In the high case, well water is considered an unimproved water supply and pit latrines are not considered to be basic sanitation. In the low case, well water is considered an improved water supply and pit latrines are considered to be basic sanitation. Because the DHS data do not provide information on treated versus untreated piped water supply, table 6.10 makes no distinction between treated and untreated piped water supply.

Data from the MAVDT were used to provide an estimate of the urban population share with piped water supply that is not treated at source. According to MAVDT data, there were 174 municipalities that did not have a water treatment plant in 2002, and there were 164 municipalities with water treatment plants that were not in operation. While these figures represent over 30 percent of the total number of municipalities in Colombia, they represent only a little over 5 percent of the population served by a water supply network.[10]

The 2003 Colombia Quality of Life Survey reports that 53 percent of urban households and 58 percent of rural households disinfect their drinking water (point-of-use disinfection).[11] The Quality of Life Survey does not provide the share of households that use disinfection in relation to their type of water supply and sanitation. The data on disinfection is therefore applied uniformly to each of the scenarios. Tables 6.10 and 6.11 suggest that most health benefits from improved water supply and sanitation can be realized in rural areas. The benefit-cost analysis in this report therefore focuses on rural service improvements. Larsen (2005)

Table 6.9 Scenario Allocation Rules

Scenario	*Allocation rule*
VI	The lesser of the population share without improved water supply and without basic sanitation
Vb	The difference between population share with improved water supply but without basic sanitation, if difference is > 0
Va	The difference between population share with basic sanitation but without improved water supply, if difference is > 0
IV	The lesser of the population share with improved water supply and basic sanitation less the population share with piped water
IIId	Population share with piped water supply
IIIc	Population share with piped water supply

Source: Larsen 2005.

Table 6.10 Rural Water Supply and Sanitation in Colombia

% rural population

Scenario	*Description*	*High*	*Low*
VI	No improved water supply and no basic sanitation	42	27
Vb	Improved water supply but no basic sanitation	0	2
Va	Basic sanitation but no improved water supply	4	0
IV	Improved water supply and basic sanitation	4	21
IIId and IIIc	IV and water supply piped to household (no source treatment)	50	50

Source: Larsen 2005.

Note: "High" and "low" refer to population share without improved water supply, without basic sanitation, or with neither, as described in the text.

Table 6.11 Urban Water Supply and Sanitation in Colombia

% urban population

Scenario	*Description*	*High*	*Low*
VI	No improved water supply and no basic sanitation	1.5	0.3
Vb	Improved water supply but no basic sanitation	2.5	1.1
Va	Basic sanitation but no improved water supply	0.0	0.0
IV	Improved water supply and basic sanitation	0.0	0.6
IIId	IV and water supply piped to household (no source treatment)	5.0	6.0
IIIc	IV and water supply piped to household (source treatment)	91.0	92.0

Source: Larsen 2005.

Note: "High" and "low" refer to population share without improved water supply, without basic sanitation, or with neither, as described in the text.

based on the Colombia DHS 2000 survey and data from INS (table 6.12) estimated the total number of annual cases of diarrheal illness at close to 30 million, or equivalent to 0.7 cases per person.

Estimated cases of diarrheal illness per person per year in rural areas in Colombia are estimated for scenarios IIIc through VI from the relative risks in table 6.7, the scenario population distribution in table 6.10, and the average diarrheal cases per person in table 6.12. Table 6.13 indicates that the number of cases per person is on average 0.45 in households with piped water supply and basic sanitation that practice disinfection of drinking water, and 1.35 per year in households that do not have improved water supply, do not have basic sanitation, and do not practice drinking water disinfection. This is based on the high case in table 6.10. For the low case, the range is 0.47 to 1.42 (not shown in table).

Providing piped water supply to all rural households is likely to be very expensive. A realistic objective might be to at least provide improved water

Table 6.12 Estimated Annual Cases of Diarrheal Illness in Colombia, 2000

Cases	*National*	*Urban*	*Rural*
Children under age 5 with chronic diarrhea (lasting two weeks) (%)	13.9	13.2	15.6
Population age 5 and over with chronic diarrhea (lasting two weeks) (%)	2.0	1.9	2.2
Annual diarrhea cases in children under age 5 (thousands)	13,800	9,300	4,500
Annual diarrhea cases in population age 5 and over (thousands)	16,100	10,900	5,200
Total annual diarrhea cases (thousands)	29,900	20,200	9,700
Diarrhea cases per person (all population)	0.68	0.65	0.77

Source: Larsen 2004.

Table 6.13 Estimated Annual Cases of Diarrheal Illness per Person in Rural Colombia, High Estimate

		Cases of diarrheal illness per person	
Scenario	*Description*	*Without point-of-use disinfection*	*With point-of-use disinfection*
VI	No improved water supply and no basic sanitation	1.35	0.72
Vb	Improved water supply but no basic sanitation	1.01	0.54
Va	Basic sanitation but no improved water supply	0.92	0.49
IV	Improved water supply and basic sanitation	0.92	0.49
IIId	IV and water supply piped to household (no source treatment)	0.83	0.45
IIIc	IV and water supply piped to household (source treatment)	0.74	0.45

Source: Larsen 2005.

supply (protected well or borehole) and sanitation facilities (improved pit latrine or pour-flush latrines). Benefits and costs are presented in tables 6.14 and 6.15 for three interventions: (a) improved water supply *and* sanitation facilities; (b) improved sanitation facilities only; and (c) improved water supply only. Referencing table 6.13, these interventions are equivalent to improving service levels to scenario IV for the entire rural population.

The population receiving improved water supply and sanitation is calculated from table 6.10. Diarrheal cases averted are calculated from table 6.13. Deaths averted are calculated on the basis of an estimated

Table 6.14 Benefits and Costs of Improved Rural Water and Sanitation, Low Case

	Improvement		
	Water supply and sanitation	*Sanitation only*	*Water supply only*
Impacts			
Population receiving improved sanitation (thousands)	3,665	3,665	n.a.
Population receiving improved water supply (thousands)	3,413	n.a.	3,413
Diarrhea cases averted per year	1,170	1,170	900
Diarrhea cases averted per year (% reduction)	4	4	3
Deaths of children because of diarrhea averted	65	65	50
Deaths of children because of diarrhea averted (%)	4	4	3
Value of costs and benefits (billion pesos)			
Annualized cost of service provision	128	70	57
Health benefits of service provision	38	38	29
Value of time savings from improved water supply	90	n.a.	90
Value of time savings from improved sanitation	167	167	n.a.
Benefit-cost ratios			
Health benefits only	0.30	0.54	0.51
Health benefits and time savings	2.31	2.91	2.08

Source: Larsen 2005.

Note: n.a. = not applicable. US$1 = Col$2,150. Low case refers to the low estimate of population without improved water supply and sanitation in table 6.10.

case fatality rate of 0.118 per 1,000 cases in children under age 5, based on data presented in Larsen (2004). Health benefits of service provision are estimated on the basis of a cost of diarrheal illness of Col$25,000 (US$11.63) per case averted (morbidity) and a cost of Col$136 million (US$63,255) per death averted in rural areas (Larsen 2004).[12]

Estimated household time savings as a result of improved water supply are presented in table 6.16. Data on households with more than 15 minutes to water source is from the Colombia DHS 2000. A lower bound of 15 minutes is assumed in table 6.16 to provide a conservative estimate of time savings. To estimate time savings for households that have less than 15 minutes to water source, only households relying on surface water (DHS 2000) are assumed to save time from improved water supply. An average time savings of five minutes to water source is assumed. To place a monetary value on time savings, economists commonly apply a range of 50 to 100 percent of wage rates. The value of time savings presented in tables 6.14 and 6.15 is estimated based on 75 percent of average wage rate. For sanitation improvements, a time savings of five minutes per day per person has been applied.

Table 6.15 Benefits and Costs of Improved Rural Water and Sanitation, High Case

	Improvement		
Benefits and Costs	*Water supply and sanitation*	*Sanitation only*	*Water supply only*
Impacts			
Population receiving improved sanitation (thousands)	5,310	5,310	n.a.
Population receiving improved water supply (thousands)	5,815	n.a.	5,815
Diarrhea cases averted per year	1,680	1,680	1,310
Diarrhea cases averted per year (% reduction)	6	6	4
Deaths of children because of diarrhea averted	90	90	70
Deaths of children because of diarrhea averted (%)	6	6	4
Value of costs and benefits (billion pesos)			
Annualized cost of service provision	200	102	98
Health benefits of service provision	54	54	42
Value of time savings from improved water supply	90	n.a.	90
Value of time savings from improved sanitation	167	167	n.a.
Benefit-cost ratios			
Health benefits only	0.27	0.53	0.43
Health benefits and time savings	1.56	2.18	1.36

Source: Larsen 2005.
Note: n.a. = not applicable. US$1 = Col$2,150. High case refers to the high estimate of population without improved water supply and sanitation in table 6.10.

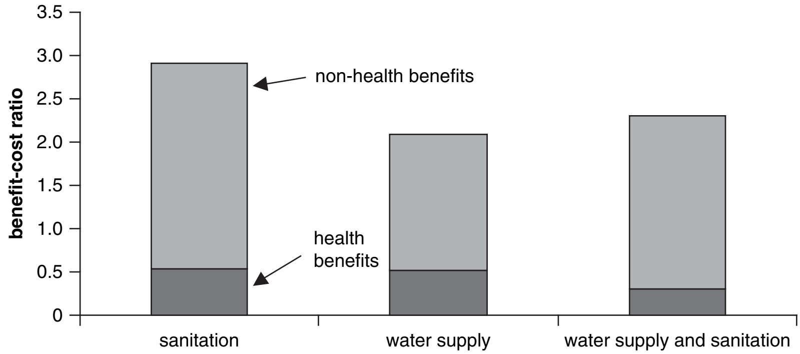
Table 6.16 Household Time Savings from Improved Water Supply

Rural population share with time savings > 15 minutes to water source (%)	7
Number of households with > 15 minutes to water source (thousands)	177
Assumed average number of minutes to water source	15
Trips per day to water source	2
Time savings from improved water supply (minutes per day per household)	30
Percentage of households relying on surface water	25
Number of households using surface water (thousands)	632
Number of households with < 15 minutes to water source (thousands)[a]	455
Assumed average number of minutes to water source	5
Trips per day to water source	2
Time savings from improved water supply (minutes per day per household)	10

Source: Larsen 2005.
a. Calculation: 632 – 177 = 455.

The annualized cost of service provision reflects an annualized per capita cost of Col$19,000 (US$8.84) for improved sanitation (improved latrines) and Col$17,000 (US$7.91) for improved water supply (protected well or bore hole). This is based on a 10 percent annual discount rate, a per capita

Figure 6.4 Benefit-Cost Ratios of Rural Water Sanitation, Low Case



Source: Larsen 2005.
Note: "Low case" refers to the low estimate of population without improved water supply and sanitation (Scenario VI) in Table 6.10.

investment cost of Col$125,000 (US$58.14) for sanitation (plus an annual 5 percent operations and maintenance cost and 5 percent promotion cost, and Col$5,000 [US$2.33] in annual sewerage cost), and a per capita investment cost of Col$130,000 (US$60.47) for improved water supply (plus an annual 5 percent operations and maintenance cost and 5 percent water source protection cost).[13]

As seen in tables 6.14 and 6.15 and figure 6.4, the estimated benefit-cost ratio that includes only health benefits is close to 0.5 for either water supply improvements or sanitation improvements. For water supply *and* sanitation, the health cost-benefit ratio is close to 0.3.[14] These estimates, in the case of Colombia, suggest that the health benefits are only one-third to one-half of the cost of water and sanitation improvement costs. By including time savings, however, the benefit-cost ratio is greater than 1 in both the low and high cases.[15]

Analysis of Hygiene Improvements

The most effective hygiene intervention found in many studies is handwashing after defecation, before preparing meals, and before eating. Curtis and Cairncross (2003) provide a meta-analysis of close to 20 handwashing studies and report a mean reduction in diarrheal illness of about 47 percent. Fewtrell and Colford (2004), in their meta-analysis, report a mean reduction in diarrheal illness of about 45 percent from handwashing interventions (table 6.2). About two-thirds of the studies reviewed in the two meta-analysis studies assessed the effect of handwashing on diarrheal illness in children under age 5. The meta-analyses do not report the effect of handwashing on diarrheal illness in children under age 5 compared with older children and adults. A pooled analysis of the studies reviewed in the two meta-analyses was therefore undertaken in this report, but found no statistically significant difference in diarrheal reduction in children and adults. A reduction in diarrheal illness of 45 percent is therefore applied in the benefit-cost analysis in this report for all age groups.

A benefit-cost analysis of hygiene improvement (handwashing programs) involves an assessment of several key parameters and outcomes, as listed in table 6.17. The costs of improved handwashing practices are twofold. First, a program to encourage behavioral change (improved handwashing) has a cost that should be fully captured, including the cost of program preparation and implementation. Second, improved handwashing practices have a private cost that includes cost of increased water and soap consumption. The most uncertain and critical parameter is the effectiveness of the handwashing program for changing household and individual behavior, and the lasting effect or sustainability of changed behavior. This behavioral aspect is likely dependent on several dimensions and will vary from country to country. It will also depend on the design, duration, and overall magnitude of the handwashing program. The expected benefit of the program can be estimated from the reductions in risk of diarrheal illness reported in Curtis and Cairncross (2003) and Fewtrell and Colford (2004), and the monetized benefits (or costs avoided per case of diarrheal illness reduction) presented in Larsen (2004) for Colombia.

A review of three handwashing programs that provide program costs and behavioral change is presented in table 6.18. The program in Guatemala was national in scope and targeted households with children under age 5 (Saadé, Bateman, and Bendahmane 2001). The program in Thailand focused on all households in a set of rural villages and involved

Table 6.17 Key Parameters and Outcomes in a Benefit-Cost Analysis of Handwashing

Key parameters	*Outcomes*
Program cost	Overall cost of handwashing program
Program effectiveness	Behavioral change in target population (percentage of population that improves or starts regular handwashing)
Program sustainability	The lasting effect of the program
Private cost	Costs of handwashing in the group with behavioral change (increased water and soap expenditures)
Program benefits	Percentage reduction in diarrheal illness from handwashing in group with behavioral change
	Monetized benefits of reduced diarrheal illness

Source: Larsen 2005.

Table 6.18 Review of Costs and Effectiveness of Handwashing Programs

		Thailand		
Factors	*Guatemala*	*Low intervention*	*High intervention*	*Burkina Faso*
Target area	National	25 rural villages	One city	—
Target households	With children under age 5	All households	With children under age 3	—
Number of target households	1,570,000	10,000	6,550	38,600
Duration of program implementation	1 year	3–4 months	3–4 months	3 years
Behavioral change (% target population)	10	11	16	18
Program cost (US$)	561,400	5,960	7,715	194,000
Program cost per household (US$)	0.36	0.60	1.18	5.03
Program cost per target household or primary caretaker with behavioral change (US$)	3.58	5.42	7.36	27.92

Sources: Derived from Borghi and others (2002); Pinfold and Horan (1996); and Saadé, Bateman, and Bendahmane (2001).
Note: — = not available.

a different level of program intervention in two subsets of the villages (Pinfold and Horan 1996). The program in Burkina Faso involved one city and targeted households with children under age 3 (Borghi and others 2002). As seen in table 6.18, the percentages of the target population that changed behavior (that is, started regular handwashing or improved handwashing practices) range from 10 percent in Guatemala to 18 percent in Burkina Faso. In addition, the cost per target household ranges from US$0.36 in Guatemala to US$5.03 in Burkina Faso. While the studies are too few to draw a definite conclusion, the results do suggest that program cost per unit of behavioral change (per percentage point increase in population with behavioral change) may increase substantially if the objective is to achieve behavioral change in a large share of the target population. This issue may, therefore, have a major impact on the overall cost of hygiene programs that aim to achieve substantial reductions in the overall number of cases of diarrheal illness in a country.

Program cost per target household with behavioral change is the most relevant unit cost in table 6.18 for a benefit-cost analysis. This cost can then be compared to the reduction (and thereby benefits) in diarrheal illness in the target population with behavioral change.

A benefit-cost analysis of a national handwashing program in Colombia is presented in table 6.19. Three scenarios are provided for diarrheal reduction in children under age 5, and two scenarios for the population age 5 and over. The low to high scenarios for children represent (a) a program effectiveness of 10 to 20 percent of households (or primary caretakers of children) that start regular handwashing or improve handwashing practices for the protection of child health; and (b) a program cost ranging from US$0.40 to US$5.00 (Col$10,750) per targeted household or primary caretaker (US$4.00 to US$25.00 [Col$360] per household or primary caretaker with behavioral change). These ranges of program effectiveness and costs are based on the figures in table 6.18. The high scenario corresponds to the experience in one city in Burkina Faso. However, it is possible that a national program will benefit from economies of scale and therefore

Table 6.19 Benefits and Costs of a National Handwashing Program in Colombia

	Under age 5			*Age 5 and over*	
Factors	*Low*	*Medium*	*High*	*Low*	*High*
Baseline data					
Total population by age group (DANE)	4,767,533	4,767,533	4,767,533	39,763,901	39,763,901
Diarrhea cases per person per year	2.9	2.9	2.9	0.4	0.4
Total diarrhea cases per year	13,826,000	13,826,000	13,826,000	16,104,000	16,104,000
Deaths from diarrhea (children under age 5)	1,634	1,634	1,634	n.a.	n.a.
Diarrhea fatality rate (per 1,000 cases)	0.118	0.118	0.118	n.a.	n.a.
Program cost					
Reach (% population)	100	100	100	100	100
Cost per primary target (US$)	0.40	1.20	5.00	n.a.	n.a.
Total cost (million pesos)	4,577	13,730	57,210	n.a.	n.a.
Program effectiveness					
Individuals with behavioral change (%)	10	15	20	5	10
Cost per person with behavioral change (US$)	4.00	8.00	25.00	n.a.	n.a.
Reduction in diarrhea incidence among individuals with behavioral change (%)	45	45	45	45	45
Overall reduction in diarrhea cases (%)	4.5	6.8	9.0	2.3	4.5

Table 6.19 Benefits and Costs of a National Handwashing Program in Colombia *(continued)*

	Under age 5			*Age 5 and over*	
Factors	*Low*	*Medium*	*High*	*Low*	*High*
Private costs for improved hygiene					
Increased daily water use (liters/person)	3	3	3	3	3
Increased annual water use (m^3/person)	1.095	1.095	1.095	1.095	1.095
Cost of water (pesos/m^3)	720	720	720	720	720
Cost of water per person per year (pesos)	788	788	788	788	788
Soap consumption per person per year	6	6	6	3	3
Cost per unit of soap (pesos)	2,000	2,000	2,000	2,000	2,000
Cost of soap per person per year (pesos)	12,000	12,000	12,000	6,000	6,000
Total private cost per year (million pesos)	6,097	9,145	12,194	13,497	26,993
Program benefits					
Reduction in annual cases of diarrhea	622,170	933,255	1,244,340	362,340	724,680
Deaths averted (children under age 5)	74	110	147	n.a.	n.a.
Cost per case of diarrhea (pesos)	35,000	35,000	35,000	30,000	30,000
Cost per death from diarrhea (million pesos)	136	136	136	n.a.	n.a.
Morbidity benefits per year (million pesos)	21,776	32,664	43,552	n.a.	n.a.
Mortality benefits per year (million pesos)	10,000	15,000	20,000	n.a.	n.a.
Total benefits per year (million pesos)	31,776	47,664	63,552	10,870	21,740
Benefit-cost ratios					
Program cost (million pesos)	4,577	13,730	57,210	0	0
Private cost per year (million pesos)	6,097	9,145	12,194	13,497	26,993
Benefits per year (million pesos)	31,776	47,664	63,552	10,870	21,740
Benefit-cost ratio	3.0	2.1	0.9	0.8	0.8

Source: Larsen 2005.
Note: m^3 = cubic meter; n.a. = not applicable. US$1 = Col$2,150. For children under age 5, the low, medium, and high scenarios correspond to 10, 15, and 20 percent effectiveness, respectively, in individuals whose behavior is changed. For population age 5 and over, the low and high scenarios represent 5 and 10 percent effectiveness, respectively.

achieve 20 percent effectiveness at a unit cost lower than US$5.00 per primary caretaker of children under age 5. It is therefore possible that the high scenario represents a higher bound of program cost. It is also possible that the low scenario with a program effectiveness of 10 percent can be achieved at a lower cost than in Guatemala if further economies of scale are achieved, given that the population of Colombia is substantially larger than that of Guatemala.

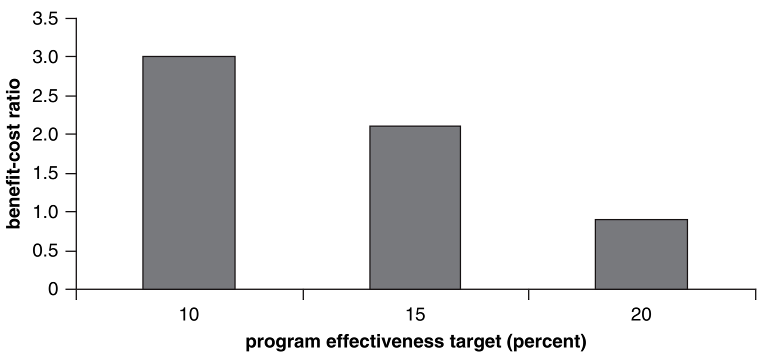
The diarrheal illness baseline data and cost of illness per case of diarrhea and diarrheal mortality in table 6.19 are taken from Larsen (2004). Avoided cost of illness is the program benefit per case of reduced or averted diarrheal morbidity and mortality. Mortality is valued by the human capital approach as shown in this chapter on water and sanitation improvement. The reduction in diarrheal illness (45 percent) in children with caretakers who start regular handwashing or improve handwashing practices is taken from Curtis and Cairncross (2003) and Fewtrell and Colford (2004), as presented in table 6.2. The quantity of increased water and soap consumption that make up the private cost of handwashing reflects the findings in Borghi and others (2002). Price of water reflects an average for Colombia, and the cost of soap is based on a spot survey of soap retail prices in Colombia.

The estimated reduction in annual cases of diarrheal illness ranges from 0.6 million to 1.2 million in children under age 5. At a cost of Col$35,000 (US$16.28) per averted case of illness (morbidity) and Col$136 million (US$63,256) per averted case of death (mortality), the total program benefit ranges from Col$31 billion (US$14.4 million) to Col$63 billion (US$29.3 million).[16] Total program cost ranges from less than Col$5 billion (US$2.3 million) to Col$57 billion (US$26.5 million), and total private cost ranges from Col$6 billion (US$2.8 million) to Col$12 billion (US$5.6 million). The total estimated benefits and costs result in a benefit-cost ratio that ranges from 3.0 in the low scenario to 0.9 in the high scenario (see also figure 6.5).

The benefits of a handwashing program are not limited to children under age 5. The population age 5 and over can also benefit, as discussed at the beginning of this section. To simplify the analysis, it is assumed in table 6.19 that changes in handwashing behavior in the population age 5 and over can be achieved at no incremental program cost, but that the effectiveness only ranges from 5 to 10 percent. It is also assumed that soap consumption per person is only half the soap consumption required for improved hygiene for children under age 5. In this case, the benefit-cost ratio is 0.8.[17] This low ratio, even at zero incremental program cost, can be explained by the fact that diarrheal incidence is on average substantially lower in this population group than in children under age 5.

One important aspect of the benefit-cost analysis presented is that it implicitly assumes that the benefit of the program is realized for only one year, or that behavioral change (handwashing) lasts only one year. While it is difficult to assess the sustainability of behavioral change, benefits lasting only one year is clearly a very conservative assumption. If benefits were sustained for two years, the estimated benefit-cost ratios would increase to the levels presented in table 6.20. For a program effectiveness target of 20 percent, the estimated ratio increases from 0.9 to 1.5 for children under age 5. The benefit-cost ratio does not change for the population age 5 and over because of the assumption that behavioral change takes place at no incremental program cost.[18] Figure 6.6 presents benefit-cost ratios for

Figure 6.5 Estimated Benefit-Cost Ratios for Handwashing, by Degree of Program Effectiveness



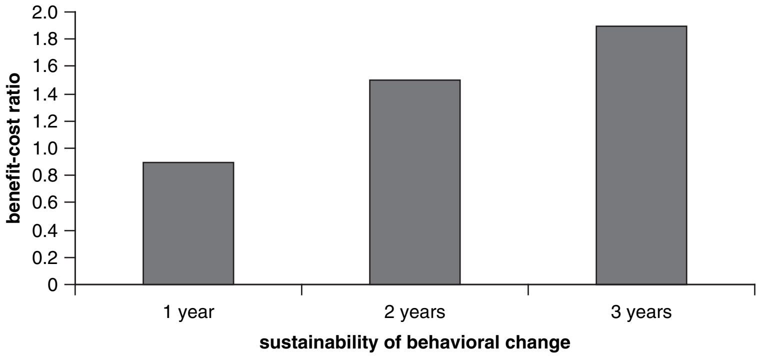
Source: Larsen 2005.

Table 6.20 Benefits and Costs of a National Handwashing Program (Behavioral Change Lasting Two Years)

	Under age 5			*Age 5 and over*	
Costs and benefits (million pesos)	*Low*	*Medium*	*High*	*Low*	*High*
Program cost (year 1)	4,577	13,730	57,210	0	0
Private cost per year (year 1)	6,097	9,145	12,194	13,497	26,993
Private cost per year (year 2)	5,543	8,314	11,085	12,270	24,539
Benefits per year (year 1)	31,776	47,664	63,552	10,870	21,740
Benefits per year (year 2)	28,887	43,331	57,775	9,882	19,764
Benefit-cost ratio	3.7	2.9	1.5	0.8	0.8

Source: Larsen 2005.
Note: US$1 = Col$2,150. Costs and benefits are discounted at an annual rate of 10 percent.
For children under age 5, the low, medium, and high scenarios correspond to 10, 15, and 20 percent effectiveness, respectively, in number of individuals whose behavior is changed. For population age 5 and over, the low and high scenarios represent 5 and 10 percent effectiveness, respectively.

Figure 6.6 Benefit-Cost Ratios over Time for Handwashing for Children Age 5 (20 Percent Effectiveness Target)



Source: Larsen 2005.

children under age 5 for a target effectiveness of 20 percent for a program with sustainability of behavioral change lasting from one to three years.

Analysis of Drinking Water Disinfection

The 2003 Colombia Quality of Life Survey reports that about 55 percent of households disinfect their drinking water (point-of-use disinfection). According to the survey, the most common method of disinfection is boiling of water and is therefore the method of disinfection considered in the benefit-cost analysis presented in table 6.21. Fewtrell and Colford (2004) report from their meta-analysis that disinfection of drinking water at point of use on average reduces diarrheal illness by 47 percent in rural areas and 23 percent in urban areas. Applying these figures to the urban and rural population shares in Colombia would suggest a weighted average diarrheal illness reduction of 30 percent from disinfection. These baseline data are presented in table 6.21.

To estimate the reduction in the number of cases of diarrheal illness, it is necessary to estimate the diarrheal incidence in the population share that does not practice point-of-use disinfection of drinking water. This is given by the following equation:

$$P_s d + (1 - Ps)d(1 - r) = d_A \qquad (6.1)$$

where P_s is the population share not practicing disinfection, d is diarrheal incidence in P_s, r is reduction in diarrheal incidence from disinfection, and d_A is the national average diarrheal incidence. This equation provides an estimated diarrheal incidence of 0.81 in the population not practicing disinfection, compared to a national average of 0.68 from Larsen (2004).

Table 6.21 Benefits and Costs of a Drinking Water Disinfection Program

Factors	*Program effectiveness target*		
	Low	*Medium*	*High*
Baseline data			
Total population (DANE)	44,531,434	44,531,434	44,531,434
Population that does not disinfect drinking water (%)	45	45	45
Target population (not practicing disinfection)	20,039,000	20,039,000	20,039,000
Target households	4,008,000	4,008,000	4,008,000
Average diarrhea cases per person per year	0.68	0.68	0.68
Reduction in diarrhea cases from disinfection (%)	30	30	30
Diarrhea incidence in target population	0.81	0.81	0.81
Total diarrhea cases per year in target population	16,289,000	16,289,000	16,289,000
Diarrhea fatality rate in children under age 5 (per 1,000 cases)	0.119	0.119	0.119
Estimated diarrheal child mortality in target population	950	950	950
Program cost			
Reach (% of target households)	100	100	100
Cost per household (US$)	0.40	1.20	5.00
Total cost (million pesos)	3,848	11,543	48,096
Program effectiveness			
Individuals with behavioral change (%)	10	15	20
Cost per target household with behavioral change (US$)	4.00	8.00	25.00
Reduction in diarrhea cases among individuals with behavioral change (%)	30	30	30
Reduction in diarrhea cases in target population (%)	3.0	4.5	5.9
Private costs			
Cost of boiling drinking water per person per year (pesos)	5,700	5,700	5,700
Total private cost per year (million pesos)	11,422	17,133	22,844
Program benefits			
Reduction in annual cases of diarrhea	484,109	726,164	968,218
Reduction in deaths from diarrhea (children under age 5)	28	42	56
Cost per case of diarrhea (pesos)	32,000	32,000	32,000
Cost per death from diarrhea (million pesos)	136	136	136
Annual benefits from reduced morbidity (million pesos)	15,491	23,237	30,983
Annual benefits from reduced mortality (million pesos)	3,840	5,760	7,680
Total benefits per year (million pesos)	19,331	28,997	38,663
Benefit-cost ratios			
Program cost (million pesos)	3,848	11,543	48,096
Private cost per year (million pesos)	11,422	17,133	22,844
Benefits per year (million pesos)	19,331	28,997	38,663
Benefit-cost ratio	1.3	1.0	0.5

Source: Larsen 2005.

Note: US$1 = Col$2,150. The low, medium, and high scenarios correspond to 10, 15, and 20 percent effectiveness, respectively, in number of individuals whose behavior is changed.

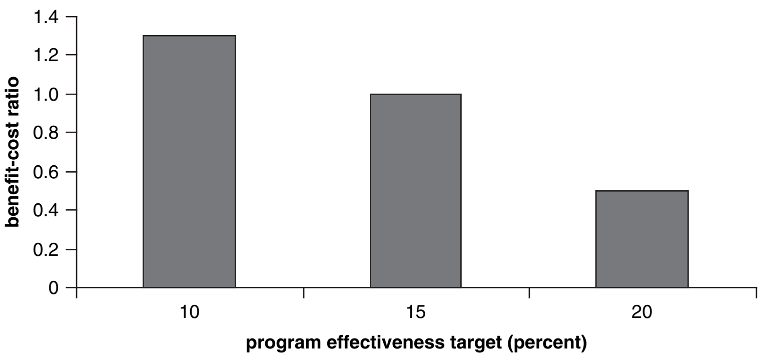
There are no estimates available in the literature of program costs to promote drinking water disinfection at point of use in Colombia. The same costs as for handwashing programs (and for the same three scenarios of effectiveness ranging from 10 to 20 percent) have therefore been applied in table 6.21. The program cost, instead of per primary caretaker of children, is expressed per household with the assumption that one person in the household is primarily responsible for boiling drinking water. Cost of boiling drinking water is taken from Larsen (2004) with a mean estimate of about Col$5,700 (US$2.65) per person per year, based on an average drinking water consumption of 0.75 liters per person per day. The disinfection program benefits are estimated the same way as for a handwashing program.

The benefit-cost ratios range from 1.3 in the low scenario with program effectiveness of 10 percent and program cost of US$0.40 (Col$860) per household to a ratio of 0.5 in the high scenario with a program effectiveness of 20 percent and program cost of US$5.00 (Col$10,750) per household (figure 6.7).

As in the case of the handwashing program, it is implicitly assumed that the benefit of the disinfection program is sustained for only one year, or that behavioral change (boiling of drinking water) lasts only one year. While it is difficult to assess the sustainability of behavioral change, the assumption that benefits last for only one year is clearly conservative. If benefits were sustained for three years, the estimated benefit-cost ratios would increase to close to 1.0 for the program, with an effectiveness target of 20 percent (figure 6.8).

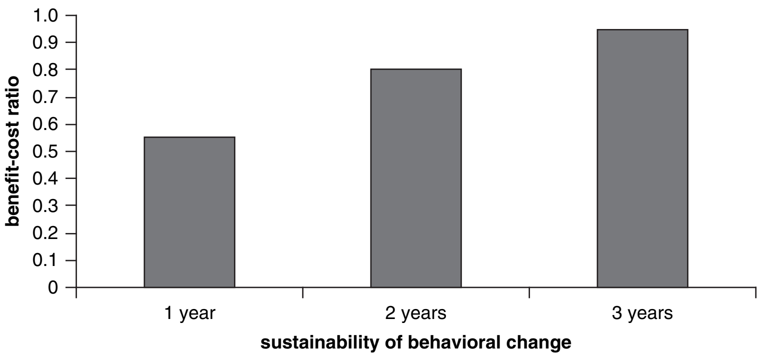
Tables 6.22 and 6.23 summarize the benefits of the interventions analyzed in this report. The hygiene program is estimated to have the largest

Figure 6.7 Benefit-Cost Ratios for Drinking Water Disinfection Program, by Degree of Program Effectiveness



Source: Larsen 2005.

Figure 6.8 Benefit-Cost Ratios over Time for Drinking Water Disinfection Program (20 Percent Effectiveness Target)



Source: Larsen 2005.

Table 6.22 Benefits of Intervention Alternatives in Colombia, Morbidity

	Effectiveness target	
Diarrheal illness	*Low*	*High*
Baseline annual cases (Larsen 2004) (million cases per year)	30.0	30.0
Avoided annual cases (million cases per year)		
Improved water supply and sanitation (rural areas)	1.2	1.7
Hygiene program (improved handwashing)[a]	1.0	2.0
Drinking water disinfection program (household boiling of water)	0.5	1.0
Total avoided annual cases	2.7	4.7
Total avoided cases (% baseline cases)	9	16

Source: Larsen 2005.
a. Includes approximately 0.35 million to 0.70 million cases in the population age 5 and over.

Table 6.23 Benefits of Interventions in Colombia, Child Mortality

	Effectiveness target	
Diarrheal child mortality	*Low*	*High*
Baseline estimated annual cases (Larsen 2004)	1,634	1,634
Avoided annual cases		
Improved water supply and sanitation (rural areas)	65	90
Hygiene program (improved handwashing)	74	147
Drinking water disinfection program (household boiling of water)	28	56
Total avoided annual cases	167	293
Total avoided cases (% baseline cases)	10	18

Source: Larsen 2005.

potential health benefits, but only if at least 20 percent of the population responds favorably to the program and improves handwashing practices. With a 20 percent response rate to a hygiene program and a household drinking water disinfection program, and provision of improved rural water supply and sanitation facilities, the estimated total avoided cases of diarrheal morbidity and diarrheal child mortality are 16 and 18 percent of baseline cases, respectively.[19]

Hygiene improvement and disinfection of drinking water at point of use have substantial potential to reduce diarrheal illness and mortality, as indicated in table 6.2. The challenge, however, is to develop and deliver programs that induce sustained behavioral response on a large scale, while maintaining program costs at an affordable level.

Conclusions and Recommendations

A hygiene program that includes a handwashing component has the largest potential health benefits. With 20 percent program effectiveness, that is, if 20 percent of the targeted population practices handwashing, and implements a household drinking water disinfection program, plus provision of improved rural water supply and sanitation facilities, the estimated total avoided cases of diarrheal illness and diarrheal child mortality are 16 and 18 percent of baseline cases, respectively.

Hygiene improvement and disinfection of drinking water at point of use have substantial potential to reduce diarrheal illness and mortality. The challenge, however, is to develop and deliver programs that induce sustained behavioral response on a large scale, while maintaining program costs at an affordable level.

An additional element of a comprehensive approach to tackle problems related to water supply and sanitation that might be considered is interventions aimed at improving water supply and sanitation services in medium and small municipalities. It would be advisable to apply the policy developed by the government of Colombia, with the support of the Water Sector Reform Assistance Loan (World Bank Loan 7077-CO), to provide support to such municipalities based on institutional improvements of those utilities accomplished through private sector participation, and with provision of subsidies to the reformed utilities. Subsidies are directed exclusively to benefiting the poor.

It would also be advisable to reform the environmental regulatory framework, which continues to constrain private sector participation in water supply and sanitation. Providing improved rural water supply and sanitation facilities would be a central pillar of a policy to prevent waterborne diseases. From the perspective of environmental protection, private sector participation in water supply and sanitation can be promoted through the design and implementation of efficient, clear, and transparent "rules of the game" for investment, particularly those rules regarding drinking water quality standards, environmental impact assessment, discharge standards, and effluent fees. To correct the deficiencies associated with EIA regulations, new mechanisms might be designed that categorize projects based on the significance and magnitude of their potential environmental impacts, guarantee adequate public participation, and appraise environmental liabilities. Such regulations should define methodologies for preparation of EIAs and for the scope of environmental management plans. Problems with the water pollution fee system might be addressed by designing a progressive scheme tailored to local conditions. To overcome the obstacles posed by Decree 1594 of 1984 associated with effluent standards, it is advisable to modify the regulated parameter so that pathogens and toxic and hazardous substances can be controlled.

Table 6.24 contains a summary of these recommendations.

Table 6.24 Summary of Recommendations for Reducing Waterborne Diseases in Colombia

Recommendation	*Responsible government agencies*
Design and implement a hygiene program that includes components on handwashing and point-of-use disinfection of drinking water	MSPS, MAVDT, CARs, INS
Reform environmental regulatory framework to remove constraints on private sector participation in water supply and sanitation	Congress, MAVDT, DNP
Modify EIA regulations to expedite water supply and sanitation works including the design of new mechanisms that categorize projects based on significance and magnitude of potential environmental impacts, and guarantee adequate public participation	Congress, MAVDT, CARs
Modify water pollution fee system to suit local conditions	Congress, MAVDT, CARs
Modify law and regulations on parameters of effluent standards so that pathogens and toxic and hazardous substances are regulated	Congress, MSPS, MAVDT, CARs

Source: Authors.
Note: DNP = *Departamento Nacional de Planeación*; INS = *Instituto Nacional de Salud*; MSPS = *Ministerio de Salud y Protección Social*.

Notes

1. Bjorn Larsen and Ernesto Sánchez-Triana are the authors of this chapter, which draws heavily from background documents prepared for this study by Larsen (2005) and Enríquez (2004).
2. Diarrhea is a symptom of infection caused by a host of bacterial, viral, and parasitic organisms, most of which can be spread by contaminated water. It is more common when there is a shortage of clean water for drinking, cooking, and cleaning; basic hygiene is important in prevention. Diarrhea can also spread from person to person, aggravated by poor personal hygiene. Food is another major cause of diarrhea when it is prepared or stored in unhygienic conditions. Water can contaminate food during irrigation, and fish and seafood from polluted water may also contribute to the disease.
3. The lower bound for diarrheal mortality (1,450 deaths) is based on 7.3 percent of official death records, while the upper bound (1,820 deaths) is based on 7.3 percent of total estimated child mortality published by DANE. Official death records represent a significant understatement of actual deaths in most developing countries because of underreporting by households. DANE therefore publishes estimated mortality in addition to official records.
4. The DALY is a standard metric of the burden of disease that combines life years lost as a result of illness and disability, with one DALY being equal to the loss of one healthy life year (Murray and López 1996).
5. This program has been financed partially with proceeds from World Bank Loan 7077-CO.
6. Screening refers to the procedure used to define whether the potential environmental impacts of the project under consideration are significant and thus trigger the preparation and define the scope of an EIA (Sánchez-Triana and Morillo 1998).
7. Scenario II corresponds to the situation typically found in developed countries.
8. The reduction in diarrheal illness from the combined results of Huttly, Morris, and Pisani (1997) and Quick and others (1999) is calculated by $1 - [(1 - 0.35)(1 - 0.45)] = 0.65$, as applied by Pruss and others (2002).
9. Mead and others (1999) found that 35 percent of intestinal illness is foodborne in the United States.
10. The urban share of the population in scenario III in table 6.11 is lower than the share with piped water in the high case because some households (approximately 2 percent) do not have basic sanitation and are therefore not included in scenario III.
11. Most of the households boil water to disinfect it.

12. Health benefits include the avoided cost of treatment of diarrheal illness (cost of visits to medical facilities and cost of medicines) and the value of avoided time losses.
13. Per capita investment costs represent average costs in South America (WHO and UNICEF 2000).
14. The reason for the lower ratio for a combined delivery of improved water and sanitation is that the relative risk in scenarios Va and IV in table 6.6 is the same.
15. A benefit-cost analysis is not undertaken for urban water and sanitation improvement because of the low population share that would benefit from improvements to scenario IV according to table 6.11.
16. The cost of 35,000 pesos is higher than the figure for rural areas used in the water and sanitation section. This is because the cost of 35,000 pesos reflects higher medical costs and value of caretakers' time in urban areas, and because the medical cost of diarrheal illness in children is higher than in adults because a higher share of diarrheal illness in children is treated than in adults.
17. Note that the ratio is 0.8 regardless of program effectiveness because of the assumption that incremental program cost is zero.
18. If incremental program cost were positive, then the benefit-cost ratio would be lower than 0.8, but would be somewhat higher for a two-year behavioral change scenario than for a one-year scenario.
19. The sum of avoided cases for the three interventions is an overestimate to the extent that some of the same households receive improved water supply and sanitation, improve their handwashing practices, and start disinfection of their drinking water. The extent of the overestimate could be 1 to 2 percentage points.

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CHAPTER 7

Improving Air Quality

Poor air quality is a significant problem in Colombia, especially for the three-quarters of Colombians who live in urban areas. Air pollution is associated with increased respiratory illnesses and premature mortality, damage to buildings and vegetation, and poor visibility. Particulate matter alone is responsible for an estimated 6,000 premature deaths and 7,400 new cases of chronic bronchitis in the country every year. To tackle this problem, Colombia urgently needs to intensify its efforts to implement a broad strategy for reducing general urban air pollution, particularly fine particulate matter.

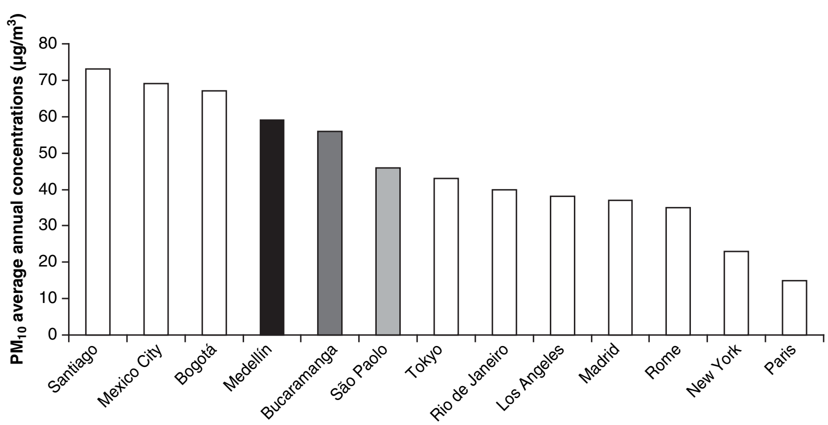
Air quality problems tend to be most severe in urban areas, where both population and pollution sources, such as automobiles and industry, are most concentrated.[1] In Colombia, more than three-fourth of the population live in urban areas, and about one-third live in cities with more than 1 million inhabitants (World Bank 2005). Increased respiratory illness and premature mortality are the principal air pollution–induced health problems in the country. In addition, air pollution damages buildings and vegetation and lowers visibility.

Comparisons between the annual mean concentrations of particulate matter less than 10 microns in diameter (PM_{10}) in Colombia's main cities and those of other urban centers must be made with caution because of the complexities and challenges associated with the measurement of these pollutants. In many cases, cities have a monitoring network in which concentrations vary widely from one station to another or from one time period to the next, and thus the mean value may not accurately reflect the severity of air pollution. However, a first approximation suggests that PM_{10} concentrations in Bogotá are similar to those in other Latin American cities with severe air pollution, including Mexico City and Santiago, Chile. The differences in mean PM_{10} concentrations are much more obvious when compared with those of cities outside the region. Cities such as Los Angeles, Rome, and Tokyo have successfully reduced their ambient concentrations to levels lower than in Medellín and Bucaramanga (figure 7.1).

Although several major pollutants, including ozone, cause concern in urban areas, the most serious health effects are caused by respirable particulate matter of less than 2.5 microns ($PM_{2.5}$). Pollution from particulate matter is responsible for an estimated 6,000 premature deaths and 7,400 new cases of chronic bronchitis every year (Larsen 2004). Air pollution in Colombia contributes to about 13,000 hospitalizations and 255,000 emergency room and outpatient visits to hospitals each year (table 7.1).

As detailed in chapter 5, the mean estimated annual health cost of urban air pollution from particulate matter (PM) alone is about Col$1.5 trillion (US$698 million), or 0.8 percent of gross domestic product (GDP). About 65 percent of the cost is associated with mortality, and 35 percent with morbidity. Because PM has the greatest health and economic impacts it is the main focus of this chapter.

Figure 7.1 Mean Annual Concentration of PM_{10} in Cities



Source: World Bank 2005.
Note: μg/m^3 = micrograms per cubic meter.

Table 7.1 Estimated Health Impact of Urban Air Pollution in Colombia

	Annual impacts	
Health categories	*New cases*	*Total DALYs*
Premature mortality	6,040	45,300
Chronic bronchitis	7,410	16,300
Hospital admissions	12,970	210
Emergency room visits and outpatient hospital visits	255,000	1,150
Restricted activity days	42,000,000	12,640
Lower respiratory illness in children	585,000	3,800
Respiratory symptoms	135,000,000	10,100
Total	n.a.	89,500

Source: Larsen 2004.
Note: DALYs = disability-adjusted life years; n.a. = not applicable.

More than 80 percent of national costs from PM are concentrated in only four departments and the Bogotá capital district. Bogotá alone accounts for 50 percent of national costs, which is equivalent to nearly 2 percent of Bogotá's GDP, or nearly 3 percent of GDP if the cost of mortality is based on the value of statistical life (VSL) approach (Larsen 2005b).

The rest of this chapter will examine the existing legal and regulatory framework for air quality management, the performance of that framework, the range of potential interventions to control air pollution, the costs and benefits of interventions to control emissions from mobile sources in Bogotá, and conclusions and recommendations for improving air quality in Colombia.[2]

Air Quality Management

The following sections describe the legal framework that governs air quality management in Colombia. This is followed by examination of key pollutants and monitoring systems, and controls relating to stationary, mobile, and nonpoint sources of air pollution.

Legal Framework

The framework for Colombia's air quality management system originated in Law 2811 of 1974, the National Code for Renewable Natural Resources and Environmental Protection. That code did not include specific regulations for air pollution control, but Article 75 specified that the national government should approve regulations to prevent air pollution. Consequently, Law 9 of 1979 (the Sanitary Code) defined the general criteria for further development of regulations related to the management and control of wastes, effluents, and emissions that could affect human health. The Sanitary Code was prepared by the Ministry of Health and led to preparation and approval of Decree 2 of 1982, which defined national ambient standards for five air pollutants—total suspended particulates (TSP), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides measured as nitrogen dioxide (NO_2), and ozone (O_3). These standards, determined by the Ministry of Health and the Department of National Planning, were developed without public participation because participatory mechanisms were very limited at the time (Universidad de los Andes 2004b).

Before 1993, the key authorities responsible for air quality management in Colombia were the national and local health authorities, while in Bogotá the Department of Transportation was responsible for controlling air pollution emissions generated by vehicles (Universidad de los Andes 2004b). Law 99 of 1993, which created both the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA) and the National Environmental System, transferred responsibility for air quality management to environmental authorities.

The Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT) is responsible for issuing all environmental legislation related to air quality or emissions generated by every type of source (fixed, mobile, or nonpoint). The Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs) or Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs) are in charge of implementing or complying with these norms. Nevertheless, the CARs and AAUs can, under the subsidiary principle considered in Law 99 of 1993, issue more stringent requirements that are initially temporary (for two months), and the ministry, through an evaluation presented by the CARs or AAUs, can make those requirements permanent in accordance with the requirements and parameters established in Decree 948 of 1995 (MAVDT 2006, p. 7).

Based on Law 99 of 1993, Decree 948 of 1995 established the first standards for fuel quality and for emissions from mobile and nonpoint sources. Decree 948 was followed by a series of additional decrees and resolutions, described in table 7.2, that regulated emissions from both mobile and stationary sources.

Key Pollutants and Monitoring Systems

Key sources of air pollution include stationary point sources such as factories and power plants; mobile sources that consist almost entirely of

Table 7.2 Development of National Norms on Air Pollutant Emissions, 1995–2002

Decree or resolution	*Regulation or requirements*
Decree 948 (1995)	Structures the legal framework to be developed for air, not only with respect to emission standards for mobile sources but also for fixed, dispersed, and nonpoint sources; the development of intake emission norms and the mechanisms for their monitoring and oversight; fuel quality guidelines for developing standards on noise and odors; functions of environmental authorities; permits and licenses; public participation; and penalty rulings. In general, it establishes the policy framework for developing measures to prevent and control atmospheric pollution and to protect air quality (MAVDT 2006, p. 7).
Decree 2107 (1995)	Relaxes some restrictions on heavy oils, controlled burning, and the time required to adopt cleaner technologies to protect the atmosphere (issued in Decree 948 of 1995). Establishes regulations on diesel vehicles, emissions by mobile sources, and requirements for emissions permits.
Res. 898 (1995)	Regulates environmental criteria for quality of solid and liquid fuels used in commercial and industrial kilns and boilers and in motor vehicle engines; • Regulates quality of liquid fuels, gasoline, and diesel • Regulates quality of mineral coal used in kilns and boilers • Establishes maximum sulfur content of 1.7 percent by weight for industrial fuel oil
Res. 1351 (1995)	Adopts Form IE-1 (Industrial Emissions), also called the "Report of the State of Emissions," to be filled out and presented to the competent environmental authority by emissions producers or their legal representatives.
Res. 005 (1996)	Includes a glossary of technical definitions, general regulations for emissions, procedures to measure emissions, requirements for operation of measuring equipment, certification for mobile emission sources, mandatory verification process, and monitoring of diagnostic centers. Partially modified by Resolution 909 of 1996.
Res. 378 (1997)	Establishes the characteristics for emission certification tests for car manufacturers and importers of vehicles.
Res. 619 (1997)	Determines the factors for granting permits to nonmobile emission sources.
Decree 1228 (1997)	Requires importers of vehicles and vehicle assembly kits to present an Emissions Certification by Dynamic Test that is approved by the Ministry of Environment as complying with emissions requirements by vehicle weight.
Decree 1697 (1997)	Loosens Decree 948 by establishing new regulations for burning used lubricant oils and for sulfur content and other polluting substances in fuels.

(*continued*)

Table 7.2 Development of National Norms on Air Pollutant Emissions, 1995–2002 *(continued)*

Decree or resolution	*Regulation or requirements*
Res. 0415 (1998)	Relaxes Decree 948 and establishes specific requirements for oil combustion based on source, usage, and concentrations. Establishes procedures to issue emissions permits and requires users to keep a log that includes information on the used oil provider, source of the oil, volume and proportion of the oil used in the mixture, and type of fuel used in mixture with the used oil.
Res. 0623 (1998)	Modifies Resolution 898 of 1995 regarding quality of solid and liquid fuels used in commercial and industrial kilns and boilers and establishes new parameters on coal quality and mixtures used as fuel.
Res. 1048 (1999)	Establishes limits on pollutants emitted by mobile sources with diesel and gasoline engines, based on dynamic tests, for vehicles built after 2001.
Res. 0970 (2001)	Establishes emissions limits when pesticide containers are incinerated in kilns or cement factories.
Res. 058 (2002)	Establishes requirements for maintenance and control of solid and liquid waste incinerators and sets emission limits based on • Average daily and half-hourly concentrations per contaminant, • Concentrations of heavy metals, • Concentrations of dioxins and furans.
Res. 0886 (2004)	Relaxes emission time limits and maximum emission restrictions, clarifies and distinguishes operating limits and characteristics (particularly temperatures and chambers) for incineration plants according to loads and for crematory ovens.
Res. 1446 (2005)	Modifies Resolution 0415 of 1998, establishing conditions for the use of untreated, used oil as fuel and the specifications and conditions under which treated, used oil can be used, for which a specific degree of treatment and quality standards (particularly concentrations of heavy metals) should be complied with.

Source: Blackman and others 2005; Universidad de los Andes 2004b.

exhaust from vehicles; and nonpoint sources that include agriculture, construction, and emissions from the residential and commercial sectors.

Particulate matter is the term for airborne particles, including dust, dirt, soot, smoke, and liquid droplets. Particles can be suspended in the air for long periods. Some particles are directly emitted into the air. They come from a variety of sources such as vehicle exhaust, factories, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Particles also can be created by atmospheric conversion of SO_2 and nitrogen oxide (NO_x) into sulfates and nitrates. Most measurements of particulate matter in Colombia are of TSP. Only Bogotá has monitoring stations that measure PM_{10}, which can be inhaled into the lungs and lead to respiratory illness associated with premature mortality. Despite strong scientific evidence that elevated concentrations of $PM_{2.5}$ pose an even greater health risk than PM_{10}, no systematic monitoring information on $PM_{2.5}$ is available in Colombia.[3]

Sulfur dioxide (SO_2) is a by-product of burning fossil fuels such as crude oil and coal. Increased use of lower sulfur fuels for energy generation appears to have reduced SO_2 concentrations in Colombia over the past two decades (Universidad de Los Andes 2004). SO_2 is a stinging gas that causes respiratory ailments in humans and, as noted earlier, can be transformed in the atmosphere into sulfates that appear as fine particles. In moist environments, SO_2 emissions result in acidification and winter smog.[4]

Nitrogen oxides (NO_x) also contribute to respiratory ailments in humans. They result from vehicle exhaust, combustion installations such as power plants, and industrial and agricultural activity. NO_x react with other air pollutants to form ozone and fine particulates (nitrates) in the lower atmosphere and also contribute to acidification processes. The use of catalyzers in car exhaust systems can reduce NO_x emissions from motor vehicles.

Volatile organic compounds (VOCs) encompass various contaminants, including organic compounds and solvents. These compounds are emitted from petroleum reservoirs, storage systems for gasoline and other volatile compounds, industrial processes and fuel combustion, use of paints and cleaners, and agricultural activities. VOCs are the main cause of smog in the lower atmosphere. They react with other chemicals in the atmosphere to create harmful secondary pollutants, including ozone, and cause health problems ranging from eye irritation to decreased lung capacity and even cancer.

Carbon monoxide (CO) is a product of incomplete combustion of fuels. CO binds to hemoglobin in the blood, preventing the transport of oxygen to vital organs.

Colombia has a fairly long history of air quality monitoring. During 1967 to 1975, the Pan American Health Organization and the Ministry of Health set up and operated systems to monitor TSP and SO_2 in several cities, including Bogotá and Medellín. These programs were taken over fully by the Ministry of Health in 1974. More monitoring stations were set up in many locations in response to Decree 2 of 1982. In Bogotá, the

Department of Health installed and operated 12 monitoring stations during 1983 to 1991. During 1990 to 1993, the Japan International Cooperation Agency financed the installation and operation of five additional monitoring stations. The data generated by these stations were used extensively by the Ministry of Health to control air pollution in the most important urban centers.

Law 99 of 1993 removed all responsibility for air pollution control from the Ministry of Health and the Secretariats of Health. As a result, during 1993 to 1997 there were no air quality monitoring networks in operation in Colombia. In 1997, the AAU for Bogotá (*the Departamento Administrativo del Medio Ambiente*, DAMA) installed a new network of 12 stations that monitored a range of pollutants, including $PM_{2.5}$, PM_{10}, the five pollutants specified in Decree 2 of 1982, and others. However, $PM_{2.5}$ was only monitored until 1999, when the equipment was damaged and not replaced. The story is somewhat similar in Medellín, with the installation of seven stations by the Department of Health in 1983. These stations were replaced by a new system in the late 1990s, composed of 18 stations in the Aburra Valley with the capacity to measure PM_{10} and the five pollutants noted in Decree 2 of 1982. However, the operation of this newest network has been interrupted several times by legal issues and problems associated with calibration of equipment, resulting in information voids (Universidad de los Andes 2004b).

Air Quality Standards

Table 7.3 shows the maximum annual, daily, and hourly ambient concentrations for TSP, SO_2, CO, NO_2, and O_3 established in Decree 2 of 1982, which are still in effect today. Limits refer to continuous samples taken over a specific period (1, 3, 8, or 24 hours). The annual limit allows for days with higher concentrations as long as the annual average concentration does not exceed the specified levels. Similarly, concentrations can exceed the daily or hourly limits as long as the overall concentration for the day or hour period specified is below the level.

In Bogotá, DAMA issued Resolution 1208 of 2003, which established more stringent requirements or shorter averaging periods for a number of pollutants and, most important, introduced a formal standard for PM_{10}. For the purpose of measuring air quality, DAMA divided the city into five sectors served by a total of 14 stations with air quality monitors that have been in operation since 1997. Rules for monitoring and standards for concentration levels are included in DAMA Resolution 391 of 2001. The standards in effect in 2003, along with future requirements for 2006 and 2010, are shown in table 7.4.

Table 7.3 Air Quality Standards: Decree 02 of 1982

Pollutant	*Limit*	*Observations*
Total suspended particles (TSP)	100 µg/m³	Annual geometric average of all daily samples
	400 µg/m³	Maximum daily concentration, exceeded only once a year
Suspended particles (PM_{10})	No separate limit established	
Sulfur dioxide (SO_2)	100 µg/m³	Annual arithmetic average of all daily samples
	400 µg/m³	Maximum daily concentration, exceeded only once a year
	1,500 µg/m³	Maximum 3-hour concentration, exceeded once a year
Carbon monoxide (CO)	15 mg/m³	Maximum 8-hour concentration
	50 mg/m³	Maximum 1-hour concentration
Nitrogen dioxides (measured as NO_2)	100 µg/m³	Annual arithmetic average of all daily samples
Photochemical oxidants (expressed as ozone, O_3)	170 µg/m³	Maximum 1-hour concentration, exceeded once a year

Source: Sánchez-Triana and Medina 1994.
Note: µg/m³ = micrograms per cubic meter.

Table 7.4 Standards for Air Quality in Bogotá, DAMA Resolution 1208 of 2003

			Limit (µg/m³)		
Pollutant	*Period*	*Description*	*2003*	*2006*	*2010*
Carbon monoxide (CO)	8 hours	Average hourly concentration for 8 hours	12,000	11,000	10,000
	1 hour	Average hourly concentration	40,000	40,000	40,000
Sulfur dioxide (SO_2)	Annual	Arithmetic average of the average daily concentrations for 365 days	80	70	60
	24 hours	Average hourly concentration for 24 hours	350	325	300
	3 hours	Average hourly concentration for 3 hours	1,400	1,350	1,300
Nitrogen dioxide (NO_2)	Annual	Arithmetic average of the average daily concentrations for 365 days	100	100	100
	24 hours	Average hourly concentration for 24 hours	220	180	150
	1 hour	Average hourly concentration	320	320	320
Ozone (O_3)	8 hours	Average concentration for 8 hours	130	110	100
	1 hour	Average hourly concentration	170	155	150
Total suspended particles (TSP)	Annual	Geometric average of the average daily concentrations for 365 days	100	85	80
	24 hours	Average hourly concentration for 24 hours	400	300	300
Particulate matter (PM_{10})	Annual	Arithmetic average of the average daily concentrations for 365 days	80	55	50
	24 hours	Average hourly concentration for 24 hours	180	155	150

Source: Universidad de los Andes 2004b.
Note: µg/m³ = micrograms per cubic meter.

Stationary Source Controls

Emission standards established under Decree 02 of 1982 govern the volume and concentration of PM, SO_2, and NO_2 that may be emitted to the outside air through a duct. They also establish minimum allowable stack heights. PM is classified according to the type of activity involved:

- Coal-fired boilers
- Cement industry, including kilns (where clinker is produced), mills (where clinker is crushed), and clinker coolers
- Metallurgy industry because it uses induction kilns and electric arc furnaces
- Asphalt factories
- Incinerators of all waste types (domestic, industrial, special, and hazardous).

The allowable stack height for boilers depends on the location (rural or urban). The minimum height is 15 meters. The volume of allowable emissions is based on energy consumption. The standard is stated in kilograms of particles per million kilocalories of energy consumed per hour. The emissions standards established for boilers in Decree 02 of 1982 are still in effect today.

Allowable emissions for clinker kilns in the cement industry depend on output. That is, the standard is stated in terms of PM per tons of cement produced. The minimum height of the chimney is 30 meters.

There are specific controls on emissions for some activities. For example, allowable emissions from the production of sulfuric acid (H_2SO_4) are stated in terms of SO_2, SO_3, and H_2SO_4 per ton of output and the minimum stack height is set at 25 meters. Article 79 of the Decree contains specific controls for boilers, kilns, and other combustion processes that generate SO_2 emissions. While Article 79 does not limit the concentration of SO_2 emissions, it does govern stack height according to the sulfur content of the fuel. Similarly, Chapter VI of the Decree governs emissions of NO_2 from the production of nitric acid.

Resolution 058 of 2002 and Resolution 0886 of 2004 regulate emissions from incinerators that burn any of a wide range of wastes, including wastes containing polycyclic aromatic hydrocarbons such as polychlorinated biphenyls, pentachlorophenol, nonexplosive liquid or solid wastes, additives for lubricant oils, wood treated with halogenated compounds, domestic waste, residues from petroleum refineries and naphtha production, medical waste, and any other waste indicated by the Ministry of Health.[5]

Although detailed information about compliance is not available for these standards, it is widely believed that noncompliance is a serious problem. According to Blackman and others (2005), in the case of incinerators, informal interviews with industrial experts undertaken by Resources for the Future (RFF) suggest that the combination of stringent technical standards and siting problems may be an important deterrent to compliance. However, the MAVDT (2006, p. 8) considers that the standards established in the country for incinerators are similar to those established by the U.S. Environmental Protection Agency and that some parameters (such as dioxins and furans) are more flexible (time limits of 10 years to comply with standards that in some cases are more lax than those of the U.S. Environmental Protection Agency), and that compliance is economically and technically feasible.

Mobile Source Controls

On the basis of studies conducted by Fedesarrollo (Perry and others 1991; Perry and others 1993) and a study conducted by the Colombian Petroleum Company (Ecopetrol 1992), the National Planning Department decided, in 1994, to phase out leaded gasoline. This decision marked the most notable advance to date in the history of air pollution control in Colombia.

Resolution 005 of 1996 regulates hydrocarbon (HC) and CO emissions from gasoline vehicles and the opacity of emissions from diesel vehicles, measured via static tests (idling or running). In addition, it includes HC, CO, and NO_x emission standards for dynamic testing of vehicles imported since 1997 (modified by Resolution 1048 of 1999). These standards apply to all types of vehicles: public and private, automobiles, buses, and trucks (MAVDT 2006, p. 8).

In the 1990s, *Departamento Técnico Administrativo del Medio Ambiente, Bogotá* (DAMA) and *Departamento Administrativo de Gestión del Medio Ambiente, Cali* (DAGMA) established environmental vehicle control programs. Requirements for periodic emissions tests of vehicles were established. Emissions certificates are issued at specialized diagnostic centers to vehicles that pass the emissions test. If the vehicle does not pass the test, the owner must perform the required adjustments to the engine. The diagnostic centers are audited periodically to determine if the proper procedures are being followed.

In some cities, mobile brigades have been introduced to check vehicles for current emissions certificates. Bogotá introduced a “day without my car” program on a pilot basis that designated day each year private vehicles (excluding buses or taxis) are banned from city streets.

In addition to tailpipe emission standards, fuel quality is a major contributor to mobile source emissions. Table 7.5 shows standards for the sulfur content of gasoline and diesel. In Bogotá, with the advent of the Transmilenio System, a new type of fuel called diesel extra with a sulfur content of 1,200 parts per million (ppm) was introduced for use in buses (Resolution 068 of 2001).

Resolution 1565 of 2004, issued by MAVDT and the Ministry of Mining and Energy, postponed until July 1, 2008, the requirement that the sulfur content of all gasoline and diesel in Colombia be reduced to 500 ppm or less. To meet this new standard, Ecopetrol plans to modernize its Cartagena refinery and implement a new hydro-treatment program at the Barrancabermeja refinery. If those modernization plans are not completed on time, fuel imports may have to be increased to meet the new standard. Finally, efforts are under way to further increase the availability of natural gas and encourage its use as a transportation fuel, especially in the largest urban centers.

Fuel Subsidies

Historically, the price of fuels in Colombia has been controlled in line with domestic production costs rather than international prices. These price controls have in effect subsidized domestic fuel consumption, thereby exacerbating congestion, air pollution, and health and environmental damage. In the 1990s, several studies (Krupnick, McConnell, and Uribe Botero 1996; Perry and others 1991; Perry and others 1993) estimated that gasoline prices were about 30 to 35 percent below international levels. Diesel prices are reportedly even further below international levels.

The current policy is to reduce future demand for fuel in the transportation sector by bringing local prices of gasoline and diesel into line with international prices by 2006 through annual adjustments of about 15 percent in 2005 and 2006. One study estimated that this policy would reduce demand for transportation fuels by 8 percent relative to 2002 levels (Brugman 2004). Corresponding reductions in emissions of

Table 7.5 Regulation of Sulfur Content in Gasoline and Diesel Fuels

	Sulfur content (ppm)		
Resolution (Ministry of Environment)	*Gasoline*	*Diesel*	*Diesel extra*
898 of 1995	1,500	6,000	n.a.
068 of 2001	1,000	4,500	1,200

Source: Blackman and others 2005; Universidad de los Andes 2004.
Note: n.a. = not applicable; ppm = parts per million.

PM_{10}, SO_x, and NO_x are estimated to be about 2.3 percent in 2005 and 7.7 percent by 2020. In addition, a 20 percent local surtax on gasoline has been introduced as part of the Transmilenio mass transit system, with half of the revenues (mostly paid by private vehicles) used to support Transmilenio while the other half is earmarked for road maintenance and related activities.

Currently, about 15 percent of the 7 million daily trips by public transportation in Bogotá are made on Transmilenio.[6] Transmilenio uses high-capacity buses that travel at an average speed of 27 kilometers (16.9 miles) per hour along 56 kilometers (35 miles) of exclusive corridors. For each new bus added to the Transmilenio system, seven old buses are destroyed. As part of the Transmilenio system, extensive bicycle paths also have been constructed throughout the city.

One study evaluated the reduction of emissions associated with mass transportation systems in Barranquilla, Bogotá, Cali, Medellín, and Pereira (Brugman 2004). According to this study, these systems are expected to reduce emissions of PM_{10}, SO_x, and NO_x caused by mobile sources by an estimated 4.2 percent, 0.9 percent, and 2.6 percent, respectively, in 2005, and by 6.5 percent, 1.6 percent, and 5.9 percent, respectively, by 2020 (table 7.6). Unfortunately, no specific data are available on the air quality effects of Transmilenio. However, the diesel extra used by the Transmilenio buses does have a lower sulfur content.

Nonpoint Sources

Although a considerable number of nonpoint sources contribute to the degradation of air quality in Colombia, most attention has focused on the practice of burning sugarcane fields at certain stages of the cultivation

Table 7.6 Emissions Reductions with Mass Transportation Systems, 2004–20

	Pollutant (tons)				*Pollutant (percent)*			
Year	*PM_{10}*	*SO_x*	*NO_x*	*Total*	*PM_{10}*	*SO_x*	*NO_x*	*Total*
Average emissions, 2001–03	36,067	108,017	237,961	382,045	100	100	100	100
Reduction								
2004	684	443	2,820	3,947	1.9	0.4	1.2	1.0
2005	1,500	1,014	6,124	8,638	4.2	0.9	2.6	2.3
2010	2,480	1,528	12,183	16,192	6.9	1.4	5.1	4.2
2015	2,296	1,643	12,550	16,488	6.4	1.5	5.3	4.3
2020	2,333	1,750	14,124	18,207	6.5	1.6	5.9	4.8

Source: Brugman 2004.
Note: The systems include those of Barranquilla, Bogotá, Cali, Medellín, and Pereira.

cycle, which can cause serious air pollution problems. Efforts have been made to restrict burning and reburning in populated areas. For example, the Regional Autonomous Corporation for the Cauca Valley (*Corporación Autónoma Regional del Valle de Cauca*, CVC) has reached a voluntary agreement with the association of sugarcane farmers under which they use the so-called green cut method[7] for harvesting crops within 1,000 meters of urban areas, 30 meters from villages, 80 meters from highways, and 30 meters around high-tension transmission lines.

According to MAVDT (2006, p. 8), the "sugarcane sector has been working for almost 10 years on the mechanization of crops and their development, using scientific studies and knowledge of atmospheric conditions to create mechanisms that minimize the impact of the practice of burning the sugarcane fields, which are the circumstances under which the Ministry issued Resolution 1565 of 2004 establishing the conditions and measures necessary to promote this practice. While the impact of this burning cannot be denied, medical studies by the Colombian Pneumological Foundation have not found greater impacts than those of other activities, aside from 'the serious problems' of air pollution."

Performance of the Air Quality Management System

Information available on the performance of Colombia's air quality management system falls into two general categories: process measures and outcome measures. Process measures are specific actions undertaken with the goal of improving air quality, such as the number of vehicles inspected or the number of hectares of sugarcane harvested through green cuts. Outcome measures are more direct indicators of air quality. The most direct outcome measures are ambient concentrations of fine particles or other major pollutants, calculated on a daily or annual basis. Despite the obvious limitations, emissions also are treated as outcome measures of the air quality management system.

Emissions by Pollutant

Air quality regulations have been in effect in some form for over two decades in Colombia. The Institute of Hydrology, Meteorology, and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) has developed a number of baseline indicators. The methodology underlying these indicators has been used to develop national estimates and to assist with the management of urban air quality throughout the country.

Emissions estimates are based on a standard formulation that relies on emissions factors rather than monitoring data.[8] Information on economic activity is derived from the yearly manufacturing survey of the National Administrative Statistics Department (*Departamento Administrativo Nacional de Estadísticas*, DANE). Emissions factors are taken from various sources including the Industrial Pollution Projection System, the Intergovernmental Panel on Climate Change, the U.S. Environmental Protection Agency, and the European Union's emission inventory program. Emissions estimates cover 232 municipalities included in DANE's manufacturing survey, but only include industries with more than 10 employees or output valued at Col$70.5 million (US$32,800) or more per year (1999 values). Thus, brick kilns and other small firms—which may be large sources of emissions—are typically excluded.

Although the preferred approach for aggregating emissions across pollutants is based on the economic damage caused by the emissions, a simple aggregation based on the total tons can reveal patterns about emission sources. For example, Bogotá clearly tops the list for total (aggregate) tons of particulate matter emitted. However, the municipality of Nobsa, with a population of less than 10,000, has higher emissions than many large cities (Pereira, for example) because of its relatively high concentration of artisan brick kilns and cement and steel factories. The highest aggregate level of SO_2 emissions is found in cities with a large number of power plants or other industrial facilities burning biomass, coal, or high-sulfur fuel oil.

It is also useful to look beyond the legal boundaries of cities and examine emissions in the broader context of urban and industrial centers. Such an examination shows that there are sometimes large differences, measured in tons of pollution, between emissions from within the municipal boundaries and those from the larger urban and industrial centers. For example, stationary emissions of PM in the industrial corridor of Cali-Yumbo are higher than those in the city of Cali itself.

More detailed information is available for selected areas. A study by the Universidad de los Andes (2004b) found that in Bogotá, PM emissions from stationary sources grew by 182 percent during 1989 to 1999, with industrial kilns and furnaces—including many small and medium enterprises—accounting for three-fourths of the emissions from these sources. According to the study, the principal fuels used in the manufacturing sector in Bogotá are diesel (44.9 percent), crude oil (24.7 percent), and coal (7.5 percent). In Medellín and the 10 surrounding municipalities that form the metropolitan area of the Aburra Valley, the main polluting industries are paper, cement, brickmaking, and steel, and the key energy sources are hydroelectric (16.6 percent), diesel (12.2 percent), coal (49.1 percent), and crude oil (22.1 percent).

Unfortunately, environmental regulatory agencies generate very little information about compliance by stationary sources of emissions. However, the 2004 Universidad de los Andes study shows that in Bogotá, 2,372 permitted facilities self-report their emissions on an annual basis and that DAMA audits a group of 70 randomly selected facilities. In 2003, these facilities recorded a 63 percent compliance rate with national air emissions standards (Decree 2 of 1982) and a 41 percent compliance rate with the local standards (Resolution 391 of 2001). In Medellín, 160 random inspections of industries were conducted in 2003, covering about 30 percent of all industrial establishments, according to the study. In addition, 53 inspections were conducted in response to public complaints. However, information on the degree of noncompliance is not available.

Ambient Monitoring for Select Areas

In contrast to emissions, which reflect the amount of pollution entering the atmosphere, ambient information reflects the quality of air to which people are actually exposed. While CO, O_3, NO_x, VOCs, and TSP are all associated either directly or indirectly with respiratory or other health effects, the strongest epidemiological link between air pollution and premature mortality is through elevated concentrations of PM_{10}. Given that an estimated 6,000 premature deaths in Colombia result each year from elevated PM_{10} concentrations (Larsen 2004), it is appropriate that a review of the monitoring data should focus on ambient concentrations of this pollutant.

Bogotá and Cali are the only cities with ambient PM_{10} standards. Unfortunately, only limited monitoring data are available to measure compliance. There are about 70 air quality monitoring stations in Colombia (Kojima 2004). Most of them track TSP, a few monitor PM_{10}, and none monitor $PM_{2.5}$ regularly. No nationwide specifications apply to monitoring equipment or operating procedures. Automated instruments are used only in Bogotá, Cali, Bucaramanga, and Barranquilla, while manual or manual-automated combinations are used in other areas. Various technical problems have been reported related to the operation and maintenance of the automated instruments, which rely on sophisticated electronics.[9] Furthermore, the data that are collected are not analyzed at a central level. Concerns also have been raised about the location of the monitors, specifically, that they exclude likely "hot spots." Reportedly, there are plans to relocate some stations.

Notwithstanding the many technical issues surrounding the quality of data on ambient air quality, table 7.7 displays the available monitoring results for annual PM_{10} concentrations in Bogotá and other selected urban areas from 1998 to 2004. In Bogotá, monitoring stations are distributed throughout the city. In most other urban areas, monitoring is more limited. For example, in Bucaramanga there reportedly is only one monitoring station.

Table 7.7 Annual Ambient PM_{10} Levels in Selected Cities

μg/m³

Region and station	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*Change*
Bogotá	—	—	—	65	67	60	—	⬇
CADE	71	65	68	52	54	46	—	⬇
Sony	80	79	69	75	74	56	—	⬇
Cazuca	85	75	70	62	65	56	—	⬇
Santo Tomás	32	30	38	33	42	33	—	⬇
MAVDT	49	49	53	42	55	42	—	⬇
Escuela	—	—	—	—	50	53	—	⇧
Bosque	33	31	32	30	26	—	—	⬇
Corpas	54	45	42	61	97	92	—	⇧
Carrefour	—	—	—	59	97	89	—	⇧
Fontibón	—	—	—	93	93	97	—	⇧
Merck	—	—	—	96	92	101	—	⇧
Olaya	64	—	—	—	—	—	—	—
Bucaramanga	—	—	—	51	56	57	—	⇧
Medellín	—	—	—	—	59	63	64	⇧
Yumbo and Palmira								
Palmira	—	43	—	54	—	—	—	⇧
Yumbo Center (Sta. Station)	—	—	31	—	—	—	—	—
Yumbo Center (Mob. Station)	—	—	68	—	—	—	—	—
Acopi	—	—	70	—	—	—	—	—
Barranquilla								
Agrecon	—	—	—	—	—	—	70[a]	—
Biblioteca	—	—	—	—	—	—	96[b]	—
San Nicolás Valley								
Salenca	32	27	32	26	32.8	—	—	⇧
Hospital	38	61	42	22	30.6	—	—	⬇
Zona Franca	30	21	24	18	23.1	—	—	⬇

Source: Environmental authorities of selected regions; for Medellín: Universidad Pontifica Bolivariana, Redaire's operator at Aburra Valley.

Note: — = not available; μg/m³ = micrograms per cubic meter.

a. Mean of February–June 2004 reading (60, 90, 60, 60, 80).

b. Mean of February–June 2004 reading (110, 120, 50, 180, 120).

Overall, virtually all citywide estimates (except San Nicolás Valley) and most individual monitoring sites report annual PM_{10} concentrations in excess of the 50 micrograms per cubic meter (μg/m^3) standard established by the U.S. Environmental Protection Agency. Because the standards in Colombia are much less stringent than 50 micrograms per cubic meter (μg/m^3), not all these results are counted as violations. For example, in Cali the current annual standard is 70 μg/m^3, and the PM_{10} standard in Bogotá will be tightened to 50 μg/m^3 in 2010 (see table 7.4). Four of the monitoring stations located in the industrial areas of Bogotá (Corpas, Carrefour, Fontibón, and Merck) recorded annual averages well in excess of the local standard.

Among the other cities with monitoring information, Medellín and Barranquilla report annual averages above 60 μg/m^3, as do two of the stations in Yumbo. The Bucaramanga and Palmira sites all report annual averages below 60 μg/m^3.

Although it is difficult to make a strong statement about trends in air quality based on such a limited time series, a rough assessment of the available information can be made. The results are reported as up or down arrows on the right-hand side of table 7.7. Overall, a mixed picture emerges of the trends in air quality. In Bogotá, the measured trend for the citywide average is favorable, although the reverse is true for the industrial areas of the city already in violation of the standards. Given the large increase in vehicles in the city (estimated by the local Transit Authority to have risen by one-third between 2001 and 2003), the observed improvements in the citywide (average) air quality represent a substantial achievement reflecting, no doubt, the restrictions on vehicle use, improvements in mass transit, increased use of natural gas, and other policies recently put in place.

In some cities, the data are more limited and trend analysis is more difficult. In other cities, the available data are not recent enough to capture the impacts on air quality of certain newly instituted policies, such as the recently established vehicle restrictions in Medellín.

Daily PM_{10} Concentrations

Although maximum average pollutant concentrations allowed over a 24-hour period are higher than average annual limits, compliance generally is more difficult. Limited information is available in Colombia on daily PM_{10} concentrations, but average monthly concentrations have increased since 1996 according to one report (Universidad de los Andes 2004).

The pattern of daily PM_{10} concentrations in Bogotá is roughly similar to the average annual concentrations shown in table 7.7, with the highest concentrations in the western part of the city. This is predominantly an industrial area that includes Merck and Fontibón in southwest Bogotá, Clínica Corpas and Calle 80 in northwest Bogotá, and Carrefour in the midwest section of Bogotá.

In Tolima, an air quality monitoring network began operating in 2004 with stations in the municipalities of Ibagué, Payandé, Lérida, and Espinal. Because the monthly average readings are not strictly consistent with the daily (or annual) standards, it is impossible to assess these results. The network is still evolving, and in future years it is expected that the information will be reported in a format consistent with data from other regions.

Pollution Abatement Expenditures

Pollution abatement expenditures are often used as a measure of efforts to reduce emissions. In the United States and many other Organisation for Economic Co-operation and Development nations, expenditure information is generally available on a comprehensive basis, including snapshot measures at different times. Unfortunately, the data available on pollution abatement control expenditures in Colombia are quite limited. There are no consistent national data even for large industrial sectors. Available data are from multiple sources, often with inconsistent definitions. Time series information is virtually nonexistent. Notwithstanding these gaps, it is useful to review the available data for the electric generation and petroleum refining industries.

Law 99 of 1993 mandates that companies that generate electricity from gas, coal, and hydropower allocate 4 percent, 8 percent, and 12 percent of their investments, respectively, to environmental management programs. At the same time, the power generators transfer an estimated 2 to 3 percent of their revenues to the environmental authorities in their jurisdictions. These revenues, in turn, are used to fund reforestation and river basin management activities in the local CARs and AAUs. If consistently applied to environmental management, these revenues would be considered large, even by international standards.

Another effort relevant to investments in pollution abatement involves the establishment of value-added tax (VAT) exemptions provided by Law 223 of 1995. These exemptions were established to allow acquisition of equipment and associated supplies, national or imported, to be used in the construction, installation, assembly, and operation of control

Table 7.8 VAT Exemptions for Environmental Investments, 1997–2003

Year	*Amount (billion Colombian pesos)*
1997	9.0
1998	47.9
1999	57.8
2000	16.2
2001	11.0
2002	6.6
2003	8.6

Source: Controlaría 2004.
Note: US$1 = Col$2,150.

and monitoring systems for recycling and waste processing and treatment of sewerage or atmospheric emissions (or both). The value of exemptions granted during 1997 to 2003 is displayed in table 7.8. As shown, the value of the exemptions rose dramatically during 1997 to 1999 but declined in an equally dramatic manner during 2000 to 2003. It is not clear to what extent these changes reflect underlying patterns of pollution abatement investment or changes in the administration of Law 223 of 1995. According to MAVDT (2006, p. 9), one "of the causes for the decline in the amount of VAT exemptions authorized in 2001 is the issuance of Decree 2532 of 2003, which established specific definitions and criteria that more clearly delimit the granting of tax benefits for pollution abatement investments."

With respect to income tax exemptions, Law 788 of 2002 specifies that the environmental authority should certify whether a company has the right to deduct from its annual income the amount of its environmental investments made in any given fiscal year. Unfortunately, specific information on the operation of this provision is not available.

Mobile Source Policies

Reflecting the large contribution of vehicle emissions to urban air quality, mobile source programs have been established in major Colombian cities. Some highlights from the program implemented by DAMA in Bogotá are listed below (DAMA 2003):

- *Emission certification tests*. Between October 2002 and October 2003, 615,200 certificates were issued to vehicles that passed emissions tests.
- *Checks of motor vehicles for valid emission certificates*. Some 27,411 vehicles were checked in 2001, of which 40 percent had valid certificates. In 2002, 30,120 checks were made, with the same percentage of

valid certificates. In 2003, there were 45,320 vehicle checks and the percentage with valid certificates increased to 60 percent.

- *Audits of certified diagnostic centers*. The performance of diagnostic centers and their compliance with current regulations, procedures, and equipment specifications for issuing emission certificates increased dramatically in recent years. The number of centers that satisfied the audits increased from only 1.9 percent in 2001 to 52.0 percent in 2003.
- *Día Sin Carro*. The "Day Without My Car" program bars private vehicles (not including buses and taxis) from using city streets on a specific day once or twice a year. The results for 2001 to 2003 are shown in table 7.9. The reason for increases on two of the days is not clear. Although some of the increase might be explained by weather patterns, it may also reflect greater emissions from diesel-powered buses and taxis that were used more extensively on the days that car use was restricted.

In Cali, beginning in 1996, DAGMA established an environmental control program for motor vehicles. The results of the emission inspections in the city during 1997 to 2003 for gasoline and diesel vehicles are displayed in table 7.10.

As shown, the number of inspections of gasoline-powered vehicles rose during 1997 to 2000 but then declined somewhat after 2000. The rejection rate, however, has declined considerably over the entire period,

Table 7.9 PM_{10} Concentrations on "Day Without My Car" versus Daily Average

Time frame	*Percent change in PM_{10}*
2001	+17.0
2002	−6.4
February 6, 2003	+9.4
September 22, 2003	−26.0

Source: DAMA 2003.

Table 7.10 Emission Inspections of Motor Vehicles in Cali, 1997–2003

	Inspections and approval rates						
Fuel type, result	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*
Gasoline vehicles	31,291	56,638	79,057	91,474	72,831	67,351	70,102
Approved (%)	81.6	86.4	92.1	94.4	95.5	94.5	96.0
Rejected (%)	18.4	13.6	7.9	5.6	4.5	5.5	4.0
Diesel vehicles	1,040	3,594	5,349	5,793	6,164	6,763	7,851
Approved (%)	91.4	90.7	90.4	93.0	93.4	90.6	92.2
Rejected (%)	8.6	9.3	9.6	7.0	6.6	9.4	7.8

Source: DAGMA 2004.

from a high of 18 percent in 1997 to about 4 percent in 2003. These results were probably influenced by a series of administrative reforms undertaken in 2001 that reduced staffing levels at DAGMA and the transit authorities. For diesel-powered vehicles, which consist mostly of buses and large trucks, a slightly different story emerges. Although there are fewer such vehicles, total inspections of diesel-powered vehicles have continued to increase over the entire seven-year period. The rejection rate has varied slightly from year to year, but has generally remained within the range of 7 to 9 percent.

While the principal purpose of the inspection program is to reduce pollution in the urban environment, DAGMA also has a financial interest in the system. As shown in table 7.11, inspection fees, which increased considerably during 1997 to 2003, generate significant revenues. These revenues are split between the government and the participating inspection centers. According to data provided by the *Centro de Diagnóstico Automotor del Valle* (CDAV), the main vehicle services and emission inspection center in Cali, there were 346,544 vehicles registered in the city as of March 2004, of which 4,405 were official (owned by public entities), 299,745 were private, and 42,394 were for public or commercial use. Some vehicles, including motorcycles and vehicles used in agriculture, were exempt from emission inspection.

CORNARE, the CAR for the Rionegro-Nare region (*Corporación de Autónoma Regional de las Cuencas de los Ríos Negro y Nare*), has also implemented a system to control emissions from mobile sources by establishing an emissions certificate for vehicles. According to information provided by CORNARE's monitoring unit, while only 47 percent of

Table 7.11. Revenues from Vehicle Inspection Program in Cali, 1997–2003

		Fee		Revenue (million pesos)	
Center	*Year*	*(pesos)*	*Inspections*	*Total*	*DAGMA (15%)*
CDAV	1997	11,500	33,126	382	57
	1998	14,000	61,715	836	125
	1999	15,800	73,255	1,153	173
	2000	17,400	97,853	1,694	254
	2001	19,000	74,617	1,506	226
	2002	20,600	32,443	704	132
	2003	22,200	50,648	1,126	268
Other centers	2003	22,100	5,921	130	32
Total				8,363	1,475

Sources: CDAV, private centers, and DAGMA reports.

Note: CDAV = *Centro de Diagnóstico Automotor del Valle;* US$1 = Col$2,150. Yearly revenues may not equal the fee times the total inspections because in the CDAV reports some inspections were registered with the prior year's fee.

vehicles inspected passed the emissions test in 2001, in 2002 the approval rate increased to 62 percent, and in 2003 the rate was 61 percent.

A vehicle inspection program has also been introduced in Medellín. During 2002, 150,000 vehicles, representing almost 40 percent of all vehicles in the area, were inspected. In the first half of 2003, there was an increase of 6.2 percent in the number of inspections compared with those in the same period in the previous year. Unfortunately, there is no information available on the failure rate of these inspections.

An examination of the testing programs in place in several Colombian cities reveals limitations of the test procedures (Kojima 2004). Specifically, the reliance on the one-speed idle test is largely ineffectual, because the CO and HC emissions from an older gasoline vehicle can be reduced by delaying the ignition timing and increasing the air-to-fuel ratio. This so-called late-and-lean approach has reportedly been widely used to pass the idle test. However, vehicles that pass the test in this fashion routinely fail roadside tests because emissions increase considerably under load conditions. The preferred approach is to test emissions under load, which requires a dynamometer. Unfortunately, no dynamometer-based testing is available in Colombia.[10]

Fuel Quality

Refined petroleum products in Colombia are produced at refineries in Cartagena and Barrancabermeja. The sulfur content of gasoline produced at these refineries is about 1,000 ppm, while the sulfur content of regular diesel is about 4,500 ppm (Brugman 2004). Ecological diesel produced in Barrancabermeja has a sulfur content of 1,200 ppm. Imported gasoline has a sulfur content of 300 ppm, while imported diesel contains 500 ppm of sulfur.

The maximum allowed content of sulfur for all fuels used in Colombia originally was scheduled to drop to 500 ppm by 2002, but the stricter standard was postponed until 2004, and postponed again until July 1, 2008. The main reason for the postponements was that Ecopetrol needed more time to retrofit the Barrancabermeja and Cartagena refineries.

Recent Developments in the Energy Sector

In 1999, Colombia adopted a fuel price liberalization policy aimed at equalizing the prices of regular gasoline and diesel with the prices of imports (using prices in the Gulf of Mexico as a reference). In addition, an excise tax on gasoline was introduced to generate funds for street paving and maintenance in urban areas.

Although these policies were primarily driven by economic rather than environmental considerations, there are some clear environmental benefits. Specifically, the consumption of gasoline has shown a downward trend, from 125,300 barrels/day in 1994 to 88,612 barrels/day in 2003. This is attributable, in part, to the substitution of diesel and compressed natural gas (CNG) for gasoline and to the rise in gasoline prices. Consumption of diesel fuels, for which subsidies are continuing, has increased. In 1994, an average of 50,400 barrels/day were consumed, and in 2003, the average was 69,661 barrels/day (UPME 2005).

In 1994, national production of natural gas was 400 million cubic feet per day (MMcfd). It was delivered by four isolated systems: the Atlantic Coast, Santander, Huila, and Meta-Bogotá. The main producing fields were situated in the department of La Guajira (at Ballena, Chuchupa, and Riohacha), and the gas transportation infrastructure was concentrated on the Atlantic Coast with a few minor pipelines in the interior of the country. There were no connections between the large population centers and main production areas. The amount of proved and probable reserves was estimated to be between 7,544 giga cubic feet (Gcf) and 8,800 Gcf, equivalent to 50 years' production (UPME 2005).

By the beginning of 1997, the country had a total of 11,468 Gcf of gas in proved and probable reserves, and production (and average consumption) reached 579 MMcfd. Transportation of gas from the coast to the interior was expanded with implementation of the Mass Gas Plan, the construction of the Ballena-Barrancabermeja pipeline, and the interconnection of this line with the other production centers using the Barrancabermeja-Neiva and Cusiana-Apiay pipelines. By the end of 2003, the country had 4,040 Gcf of commercial reserves, equivalent to a 22-year supply. With the launch of the western pipeline in August 1997 and the increase in the production capacity in La Guajira following construction of the second platform at the Chuchupa field, the availability of gas rose from 430 MMcfd to 700 MMcfd.

With the goal of increasing the availability of gas service to the poor, the national government, through the Ministry of Mining and Energy, established exclusive service areas for natural gas distribution in the western, eastern, and central zones of the country in 1997 and 1998. The Mass Gas Plan helped increase gas use in both the domestic and the industrial sectors. In 1994, there were 790,000 gas installations, and by June 2004, there were 3,250,000. This means that nearly 14 million Colombians now have access to natural gas.

Along with the development of natural gas distribution systems for domestic and industrial consumption, a new program to promote

Table 7.12 Vehicles Converted to CNG as of July 2004

City	*Department*	*As of December 2003*	*January–July 2004*	*Total*
Barranquilla	Atlántico	7,673	1,246	8,919
Cartagena	Bolívar	2,259	897	3,156
Santa Marta	Magdalena	1,452	320	1,772
Monteria	Córdoba	892	367	1,259
Sincelejo	Sucre	521	143	664
Cali-Yumbo	Valle	2,268	1,149	3,417
Tulua	Valle	0	145	145
Palmira	Valle	0	58	58
Armenia	Quindío	192	320	512
Riohacha/Cerrejon	Guajira	210	23	233
Bogotá	Cundinamarca	8,383	3,878	12,261
Bucaramanga	Santander	1,854	465	2,319
Medellín	Antioquía	3,208	1,357	4,565
Dos Quebradas	Risaralda	129	65	194
Villavicencio	Meta	706	328	1,034
Neiva	Huila	138	205	343
Ibagué	Tolima	37	111	148
Total		29,922	11,077	40,999

Source: Ministry of Mining and Energy and *Publigás Magazine* (September 2004) as cited in Blackman and others 2005.

substitution of CNG for gasoline in motor vehicles started in 1985. However, only modest progress has been made over the past 20 years. Despite the economic attractiveness of natural gas compared with gasoline, substitution has been constrained by the high cost of converting vehicles to CNG, continuing public concerns about safety, and limited incentives to build CNG fueling stations (table 7.12).

Nonpoint Sources (Sugarcane Burning)

Information on nonpoint source control in sugarcane fields is quite limited. Table 7.13 indicates that 30,000 to 40,000 hectares per year reportedly were harvested through *green cuts* over the past several years in CVC. This represents less than 23 percent of the harvested area. The practice of green cuts appears to have peaked in 2000 and then declined somewhat.

Potential Interventions to Control Air Pollution

Brugman (2004) analyzed potential interventions to control air pollution, including (a) removal of subsidies for gasoline and diesel, (b) use of CNG-powered vehicles in cities, (c) substitution of CNG for biomass and coal in urban factories, (d) promotion of urban mass transportation

Table 7.13 Hectares of Sugarcane in CVC with Green Cuts, 1997–2003

		Green cuts	
Year	*Total crops (hectares)*	*Hectares*	*% total*
1997	151,175	19,930	13
1998	167,399	28,462	17
1999	156,166	32,922	21
2000	176,648	40,171	23
2001	166,392	36,730	22
2002	162,152	34,070	21
2003[a]	79,117	14,094	18

Source: Blackman and others 2005.
a. To June 30, 2003.

systems, and (e) retrofitting of the refineries at Barrancabermeja and Cartagena to lower the sulfur content in fuels.

Removing subsidies to gasoline and diesel is intended to bring domestic prices in line with international prices and eliminate the difference in tax rates for gasoline and diesel. According to Brugman (2004), removing subsidies would reduce demand for fuel in the transportation sector by 8 percent.

Retrofitting the Barrancabermeja refinery includes hydrogenation and desulfurization of the gasoline and diesel produced there, which represents about 80 percent of the nation's domestic supply. In Cartagena, the aim of the retrofitting project is to enlarge the refinery and provide hydrogenation and desulfurization of its production of gasoline and diesel, which represents about 20 percent of the nation's domestic supply. By 2008, emissions of PM_{10}, SO_x, and NO_x would be reduced by about 2 percent compared with 2002.[11] The costs of the investments in Cartagena are expected to be about US$806 million. These investments could be delayed by importing low-sulfur diesel. Brugman (2004) estimates that importing 5,600 barrels/day of low-sulfur diesel during 2005 to 2007 would cost between US$33 million and US$35 million.

The campaign to promote CNG-powered vehicles seeks to substitute CNG for 30 percent of the gasoline and diesel used in the eight largest urban and industrial areas in the country. The cost of investments in vehicles (without counting the net benefits of substituting imported gasoline and diesel with CNG) is estimated at between US$262 million (Col$563,300 million) and US$280 million (Col$602,000 million).

Substituting natural gas for coal in urban industries could amount to 10 MMcfd additional on the northern coast and 20 MMcfd in the interior. Emissions of PM_{10} and SO_2 would be reduced on a national basis. The costs of supply and transportation of gas are higher than the costs of coal use by between US$136 million and US$178 million.

These proposals have been under study in the Department of National Planning (*Departamento Nacional de Planeación*, DNP) and the MAVDT, but no final decisions have been made. On March 14, 2005, the national government approved National Council on Economic and Social Policy (*Consejo Nacional de Política Económica y Social*, CONPES) Document 3344, which establishes terms of reference for the design of a national policy on prevention and control of air pollution, with options and programs to control atmospheric contamination in urban areas. The CONPES document proposes the establishment of a National Intersectoral Téchnical Commission for Prevention and Control of Air Pollution (*Comisión Técnica Nacional Intersectorial para la Prevención y el Control de la Contaminación del Aire*, CONAIRE) that will be chaired by the Minister of the MAVDT and will include representatives from the Ministries of Transportation, Mining and Power, Environment, and Social Protection, as well as from IDEAM, DNP, Ecopetrol, CARs, and AAUs. Periodically, other public or private institutions may be invited to participate. The commission's main function will be to design national strategies to manage air quality. CONAIRE will also promote the creation of related councils and coordination at the local level. CONPES Document 3344 also proposes creation of an Air Quality Information System (*Sistema de Información Sobre Calidad del Aire*, SISAIRE), to be managed by IDEAM, to collect, update, and analyze relevant information generated by the monitoring network and by environmental, sanitation, transportation, and energy authorities.

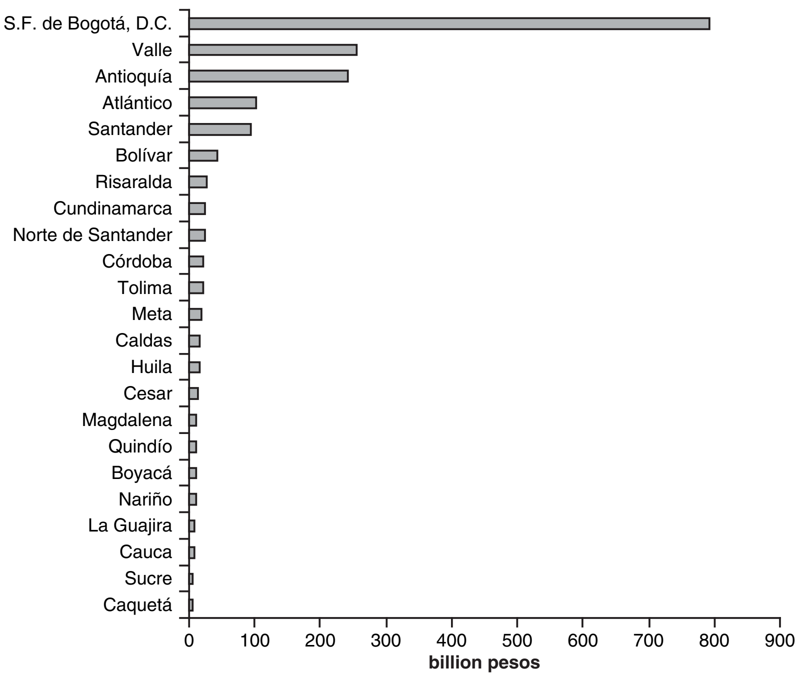
The government of Colombia is considering a series of intersectoral measures aimed at tackling two major sets of issues that constrain air pollution control. The first is to make the findings of past reviews of experience and lessons learned more widely available and to apply those lessons to future strategies for air pollution control. The terms of reference for CONAIRE contained in CONPES Document 3344 give the proposed commission responsibility for disseminating information related to air quality and pollution prevention to foster greater awareness and learning and to guide research. The second relates to the potential challenges involved in achieving full implementation of the CONPES proposals. The government of Colombia is considering new efforts to strengthen the implementation process and specifically to counterbalance the influence of interest groups by strengthening civil society participation in the design and implementation of air pollution control policies and measures (Suárez, Montenegro, and Carasquilla 2005).

Benefit-Cost Analysis of Interventions to Control Air Pollution from Mobile Sources in Bogotá

More than 80 percent of the estimated costs resulting from the health impacts of air pollution in Colombia are concentrated in only four departments and the city of Bogotá. The costs for Bogotá alone represent 50 percent of the national total and are over three times higher than in Valle and Antioquía, the departments with the next-highest cost (figure 7.2). The annual cost in Bogotá is equivalent to nearly 2 percent of Bogotá's GDP and could reach almost 3 percent of GDP if mortality costs are based on the value of statistical life (VSL) approach (Larsen 2005b).

For these reasons, and because of the substantial data requirements and complexity of estimating the benefits of pollution control measures, the analysis of costs and benefits of urban air pollution control in this section deals only with Bogotá. The analysis focuses on emissions from mobile sources, which are a significant contributor to urban air pollution in Bogotá.

Figure 7.2 Annual Health Cost of Urban Air Pollution



Source: Larsen 2005b.
Note: Costs are the mean of a low estimate using the human capital approach for the cost of mortality, and a high estimate using the value of statistical life approach. US$1 = Col$2,150.

Health effects of air pollution are a function of ambient air quality. An estimation of the benefits of urban air pollution control therefore requires an emissions inventory, a relationship between the inventory and ambient air quality, and an estimate of emissions reductions from individual pollution control measures.

The cost of urban air pollution in Bogotá presented in Larsen (2004) is based on a population-weighted, estimated annual average ambient PM_{10} concentration of 62 $\mu g/m^3$. PM_{10} was then converted to $PM_{2.5}$ using a factor of 0.6 based on observed $PM_{2.5}/PM_{10}$ ratios in similar conditions in the United States and on spot estimates of particle size distribution in Bogotá undertaken by Universidad de los Andes (2004a) and Brugman (2004), shown in table 7.14.

The primary focus of the Universidad de los Andes (2004a) study was to assess emissions from mobile sources, and the primary focus of the Brugman study was fossil fuel use in urban areas. The estimates do not include fugitive dust from roads, agriculture, and other sources. Nor do the emissions reflect secondary particulate formation (nitrates and sulfates) from gaseous emissions (nitrogen oxides and sulfur), which can represent a substantial share of atmospheric concentrations of PM_{10} and $PM_{2.5}$. Ignoring these sources of PM could potentially result in an overestimation of the costs of both damages from mobile and stationary source emissions and health benefits of PM emission control. A simple model was therefore developed in this analysis to provide a broad estimate of the contribution of fugitive dust, nitrates, and sulfates to ambient concentrations of $PM_{2.5}$ and PM_{10} in Bogotá. The derived ambient $PM_{2.5}$ concentration was then used to estimate annual mortality, and PM_{10} was used to estimate annual morbidity.

As shown in table 7.15, the $PM_{2.5}/PM_{10}$ ratios for emissions from fuel combustion (petroleum products) from both mobile and stationary

Table 7.14 Estimated PM_{10} Emissions in Bogotá, 2002

tons/year

	Study	
Source	*Universidad de Los Andes*	*Brugman*
Mobile	1,560	2,400
Stationary (fuels)	n.a.	2,100
Stationary (processes)	n.a.	800
Stationary	2,940	n.a.
Total	4,500	5,300

Source: Universidad de los Andes 2004; Brugman 2004.

Note: n.a. = not applicable.

sources are well above 0.9. This is also the case from waste and residue burning and forest fires. The ratio for fugitive dust, however, is generally very low, and the ratio for emissions from industrial processes is usually somewhere between the ratios for fugitive dust and for fuel combustion, depending on the type of industry, process technology, and pollution abatement technology. The ratio of 0.55 reported in table 7.15 represents an average for various processes, and will vary significantly depending on the type of process and emission abatement technology.

Recent studies from the United States indicate that nitrates and sulfates constitute around 30 percent of ambient concentrations of $PM_{2.5}$ in California, and as much as 45 to 50 percent of $PM_{2.5}$ in the eastern states. However, the ratio of nitrates to sulfates is much higher in California, mainly because emissions there are mostly from mobile sources, while the eastern United States is more heavily affected by sulfur emissions from power plants (table 7.16).

Table 7.15 Emission Source Ratios of $PM_{2.5}$ and PM_{10}

Source	*$PM_{2.5}/PM_{10}$ ratio*
Stationary	
Fuel combustion	0.96
Industrial processes	0.55
Fugitive dust	
Paved roads	0.25
Unpaved roads	0.15
Construction and demolition	0.15
Farming operations (tilling and so forth)	0.20
Miscellaneous processes	
Waste burning	0.96
Agricultural residue burning	0.93–0.96
Forest fires	0.93
Mobile	
Onroad	0.98

Source: Reproduced from table in Countess (2003); for rice, wheat, and corn of agricultural residue burning: Scarborough, Clinton, and Gong (2002).

Table 7.16 Nitrates and Sulfates in PM_2

	Share of ambient $PM_{2.5}$ (percent)	
Region	*Nitrates*	*Sulfates*
California	20–25	5–8
Eastern states of United States	5–15	25–40

Source: Derived from "Latest Findings on National Air Quality: 2000 Status and Trends." http://www.epa.gov/airtrends/.

The share of nitrates and sulfates in ambient $PM_{2.5}$ concentrations in Bogotá is unclear. A midpoint of 15 percent for nitrates and 15 percent for sulfates has been used to estimate an emissions inventory that includes both primary and secondary PM. Applying the model that includes estimated contributions of fugitive dust, nitrates, and sulfates in ambient PM concentrations results in the concentration levels presented in table 7.17. The model was applied by setting sulfates and nitrates to 15 percent of $PM_{2.5}$, applying the PM ratios in table 7.15, using the emissions from Brugman (2004) in table 7.14, and using an aggregate $PM_{2.5}/PM_{10}$ ratio of 0.6 as in Larsen (2004).[12]

Two scenarios are presented in table 7.17 to account for uncertainty in the contribution of stationary sources (mainly industrial emissions) to urban ambient concentrations of PM_{10} and $PM_{2.5}$. This contribution depends on industrial location, stack heights, wind direction, and other factors. A low assumption of 25 percent is used in scenario 1 and a high

Table 7.17 Model Results for Annual Emissions Inventory in Bogotá

Source	*PM_{10} emissions (tons)*	*Percentage that becomes urban PM_{10}*	*Urban PM_{10} (tons)*	*$PM_{2.5}$/ PM_{10}*	*Urban $PM_{2.5}$ (tons)*
Scenario 1 (low)					
Mobile	2,400	100	2,400	0.98	2,352
Stationary (fuels)	2,100	25	525	0.96	504
Stationary (industrial processes)	800	25	200	0.50	100
Sulfates (15% of $PM_{2.5}$)	850	100	850	0.95	808
Nitrates (15% of $PM_{2.5}$)	850	100	850	0.95	808
Forest fires and waste burning	0	[a]	0	0.93	0
Fugitive emissions	4,190	100	4,190	0.20	838
Total	11,190	n.a.	9,015	0.60	5,410
Scenario 2 (high)					
Mobile	2,400	100	2,400	0.98	2,352
Stationary (fuels)	2,100	75	1,575	0.96	1,512
Stationary (industrial processes)	800	75	600	0.50	300
Sulfates (15% of $PM_{2.5}$)	1,250	100	1,250	0.95	1,188
Nitrates (15% of $PM_{2.5}$)	1,250	100	1,250	0.95	1,188
Forest fires and waste burning	200	[a]	200	0.93	186
Fugitive emissions	5,900	100	5,900	0.20	1,180
Total	13,900	n.a.	13,175	0.60	7,906

Source: Larsen 2005a.

Note: n.a. = not applicable.

a. The low scenario assumes that no PM_{10} from forest fires and waste burning end up in the urban ambient environment, while the high scenario assumes that these sources contribute 200 tons of PM_{10}. No estimate is available of total emissions from these sources or of the percentage that becomes ambient PM_{10} in Bogotá.

assumption of 75 percent is used in scenario 2 to estimate the share of total emissions from stationary sources that actually end up in the urban ambient environment. Forest fires and waste burning are assumed to contribute no PM_{10} to the urban ambient environment in the low scenario and 200 tons in the high scenario. The fugitive emissions estimated by the model contribute roughly 45 percent of total PM_{10}, but only about 15 percent of total $PM_{2.5}$.

Cost of Damage from Mobile Sources

Table 7.18 presents the estimated total annual costs of damage caused per ton and by source of PM_{10} emissions.[13] The low estimate is based on the human capital approach (HCA) to valuation of mortality risk and the high

Table 7.18 Estimated Cost of Damage Caused by PM_{10} in Bogotá

	Estimated cost per year (billion pesos)		*Cost per ton of PM_{10} (million pesos)*		*Cost per ton of PM_{10} (thousand US$)*	
Emission source	*Low*	*High*	*Low*	*High*	*Low*	*High*
Scenario 1 (low PM_{10})						
Mobile	85	337	35	140	14	56
Stationary (fuels)	18	72	9	34	4	14
Stationary (industrial processes)	6	16	7	21	3	8
Sulfates (15% of $PM_{2.5}$)	30	117	35	137	14	55
Nitrates (15% of $PM_{2.5}$)	30	117	35	137	14	55
Forest fires and waste burning	n.a.	n.a	n.a	n.a	n.a	n.a
Fugitive emissions	104	194	25	46	10	18
All sources	273	853	24	76	10	30
Scenario 2 (high PM_{10})						
Mobile	58	231	24	96	10	39
Stationary (fuels)	38	149	18	71	7	28
Stationary (industrial processes)	12	34	15	42	6	17
Sulfates (15% of $PM_{2.5}$)	30	117	24	94	10	38
Nitrates (15% of $PM_{2.5}$)	30	117	24	94	10	38
Forest fires and waste burning	5	18	24	92	10	37
Fugitive emissions	100	187	17	32	7	13
All sources	273	853	20	61	8	25

Source: Larsen 2005a.

Note: n.a. = not applicable. Scenario 1 uses a low estimate of ambient PM_{10} and scenario 2 uses a high estimate. The columns for low and high costs are based on different methods for the valuation of mortality risk—the HCA is used for the low estimate and the VSL approach is used for the high estimate. US$1 = Col$2,150.

estimate is based on the VSL approach (Larsen 2004). The average cost of damage from all sources is estimated at between Col$20 million and Col$24 million (US$8,000 to US$10,000) per ton of PM_{10} in the low cost case, and between Col$61 million and Col$76 million (US$25,000 to US$30,000) for the high cost case.

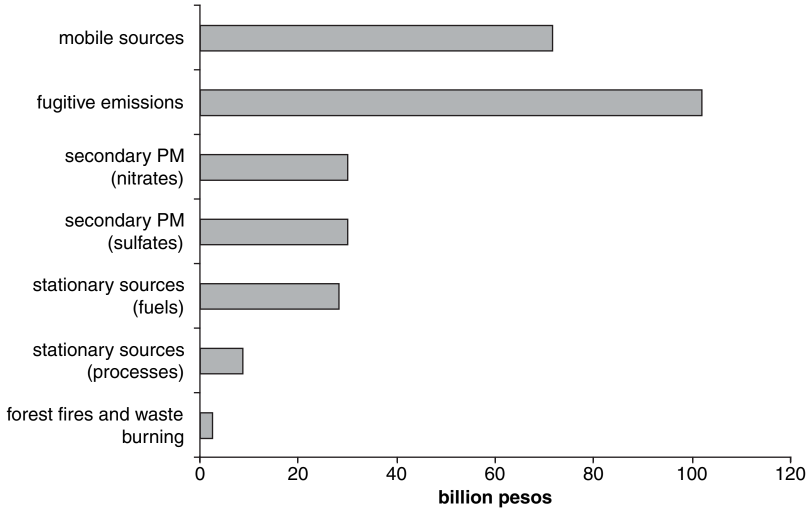
Figure 7.3 shows the average of the low (HCA-based) annual cost estimates of PM_{10} for the two different emission scenarios, and figure 7.4 shows the average of the high cost (VSL-based) estimates for the two scenarios. The main difference between the two figures is the relative magnitude of damages and costs from mobile sources and fugitive emissions. In figure 7.3, the cost from fugitive emissions is higher than from mobile sources, while the opposite is the case in figure 7.4. This is because of the application of the HCA for valuation of mortality in figure 7.3, which implies a relatively low damage cost to $PM_{2.5}$ compared with PM_{10}. Thus, the cost of fugitive emissions is more prominent, because the total quantity of fugitive emissions, measured by PM_{10}, is higher than from mobile sources (table 7.17). In figure 7.4, however, the damage cost reflects valuation of mortality using the VSL approach, which implies a higher damage cost of $PM_{2.5}$ relative to PM_{10}. Because emissions from mobile sources are higher in $PM_{2.5}$ than are fugitive emissions, total damage cost of mobile emissions is higher than of fugitive emissions.

Figures 7.5 and 7.6 present the estimated damage cost by emission source per ton of PM_{10}. The figures are averages of scenarios 1 and 2. Damage cost is highest from mobile sources in both the low and the high cases, ranging from about Col$30 million to Col$120 million per ton (US$12,000 to US$48,000). The estimated damage cost per ton of secondary particulates is just as high as the cost per ton of particulates from mobile sources because the $PM_{2.5}$ fraction of sulfate and nitrate particulates is very similar to particulates from mobile sources.

Table 7.19 presents estimates of the vehicle fleet, the share of the vehicle fleet with diesel and gasoline engines, vehicle driving distance, and fuel consumption (Brugman 2004). CNG vehicles are not included in the table; they represent only a very small fraction of vehicles. Taxis are in the public urban cars category. Many of the buses and trucks are used on interurban routes. This issue is discussed later with respect to the damage cost of pollution for each of the vehicle classes.

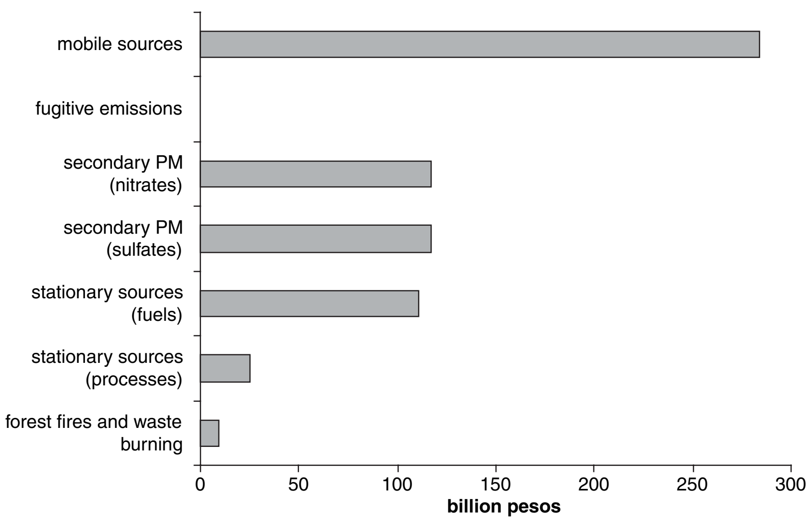
Table 7.20 presents PM_{10} emissions factors in kilograms per gigajoule (Brugman 2004). These factors should be considered broad averages. Emissions from any given vehicle will vary substantially depending on engine condition, maintenance, and other factors. Old diesel vehicles

Figure 7.3 Annual Cost of Damage by Emission Source, Low Cost Estimate



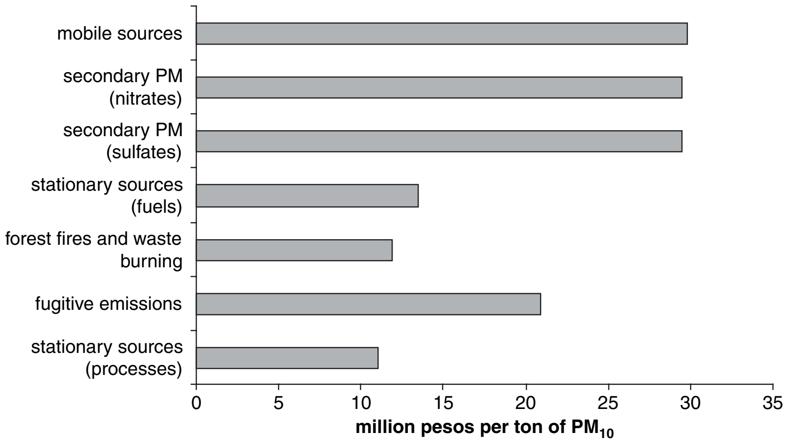
Source: Larsen 2005a.
Note: US$1 = Col$2,150.

Figure 7.4 Annual Cost of Damage by Emission Source, High Cost Estimate



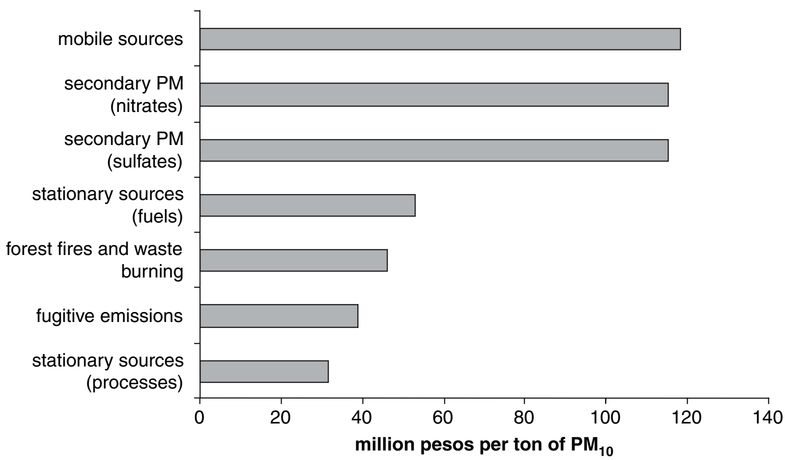
Source: Larsen 2005a.
Note: US$1 = Col$2,150.

Figure 7.5 Damage Cost per Ton of PM_{10}, Low Cost Estimate



Source: Larsen 2005a.
Note: US$1 = Col$2,150.

Figure 7.6 Damage Cost per Ton of PM_{10}, High Cost Estimate



Source: Larsen 2005a.
Note: US$1 = Col$2,150.

refers to aging fleet vehicles in Colombia and newer diesel vehicles that lack technology to control PM emissions. The emissions factors for new diesel vehicles can in many instances be considered applicable to in-fleet diesel vehicles with retrofit technology such as trap oxidizer

Table 7.19 Estimates of Vehicles and Fuel Consumption in Bogotá

Vehicle class	Number of vehicles	Fuel type (% of fleet)		Average usage (km/year)	Average fuel economy (km/gallon)	
		Gasoline	Diesel		Gasoline	Diesel
Cars						
Private	359,682	96.0	3.5	12,640	31.8	31.9
Public urban	54,805	90.0	8.0	46,310	28.4	28.4
Public interurban	7,473	90.0	8.0	46,310	28.4	28.4
SUVs and vans						
Private	58,602	96.0	3.5	13,850	19.5	19.7
Public urban	285	96.0	3.5	13,850	19.5	19.7
Public interurban	4,432	96.0	3.5	13,850	19.5	19.7
Trucks						
C2-U	7,143	80.0	19.8	48,000	8.1	10.4
C2-I	5,702	80.0	19.8	48,000	8.1	10.4
C3-I	711	1.9	98.1	66,000	5.3	6.7
C4-I	62	1.9	98.1	66,000	5.3	6.7
C5-I	947	1.9	98.1	66,000	4.3	5.3
C5>I	454	1.9	98.1	66,000	4.3	5.3
Buses						
P300 U	6,808	19.8	80.0	47,410	7.5	8.6
P600 U	13,747	19.8	80.0	50,350	6.7	8.2
MICROS U	132	80.0	19.8	64,640	19.1	19.4
P300 I	3,195	19.8	80.0	47,410	7.5	8.6
P600 I	10,927	19.8	80.0	50,350	6.7	8.2
P900 I	1,351	19.8	80.0	50,350	6.7	8.2

Source: Reproduced from Brugman (2004).
Note: km = kilometer; SUVs = sport utility vehicles.

systems and oxidation catalysts. For new diesel vehicles with advanced particulate control technology running on low-sulfur diesel, emissions can be expected to be substantially lower than reported in table 7.20. For a discussion of emissions monitoring results from in-fleet vehicles in many countries around the world, see Faiz, Weaver, and Walsh (1996).

Table 7.21 presents estimates of the cost of damages caused by pollution per vehicle per year. The low cost estimate is based on US$10,000 per ton of PM_{10} from scenario 1 in table 7.18, which was estimated by using the HCA for mortality valuation and the assumption that 75 percent of industrial emissions end up in the urban environment. The high cost estimate is based on US$56,000 per ton of PM_{10} from scenario 1 in table 7.18, which used the VSL approach to mortality valuation, and the assumption that only 25 percent of industrial emissions end up in the urban environment. About 70 percent of the difference between the low and high estimates is associated with the

Table 7.20 PM_{10} Emissions Factors

Vehicle class	*PM_{10} emissions (kg/GJ)* Gasoline vehicles	Old diesel vehicles	New diesel vehicles
Cars			
Private	0.01	0.17	0.09
Public urban	0.01	0.17	0.09
Public interurban	0.01	0.17	0.09
SUVs and vans			
Private	0.01	0.17	0.09
Public urban	0.01	0.17	0.09
Public interurban	0.01	0.17	0.09
Trucks			
C2-U	0.01	0.18	0.10
C2-I	0.01	0.18	0.10
C3-I	0.01	0.21	0.05
C4-I	0.01	0.21	0.05
C5-I	0.01	0.21	0.05
C5>I	0.01	0.21	0.05
Buses			
P300 U	0.01	0.18	0.10
P600 U	0.01	0.18	0.10
MICROS U	0.01	0.18	0.10
P300 I	0.01	0.18	0.10
P600 I	0.01	0.18	0.10
P900 I	0.01	0.18	0.10

Source: Reproduced from Brugman (2004).
Note: kg/GJ = kilogram per gigajoule; SUVs = sport utility vehicles.

mortality valuation procedures, and 30 percent of the difference is associated with the assumptions about the contribution of industrial emissions to urban ambient air quality.

The estimated damage cost per vehicle is much higher for trucks and buses than for cars and SUVs and vans. This is mainly a function of differences in annual driving distances and fuel economy. Estimated damage cost for taxis ("public urban cars") with old diesel engines is also relatively high. It should be noted that the estimated damage cost per vehicle in table 7.21 is based only on primary PM emissions and does not reflect the damage cost of secondary particulates (sulfates and nitrates).

Interventions

Interventions to control primary and secondary particulate emissions from mobile sources can broadly be classified into the following categories: (a) market-based instruments such as fuel pricing and taxation, vehicle

Table 7.21 Estimated PM_{10} Damage Cost per Vehicle in Bogotá

	PM_{10} damage cost per vehicle (US$/year)			
	Old diesel vehicles		*New diesel vehicles*	
Vehicle class	*Low*	*High*	*Low*	*High*
Cars				
Private	100	560	50	300
Public urban	400	2,300	210	1,200
Public interurban	400	2,300	210	1,200
SUVs and vans				
Private	170	1,000	90	520
Public urban	170	1,000	90	520
Public interurban	170	1,000	90	520
Trucks				
C2-U	1,200	6,900	700	3,800
C2-I	1,200	6,900	700	3,800
C3-I	3,000	17,100	700	4,100
C4-I	3,000	17,100	700	4,100
C5-I	3,800	21,800	900	5,200
C5>I	3,800	21,800	900	5,200
Buses				
P300 U	1,400	8,200	800	4,600
P600 U	1,600	9,100	900	5,100
MICROS U	900	5,000	500	2,800
P300 I	1,400	8,200	800	4,600
P600 I	1,600	9,100	900	5,100
P900 I	1,600	9,100	900	5,100

Source: Estimated by Larsen (2005b).
Note: SUVs = sport utility vehicles. Figures below US$600 are rounded to the nearest US$10. Figures above US$600 are rounded to the nearest US$100. US$1 = Col$2,150.

taxation, and emission taxes; (b) vehicle technology standards and regulations, including in-fleet technology retrofitting and inspection and maintenance programs; (c) fuel quality improvements and fuel use regulations, such as low-sulfur diesel and conversion to CNG; and (d) traffic management and urban planning, including public transportation policies.

The focus in this analysis will be on some obvious options such as diesel pricing policies, in-fleet technology retrofitting and technology standards for new vehicles, CNG conversion for high-usage vehicles, and diesel quality improvements in relation to technology to control particulate emissions from diesel-powered vehicles.

Diesel pricing. Data on retail fuel prices during 1980–2004 reveal that prices of diesel and regular gasoline were practically unchanged during

1980 to 1998. After 1998, gasoline prices increased at a much faster rate than diesel prices, in both nominal and real terms. By 2004, diesel prices were 30 percent lower than regular gasoline prices, and 50 percent lower than high-octane gasoline. Brugman (2004) estimates that removal of fuel subsidies could reduce overall transport diesel consumption (relative to baseline demand projections) by 7 to 8 percent, based on a study in Colombia of price elasticities of fuel demand. While such a reduction in diesel consumption may not appear to be substantial, much of the reduction is likely to come from light-duty diesel vehicles, which gain less from having a diesel engine than do heavy-duty vehicles. Fuel subsidy removal could therefore help prevent, and in the longer run even reverse, the trend toward using light-duty diesel vehicles. This is a desirable outcome, if it is assumed that new light-duty diesel vehicles are not equipped with modern particulate control technology that effectively reduces PM emissions.

Particulate control technology. Buses and trucks are responsible for the majority of PM emissions from mobile sources in Bogotá. While the new Transmilenio buses emit fewer particulates than the average bus or truck in Bogotá, the old bus and truck fleet is still a major source of urban air pollution. Retrofitting these buses and trucks with particulate control technology is an option to reduce PM emissions. However, because retrofit control technology is not inexpensive, consideration might be given to the expected remaining useful life of many of the aging buses and trucks. Options might be provided to bus and truck operators either to retrofit or to remove the vehicles from the fleet within a certain time frame.

Retrofit technology, such as trap oxidizer systems or oxidization catalysts, could cost several thousand U.S. dollars and as much as US$7,000 to US$8,000 per bus (Walsh 1998). The potential benefits of retrofit technology are shown in table 7.22. The benefits are estimated as the difference in emissions and damage costs in tables 7.20 and 7.21, respectively. For heavy trucks, the payback period in terms of environmental health benefits could be less than one year if valuation of mortality is based on VSL (high estimate). If the HCA (low estimate) is applied, the payback period ranges from 2 to 3 years. For buses and lighter trucks, the payback period could range from as little as 2 to 3 years for the high estimate to as much as 6 to 10 years for the low estimate.

These payback estimates are for buses and trucks used mainly within Bogotá. Most of the pollution from interurban buses and long-haul trucks would be emitted outside the cities, and the damage cost would

Table 7.22 Benefits of Diesel Vehicle Retrofit Technology

	Retrofit benefits (US$/vehicle/year)	
Vehicle class	*Low*	*High*
Trucks		
C2-U	500	3,100
C2-I	500	3,100
C3-I	2,300	13,000
C4-I	2,300	13,000
C5-I	2,900	16,600
C5>I	2,900	16,600
Buses		
P300 U	600	3,600
P600 U	700	4,000
MICROS U	400	2,200
P300 I	600	3,600
P600 I	700	4,000
P900 I	700	4,000

Source: Larsen 2005b.
Note: US$1 = Col$2,150.

be substantially less, if not minimal. Based on the estimates here, priority should be given to retrofitting buses and trucks used predominantly within urban areas.

CNG conversion. Conversion to CNG would practically eliminate particulate emissions. It is often considered a viable option for taxis and other high-usage vehicles. In some countries, large buses also run on CNG. Potential benefits of conversion to CNG for diesel vehicles are presented in table 7.23. For large diesel buses, however, CNG conversion would need to be carefully evaluated and compared with the option of retrofitting with particulate control technology.

Diesel quality improvement. One important aspect of diesel quality is sulfur content. Low sulfur content has direct benefits in that it usually provides some reduction in particulate emissions from diesel combustion. The other benefit is that low sulfur content is often a prerequisite for advanced particulate control technology on diesel vehicles, or it at least makes the control technology more effective. Low sulfur content can also reduce secondary particulate formation (sulfates), providing an added benefit to health.

Sulfur content in diesel in Bogotá is 0.1 percent by weight. While this is lower than in other cities in Colombia, to take full advantage of the

Table 7.23 Benefits of Conversion to CNG

Vehicle class	CNG conversion benefits (US$/vehicle/year) Low	High
Cars		
Diesel taxis	400	2,300
Buses		
P300 U	1,400	8,200
P600 U	1,600	9,100
MICROS U	900	5,000
P300 I	1,400	8,200
P600 I	1,600	9,100
P900 I	1,600	9,100

Source: Larsen 2005b.
Note: US$1 = Col$2,150.

advanced technology available for particulate control in new diesel vehicles, sulfur would have to be further reduced.

Estimated benefits from a 5 percent reduction in PM emissions by reducing the sulfur content of diesel to 0.05 percent are shown in table 7.24. In the low-benefit scenario, the PM decrease might not be sufficient to justify such a reduction. In the high-benefit scenario, the estimated benefits are substantially higher than the incremental cost of supplying low-sulfur diesel. Two issues should be mentioned. First, because the benefits of emission reductions are based on urban emissions, the estimates apply only to vehicles used predominantly in urban areas and not to interurban transport. Low-sulfur diesel should therefore be prioritized for the urban market. Second, low-sulfur diesel has important benefits other than direct PM reductions, such as allowing for adoption of advanced particulate control technology on new diesel vehicles.

Conclusions and Recommendations

Colombia has made major efforts during the past decade to improve air quality in Bogotá and several other large urban areas. These efforts have been bolstered by increased awareness by experts and the public of the links between air pollution and public health. However, the damage to human health associated with current air pollution levels—particularly elevated concentrations of fine particles—remains high. Despite severe

Table 7.24 Benefits of Converting to Low-Sulfur Diesel

	Benefits of reducing sulfur in diesel, to 0.05 percent by weight (US$/ton diesel)	
Vehicle class	*Low*	*High*
Cars		
Private	3.7	21
Public urban	3.7	21
Public interurban	3.7	21
SUVs and vans		
Private	3.7	21
Public urban	3.7	21
Public interurban	3.7	21
Trucks		
C2-U	3.9	23
C2-I	3.9	23
C3-I	4.6	26
C4-I	4.6	26
C5-I	4.6	26
C5>I	4.6	26
Buses		
P300 U	3.9	23
P600 U	3.9	23
MICROS U	3.9	23
P300 I	3.9	23
P600 I	3.9	23
P900 I	3.9	23

Source: Larsen 2005b.
Note: SUVs = sport utility vehicles. Current sulfur content is 0.1 percent by weight.

data limitations, this chapter has documented a number of problems in the areas of stationary, mobile, and nonpoint sources, and some basic measurement issues affecting all sources.

Notwithstanding ongoing concerns about carbon monoxide, hydrocarbons, and possibly other pollutants, overwhelming evidence points to elevated levels of fine particles as the most important cause of air pollution–related health impacts. Accordingly, it would be advisable to develop a broad strategy to reduce exposure to elevated concentrations of fine particles (table 7.25). Key elements of this strategy might include the establishment of national ambient standards for PM_{10} and $PM_{2.5}$, plus the strengthening of technology-specific emission standards for PM and its precursors (particularly sulfur and nitrogen oxides). Additional resources are also needed to enhance monitoring and enforcement activities to address the challenge posed by this pollutant.

Table 7.25 Summary of Recommendations for Improving Urban Air Quality in Colombia

Recommendation	*Priority: Short (S), medium (M), and long term (L)*	*Government agencies*
Ambient standards		
Design and approve an air pollution control law.	S	Congress
Design and implement an environmental policy to reduce urban air pollution, including the establishment of national ambient standards for PM_{10} and $PM_{2.5}$.	S	MAVDT, MSPS, INS, MME, DNP, AAUs, CARs
Review experiences and lessons learned from past attempts to improve air quality in Colombia.	M–L	CONAIRE, MHCP, MAVDT, MSPS, INS, MME, DNP, AAUs
Issue regulations to establish and implement a new air pollution control scheme to promote behavioral change consistent with air pollution control.	S	Congress, MAVDT, AAUs, CARs
Establish standards for air quality monitoring equipment and procedures at the national level.	S	MAVDT, IDEAM
Implement a national air quality monitoring system for PM_{10} and $PM_{2.5}$ in priority urban areas.	S–M	MAVDT, AAUs, CARs
Strengthen monitoring networks in major municipalities throughout the country.	S–M	MAVDT, CARs, AAUs
Revise 1982 national ambient standards and establish national standards for PM_{10} and $PM_{2.5}$.	S	MAVDT, IDEAM, MSPS, INS
Stationary pollution sources		
Update major emissions standards for stationary sources to reflect new scientific and technological advances, with a focus on fine particles.	S	MAVDT, IDEAM
Encourage efforts to improve fuel quality in power plants and heavy industry, including expanded use of natural gas to replace coal and low-sulfur oil.	S	MME, DNP, Ecopetrol
Establish new regulatory programs for specific sectors and smaller sources not currently covered by enforceable regulations.	M	MAVDT, CARs, AAUs
Reform the compliance and enforcement systems, including adoption of a rigorous penalty system.	S	Congress, MAVDT
Conduct a major audit of current tax incentives for procuring new pollution abatement and related equipment.	M–L	MHCP, MAVDT, DNP
Based on findings of audit, recommend appropriate reforms of incentives for procurement of new pollution abatement and related equipment.	L	MHCP, MAVDT, DNP

(continued)

Table 7.25 Summary of Recommendations for Improving Urban Air Quality in Colombia (*continued*)

Recommendation	*Priority: Short (S), medium (M), and long term (L)*	*Government agencies*
Mobile pollution sources		
Continue efforts to raise motor fuel prices to international levels, including gasoline and diesel. Maintain 2006 deadline.	M	MME, DNP, Ecopetrol
Continue efforts to improve fuel quality by increasing clean fuel imports. Meet the 2008 deadlines on reduction of sulfur content in fuels, and if possible bring them forward to 2007.	S–M	MME, MAVDT, DNP, Ecopetrol
Continue and expand efforts to encourage use of CNG in vehicles.	S	MME, Ministry of Transport, MAVDT, DNP
Establish regulations for upgrading urban bus fleets and other forms of mass transit in major cities.	S–M	MHCP, MAVDT, CARs, IDEAM
Establish regulations and incentives aimed at scrapping older vehicles.	M–L	Ministry of Transport, DNP, MAVDT
Reexamine methods for testing vehicle exhaust in light of international experience, and introduce more rigorous approaches to vehicle emissions testing.	S	MAVDT, Ministry of Transport, AAUs, CARs
Nonpoint pollution sources		
Implement monitoring methods for green cut programs.	S	MAVDT, CARs, IDEAM
Enact national-level sanctions, including withholding financial support for continued noncompliance.	S	MAVDT

Source: Authors.
Note: INS = *Instituto Nacional de Salud;* MHCP = *Ministerio de Hacienda y Crédito Públicó;* MME = *Ministerio de Minas y Energía;* MSPS = *Ministerio de Salud y Protección Social.*

Measurement and Monitoring

The old adage that it is impossible to manage what is not measured is particularly applicable to air quality. The importance of this point cannot be overstated. The modest amount of actual monitored data presented in this chapter reflects the limited data available. In some cities only single monitors are in operation. Specialized equipment, regular maintenance, standardized protocols for reading and interpreting the data, and training of personnel are all essential elements of viable control policies. Furthermore, a centralized depository might be established to review and analyze data from across the country. Overall, a strong institutional structure, combined with solid base funding and continued oversight, is essential for achieving reliable and consistent measurements over time. Specifically, standards for air quality monitoring equipment and procedures to measure particulate matter, mainly $PM_{2.5}$ and PM_{10}, could be established at the national level, and monitoring networks should be strengthened in major municipalities throughout the country.

Ambient Standards

The national ambient standards for key air pollutants, first issued in 1982, are still in effect today. Over the past two decades considerable advances have been made in understanding the link between air pollution and public health. On an international basis, most nations with large urban populations have reflected the new scientific developments in their standards. The fact that Bogotá and Cali have updated the 1982 standards is a positive step. However, with new information available and progress in research and technology, it is time to revise national standards. Accordingly, it is advisable that the 1982 national ambient standards be updated to reflect the latest developments in science and policy making. Given the demonstrated health damages associated with elevated concentrations of fine particles, the establishment of national standards for PM_{10} and $PM_{2.5}$ is recommended. A point of reference for setting these standards is the 50 $\mu g/m^3$ average annual limit established by the U.S. Environmental Protection Agency.

Stationary Sources

Based on the review of the regulatory structure, the government might consider a number of actions to reduce the negative impacts of stationary sources of air pollution:

- Major emissions standards for stationary sources might be updated to reflect new scientific and technological advances, with a focus on fine particles.
- It would be advisable to encourage efforts to improve fuel quality used by power plants and heavy industry, including expanded use of natural gas to replace coal, and use of low-sulfur oil.
- The establishment of new regulatory programs for specific sectors (and smaller sources) not currently covered by enforceable regulations is recommended. As noted, brick kilns are a major source of air pollution in some areas, such as Nobsa. Innovative programs in other developing countries, such as Mexico, can serve as models for these activities.

- An extensive reform of compliance and enforcement systems might be considered. At present, the penalties for noncompliance appear to be extremely modest. A more serious penalty system could be adopted, and it might be accompanied by strong MAVDT oversight. National-level sanctions could include the withholding of financial support for continued failure to uphold the laws.
- A major audit of existing tax incentives for new pollution abatement and related equipment might be considered. Based on the findings of the audit, recommendations could be made for appropriate reforms, including possible expansion of the incentives.

Mobile Sources

Because mobile sources represent a large and growing contribution to urban air pollution, the government might consider several actions:

- Harmonization of motor fuel, particularly diesel, prices with international levels could be considered. The 2006 deadline established by the government is adequate and should be maintained.
- Efforts to improve fuel quality by increasing imports of clean fuels, particularly for diesel consumption in Bogotá, Cali, Medellín, Barranquilla, and Barrancabermeja, are appropriate, and it is advisable to keep them in place. The 2008 deadlines on sulfur content of fuels are adequate, as well, and it is suggested they be maintained.
- The continuation and expansion of the use of CNG in vehicles is advisable.
- Additional funding could be made available for upgrading urban bus fleets and other forms of mass transit in major cities.
- Additional funding for programs to scrap older vehicles is recommended.
- A reexamination of the testing methods for vehicle exhaust would be advisable in light of the experiences of other countries with similar methods (such as Mexico and the United States). Other, more rigorous, approaches to testing vehicle emissions might be considered.
- Following the proposals of Brugman (2004), additional incentives to encourage use of natural gas, and economic incentives consistent with Law 99, should be considered.

Nonpoint Sources

Burning of sugarcane residue is the sole nonpoint source examined in this chapter. The evidence presented indicates that compliance with so-called green cut procedures is inadequate to limit potentially harmful pollution levels at specified times of the year. Part of the resistance to the use of green cuts is associated with allegiance to traditional practices. Accordingly, it would be advisable that national-level sanctions, including the withholding of financial support for continued noncompliance, be built into the arsenal of compliance tools available to government authorities (Blackman and others 2005).

Notes

1. Richard Morgenstern, Bjorn Larsen, and Ernesto Sánchez-Triana are the authors of this chapter, which draws heavily from background documents prepared for this study by Blackman and others (2005); Brugman (2004); and Larsen (2004, 2005a, and 2005b).
2. According to MAVDT (2006, p. 7), "air quality modeling for Bogotá . . . indicates that . . . the air quality problems associated with particulate matter (PM_{10}) stem from fixed sources (65%) and mobile sources (35%). Recent studies from the Universidad de los Andes indicate that, if only the problem of sulfur content in diesel fuel used in the country is analyzed, in the best cases 50% would stem from fixed sources and 50% from mobile sources, without taking into account an analysis of the fuels used in the industrial sector such as coal and fuel oil which have sulfur contents that are greater than that of vehicle diesel. It should also be taken into account that the automotive park in Bogotá is made up of approximately 92% gasoline vehicles and only 8% diesel vehicles."
3. Information from MAVDT (2006, p. 8) indicates that in "Bogotá all stations operate on the basis of PM_{10} equipment (there are 11 stations, 9 with PM_{10} and 2 with PM_{10} and TSP), while in Medellín they are based on TSP (of 18 stations, 1 has PM_{10}, 2 have TSP and PM_{10}, and the remaining 15 have only TSP), in Cali stations are based on PM_{10} (8 stations), in Bucaramanga PM_{10} (3 stations), in Barranquilla PM_{10} (3 stations), in CORNARE PM_{10} (3 stations), in Cúcuta TSP and PM_{10} (of 5 stations, 4 have PM_{10} and 1 has TSP and PM_{10}), in Santa Marta TSP (of 10 stations, 8 measure TSP and 2 TSP and PM_{10}), in Pereira PM_{10} (4), in Cundinamarca PM_{10} (of 11 stations, 5 have PM_{10} and 6 have PM_{10} and TSP)."
4. According to data from MAVDT (2006, p. 8) "SO_2 is a by-product of the combustion of fossil fuels . . . such as motor diesel (mobile sources) and fuel and crude oils and coal in the industrial sector (fixed sources); the latter with higher sulfur contents, in the order of 1.7% in weight, compared with vehicle diesel that actually is around 0."
5. Resolution 058 does not permit the incineration of pesticides, except in trace amounts. The resolution applies to the incineration of "liquid and solid wastes

containing polychlorinated aromatic hydrocarbons such as polychlorinated biphenyls (PCBs), chlorinated hydrocarbon pesticides or pentachlorophenol (PCP) less than or equal to 50 mg/kg. Higher concentrations are prohibited." According to MAVDT (2006, p. 8), the ministry "has not authorized the thermal treatment of these wastes in the clinker ovens of cement industries which have temperatures greater than 1500°C and residence times in the order of 5 seconds (in addition, the incineration of containers is only authorized on the condition that they are triple washed)." This same condition is maintained under Resolution 0886 of 2004 which modifies Resolution 058 of 2002.

6. See http://www.transmilenio.gov.co.
7. *Green cut* refers to using manual or mechanical methods to remove sugarcane instead of burning out the fields for planting.
8. The standard formulation provides

$$E_i = \sum_{j=1}^{n} \left\{ \left(P_j * FE_{ij} \right) * \left(1 - R_{ij} \right) \right\}$$

where E = atmospheric emissions; P = parameter associated with economic activity in terms of number of employees, production volume, and production's value or aggregated value; FE = emission factor; R = coefficient of reduction of emissions; i = type of polluting agent measured; and j = type of economic activity.

9. Lack of funds to perform annual maintenance (including dynamic gas calibration systems for diluting concentrated certified gas with zero air), to purchase calibration gases, and to pay for repair service and spare parts has resulted in instruments not operating or collecting data of questionable quality. In some cases, such as nonoperational hydrogen generators for HC analysis, staff members reported having worked on the problem for six months without success (Kojima 2004).
10. See Kojima (2004, pp. 4–6) for more details.
11. The reduction would occur under a scenario where the refinery is still operated with the current facilities.
12. For any given level of ambient PM concentrations, the estimated damage cost of a ton of PM, or the benefit of a ton of PM emissions reduction, is an inverse function of total emissions. The estimate of emissions by Brugman (2004), and not the estimate by the Universidad de los Andes (2004), is therefore applied in this analysis to provide a more conservative estimate of damage cost.
13. The total annual cost of between Col$273 billion and Col$854 billion is from Larsen (2004).

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CHAPTER 8

A Silent Killer: Indoor Air Pollution

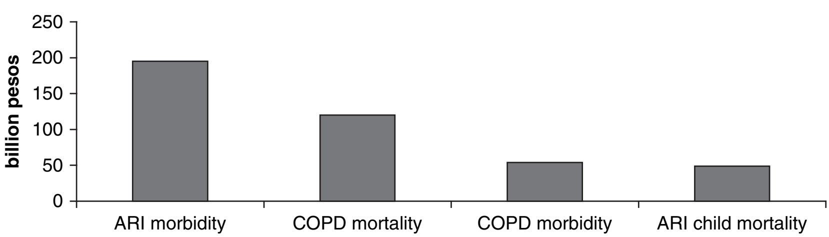
About 60 percent of rural households and 3 percent of urban households in Colombia burn solid fuels for domestic purposes. Exposure to indoor air pollution as a result of domestic use of solid fuels has adverse health impacts and is linked to illnesses such as acute respiratory infections and chronic obstructive pulmonary disease. In rural households, especially, burning solid fuels in poorly designed stoves or hearths exposes women and children to harmful concentrations of particulate matter and gaseous pollutants. Such households typically cannot afford cleaner fuel options or are not connected to the electricity grid. Children under age 5 and the women who look after them and spend large amounts of time cooking are most vulnerable to the adverse health effects of indoor air pollution. The findings of this chapter underscore the urgent need to address the problem of indoor air pollution through a program of cross-sectoral interventions that include facilitating awareness of the problem, technical mitigation options, fuel substitution, behavioral change, and improved housing design.

Indoor air pollution is a priority environmental issue in Colombia. The data from Demographic Health Surveys (DHSs) indicate that around 60 percent of rural households and less than 3 percent of urban households used fuelwood or charcoal and coal products in 2000.[1] On a national level, about 18 percent of households used fuelwood or charcoal and coal products during this period. Even though rapid inroads were made with respect to the use of liquefied petroleum gas (LPG) or natural gas in both rural and urban households during 1995 to 2000, replacing both traditional fuels and electricity for cooking, the share of rural households using traditional fuels remains substantial (Larsen 2004).

Larsen (2004) estimated that the annual cost of health impacts from indoor air pollution associated with the use of traditional fuels, mainly fuelwood, is Col$415 billion (US$193 million). Taken together, the damages associated with indoor and outdoor air pollution represent almost 1 percent of Colombia's gross domestic product (GDP). Acute respiratory illness (ARI) in children and adult females accounts for 47 percent of this cost, adult female chronic obstructive pulmonary disease (COPD) mortality accounts for 28 percent, adult female COPD morbidity accounts for 13 percent, and respiratory child mortality accounts for about 12 percent (figure 8.1).

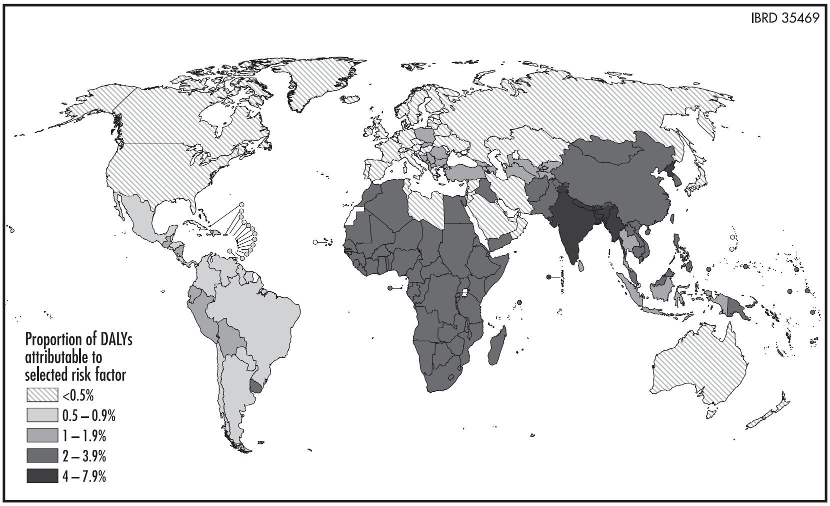
The urgent need to address indoor air pollution is evident throughout most of the developing world. The World Health Organization (WHO 2002) estimates that more than 75 percent of people in India, China, and other Asian countries, and 50 to 75 percent of people in parts of South America and Africa, continue to rely on solid fuels such as dung, wood, agricultural residues, or coal for heating and cooking. The use of these fuels in simple stoves generates substantial amounts of pollutants that are known to cause respiratory infections, pulmonary disease, and cancer. Exposure to these pollutants is greater for children and women, who usually spend a greater share of their time indoors. As a result, an estimated 2.7 percent of disability-adjusted life years (DALYs) worldwide are attributable to indoor smoke, 2.5 percent in males and 2.8 percent in females. In most Latin American countries, including Colombia, the proportion of DALYs attributable to indoor smoke from solid fuels is 0.5 percent to 0.9 percent (figure 8.2).

Figure 8.1 Annual Costs of Indoor Air Pollution



Source: Larsen 2005a.
Note: US$1 = Col$2,150.

Figure 8.2 Proportion of DALYs Attributable to Indoor Smoke from Solid Fuels



Source: WHO 2002.
Note: DALYs = Disability-adjusted life years.

Currently, under Law 99 of 1993, the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA) is responsible for the preparation of national standards, and the Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs) are responsible for the development and enforcement of local standards. As of August 2005, there were no policies or programs to control indoor air pollutants.

Acute Respiratory Illness in Colombia

The prevalence rate of ARI in children as reported by the 2000 Colombia DHS varies substantially across departments and subregions, with a range of 7.6 percent to 24.4 percent (table 8.1).[2]

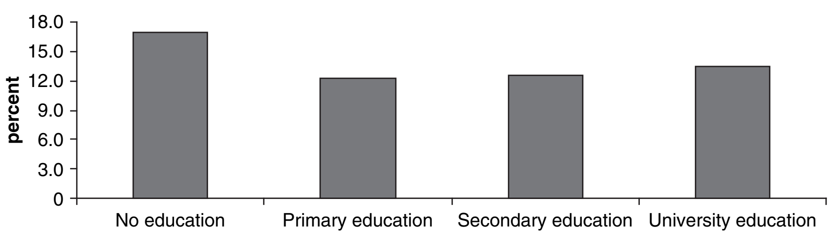
The ARI prevalence rate does not vary much with a mother's education, although it is somewhat higher in children with mothers who have no education (figure 8.3). However, the percentage of ARI cases that receive medical attention is more than three times higher for children with mothers who have a university education compared with children with mothers who have no education (table 8.2). Because lack of treatment increases the risk of ARI mortality, the figures in table 8.2 may indicate that the burden of ARI, expressed in morbidity and mortality, is higher among lower socioeconomic groups. These groups are also more likely to use solid fuels for cooking, increasing the risk of ARI morbidity and mortality in children.

Table 8.1 Acute Respiratory Illness Prevalence Rates in Children

Departments (grouped by region)	*Percentage of children under age 5 with ARI during the two weeks before survey*
La Guajira, Cesar, Magdalena	12.7
Atlántico, Bolívar Norte	19.7
Bolívar, Sucre, Córdoba	24.4
Santanderes	9.1
Boyocá, Cundinamarca, Meta	9.4
Antioquía	11.6
Medellín	12.9
Caldas, Risaraldo, Quindío	7.6
Tolima, Huila, Caqueta	9.0
Cauca, Nariño	11.0
Bogotá	10.3
Valle del Cauca	13.8
Litoral Pacífico[a]	17.5
Cali	14.3
All Colombia	12.6

Source: DHS 2000.
a. Litoral Pacífico includes Chocó.

Figure 8.3 ARI Prevalence in Children by Mother's Education Level



Source: DHS 2000.
Note: ARI prevalence refers to percentage of children under age 5 with ARI in the two weeks preceding the date of the household survey.

Table 8.2 Child Health, ARI Treatment, and Maternal Education

Maternal education	*ARI prevalence rate in children (%)*	*Child mortality rate (per 1,000 births)*	*Percentage of ARI cases treated at health facilities*
No education	16.9	44	25.7
Primary education	12.2	33	41.0
Secondary education	12.5	24	55.8
University education	13.5	15	83.8

Source: Data are from DHS (2000) for children under age 5.
Note: Diarrheal prevalence rate is for two weeks before survey date.

Health Effects of Indoor Air Pollution

It is well documented from studies around the world that indoor air pollution from burning solid fuels for cooking and heating in the indoor environment has substantial respiratory health effects. Women and young children appear to bear the largest effects, because they tend to spend more time indoors or closer to the cooking areas, or both. Some studies have also reported health effects in men. Smith, Mehta, and Feuz (2004) and Desai, Mehta, and Smith (2004) report results of health effects from biomass smoke (fuelwood and so forth) and coal smoke based on a meta-analysis of available studies. The results of the meta-analysis are presented in table 8.3. The relative risk (RR) represents the risk of health effect or illness from the use of solid fuels relative to the risk of illness from the use of clean fuels such as LPG. The RR for households using LPG is therefore 1.0.

The strongest evidence of health effects is for acute lower respiratory illness in children under age 5, COPD in adult females, and lung cancer in adult females from coal smoke. Smith, Mehta, and Feuz (2004) and Desai, Mehta, and Smith (2004) do not report an RR ratio for ARI in age groups age 5 and over because most studies have concentrated on children under age 5. However, Ezzati and Kammen (2002), from a study in Kenya, find that the RR for the group age 5 to 49 is similar to the RR for children under 5 at various levels of exposure to indoor air pollution.

A Benefit-Cost Analysis Framework

A benefit-cost analysis of interventions to reduce indoor air pollution from solid fuels presents a challenge for many reasons. The relative risks reported in table 8.3 are averages from many studies and do not necessarily reflect the pollution exposure situation in households that use solid fuels in Colombia. Moreover, the pollution load from solid fuels is not homogeneous across households. Some households use unimproved stoves or open fires while others use improved stoves with chimneys, and some households use a combination of solid fuels and clean fuels such as LPG. A benefit-cost analysis framework should therefore be flexible enough to accommodate these differences and allow for a sensitivity analysis of parameters that will influence the benefits and costs of interventions to reduce pollution loads or exposure or both.

Table 8.3 Relative Risks for Strong and Moderate Health Outcomes

Evidence	*Health outcome*	*Group*	*RR*	*CI*
Strong	ALRI	Children < 5 yrs	2.3	1.9–2.7
	COPD	Women > 30 yrs	3.2	2.3–4.8
	Lung cancer (from coal smoke)	Women > 30 yrs	1.9	1.1–3.5
Moderate-I	COPD	Men > 30 yrs	1.8	1.0–3.2
	Lung cancer (from coal smoke)	Men > 30 yrs	1.5	1.0–2.5
Moderate-II	Lung cancer (from biomass smoke)	Women > 30 yrs	1.5	1.0–2.1
	Asthma	Children 5–14 yrs	1.6	1.0–2.5
	Asthma	All > 15 yrs	1.2	1.0–1.5
	Cataracts	All > 15 yrs	1.3	1.0–1.7
	Tuberculosis	All > 15 yrs	1.5	1.0–2.4

Source: Desai, Mehta, and Smith 2004.
Note: ALRI = Acute lower respiratory infection; CI = confidence interval; RR = relative risk.

For the purposes of this report, five scenarios were selected that portray five stylized situations commonly found in most developing countries (table 8.4). These stylized situations represent reasonably well the pollution loads from solid fuel use. Actual pollution exposure, however, can vary substantially in each scenario and depends on additional factors such as household ventilation practices, housing characteristics, and household behavior. Because data on these factors are not readily available at the national level, a sensitivity analysis of relative risk will need to be undertaken to assess the likely influence of these factors on the benefit-cost ratios of interventions.

The next step is to assign population shares and relative risks to each of the stylized situations in table 8.4. According to the Colombia DHS 2000, about 18 percent of the population in Colombia relies on fuelwood (17 percent) and charcoal (1 percent) as the main fuels for cooking. In rural areas, over 60 percent of the population relies on these fuels. The Mining and Energy Planning Unit (*Unidad de Planeación Minero Energética*, UPME) presents very similar statistics and estimates that the total annual fuelwood consumption is 4.5 million to 5.0 million metric tons. Furthermore, nearly 1.5 million households use fuelwood and charcoal as their primary energy sources for cooking and account for an average annual household consumption of 3.15 tons. Unfortunately, the data on fuel use are insufficient to accurately assign the population shares that fall in each of the scenarios or stylized situations presented in table 8.4. Therefore, it is necessary to apply a base case on which a sensitivity analysis should be performed.

Table 8.4 Fuels, Stove Technology, and Pollution Scenarios

Stylized situation	*Stylized description*	*RR*
I. Unimproved wood stoves or open fire	Low energy efficiency; no chimney or ventilation device; very high indoor pollution load	Very High
II. Improved wood stoves	Relatively low energy efficiency; chimney (or other ventilation device) taking much of the smoke outdoors; still relatively high indoor pollution load if stove or chimney is not well maintained	High
III. Unimproved wood stoves and LPG (or other clean fuel)	Pollution load reduced in proportion to the use of LPG (relative to situation I)	Medium
IV. Improved wood stoves and LPG (or other clean fuel)	Pollution load reduced in proportion to the use of LPG (relative to situation I)	Medium to Low
V. LPG or other clean fuel	Absence of smoke from solid fuels	Low

Source: Authors.
Note: The framework in this table is very similar to the exposure scenario framework presented in Pruss and others (2002), which was applied in chapter 6 of this book.

Moreover, little information is available in Colombia that allows assignment of relative risks to each of the stylized situations in table 8.4. While some information on assigning relative risks is available from the international literature, the situation-specific evidence is weak compared with that for water and sanitation. It is therefore necessary to apply a base case of RRs to each of the stylized situations and perform a sensitivity analysis. The following set of equations can be used to establish a base case of RRs:

$$S_U RR_U + S_I RR_I + S_{UL} RR_{UL} + S_{IL} RR_{IL} = S_{SF} RR_{SF} \tag{8.1}$$

$$RR_I = 1 + (RR_U - 1)(1 - r) \tag{8.2}$$

$$RR_{UL} = 1 + (RR_U - 1) L_U \tag{8.3}$$

$$RR_{IL} = 1 + (RR_I - 1) L_I \tag{8.4}$$

where S is population share and RR is the relative risk of using an unimproved stove (U), an improved stove (I), a combination of an unimproved stove and LPG (UL), and a combination of an improved stove and LPG (IL). S_{SF} is the total population share using solid fuels (with or without LPG), and RR_{SF} is the weighted-average relative risk of illness in these households. In equation (8.2), r is the "excess" risk reduction from using improved stoves relative to unimproved stoves. L is the share of energy derived from LPG in households using LPG and an unimproved stove (*U*) and in households using LPG and an improved stove (*I*).

The base cases for different population shares and relative risks are presented in table 8.5. Because solid fuel is used almost exclusively in rural areas in Colombia, rural population shares are applied in table 8.5. About 35 percent use LPG or other clean fuel. As previously mentioned, the DHS and UPME data do not provide the population shares for situations I through IV. On the basis of data from Guatemala (Ahmed and others 2005), it is estimated that around 20 percent of rural households use a combination of solid fuels and LPG in Colombia. This share is split evenly between unimproved and improved stoves so that the rural population share in situations III and IV is 10 percent. Moreover, it is assumed that these households on average derive 50 percent of their cooking energy demand from LPG and 50 percent from solid fuels. Of the remaining rural population, 25 percent is assigned to situation I and 20 percent to situation II. It should be noted that there are no readily available data to substantiate this allocation. The shares are therefore subjected to sensitivity analysis in later sections of this chapter.

Two more parameters must be assigned to solve the system of equations (8.1) through (8.4) and arrive at the RRs presented in table 8.5. One of them is the reduction in excess risk, *r*, from using improved stoves instead of unimproved stoves. Although there is limited guidance from the international literature on the size of *r*, there are several studies from around the world that present measurements of particulate exposure from solid fuel use, particularly from cooking. Some results from Latin America are presented in table 8.6. The 24-hour average concentration levels from open fire or traditional stoves are many times higher than urban air quality standards in most countries. The improved stoves, such as the *plancha*, produce levels of particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) or less than 3.5 microns in diameter ($PM_{3.5}$) that are often only 20 percent of those

Table 8.5 Base Case Estimation of Scenario-Specific Relative Risks

Stylized situations	*Rural population share (%)*	*RR for ARI*	*RR for COPD in women*
I. Unimproved wood stoves or open fire	25	3.0	4.4
II. Improved wood stoves	20	2.0	2.7
III. Unimproved wood stoves and LPG (or other clean fuel)	10	2.0	2.7
IV. Improved wood stoves and LPG (or other clean fuel)	10	1.5	1.8
V. LPG or other clean fuel	35	1.0	1.0
Weighted average risk of I to IV		2.3	3.2

Source: Larsen 2005b.

Table 8.6 PM Concentrations from Cooking Stoves

	Concentration in μg/m³		
Measurement	*Open fire or traditional stove*	*Improved stove*	*LPG*
24-hour $PM_{3.5}$	1,930	330	n.a.
24-hour PM_{10}	1,210	520	140
24-hour $PM_{2.5}$	520	88	45
24-hour $PM_{2.5}$	868	152	n.a.
PM_{10}	600–1,000	300	50

Source: Compiled by Larsen (2005a).
Note: n.a. = not applicable; μg/m³ = micrograms per cubic meter; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; $PM_{3.5}$ = particulate matter less than 3.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter.

from an open fire, and are even found to be less than 10 percent of that of an open fire in a study in Guatemala by McCracken and Smith (1998). According to the figures in table 8.6, the reduction in $PM_{2.5}$ concentration appears even larger than reductions in particulate matter less than 10 microns in diameter (PM_{10}) (Albalak and others 2001; Naeher, Leaderer, and Smith 2000; Saatkamp, Masera, and Kammen 2000). While the indoor concentration levels of PM can be substantially reduced by using improved stoves, it is not clear that the health benefits are proportional. The concentration levels of PM, even with an improved stove, are still substantially higher than those found in most outdoor urban environments.

Table 8.7 provides the results of a study by Ezzati and Kammen (2002), which presents odds ratios for ARI in relation to indoor concentrations levels of PM_{10}. Halving of PM_{10} levels from 1,000 to 2,000 micrograms per cubic meter (μg/m³) to 500 to 1,000 μg/m³ can correspond to the reduction in concentration levels achievable by using an improved stove instead of an unimproved stove. This reduction in concentration level is associated with a reduction in the odds ratio of about 50 percent for children under age 5 and 25 percent for the age group 5 to 49. The reduction in excess risk can be calculated from equation (8.2):

$$r = (RR_U - RR_I)/(RR_U - 1) \qquad (8.5)$$

For children under age 5, $r = (4.30 - 2.15)/(4.30 - 1) = 65$ percent. For age group 5 to 49, $r = (3.79 - 2.77)/(3.79 - 1) = 36$ percent. The simple average for the two age groups is around 50 percent. An r of 50 percent has therefore been applied in the base case in table 8.5 for ARI to establish the relative order of magnitude of the RR in situations I and II.

One additional parameter needs to be assigned a value to solve equations (8.1) through (8.4). There are two logical choices of parameters, that is,

Table 8.7 Odds Ratios for ARI

PM_{10} (μg/m³)	Children under age 5	Age 5 to 49
<200	1.00	1.00
200–500	2.42	3.01
500–1,000	2.15	2.77
1,000–2,000	4.30	3.79
2,000–3,500	4.72	—
2,000–4,000	—	4.49
>3,500	6.73	—
4,000–7,000	—	5.40
>7,000	—	7.93

Source: Ezzati and Kammen 2002.
Note: — = not available; μg/m³ = micrograms per cubic meter.

the average risk ratio RR_{SF} or the risk ratio associated with the use of an unimproved stove (RR_U). A logical candidate for the base case value of RR_{SF} is the central estimate of the RR from the international literature in table 8.3, while a logical value for RR_U might be the upper end of the confidence intervals. The former was selected in this report, given that the central estimates reflect a diverse set of situations reported in the literature. Thus, RR_{SF} is equal to 2.3 for ARI and to 3.2 for COPD in women.

Equations (8.3) and (8.4) implicitly assume that the risk of illness is proportional to the share of LPG in households that use both solid fuels and LPG (or other clean fuels). For instance, the excess risk of illness is reduced by 50 percent if a household derives 50 percent of cooking energy demand from LPG. While the study by Ezzati and Kammen (2002) presented in table 8.7 might suggest that excess risk is reduced by about 50 percent for a 50 percent reduction in PM_{10} concentration levels from 1,000 to 2,000 μg/m³ to 500 to 1,000 μg/m³, it is not clear that a 50 percent reduction in solid fuel consumption translates to a 50 percent reduction in PM concentration levels. Whereas Albalak and others (2001) estimate 45 percent lower $PM_{3.5}$ levels with the use of a combination of open fire and LPG compared with open fire only, the percentage difference in solid fuel consumption is not clear.

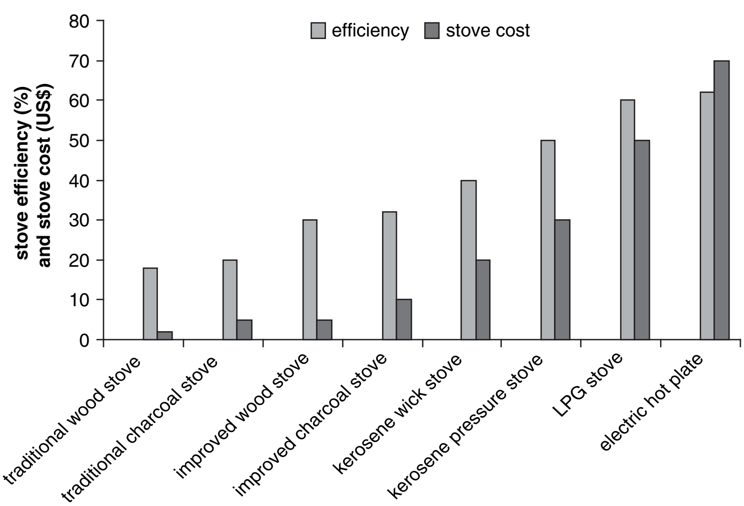
Using the parameter values as discussed, the solution to equations (8.1) through (8.4) is the RRs presented in table 8.5. Only COPD in women and ARI are included. While there is moderate evidence for increased risk of COPD in men, it is not included in this report. For ARI, however, both children under age 5 and women over age 15 are included, although ARI in adult women is not included in the meta-analysis results presented in Smith, Mehta, and Feuz (2004) and Desai, Mehta, and Smith (2004). The study by Ezzati and Kammen (2002) provides some evidence of similar ARI risk ratios for children under age 5 and the age 5 to 49 group. A sensitivity analysis is performed for ARI in women over age 15 in the benefit-cost ratio estimations later in this section.

The population shares and the relative risk ratios in table 8.5 allow a base case estimation of the health benefits of interventions such as using improved stoves and switching to clean fuels (table 8.4). To estimate benefit-cost ratios, however, the costs of interventions need to be estimated. In addition to costs of improved stoves and LPG stoves (or stoves for other clean fuels), this exercise involves an assessment of household energy consumption for cooking to estimate the recurrent cost of LPG requirements or other clean fuels. In addition, time savings from reduced fuelwood collection may be an important benefit for many households of switching to improved stoves or clean fuels. Fuelwood consumption must therefore be estimated for the various stylized situations or scenarios in table 8.4. Thus, the first step in estimating the costs of interventions is to consider stove efficiencies.

Stove Efficiency

Figure 8.4 presents an energy efficiency ladder for stoves, and typical costs that are often cited in the research literature on fuel use and indoor air pollution (for example, Baranzini and Goldenberg 1996; Luo and Hulscher 1999; and Saatkamp, Masera, and Kammen 2000). The stove

Figure 8.4 Stove Efficiency and Capital Costs



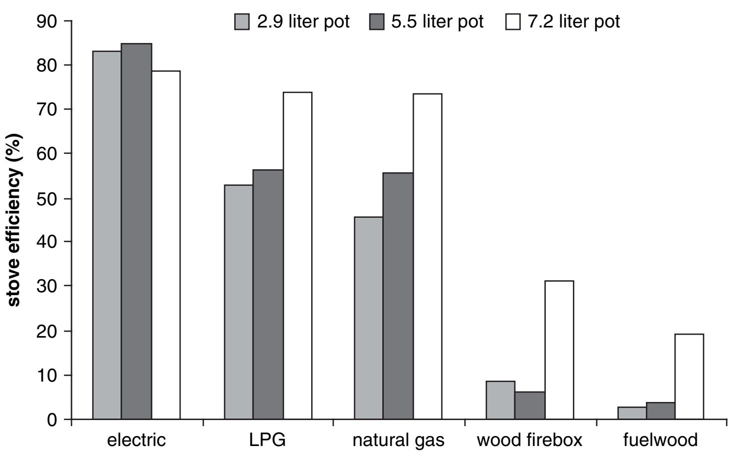
Source: Larsen 2005.

efficiency ladder provides a generic perspective on potential energy savings from improved wood and charcoal stoves and from kerosene, LPG, and electric stoves compared with traditional stoves. According to figure 8.4, improved wood and charcoal stoves are about 50 percent more efficient than traditional stoves, and LPG and electric stoves are twice as efficient as the improved wood and charcoal stoves.

A study of stove efficiency in Colombia was conducted by the Department of Physics of the National University of Colombia. The results of the study were provided by UPME for the purposes of this report, and are presented in figure 8.5. The study estimated the stove efficiency for three different sizes of pots or kettles. The efficiency for electric plates was around 80 percent for all three pot sizes. LPG and natural gas stoves had an efficiency of 45 to 55 percent for the two smallest pot sizes. The efficiency for the largest pot size was over 75 percent. For a wood firebox, an improved wood stove, the efficiency was below 10 percent for the two smallest pots, but about 30 percent for the largest pot. The efficiency of fuelwood, or a traditional open stove, was less than 5 percent for the smaller pots, and 20 percent for the largest pot.

For the most part, the results from this Colombian study are consistent with the generic efficiency ladder illustrated in figure 8.4. A study of the *plancha* woodstove in Guatemala reported an efficiency of about 10 percent, very similar to the efficiency of using open fire. A modified version of the *plancha* had an efficiency of about 12 percent (Boy and

Figure 8.5 Stove Efficiency from a Study in Colombia



Source: Study conducted by the National University of Colombia, Department of Physics. The results of the study were provided by UPME.

others 2000). McCracken and Smith (1998) reported an efficiency of 13 to 14 percent for the *plancha* and open fire. Saatkamp, Masera, and Kammen (2000) reported estimates of stove efficiencies in Jaracuaro, Mexico, and found that the efficiency of the *lorena* woodstove is not much different from traditional open stoves.

Many communities in Latin America have adopted the *plancha* and *lorena* woodstoves. While these stoves are often not very efficient, they are equipped with chimneys that remove the smoke from the indoor environment and therefore offer important potential health and quality-of-life benefits. A simple *lorena* stove is made from mud-clay mixed with sand, and a metal tube chimney. The *lorena* and *plancha* stoves have also been built from brick. Several versions of these stoves have also been developed to improve stove efficiency.

Fuelwood Consumption

Households that use fuelwood typically fall into one of three situations. Some households use open fires or traditional woodstoves. Others use improved woodstoves. Finally, some households use fuelwood in combination with LPG or another type of cleaner fuel. On the basis of data from UPME, it is estimated that the average household using fuelwood consumes 3.15 tons per year. However, household consumption for a given household size will vary depending on woodstove efficiency and whether the household also uses other fuel types for cooking.

To estimate household fuelwood consumption, the following equations are used:

$$e_U H_U = e_I H_I \tag{8.6}$$

$$H_{UL} = a_{UL} H_U \tag{8.7}$$

$$H_{IL} = a_{IL} H_I \tag{8.8}$$

$$S_U H_U + S_I H_\mathrm{I} + S_{UL} H_{UL} + S_{IL} H_{IL} = 3.15 \tag{8.9}$$

where H is annual household consumption of fuelwood in tons; S is the percentage of households using unimproved stoves (U), improved stoves (I), a mix of LPG and fuelwood with unimproved stove (UL), and a mix of LPG and fuelwood with improved stove (IL); e is stove efficiency; and a is the fuelwood consumption share in households using a mix of LPG and fuelwood. In both cases, $a = 0.5$, and it is measured in effective energy (product of net heating value and stove efficiency). The stove efficiency e is based on the findings illustrated in figure 8.5 and is set to 10 percent

Table 8.8 Estimated Annual Household Consumption of Fuelwood

Stove technology	*Fuelwood consumption (tons)*
Unimproved wood stoves	4.40
Improved wood stoves	2.90
Unimproved wood stoves and LPG stoves	2.20
Improved wood stoves and LPG stoves	1.45

Source: Authors.

for unimproved stoves and 15 percent for improved stoves, in both cases representing an average of the different pot sizes.

Solving the system of equations (8.6) through (8.9) provides estimates of annual household fuelwood consumption presented in table 8.8. These estimates are based on the assumption that the groups of households have, on average, the same demand for cooking energy.

Whether the fuelwood consumption in these four cases is realistic must be assessed. Saatkamp, Masera, and Kammen (2000) estimate fuelwood consumption in Jaracuaro, Mexico, in the range of 0.5 kilograms (kg) to 1.0 kg per meal per person for the *lorena* stove and open fire. Two meals a day for an average household size of five people implies an annual fuelwood consumption of 1.8 tons to 3.6 tons per year. For three meals a day, the annual consumption would be 2.7 tons to 5.4 tons per year. This is in the range of the estimated fuelwood consumption in table 8.8. Boy and others (2000) estimate a fuelwood consumption of 6 kg for the preparation of 0.45 kg of beans and 1.35 kg of tortillas, using a *plancha* stove. If this food were prepared twice a day, the annual fuelwood consumption would be 4.4 tons.

Cost of Interventions

The estimated annual recurrent cost of switching from fuelwood to commercial energy, or from a combination of fuelwood and LPG to LPG only, is presented in table 8.9. At energy prices (in 2004) in Colombia, natural gas is found to be the least-cost option, followed by LPG. The cost of using electricity to replace fuelwood is found to be several times higher than using natural gas or LPG as replacements for fuelwood. Furthermore, the costs of using electricity to replace fuelwood are identical for households that use unimproved wood stoves and households that use improved wood stoves (with 10 percent and 15 percent efficiency, respectively). This is because of the assumption that both households have the same effective energy demand. While natural gas seems to be the least-cost option, availability of natural gas to all rural households is

Table 8.9 Annual Recurrent Cost of Complete Fuel Substitution

	Annual cost per household (thousand pesos)			
	LPG (bottles)			
Stove technology	*17.7 gallon*	*6.6 gallon*	*Natural gas*	*Electricity*
Unimproved wood stoves	206	256	99	608
Improved wood stoves	206	256	99	608
Unimproved wood stoves and LPG stoves	103	128	n.a.	n.a.
Improved wood stoves and LPG stoves	103	128	n.a.	n.a.

Source: Authors.
Note: n.a. = not applicable.

unlikely in the short to medium term. LPG therefore seems to be the most viable option.

The cost values presented in table 8.9 are likely to underestimate the costs of providing commercial energy to distant rural areas. However, over 30 percent of rural households in Colombia already use LPG and other commercial energy sources according to the Colombia DHS 2000. Thus, supplying these fuels to other rural households may not be substantially more expensive than to households that already use commercial fuels.

Table 8.10 presents the baseline parameters used to estimate the cost of switching to commercial energy. These parameters are based on data from UPME and results of a study conducted by the National University of Colombia.

Capital costs and annualized costs of improved stoves and LPG stoves are presented in table 8.11. Capital costs are adapted from Ahmed and others (2005) from Guatemala. Although simple improved stoves used in many developing countries are found to be quite inexpensive, as presented in figure 8.4, the type of improved stoves commonly used in Latin America is far more expensive, as indicated in table 8.11. Annualized costs are calculated by employing a useful life of 10 years and an annual discount rate of 10 percent.

Benefit-Cost Analysis

A benefit-cost analysis is conducted for the five interventions shown in table 8.12, which are based on the stylized situations in table 8.4. The estimated benefits of these interventions are presented in table 8.13. Avoided cases of ARI and COPD are estimated from the relative risk ratios in table 8.5 and baseline estimates of annual cases of ARI and COPD. Baseline cases are presented in Larsen (2004). The monetary benefits of avoided cases are calculated from the estimated unit costs of

Table 8.10 Baseline Parameters for Estimating the Cost of Fuel Substitution

Substitute fuel	*Parameter*
Fuelwood	
Average gross energy content of fuelwood (MJ/kg)	19
Average net energy content of fuelwood (MJ/kg)	11
Propane (LPG)	
Average stove efficiency (propane) (%)	55
Average energy content of propane (Btu/gallon)	92,000
Cost per bottle (17.7 gallon bottles) (pesos)	39,000
Cost per bottle (6.6 gallon bottles) (pesos)	18,000
Natural gas	
Average stove efficiency (gas) (%)	55
Average energy content of natural gas (Btu/m^3)	35,395
Cost of natural gas (residential) (pesos/m^3)	406.45
Electricity	
Average stove efficiency (%)	80
Cost of electricity (pesos/kWh)	350

Sources: Energy content of LPG and natural gas, and prices of LPG, natural gas, and electricity are based on data from UPME. Gross and net energy content of fuelwood (gross and net heating content) and stove efficiencies are from a study by the National University of Colombia provided by UPME.
Note: Btu = British thermal unit; kWh = kilowatt hour; m^3 = cubic meter; MJ/kg = megajoules per kilogram. US$1 = Col$2,150.

Table 8.11 Cost Estimates of Improved Wood Stoves and LPG Stoves

	Cost[a]	
Type of cost	*Low*	*High*
Capital cost		
Improved wood stove	145,000 (60)	290,000 (120)
LPG stove	145,000 (60)	145,000 (60)
Annualized cost		
Improved wood stove	21,000	42,000
LPG stove	21,000	21,000

Source: Larsen 2005b.
Note: US$1 = Col$2,150.
a. Values without parentheses are Colombian peso amounts.

ARI and COPD morbidity and mortality, also presented in Larsen (2004). Unit costs of morbidity include medical treatment cost, value of time losses (at 75 percent of wages), and DALYs valued at GDP per capita as a proxy for the cost of reduced well-being.[3] Child mortality is valued by using the human capital approach (HCA) of discounted life earnings losses.

Adult mortality is valued by the human capital approach (HCA) as a lower bound and the value of statistical life (VSL) approach as an upper bound. VSL is derived from benefit transfer from the United States and other high-income countries using an income elasticity of 1.0, based on

Table 8.12 Interventions

Scenarios	*Description*
From I to II	From unimproved wood stove to improved wood stove
From I to V	From unimproved wood stove to LPG (or other clean fuel)
From II to V	From improved wood stove to LPG (or other clean fuel)
From III to V	From unimproved wood stove and LPG mix to LPG (or other clean fuel)
From IV to V	From improved wood stove and LPG mix to LPG (or other clean fuel)

Source: Larsen 2005.

the midpoint value from the range of US$1.5 million to US$2.5 million as estimated by Mrozek and Taylor (2002). As seen in table 8.13, the total health benefits of the interventions are greatly influenced by the choice of valuation technique for adult mortality.

An estimate of the value of time savings from reduced fuelwood collection is also included in table 8.13 for each intervention. As a base case, it is assumed that a household that uses an unimproved wood stove spends on average 30 minutes per day on fuelwood collection. Intervention (2) provides a 100 percent time saving while, for instance, intervention (1) provides a 33 percent time saving. These estimates are derived from table 8.8. In table 8.13, time is valued at 75 percent of average rural wages. In total, the estimated benefits of time savings are close to the lower bound of health benefits of interventions (2) through (5). The estimated benefits in table 8.13 represent a base case. A sensitivity analysis is performed later in this section.

Table 8.14 presents the estimated annual costs of interventions. The cost of LPG represents 80 to 85 percent of total cost of interventions (2) through (5), while the annualized cost of an LPG stove is less than 10 percent of total cost (interventions [2] and [3]). A tentative estimate of the program cost of promoting and implementing improved stoves and fuel switching to LPG, and sustaining a stove inspection and maintenance program, is also included in table 8.14. The estimated cost is based on an incremental local government staff requirement of one to four staff members in a village with 300 to 600 households.

Table 8.15 presents estimated benefit-cost ratios for the five interventions for which benefits and costs are provided in tables 8.13 and 8.14. Eight ratios are estimated for each intervention. Four ratios include only the health benefits and the remaining four ratios include both health benefits and benefits of time savings from reduced fuelwood collection, that is, total benefits. Each set of four ratios represents a combination of low and high benefits and costs. As shown in table 8.13, the low benefits reflect adult mortality valuation using the HCA, while the high benefits reflect adult mortality valuation using a VSL benefit transfer to

Table 8.13 Estimated Annual Benefits of Interventions

Indicator	*Intervention scenario* (1) From I to II	(2) From I to V	(3) From II to V	(4) From III to V	(5) From IV to V
Avoided cases of ARI	918,063	1,836,127	734,451	367,225	183,613
Avoided cases of ARI in children under age 5	589,501	1,179,002	471,601	235,800	117,900
Avoided cases of ARI in females age 15 and older	328,562	657,125	262,850	131,425	65,712
Case fatality rate in children under age 5	0.00016	0.00016	0.00016	0.00016	0.00016
Avoided child deaths	96	193	77	39	19
Cost per ARI case in children under age 5 (COI and DALY) (pesos)	44,000	44,000	44,000	44,000	44,000
Cost per ARI case in females age 15 and older (COI and DALY) (pesos)	80,000	80,000	80,000	80,000	80,000
Benefits of reduced ARI morbidity in children under age 5 (billion pesos)	25.9	51.9	20.8	10.4	5.2
Benefits of reduced ARI morbidity in females age 15 and older (billion pesos)	26.3	52.6	21.0	10.5	5.3
Cost of mortality per death (HCA) (million pesos)	136	136	136	136	136
Benefits of reduced ARI mortality in children under age 5 (billion pesos)	13.1	26.2	10.5	5.2	2.6
Total benefits of avoided ARI cases (billion pesos)	65	131	52	26	13
Avoided cases of COPD	1,480	2,960	1,184	592	296
Case fatality rate of COPD	0.186	0.186	0.186	0.186	0.186
Avoided COPD deaths	275	549	220	110	55
Cost of COPD per case (COI and DALY) (million pesos)	11.6	11.6	11.6	11.6	11.6
Cost of COPD mortality per death (HCA) (million pesos)	26.3	26.3	26.3	26.3	26.3
Cost of COPD mortality per death (VSL) (million pesos)	293	293	293	293	293
Total benefits of avoided COPD cases (HCA for mortality) (billion pesos)	24	49	20	10	5
Total benefits of avoided COPD cases (VSL for mortality) (billion pesos)	98	195	78	39	20
Total health benefits (HCA for adults)	90	180	72	36	18
Total health benefits (VSL for adults)	163	326	130	65	33

Number of individuals receiving intervention (thousands)	3,086	3,086	2,469	1,235	1,235
Average household size	5	5	5	5	5
Number of households receiving intervention	617,270	617,270	493,816	246,908	246,908
Household fuelwood savings (relative to situation II) (%)	33	100	67	50	33
Household time savings per day (hours)	0.17	0.50	0.33	0.25	0.17
Average rural wages (pesos per hour)	2,000	2,000	2,000	2,000	2,000
Value of time (% wages)	75	75	75	75	75
Value of time (pesos per hour)	1,500	1,500	1,500	1,500	1,500
Total value of time savings (billion pesos)	56.3	169.0	90.1	33.8	22.5

Source: Larsen 2005b.

Note: COI = cost of illness; VSL = value of statistical life; HCA = human capital approach. US$1 = Col$2,150.

Table 8.14 Estimated Annual Costs of Interventions

	Intervention scenario				
Indicator	*(1) From I to II*	*(2) From I to V*	*(3) From II to V*	*(4) From III to V*	*(5) From IV to V*
Intervention program cost per household, low (US$)	5	5	5	5	5
Intervention program cost per household, high (US$)	10	10	10	10	10
Intervention program cost per household, low (pesos)	12,500	12,500	12,500	12,500	12,500
Intervention program cost per household, high (pesos)	25,000	25,000	25,000	25,000	25,000
Total cost of intervention program, low (billion pesos)	7.7	7.7	6.2	3.1	3.1
Total cost of intervention program, high (billion pesos)	15.4	15.4	12.3	6.2	6.2
Annualized cost of improved stove (pesos) US$60 per stove	21,453	n.a.	n.a.	n.a.	n.a.
Annualized cost of improved stove (pesos) US$120 per stove	42,906	n.a.	n.a.	n.a.	n.a.
Annualized cost of LPG stove (pesos) US$60 per stove	n.a.	21,453	21,453	0	0
Total annualized stove cost, low (billion pesos)	13.2	13.2	10.6	0.0	0.0
Total annualized stove cost, high (billion pesos)	26.5	13.2	10.6	0.0	0.0
Annual cost of LPG per household, low (pesos)	n.a.	206,448	206,448	103,224	103,224
Annual cost of LPG per household, high (pesos)	n.a.	255,533	255,533	127,767	127,767
Total annual cost of LPG, low (billion pesos)	n.a.	127.4	101.9	25.5	25.5
Total annual cost of LPG, high (billion pesos)	n.a.	157.7	126.2	31.5	31.5
Total costs, low (billion pesos)	21.0	148.4	118.7	28.6	28.6
Total costs, high (billion pesos)	41.9	186.4	149.1	37.7	37.7

Source: Larsen 2005b.
Note: n.a. = not applicable. US$1 = Col$2,150.

Table 8.15 Benefit-Cost Ratios of Interventions

		Health benefits		*Total benefits*	
	Costs	*Low*	*High*	*Low*	*High*
Intervention 1: Unimproved to improved wood stove	Low	4.3	7.8	7.0	10.5
	High	2.1	3.9	3.5	5.2
Intervention 2: Unimproved wood stove to LPG (or other clean fuel)	Low	1.2	2.2	2.3	3.3
	High	1.0	1.7	1.9	2.7
Intervention 3: Improved wood stove to LPG (or other clean fuel)	Low	0.6	1.1	1.4	1.9
	High	0.5	0.9	1.1	1.5
Intervention 4: Unimproved wood stove and LPG to LPG (or other clean fuel)	Low	1.3	2.3	2.4	3.5
	High	1.0	1.7	1.8	2.6
Intervention 5: Improved wood stove and LPG to LPG (or other clean fuel)	Low	0.6	1.1	1.4	1.9
	High	0.5	0.9	1.1	1.5

Source: Larsen 2005b.

Colombia. The low and high costs from table 8.14 reflect low and high cost estimates of LPG, improved stoves, and an intervention program.

The estimated benefit-cost ratios of adoption of improved stoves by far exceed 1.0 even without the value of time savings. Even in the case of high-cost–low-health-benefit, the ratio is slightly higher than 2, indicating that the estimated benefits are twice as high as the estimated costs. The benefit-cost ratios for intervention (2) are also generally higher than 1.0, but no more than 1.0 in the case of high cost–low benefits. The ratios for the intervention to switch from improved stoves to LPG are only consistently higher than 1.0 if households value their time at somewhere close to 75 percent of average rural wages. Although this is unlikely to be the case for poorer households, households that have good income opportunities and thus high opportunity cost of time may value their time at this rate. The benefit-cost ratios for intervention (4) are naturally very close to the ratios for intervention (2), and the ratios for intervention (5) are close to the ratios for intervention (3).

Sensitivity Analysis

As discussed throughout this chapter, many critical parameters in the benefit-cost analysis involve significant uncertainty. A list of the most important parameters follows:

- The reduction in excess health risk of an improved wood stove compared with an unimproved wood stove or open fire (table 8.5)

- The weighted average RR of illness (ARI and COPD) from using solid fuels (table 8.5)
- Using a relative risk ratio for ARI in adult females that is similar to the risk ratio for children under age 5
- The population shares assigned to each scenario or typical solid-fuel-use situation (table 8.5)
- Time savings from less or no fuelwood collection valued at 75 percent of average rural wages.

Notes on Benefit-Cost Analysis Sensitivity Parameters

The following important aspects of the relevant parameters provide context for understanding the benefit-cost sensitivity analysis conducted in this study:

- *Lowering the excess risk reduction of improved stoves from 50 percent to 30 percent* reduces the benefit-cost ratio to 1.2 in the high-cost–low-benefit scenario of intervention (1) without time savings benefits.
- *Lowering the weighted average RR ratio for ARI and COPD by 20 percent* reduces health benefits of interventions by close to 30 percent. However, the benefit-cost ratios for adopting improved stoves are all still well above 1.0, and well above 1.0 for switching from unimproved stoves to LPG if time benefits are included.
- *Excluding ARI in adults from the benefit-cost analysis* reduces the benefit-cost ratios (health benefits only) by 15 percent (high benefits) to 30 percent (low benefits). The benefit-cost ratios for improved stoves are still well above 1.0 even without including the time savings benefits, and above 1.0 in half the cases of switching from an unimproved stove to LPG (without time savings benefits included).
- *Changing the population share from 25 percent with an unimproved stove and 20 percent with an improved stove to 20 percent with unimproved and 25 percent with improved* has only a minor impact on the benefit-cost ratios.
- *Reducing the time-savings benefits from 75 percent to 50 percent of rural wages* reduces the benefit-cost ratios by about 10 percent for the high-benefit scenario, and by 15 to 20 percent for the low-benefit scenario.
- *Reducing the time savings benefits from 75 percent to 25 percent of rural wages* brings the benefit-cost ratios for intervention (3)—improved stove to LPG—to below 1.0 for the low-benefit scenario.

Effectiveness of Indoor Air Pollution Control Programs

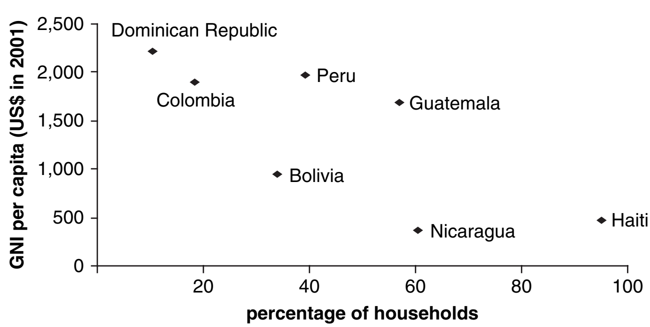
The preceding benefit-cost analysis did not consider the impact of the speed and rate of adoption of improved stoves and switching to LPG or electricity on the potential effectiveness of an indoor air pollution control program. As seen from table 8.15, household valuation of time savings is likely to play an important role in changing to LPG, especially if the household already has an improved stove. Table 8.16 presents the percentage of urban and rural households that use solid fuel for cooking. Of the countries in Latin America and the Caribbean for which DHS data with fuel use are available, only the Dominican Republic uses solid fuels less than Colombia. Figure 8.6 indicates that there is a high correlation between the percentage of households that use solid fuels as the main cooking fuel and income per capita in Latin America and the Caribbean.

Table 8.16 Households Using Solid Fuels

	Percentage of households			
Country	*Urban*	*Rural*	*Total*	*GNI per capita (2001 US$)*
Bolivia 2003	8	79	34	950
Colombia 2000	2	61	18	1,890
Dominican Republic 2002	3	24	10	2,230
Guatemala 1998–99	32	78	57	1,680
Haiti 2000	89	98	95	480
Nicaragua 2001	38	92	60	370
Peru 2000	11	87	39	1,980

Source: DHS data.
Note: GNI = gross national income.

Figure 8.6 Solid Fuels as Main Cooking Fuel in Latin America and the Caribbean

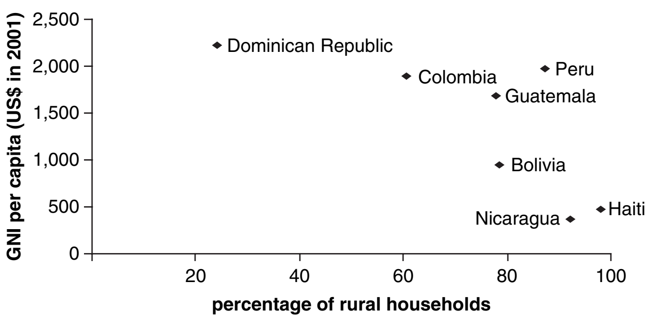


Source: Solid fuel use data are from DHS 1998–99 to 2003. Gross national income is from the World Bank 2002.
Note: GNI = gross national income.

Figure 8.7 presents rural household use of solid fuels for the same countries as in figure 8.6. The responsiveness of fuel substitution to income in rural areas seems less pronounced than at the national level, suggesting that an active rural energy and environmental health policy can help speed up the transition to cleaner fuels. The difference between the Dominican Republic (in the upper left corner of figure 8.7) and the other countries with respect to rural solid fuel use is more striking than for solid fuel use at the national level.

Table 8.17 presents changes in the percentage of households using solid fuels over a four to six year period. Data are available for only three Latin American and Caribbean countries in the DHS database. The decline in household use of these fuels is very pronounced in the Dominican Republic, even over such a short period. In Colombia, the percentage decline is largest in the rural areas. The change in solid fuel use in Bolivia was mixed for the two periods.

Figure 8.7 Solid Fuels as Main Cooking Fuel in Rural Latin America and the Caribbean



Source: Solid fuel use data are from DHS 1998–99 to 2003. Gross national income (GNI) is from the World Bank 2002.
Note: GNI = gross national income.

Table 8.17 Change in Share of Households Using Solid Fuels

Country	*Period*	*Urban (percent)*	*Rural (percent)*	*Total (percent)*
Bolivia	1994–98	–3	0	–6
Bolivia	1998–2003	+3	–1	+2
Colombia	1995–2000	–1	–6	–4
Dominican Rep.	1991–96	–15	–33	–22
Dominican Rep.	1996–2002	–2	–18	–9

Source: DHS in respective countries, 1999, 2000, 2001, 2002, 2003.

Conclusions and Recommendations

It would be advisable to implement a program of cross-sectoral interventions to tackle indoor air pollution in Colombia in the short term. The adverse health impacts of indoor air pollution clearly and disproportionately affect the poorer segments of society. Based on the experience from countries at similar levels of development, the associated benefits derived from such a program are typically realized reasonably quickly. Suggested interventions might include the following:

- Evaluating existing improved stove programs and implementing measures to ensure improved delivery and operation of the programs and to maximize their effectiveness and efficiency in contributing to the achievement of improved health outcomes in the population groups most affected by indoor air pollution, in addition to fuel efficiency
- Establishing different mechanisms to build awareness of the health effects of indoor air pollution, particularly in rural communities, through existing outreach programs, such as those for rural health care
- Including in housing subsidy programs for rural low-income housing *(Vivienda de Interés Social)* requirements for building codes and housing design in poor communities to allow for improved ventilation, including the design of chimneys
- Evaluating the availability of LPG and other cleaner fuels in areas that predominantly use fuelwood, and implementing actions to improve availability and access to fuelwood users in a safe and cost-effective manner
- Extending the coverage of rural electrification programs

These recommendations are summarized in table 8.18.

Table 8.18 Summary of Recommendations for Addressing Indoor Air Pollution in Colombia

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Design and implement a cross-sectoral program to address indoor air pollution that includes the interventions recommended in this table	S	MSPS, MAVDT, Ministry of Energy, INS, CARs

(*continued*)

Table 8.18 Summary of Recommendations for Addressing Indoor Air Pollution in Colombia (*continued*)

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Evaluate existing improved-stove programs and implement measures to ensure improved delivery and operation of the programs	S	MAVDT, Ministry of Energy, CARs
Establish different mechanisms to build awareness of health effects of indoor air pollution, particularly in rural communities	S	MAVDT, MSPS, INS, CARs
Include in housing subsidy programs for rural low-income housing (*Vivienda de Interés Social*) requirements for building codes and housing design in poor communities to allow for improved ventilation, including design of chimneys	S	MAVDT, Municipalities, Departments
Evaluate availability of LPG and other cleaner fuels in areas that predominantly use fuelwood, and implement actions to improve availability and access to fuelwood users in a safe and cost-effective manner	S	Ministry of Energy, UPME
Implement a research program to improve understanding of underlying factors that affect exposure levels	S	MSPS, MAVDT, IDEAM, UPME
Extend the coverage of rural electrification programs	S	Ministry of Energy, UPME

Source: Authors.
Note: CARs = *Corporaciones Autónomas Regionales*; IDEAM = *Instituto de Hidrología, Meteorología y Estudios Ambientales*; INS = *Instituto Nacional de Salud*; MAVDT = *Ministerio de Ambiente, Vivienda y Desarrollo Territorial*; MSPS = *Ministerio de Salud y Protección Social.*

Notes

1. Bjorn Larsen, Kulsum Ahmed, and Yewande Awe are the authors of this chapter, which draws heavily from background documents prepared by Larsen (2005b) for this study.
2. The DHS 2000 is a household survey that was carried out in thousands of households in Colombia.

3. The monetary valuation of DALYs in relation to the cost of illness is still substantially less than the difference between willingness to pay for avoiding a case of illness and cost of illness found from studies in the United States. However, there are not enough studies to rely on from Colombia. DALYs are therefore used as a proxy for reduced well-being.

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CHAPTER 9

The Environmental Cost of Accelerated Urban Growth

In Colombia, a lack of adequate planning to accompany rapid urban growth has contributed to increased risks to the welfare of the population. This chapter examines two sectors in Colombia that are the primary contributors to such risks—housing and solid waste management—and the challenges of mitigating these risks. In the housing sector, the supply of formal housing has not kept pace with rapid urban population growth. Inadequate supply, coupled with inadequate housing policies, has resulted in the expansion of the informal housing sector. Similarly, increasing amounts of waste generated by the growing population have not been sufficiently managed. Consequently, unsafe waste disposal practices, such as uncontrolled open-air dumping and burning of wastes, are common. Those unable to afford quality housing are the most affected by these deficiencies, often living in poorly constructed housing in informal settlements, situated in areas prone to natural disasters or close to unsafe waste disposal sites. The chapter proposes several recommendations to address these problems, including review of existing policies and programs, development of new policies, and simplification and improved enforcement of regulations.

This chapter examines the relationship between environment and housing policies in Colombia, and the relationship between environment and urban development more broadly.[1] Linkages between the environment and urban development can be analyzed at various levels. At a macro level, urban development and housing construction in particular affect the urban environment through congestion and air pollution, and also jeopardize the quality of public green spaces. At a micro level, housing construction also affects indoor environments, through its impacts on available space and the quality of indoor air.

This chapter focuses on the environmental effects of Colombia's housing policies because those policies could play a role in the construction of dwellings that are poorly ventilated and in the unauthorized construction of dwellings in areas prone to natural disasters. The chapter specifically examines the regulatory features of housing policies that have environmental implications. In this context, the chapter's recommendations center on how such policies can be amended or enhanced to minimize negative environmental impacts associated with their implementation.

With respect to the country's housing policies, three primary factors contribute to environmental concerns: (a) the institutional, legal, and regulatory framework that governs urban planning; (b) informal housing; and (c) housing subsidy programs, which generally provide few incentives for the construction of environmentally sound housing units. This chapter examines these three factors and provides recommendations for ways in which adverse environmental effects can be reduced.

In addition, the chapter discusses issues associated with the design and implementation of waste management activities in Colombia and summarizes key points relevant to new and existing unresolved policy issues. In the past, waste management was a relatively low priority in Colombia. Over the past decade, however, a number of large cities have made much progress in the development of formal waste disposal sites.

Although an estimated two-thirds of waste generated is disposed of in landfills, mostly in densely populated urban areas, over half of the municipalities in Colombia—typically representing the lower-income areas of the country—still do not have appropriate disposal facilities. Even in locations where landfills are in use, disposal is largely unregulated and standards for landfill development and operation do not exist. In areas on the outskirts of certain large cities, such as Bogotá, Medellín, and Cali, inadequate management of leachate discharges containing high concentrations of toxic and other hazardous substances is common.

The following sections discuss the environmental effects of urban development policies in Colombia, the government's response in addressing these effects, and challenges to policy implementation. In addition, waste management issues, challenges to adequate waste management, and the effectiveness and efficiency of policies designed to address such challenges in Colombia are examined.

Urban Growth and Environment in Colombia

Like most countries in Latin America, Colombia is highly urbanized. Around 32 million people, or 72 percent of the national population, live in urban areas. Over 20 percent of these residents live in the capital city of Bogotá, with a population of 7 million, followed by three cities with populations between 1 million and 5 million, 34 medium cities with populations between 100,000 and 1 million, and over a thousand urban centers with fewer than 100,000 inhabitants. Recent projections indicate that the urban population will reach 40 million in the next 10 years. This urban growth has been fueled by rural-urban migration, but also by the migration of victims of violence, particularly in Bogotá (Persaud and Ortiz 2003).

Cities have become Colombia's main source of growth. The most productive sectors of the economy are located in its urban centers—the seven main cities, accounting for 45 percent of the urban population, generate around 65 percent of the gross domestic product (GDP). Bogotá alone accounts for approximately 21 percent of the national urban population and contributes over 22 percent of GDP.

Unbalanced Growth of Cities

The recent urban growth is perceived to have occurred largely without the controls of formal planning (see, for example, National Council on Economic and Social Policy [*Consejo Nacional de Política Económica y Social*, CONPES] document 3305 of 2004). City expansion has generated informal and disorderly growth in urban peripheries, accompanied by deterioration of and population loss in the older city centers.

The dynamic of suburbanization in Colombia is perceived to be characterized by deficient land use in areas of environmental and agricultural importance. In turn, low densities in the peripheries have resulted in the development of large conurbations,[2] presenting challenges for planning. Unplanned urban growth has been accompanied by a lack of formal housing supply, urban land shortages in most cities, and disorderly public transport.

The country's city centers have experienced two disparate events: population flight in some central areas, and renovation and rehabilitation of medium- and high-income residential zones. Population flight has resulted in progressively decaying housing stocks where marginal activities often take place. Conversely, commercial zones and offices have expanded to old residential districts in which newly specialized urban subcenters have been created. In these subcenters, highrises have been built where older homes once stood. This process of urban renewal has generally occurred without formal planning, and often with undesirable effects on the urban structure, including the following (CONPES 3305, 2004):

- Inadequate infrastructure (roads, networks) and public spaces (parks), where existing infrastructure had been provided initially for populations three to four times smaller
- Diminished environmental quality, such as the reduction or removal of green and open spaces
- Increased road congestion and road deterioration.

Overall, urban growth has been an unbalanced process, with significant consequences for both the quality of life of inhabitants and the productivity and sustainability of cities.

Growth of Informal Housing

Precarious, informal settlements constitute the most visible manifestation of poverty and inequality in a primarily urbanized country. The natural growth of the cities, migration from the countryside, absence of formal housing alternatives for the population, and inefficiency of administrations and policies, among other factors, have generated a dynamic of informal and incomplete urban growth in Colombian cities (Caicedo 2002).

Informal urbanization results in economic, social, and environmental consequences that not only affect lower-income groups, but the urban population as a whole. The environmental impacts of informal urbanization include deterioration in the quality of life, deficiencies in the provision of public services, and the occupation of zones not suitable for urbanization. Settlements in these zones have contributed to loss of green areas and increased pollution and have led to an increased risk of natural disasters (such as landslides).

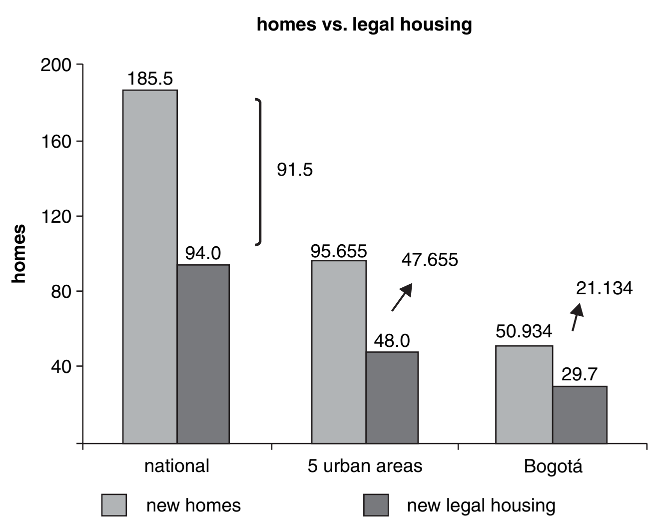
Recent estimates indicate that at least 1.3 million homes are in precarious condition. These dwellings lack basic services, are constructed with inadequate materials, or are located in zones of high natural risk (or a combination of these conditions).[3] Based on information from the cadastre, 16 percent of urban homes in the five largest cities of Colombia are precarious establishments. For medium cities (populations between 300,000 and 1 million), the corresponding percentage is 19 percent, and

24 percent of homes in cities with 100,000 to 300,000 inhabitants are in precarious condition (CONPES 3305, 2004). Thus, informal urbanization is not limited to the main cities, but is a widespread phenomenon.

The close links between informal urbanization and sustainable development have been recognized by the international community. Objective 11 of the Millennium Development Goals aims to significantly improve the lives of at least 100 million slum dwellers by 2020. In Colombia, the percentage of the urban population living in slums fell from 26.0 percent to 21.8 percent during 1990 to 2001.

The annual growth of the formal housing deficit, measured as the difference between the number of new households and the number of formal units built at the national level, is estimated to be 91,000 units, or 49 percent of the 185,000 new households formed annually (figure 9.1). In the country's five largest cities, the growth of the formal housing deficit amounts to over 47,000 units per year, or 50 percent of annual new demand. Those households without formal housing have two alternatives: cohabit with other households, or resort to informal housing solutions. As implied by the statistics on the formal housing deficit, informal settlements have grown at higher rates than formal housing in the largest cities in recent years.

Figure 9.1 Annual Gap between Formal Housing Construction and Creation of New Households



Source: DNP–DDUPRE.

In summary, rapid urbanization in Colombia has outpaced the capacity of the government to offer adequate services and prevent the development of the informal housing sector. Tackling the issue of informal housing and making land and housing affordable to low-income households continue to be fraught with difficulties. Inadequate access to financing for low-income households, low institutional capacity of municipal administrations, rigidity of city planning norms, and cumbersome delivery processes for land titles and building permits are all significant obstacles to tackling problems in the housing sector.

Housing Policy: Main Environmental Difficulties and the Government's Response

It is widely accepted in Colombia that the country's difficulties in formulating territorial policies, and in linking urban development with economic and social development, have been reflected in the development of the country's cities (CONPES 3305, 2004). It is also acknowledged that in the 1990s, the performance of national government interventions weakened on the territorial front, as evidenced by the predominance of poorly coordinated sectoral interventions at the local level.

Housing Policy Difficulties

As mentioned early in this chapter, with respect to the country's housing policies, three main factors contribute to environmental concerns. These three factors are examined below.

Institutional framework governing urban planning. The interaction between local governments and the national government has undergone important changes since the 1980s, originating in the process of decentralization and deepening with the Constitution of 1991, which recognizes the autonomy of local governments as a basic principle of the nation's organization and adopts principles that affect urban development. These principles were developed by Law 152 of 1994, the Organic Law of the Development Plan, and Law 388 of 1997, the Law of Territorial Development, both of which introduced new urban planning tools at the municipal level:

- The Development Plan includes concrete programs and projects that each mayor commits to undertake during a three-year term.
- The Land Use Plan (*Plan de Ordenamiento Territorial*, POT) is an instrument of physical planning for the medium and long term, and is

valid for 12 years. The POT synthesizes land use patterns and land rights, and the planning, management, and financing instruments for urban development. It also provides an assessment of the ecological and economic potential of certain areas and their scope for development (Lavadenz and Deininger 2003).

Seven years after the promulgation of Law 388 of 1997, assessments of the POT development process, and their adoption by municipalities, highlight the following points:

- The implementation progress and quality of the resulting plans are quite varied. This observation is partly linked to the lack of incentives provided to municipalities to prepare adequate plans, but technical capacity also plays a key role (Lavadenz and Deininger 2003).[4]
- Only a small proportion of the municipalities that have formulated their POTs have applied the management and financing instruments put in place by Law 388 of 1997 (Le Blanc 2005).
- In most cases, the links between the municipality's Development Plan and its POT are weak, as evidenced by inconsistencies in resource allocations and in development strategies and objectives. The POT tends to be perceived by municipalities as a necessary step to comply with the law rather than a strategy for long-term planning (Le Blanc 2005).

One example of the POT's limitations is found in the land reserved for future residential use. The land set aside in these territorial plans is insufficient to meet the needs of a growing population. In the five largest cities, an estimated 950 hectares each year would be required for housing development. If one compares this number with the number of hectares available for urbanization in the POTs (5,300 hectares), the land available for housing development in these cities will be exhausted within six years (CONPES 3305, 2004). It is widely perceived that this largely artificial scarcity of serviceable land encourages speculation in the land market, thereby preventing the provision of housing to low-income households, and is a direct cause of the development of informal settlements.

Another problem related to the POTs is their strictly municipal scope. As peripheral towns gather around large core cities, forming functional agglomerations, municipal frontiers decreasingly reflect the economic, social, and environmental realities of urban development. These urban agglomerations, or metropolitan centers, are expected to increase in both number and size in the coming decades and will require special institutions and policies to effectively address common problems of housing, basic services, land use, solid waste, and management of natural risks such as flooding.

Environmental risks caused by informal housing. Informal housing faces more environmental risks than other types of housing, ranging from the macro to the micro level:

- Informal settlements are located in areas considered unsuitable for housing structures within official planning documents. Such zones often include environmentally sensitive areas such as riverbanks, mountain slopes, or wetlands. Environmentally sensitive areas are more likely to be invaded than other types of land because their value for other uses may be lower; consequently, property rights may be less clear or less strictly enforced. Informal settlements give rise to specific environmental impacts: settlements located in sensitive areas, such as wetlands, may severely affect the environment (for example, water resources); and riverbanks or mountain slopes are more prone to flooding or landslides, making informal areas overall more prone to natural disasters.
- At the neighborhood level, Colombian law and regulation prevent the government from providing even the most basic of services to areas where settlements are not legally permitted. As a consequence, basic services, such as water and sanitation provision, are often lacking in informal areas.
- Because even minimum norms are not followed in the construction of dwelling units located in these informal settlements, the structures are poorly built. For example, these units have inadequate ventilation, which results in indoor air pollution from the use of solid fuels for cooking, and inadequate access to a safe water supply.

Informal housing is a product of costly regulations, inadequate planning, and a lack of enforcement of existing regulations and plans. Costly regulations (such as lengthy and expensive administrative processes for land titling, land subdivision, building permits, construction norms and standards, and zoning regulations included in the POTs) create disincentives to suppliers and builders of formal housing units. As a result, formal construction becomes unaffordable to low-income groups. Lack of enforcement results in the construction of units in areas prone to natural disasters or in areas where basic services are unavailable or very costly to provide (for example, water supply in mountainous areas). Lack of enforcement of building permits is of particular concern in Colombia because of seismic risks. Often, permits are granted for a certain number of floors in a building, but actual construction exceeds the number allowed by the permit, making those areas at risk of earthquakes or landslides even more vulnerable.

Housing subsidies. In the early 1990s, Colombia adopted a system of housing subsidies, similar to the Chilean model, called Special Interest Housing (*Vivienda de Interés Social*, VIS). While this change represented an improvement over its previous subsidy system through better targeting of lower-income groups, the new system was not flawless (Bloomberg 2001; CONPES 3178, 2002). In fact, the public housing subsidy programs often encouraged the development of environmentally unsound housing:

- The bulk of the subsidies (90 percent) went to new construction. Moreover, they went to individual housing, rather than multifamily units. This constituted a disincentive to rehabilitate or maintain old units in the city centers, encouraging urban sprawl with the related increases in congestion and pollution.
- VIS subsidies were made available only for households that possessed a legal title and wanted to build in zones classified as urban by the POTs. Thus, no subsidy was available for the informal sector. However, given the characteristics of the POTs, this meant in practice that the poorest households were largely not covered by the system, which could have helped improve hazardous conditions in informal areas.
- A significant proportion of units financed under the VIS scheme ended up without basic sanitation services or access to adequate roads. Thus, a high proportion of the VIS units were left vacant after completion because of lack of these essential public services (CONPES 3178, 2002). Often, there was no consistency between the initially approved plans for the dwellings and the units that were finally delivered.

Responses of the Government of Colombia

Sectoral programs. Faced with the challenges outlined above, the government of Colombia introduced over the years a number of sectoral programs aimed at, among other things, improving environmental outcomes in urban areas. Examples include the following:

- Integrated System for Mass Transportation (*Sistema Integrado de Transporte Masivo*, SITM) programs: The massive public transport programs, particularly in Bogotá, have succeeded in reducing air pollution caused by transport emissions. The Bogotá program also has been accompanied by unprecedented efforts to create and rehabilitate public spaces and parks.
- Upgrading of and massive titling programs for informal settlements: Programs such as the *Mejoramiento Integral de Barrios* programs have been directed at improving living conditions in informal settlements through the provision of basic services.
- Incentives for the re-densification of old centers: To stimulate the renovation process, the government passed a tax exemption for urban renovation projects (Law 788 of 2003, regulated through Decree 2755 of 2004). It is too soon to assess the full impact of this intervention.

In parallel, some large cities have managed to achieve some coordination of their urban planning actions. Medellín has made progress in consolidating its metropolitan area through development planning and infrastructure building. Bogotá has sought to address its problems through an ad hoc mechanism, the metropolitan region, which is essentially an informal planning arrangement. Through this process, Bogotá and the neighboring municipalities seek to harmonize their respective POTs and to work together to find joint solutions to their urban needs (Persaud and Ortiz 2003).

The new urban development strategy. A new urban development strategy was developed and presented in CONPES document 3305, issued in August 2004. The new strategy recognizes the need to improve living conditions in the informal neighborhoods and to provide for the densification of cities. The main elements of the strategy, which are detailed in the CONPES document, are the following:

- Promotion of the renovation and re-densification of existing neighborhoods
- Improvement of conditions in substandard neighborhoods (continuation of *Mejoramiento Integral de Barrios* accompanied by massive titling programs)

- Promotion of mechanisms that both improve public spaces and make them more sustainable
- Improvement of mobility within cities, by implementing SITM projects and linking them with other modes of transport
- Prevention and mitigation of environmental risks (incorporation of evaluation and risk mitigation in planning instruments)
- Improved quality of urban expansion through institutional, legal, and regulatory adjustments.

To optimize the urban development policy, the new strategy contemplates both institutional and regulatory measures aimed at adapting and developing relevant legislation, strengthening urban planning processes, and defining a proper scheme of interaction between the central and local governments.

Specific regulatory measures include the following:

- Linking of urban and environmental legislation on priority environmental areas such as sanitation
- The adaptation and regulation of Law 388 of 1997, to facilitate the application of financing, planning, and management instruments of urban development
- Adoption of minimum national standards for the development of housing, equipment, and public space.

Measures related to the strengthening of environmental institutions include the following:

- Devising suitable links among POTs, Development Plans, and annual municipal budgets
- Developing intermunicipal coordination mechanisms for the provision of public services and equipment, or, alternatively, the integration of municipalities to reinforce planning capacities at the local level
- Devising mechanisms to ensure that local governments adopt environmental and urban parameters that maximize the impact of investments made, at the local level, by the national government
- Strengthening Autonomous Regional Corporation (*Corporación Autónoma Regional*, CAR) support of urban management.

Challenges to Implementation of the New Urban Strategy and Recommendations for Alternative Interventions

Implementation of the new urban strategy will face a number of challenges. A plan that delineates short- and medium-term actions to implement the strategy has yet to be developed. The many objectives of the strategy are not prioritized for implementation. The following assessment of the new strategy identifies missing areas and areas in which further work is required.

Some important environmental aspects might be incorporated into the strategy, including the ones listed as follows:

- Incorporating environmental concerns into long-term planning, particularly by
  - adequately articulating environmental considerations within the POTs
  - improving enforcement of environment-related features of existing POTs (such as construction in risky or environmentally sensible areas)
- Establishing mechanisms for identifying priorities for urban development at the local level
- Establishing an environmental monitoring system for municipal governments.

Some topics, although mentioned in the objectives of the strategy, would require specific action plans:

- *Review of the compatibility of environmental and urban laws and regulations.* Such a review might include an overview of the main issues to be addressed, perhaps starting from a sectoral perspective (water, sanitation, garbage collection, planning, construction, energy, and so forth).
- *Adequate institutional structures to manage and coordinate urban planning and development at a supra-municipal level.* The need for an adequate level of coordination might be mentioned in the strategy, as well as the concrete institutional setting required to make such coordination possible.
- *The definition of priorities in the programs of technical assistance to cities, in particular concerning the drafting and revision of the POT.* It is apparent from the above that in parallel with densification, modifications of the POT might take future urban land needs into account. Furthermore, of particular relevance to the environment, the strategy mentions that the Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT)

will provide technical assistance and capacity building to municipalities so that they can incorporate environmental considerations into their planning documents, but does not make clear how this would be done.

- *The prevention of informal housing*. While the strategy includes a section on upgrading informal housing and mentions interventions to deal with existing settlements, such as the *Mejoramiento Integral de Barrios* program (one component of which addresses resettlement of households located in zones of natural risks), prevention is not treated. International experience suggests that without the adoption and implementation of a policy aimed at facilitating the supply of accessible serviced land for the poor, informal housing will continue to grow.

Conclusions and Recommendations—Housing and Urban Development

In conclusion, many challenges in the domain of urban development and the environment lie ahead. A sustainable strategy might propose actions to prevent construction in zones that present high natural risks, such as flooding, landslides, and seismic activity. This approach implies the prevention of the development of informal housing in high-risk areas. Thus, a strategy that solely addresses formal housing is only an initial step. To ensure sustainability, the causes of the development of the informal sector must be directly addressed.

The three main areas covered by the following recommendations are the institutional, legal, and regulatory framework of urban planning; prevention of informal housing; and housing subsidy programs.

Institutional, Legal, and Regulatory Framework for Urban Planning

Improving the quality of POTs. Many externalities arising from environmental degradation are localized and could be addressed through the POTs at the local level, particularly if accompanied by appropriate national policies. Experience shows that the capacity for formulation and implementation of such plans, and a mechanism for reflecting global externalities, might be strengthened (Lavadenz and Deininger 2003).

Establishment of such a mechanism and provision of assistance to the local governments in the formulation of the POT would be advisable. It would also be advisable for the government to define priorities to be addressed in technical assistance programs to cities for drafting and revising POTs, based on the capacities of the municipalities.

A legal and regulatory framework might be developed to ensure compatibility among POTs, Development Plans, and assignment of annual budgetary resources at the municipal level. The POTs could be articulated with the municipal Development Plans, which establish local policy guidelines for the duration of a mayor's term of office. These two instruments—the POTs and the municipal Development Plans—might be the basis for the formulation of annual budgets. Oversight mechanisms could be considered to ensure that such compatibility is respected.

Coordinating planning and urban management instruments at the local level. Some externalities cannot be addressed at the municipal level. In particular, harmonization of POTs and effective management of neighborhood externalities between municipalities require coordination at the supra-municipal level. For example, local planning and zoning documents should be designed at the water basin level to take flooding risk into account.

- Efficient coordination on the ground may be achieved only through adjustment of institutional settings such as establishment of metropolitan areas. Alternatively, formalizing modes of horizontal cooperation among cities might be considered, on the basis of successful experiences in Colombian cities.
- Coordination of urban development at the aggregate level may also require the creation of regional entities for the management of *integral urban operations*. These regional entities would be in charge of coordinating interventions in various sectors.
- To ensure that environmental issues with implications broader than the municipal or aggregate level (for example, flooding risks) are correctly taken into account in planning documents, functions of support to and monitoring of urban development from the environmental point of view might be created and entrusted to the appropriate governmental organization. One option is to reinforce the urban environmental management responsibilities of CARs and municipalities.

Articulating environmental and urban legislation. This task should begin with a review of the legal and regulatory apparatus, perhaps starting from a sectoral perspective (water, sanitation, garbage collection, planning, construction, energy, and so forth). Concrete ways of integrating the environment into urban planning and management tools would then have to be devised.

Prevention of Informal Housing

As argued, prevention of informal housing is as important as programs to upgrade existing informal settlements and constitutes an essential element of a sustainable, long-term urban strategy.

Lowering the cost of formal housing. At the government level, recommended actions would include studies to improve the understanding of how and why informal settlements are formed and the identification of ways to discourage informal developments by addressing the structural land supply problems, thus lowering the costs of formality. Other suggested actions include the following:

- Reviewing the land titling system in urban areas to achieve lower costs (administrative, financial, and time)
- Reviewing the land planning, zoning, and building regulations to promote participation of private developers and low-income households (for example, provisions for minimum lot size)
- Creating incentives for informal producers to gradually turn to the formal sector.

Moving toward better enforcement of planning rules and control of informal developments. Consideration might be given to better enforcement of urban planning documents, and to concrete actions upstream in the urban development process that allow better control of the development of informal housing.

- Early enforcement of existing regulations and planning documents might in particular focus on rigid control measures to prevent occupation of hazardous sites.[5]
- Forward-looking urban planning instruments could be designed, including channeling informal development by identifying and opening orderly settlements on environmentally suitable sites, minimally serviced, on which households can build following a plan that includes future space for utilities and services; the settlements are regularized later.

Housing Subsidies: VIS and Alternatives

While it is too early to evaluate the environmental impacts of the new system of VIS subsidies, some recommendations can be made to optimize the system. In addition, alternative subsidy approaches could be introduced in parallel with the VIS system.

The new system should be evaluated very early, to ensure that the new provisions of Decree 975 of 2004 and related regulations relative to compliance with minimal habitability standards are followed. Appropriate monitoring of approved VIS projects should aim at ensuring that no more cases of housing units delivered without basic services occur, or at least become less frequent.

It is important to define environmental criteria that should be included in the eligibility criteria of VIS projects to (a) minimize natural risks (floods, landslides, and seismic risks); (b) ensure minimal ventilation and indoor air quality (for example, type of fuel); and (c) require basic sanitation.

Capacity building for municipalities that do not possess specialized units, or creation of specialized units at a departmental level that will be in charge of assisting municipalities in the control and enforcement of zoning and building regulations, could be envisioned and financed through increases in collection rates of local taxes (in particular, the *Impuesto Predial* [property tax]). In parallel, a system of financial incentives for local governments could be incorporated into the subregional subsidy distribution system to ensure that local governments properly enforce those regulations.[6]

As mentioned, the VIS scheme contains implicit incentives to build far from city centers where land is cheapest, potentially causing spatial mismatch, congestion, and air pollution. In addition, the mix between new construction and improvement of existing dwellings is biased toward the former. Eligibility criteria should be revised to broaden the scope of the VIS to encompass rehabilitation, incentives to occupy "void" pockets of land within existing urban perimeters (for example, old industrial zones),[7] and multifamily housing.

Experience in Colombia has shown that the VIS subsidies depend heavily on foreign (multilateral) funds, which raises an issue of long-term sustainability. Unsecured funding for the future might imply much lower subsidies to new construction. It is thus important to consider a shift away from subsidies for new construction, and toward subsidies for amelioration and upgrading, with an emphasis on basic services and even infrastructure. These could include subsidies directed to improvement of particular services in the dwellings (sanitation, ventilation, fuel type, and so forth). A part of the budgetary cost of the subsidies could pass on to municipalities. Incentives could include formally stated matching subsidies, so that every time a collective mobilizes a certain amount of funds, the state contributes an additional specified amount.[8] Thus, the proportion of state subsidies could vary according to the type of subsidy considered.[9] From the political point of view, matching subsidies of this type might create better incentives than larger, one-shot, upfront subsidies, for both municipalities and households.

Waste Management

This section examines the design and implementation of waste management activities in Colombia. Whereas a number of major studies have been conducted in recent years on this topic (for example, Salamanca [2004] and Sánchez-Triana and Oppaluch [1996]), the purpose of this chapter is to summarize key points relevant to new and unresolved policy issues.

Waste is broadly defined as unwanted material left over from manufacturing processes or refuse from places of human or animal habitation. Within this broad category are many types of waste, including municipal solid waste, hazardous waste, and radioactive waste, which have properties that may make them dangerous or capable of having a harmful effect on human health and the environment. Wastes and contaminated lands are particularly consequential for environmental health because exposure to harmful material contained in them may result in adverse health outcomes.

Historically, the development and implementation of waste management programs have been low priorities in Colombia. Over the past decade, however, a number of large cities have moved from a situation in which it was not uncommon to find waste on streets, sidewalks, waterways, parks, empty lots, and in the sewerage system, to the development of formal waste collection systems. At the same time, however, disposal in open pits is still common in many municipalities, particularly smaller ones. Birds, insects, and domestic animals can readily spread vector-borne diseases from such sites, especially through recycling workers who live or work near disposal sites. Open burning of waste is also common.

While an estimated two-thirds of waste generated is disposed of in sanitary landfills, mostly in densely populated urban areas, over half the municipalities in Colombia—typically representing the lower-income areas of the country—do not have appropriate disposal facilities. Even where landfills are in use, disposal is largely unregulated and there are no standards for landfill development and operation. In almost all disposal sites, including those in Bogotá and Medellín, leachate discharges containing high concentrations of toxic and other hazardous substances are managed inadequately.

The 2002 Integrated Waste Management Guidelines come closest to a comprehensive national waste disposal policy. However, these guidelines lack the necessary legal authority to make compliance with them mandatory for all municipalities. Despite some efforts to adhere to the guidelines—for example, all municipalities are required to submit formal waste management plans by September 2005—overall management of such efforts has been a major challenge, especially in the absence of well-defined monitoring mechanisms and clear management accountability (MAVDT 2005).

Colombia is party to the Basel Convention of 1989 on the control of transboundary movements of hazardous wastes, which established the right of every party to prohibit the importation and exportation of hazardous wastes. Under the convention, parties must also agree that illegal trafficking of hazardous wastes is a crime. The regulations governing hazardous and medical wastes, however, are not widely enforced outside of Bogotá and Cali. In practice, hazardous and nonhazardous wastes are often mixed together and treated as municipal wastes, thus creating potentially serious consequences for public health and the environment.

Although growing in popularity on an international basis, economic incentive measures such as charge systems for waste disposal or deposit-refund schemes for glass bottles or other materials are not widely used in Colombia. As discussed in this report, the current approach to waste management is most aptly described as a patchwork quilt of policies and practices—almost exclusively of the command-and-control variety—rather than as an integrated management system.

Background and Brief History

This section provides a brief history and background of the solid waste management system in Colombia. The legislative background before 1991 and more recent legislation are discussed. Also discussed are selected national policies that govern waste management, waste management goals as established in the National Development Plan 2002–06, and basic budget information.

Legislative Background

Pre-1991 activities. The National Code on Natural Renewable Resources and Environmental Protection, Decree 2811, was issued in 1974, on the basis of Law 23 of 1973. The Sanitary Code (Law 09) was enacted in 1979. The authorities responsible for regulation and implementation of the relevant environmental policies, however, were not organized in a single agency. Instead, they were dispersed among several national entities, including the Maritime General Directorate, the Health and Mining Ministries, and various local agencies—CARs and health authorities. In general, the operations of these entities have been poorly coordinated, and they have failed to establish clear and consistent standards for waste management.

Post 1991 activities. In 1991, with the introduction of the new Constitution, the state was assigned responsibility for advancing individual rights to enjoy a healthy environment and to participate in critical decisions as part of a larger set of rights that the Constitution labeled "Collective and Environmental Rights." These rights might limit the exercise of certain other rights, such as those associated with the ownership of private property.

Among the Constitutional provisions most relevant to waste management are those that assign the Colombian state the following responsibilities:

- Preventing and controlling environmental deterioration factors
- Imposing legal sanctions and requiring reparation when damage is caused.

At the same time, the Constitution assigned municipalities the duty of regulating the use of the soil and managing and maintaining the country's ecological resources. These responsibilities clearly carry major implications for economic development, especially for industrial and energy-intensive activities.

In December 1993, Congress approved Law 99, which created the MAVDT, the National Environmental System (*Sistema Nacional Ambiental*, SINA), and CARs in regions of the country where they did not exist. The law also established Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs) in cities with more than 1 million inhabitants, five institutes of environmental research, and a special unit for the administration of the National Natural Parks System. The overall goal of these reforms was to establish a strong, coherent, internationally visible, environmental management system that also would be decentralized, democratic, participatory, fiscally solvent, and socially legitimate.

Selected National Policies for Solid Waste Disposal

Decree 605 of 1996, based on Law 142 of 1994, lays out the basic procedures for solid waste management in Colombia, including collection, storage, transport, and final disposal. Unlike waste management regulations in other countries, Decree 605 of 1996 is not supported by a broad set of agency-issued regulations, standards, and policies, backed by federal and state enforcement procedures. Thus, Decree 605 is more of a grand design than a specific implementing regulation for the management of solid wastes.

Law 430 of 1998 prohibits the introduction of hazardous wastes into the national territories under the terms of the Basel Convention. Law 430 also governs the management of hazardous wastes generated within the country, including the equipment required by customs authorities to detect the presence of wastes. The overall goals of Law 430 are to minimize the production of hazardous wastes, prevent their arrival in the country, upgrade obsolete industries that might produce them, and advance policies for clean production processes. Law 430 establishes the duty of the waste generator to determine the physical and chemical properties of the wastes at properly authorized laboratories. Special provisions also cover wastes from hospitals, clinics, medical centers, and laboratories that analyze or research pathogenic factors.[10]

The Ministries of Environment and Social Protection issued Decree 1443 in 2004, which partially amended Law 2811 of 1974, Law 253 of 1996, and Law 430 of 1998 with relation to the prevention and control of environmental contamination in the management of pesticides and hazardous waste or residue coming from them. Article 7 of the decree places the responsibility for the generation and handling of hazardous wastes originating from pesticides on the generator of the waste (manufacturer, importer, or person in possession of the wastes). The responsibility remains until the waste has been used as an input or has been disposed of in a definitive manner.

The Basel Convention became effective in Colombia on March 31, 1997, and establishes the obligations to reduce cross-border movements of wastes subject to the convention and to improve the technical capacity of countries in the management of the wastes. According to Article 81 of the Constitution, Colombia is not authorized to accept toxic wastes into its national territory.

The Stockholm Convention on Persistent Organic Pollutants, which became effective on May 23, 2004, is a global treaty to protect human health and the environment from persistent organic pollutants (POPs), which are chemicals that remain intact in the environment for long periods, becoming widely distributed geographically; accumulate in the fatty tissue of living organisms; and are toxic to humans and wildlife. Examples of POPs include pesticides (including Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptaclor, Mirex, and Toxaphene) and other chemical products (hydrochlorobenzene and polychlorinated biphenyls) or combustion by-products (dioxins and furans).[11] The MAVDT is responsible for the implementation of the Stockholm Convention, but as of June 2005 it had not developed the capacity to design policy or programs to control these wastes.

Integrated solid waste management guidelines. In 2002, the Ministries of Environment and Economic Development developed guidelines for the Integrated Management of Wastes within the framework of the Quality of Urban Life Program. The program aimed at increasing the efficiency of production processes and regulating landfills for the appropriate disposal of wastes. Near-term objectives include the following:

- Minimizing waste production by helping to establish a cultural norm to reduce waste generation and encourage waste separation at the source, and by establishing clean-production programs.
- Increasing the economic value of waste such as organic and recyclable materials. Specific goals for recycling or reuse of these materials have been established, with an interim target set at 30 percent of waste volumes generated. The overall objective of the guidelines is to provide the tools that allow the Environmental Authorities to support Urban and Regional areas for integrated management of solid wastes, based on national policies established by the Ministry of Environment (MMA 2002a, 2002b, 2002c).

Although the guidelines were disseminated to all municipalities, they are not backed by any legal authority. Nonetheless, they contain detailed technical data on the Integrated Solid Waste Management Guidelines and provide a wealth of information on the procedures that territorial entities should follow to build and operate a sanitary landfill. Given the comprehensive nature of the guidelines, there have been calls for transforming them into a mandatory rule on landfill management.

Main elements of the guidelines include the following:

- The definition of wastes and landfills
- Information on how financial institutions should characterize investment in waste management projects, and specific recommendations on the formulation of the project, selection of alternatives, identification of environmental impacts, actions to mitigate environmental impacts, and indicators for project management
- An environmental guide for sanitary landfills that describes the concept and physical structure of a landfill, lists the biological and chemical reactions that take place when treating waste, provides guidelines on siting of landfills in accordance with the Territorial Management Plan, and defines the characteristics of environmental studies required for the environmental valuation of the project
- Technological options and design criteria according to landfill type and the level of complexity of the system
- With respect to construction and operation, suggestions on supporting infrastructure and on the management of landfill cells
- Instructions for control of gases and leachates—by-products of waste decomposition in landfills
- Instructions on procedures to discontinue use of landfills.

Clean production agreements. Additional instruments for environmental management involve agreements with industry or other relevant organizations. In 1997, the National Environmental Council approved the National Clean Production Policy. This consensus-based policy has a number of broad objectives:

- Optimizing the use of natural resources and raw material
- Increasing the environmental efficiency and quality of energy resources
- Preventing and minimizing the production of polluting agents
- Preventing, mitigating, correcting, and compensating for the negative environmental impacts on local populations and sensitive ecosystems
- Adopting clean and practical technologies to continuously improve environmental management
- Minimizing production of waste and using already produced wastes as a source of raw material.

Beginning in 1995, agreements for cleaner production have been signed with a number of key sectors.

National Development Plan, 2002–06. The National Development Plan for 2002–06 includes the following waste disposal objectives:

- Developing a regulation for management of solid wastes, which should include
  - clear definition of covered waste streams, generators, and so forth
  - provisions for storage
  - provisions for biosolids
  - provisions for profitable use and reuse of certain materials
- Evaluating the impact on waste disposal of the signed agreements for cleaner production, to establish a strategy for their reformulation and implementation and a control and surveillance system
- Enforcing the strategy to extend the Clean Production Policy to the regions and to establish at least three regional hubs
- Promoting a specialized credit line to enable small and medium enterprises to adopt newer and cleaner technologies and reconvert their production systems. Once this credit line is established, US$2.5 million (Col$5,250 million) will be devoted to implementation
- Evaluating the effectiveness of potential exemptions to the value-added tax and formulating mechanisms to support adoption of cleaner technologies
- Developing the required measures to prevent and control contamination caused by wastes or dangerous residues
- Formulating a national plan to implement the Stockholm Convention on POPs, and supporting the management of priority chemical substances
- Conducting a strategic environmental evaluation of ports, roads, trains, mining, hydrocarbon sectors, and four strategic subsectors related to industrial farming processes
- Formulating a plan under CONPES on Integrated Management of Solid Wastes and completing the municipal database for the Solid Waste Information System
- Supporting territorial entities in the development of Municipal Integrated Solid Waste Management Plans (*Planes de Gestión Integral de Residuos Sólidos*, PGIRs) according to Decree 1713 of 2002
- Promoting the implementation of recycling programs in 10 large, medium, and small cities, with the cooperation of CARs and the territorial entities.

Integrated plans for solid waste management. By passage of Resolution 1045 on September 26, 2003, the MAVDT established the obligation of each municipality to have a PGIR, an initial diagnostic, future projections, and a viable financing plan to allow continuous improvement of the service provided, including an evaluation of the results (Salamanca 2004). Resolution 1045 established a methodology for formulating PGIRs, the structure of which must include objectives and specific goals for solid waste management defined through programs, taking into account demographic projections for each municipality in the country, waste generation, urban area expansion, and soil uses. The deadline for submissions of the PGIRs to the MAVDT was September 2005 (MMA 2002a).

National Waste Management Budget

The overall budget planned for the MAVDT in 2005 is Col$160,738,150 (US$63,835).[12] Approximately 60 percent of this budget, that is, Col$98,039,300 (US$38,935), is devoted to basic sanitation. It seems that the bulk of these funds will be devoted to wastewater and solid waste management.

Effectiveness of the Waste Management System

This section reviews available information on the performance of Colombia's waste management system from the following perspectives: information on the generation of solid waste throughout the country, the management of solid waste, available data on hazardous and medical wastes, the limited evaluative information on the Clean Production Agreements, and selected additional topics on waste management.

Generation of Solid Waste

The Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) has developed various indicators to track progress on environmental programs. IDEAM estimates that the total volume of solid waste generated by urban (including domestic, commercial, and institutional), industrial (manufacturing and extraction), and rural (agriculture and cattle rearing) sources was over 8 million metric tons in 2001, or about 0.71 kilograms (kg) per person per day.[13]

Table 9.1 shows the increasing volume of waste generated during 1998 to 2001. Over this four-year period, total waste increased from 7.26 million tons to 8.02 million tons, equivalent to an average increase of about 3.3 percent per year. Growth of per capita waste generation was considerably slower and averaged less than 1 percent per year.

Table 9.1 Total and Per Capita Waste Generated, 1998–2001

Year	*Ton/year*	*Ton/day*	*Kg/person/day*
1998	7,263,420	19,900	0.69
1999	7,844,203	21,491	0.73
2000	7,868,172	21,557	0.72
2001	8,015,854	21,961	0.71

Source: Superintendencia de Servicios Públicos 2003.

Table 9.2 Population Density and Waste Generation in Colombia, 1988–2001

	Waste production (kg/inhabitant/day)			
Municipal population	*1998*	*1999*	*2000*	*2001*
More than 1 million	0.82	0.82	0.82	0.81
500,000–1 million	0.73	0.84	0.73	0.65
100,000–500,000	0.66	0.70	0.66	0.67
50,000–100,000	0.59	0.68	0.59	0.66
30,000–50,000	0.69	0.70	0.69	0.62
10,000–30,000	0.68	0.68	0.68	0.71
Less than 10,000	0.62	0.61	0.62	0.68

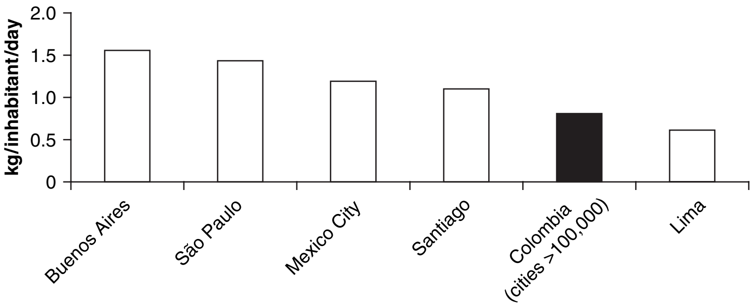
Source: Superintendencia de Servicios Públicos 2003.

Because they are hubs for employment and trade, the urban centers attract large numbers of migrants seeking both economic opportunities and greater personal security. Large cities also typically have high concentrations of populations with above-average income levels. As shown in table 9.2, affluence is generally associated with greater amounts of waste generated per capita. Per capita solid waste generation remains below 1 kilogram per day in Colombian cities with populations over 100,000. This figure is low compared with other large Latin American cities, where per capita waste production is 50 to 100 percent higher (figure 9.2).

A recent study identified the composition of solid waste from a cross-section of municipalities across Colombia (Salamanca 2004). Because the sample includes some of the largest cities in the country, the results may not be representative of small municipalities. Nevertheless, the study provides some indication of the composition of solid waste in the country.

As is the case in most developing countries, a major portion (60 percent) of Colombia's waste matter is composed of organic material, including both domestic and agricultural waste (table 9.3). Plastics and paper account for 13 percent and 11 percent of waste generated, respectively, while glass, metals, textiles and leather, and other waste make up the rest.

Figure 9.2 Solid Waste Generation in Latin American Cities



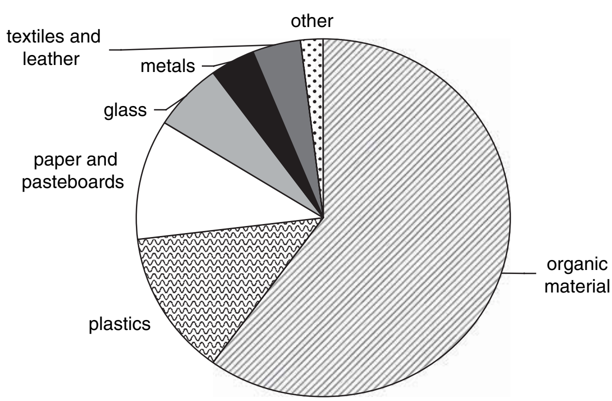
Sources: Buenos Aires: IMAE and PNUMA (2003); São Paulo: IPT and SVMA (2004); Mexico City: INEGI (2005); Santiago: IEU and PNUMA (2003); Lima: CONAM (2001).

Table 9.3 Composition of Waste

Type of waste	*Percentage of waste disposed*
Organic material	60
Plastics	13
Paper and pasteboards	11
Glass	6
Metals	4
Textiles and leather	4
Other	2
National total	100

Source: Salamanca 2004.

Figure 9.3 Composition of Waste



Source: Salamanca 2004.

Management of Solid Waste

One way to gain insight into waste management is to examine the particular disposal method employed. Based on data collected by Salamanca (2004), table 9.4 illustrates the volume and disposal practices for solid waste among Colombian municipalities. Although 65 percent of solid waste generated in Colombia is disposed of in sanitary landfills, this accounts for waste from only 33 percent of the country's municipalities. These municipalities represent more densely populated urban areas and thus account for the disproportionately large share of waste.

Conversely, 28 percent of waste generated by 575 municipalities (more than 50 percent of municipalities in Colombia) is disposed of in open dump sites, with or without burning processes. There are 338 municipalities that dispose of waste through burning and 20 that dump waste directly into streams and rivers, at a rate of 66 tons per day. These disposal methods do not include leachate treatment or vector control. In a recent investigation by the delegated *procurador* for Environmental and Agrarian Affairs of a sample of 194 locations for final disposal of solid waste, 168 responded to the survey. Of those who responded, 121 (72 percent) possessed environmental licenses, 96 (57 percent) informed the surveyors that they did not have a defined environmental management plan, and 104 (62 percent) reported that they were situated near a body of water.

Another way to gain insight into waste management is to examine patterns and trends in waste recycling. Table 9.5 displays the percentages of wastes in different categories that were recycled during 1998 to 2000. As shown, recycling rates are relatively high for pasteboards and paper (42 to 50 percent) and for metals (34 to 42 percent). For glass, 16 percent was

Table 9.4 Final Disposal of Waste

Type of disposal	*Number of municipalities*	*Waste disposed (tons/day)*	*Municipalities (%)*	*Waste disposed (%)*
Sanitary landfills	358	14,799	33	64
Dump sites with burning	338	1,946	31	9
Dump sites without burning	237	4,315	22	19
Interment	45	1,072	4	5
Water stream	20	66	2	0
Incineration	3	26	0	0
Other	56	185	5	1
Information not available	31	425	3	2
National total	1,088	22,834	100	100

Source: Salamanca 2004.

Table 9.5 Solid Wastes Recycled, by Material

	Metal		*Pasteboards and paper*		*Glass*		
Year	*Tons*	*%*	*Tons*	*%*	*Tons*	*%*	*Total recycled*
1998	315,310	34	449,630	50	150,271	16	915,211
1999	400,888	42	398,020	42	152,545	16	951,453
2000	—	—	—	—	—	—	1,255,763

Source: IDEAM, First Generation of Indicators of the Environmental Information Baseline 2002. For 2000: Superintendencia de Servicios Públicos 2003.
Note: — = not available.

recorded as recycled. Overall, however, because metals, paper, and glass account for less than 10 percent of the total waste generated, the proportion of total waste recycled in the entire waste stream is substantially less—about 15 percent in 1999. At the same time, trends in recycling are quite favorable. Over the three-year period from 1998 to 2000, total recycling rose from 915,211 tons to 1,255,763 tons, an increase of 37 percent. If corroborated by other data, these would clearly represent impressive gains.

There is also wide variation in the coverage of formal waste disposal programs among the different CARs. Table 9.6 displays the percentage of municipalities in the various CARs that report having operating waste disposal programs. Overall, only five CARs—CARDER (*Corporación Autónoma Regional de Risaralda*), CORALINA (*Corporación para el Desarrollo Sostenible del Archipélago de San Andrés, Providencia y Santa Catalina*), CORPOCALDAS (*Corporación Autónoma Regional de Caldas*), CORPOGUAVIO (*Corporación Autónoma Regional del Guavio*), and CRA (*Corporación Autónoma Regional del Atlántico*)—report that 80 percent or more of their municipalities have operating waste programs. The vast majority of CARs report that fewer than half of their municipalities have operating waste disposal programs.

A final source of information relating to waste management is from a series of field visits and reviews of three-year action plans of CARs conducted by one of the current investigators in December 2004. Although the information collected was not completely consistent across all CARs visited, summary information on the selected CARS is displayed in table 9.7. Even though the selected municipalities have independent waste disposal programs, a look at the last column on disposal shows that only part of the waste generated is disposed of appropriately.

Hazardous and Medical Waste Management

The manufacturing sector, particularly the petrochemical, carbonchemical, and thermoelectric industries, is a major generator of

Table 9.6 Disposal of Solid Waste in CARs

	Municipalities	
CAR	*Number in jurisdiction*	*Percentage with waste disposal program*
CAM	37	54
CAR Cundinamarca	104	57
CARDER	14	100
CARDIQUE	21	5
CARSUCRE	19	16
CAS	74	36
CDA	8	13
CDMB	13	62
CODECHOCO	31	3
CORALINA	2	100
CORANTIOQUIA	80	70
CORMACARENA	10	10
CORNARE	26	31
CORPAMAG	30	10
CORPOAMAZONIA	31	26
CORPOBOYACA	87	15
CORPOCALDAS	27	93
CORPOCESAR	25	4
CORPOCHIVOR	25	16
CORPOGUAJIRA	15	13
CORPOGUAVIO	8	88
CORPOMOJANA	7	0
CORPONARIÑO	64	44
CORPONOR	40	18
CORPORINOQUIA	64	16
CORPOURABA	19	11
CORTOLIMA	47	30
CRA	23	83
CRC	41	2
CRQ	12	58
CSB	24	4
CVC	42	45
CVS	28	14

Source: Asociación Colombiana de Corporaciones 2003.

hazardous wastes in Colombia. Other important sources include the mining, agricultural, and medical sectors, and some segments of the commercial sector. Vargas Bejarano (1991) and Vargas Bejarano, Prieto, and Casas (1992) estimated that production of hazardous wastes ranged from 200 tons to 1,400 tons per day. Sánchez-Triana and Oppaluch (1996) reported that efforts to manage hazardous wastes were limited to those made by Occidental in the petroleum production field of Caño

Table 9.7 Characteristics of Waste Programs in Selected Areas

CAR	*Municipalities in jurisdiction*	*Area (sq. km.)*	*Population*	*Waste (tons/day)*	*Disposal remarks*
CORANTIOQUIA	80	36,048	4,162,139	—	Half of waste disposed of properly
CORNARE	26	8,276	598,012	182	Recycled 174,444 tons in 2003
CORTOLIMA	47	23,981	1,302,998	650	Landfills receive 10,080 tons per month Open-air dumps receive 5,460 tons per month
CVC	42	21,306	4,460,850	Domestic waste 2,500	Sanitary landfills receive 427 tons per day
CVS	28	25,045	1,348,591	—	68.7 percent of the municipalities use open-air dump sites
CRA	23	3,388	2,413,803	1,902	1,496 tons are disposed of in Baranquilla's sanitary landfill per day
Bogotá–UESP	DC	—	6,635,960	29,540	Doña Juana Landfill receives 4,842 tons per day

Source: Blackman and others 2005.
Note: — = not available. DC = *Distrito Capital*; UESP = *Unidad Ejecutiva de Servicios Públicos del Distrito Capital de Bogotá*.

Limón, BASF in the manufacturing plant of Medellín, and Dow Chemical in Mamonal. Certain other private companies reportedly made limited efforts, including building secure landfills for the disposal of fiberglass and selected toxic materials. Sánchez-Triana and Oppaluch (1996) also reported that only 6 percent of public and private laboratories in Colombia had the capacity to analyze solid wastes and that none of these laboratories had equipment for analyzing or sampling hazardous wastes.

In 2002, the United Nations Food and Agriculture Organization recorded the presence of nearly 436 tons of obsolete pesticides stored in 10 departments, and approximately 4,973 tons of obsolete pesticides buried. In one of these sites (Copey in Cesar department), 170 tons of obsolete pesticides were found, which the MAVDT has tried unsuccessfully to dispose of by thermal combustion.

In 2002, the National University estimated that Colombia generates 500,000 tons of hazardous waste per year (Salamanca 2004). Because a complete inventory of hazardous wastes in Colombia does not exist, this figure may be an underestimate. Furthermore, the figure of 500,000 tons per year is much lower than the 8 million tons of hazardous waste generated by Mexico per year. The National University estimated that the city of Bogotá produced 73,000 tons of hazardous waste in 2002. By including neighboring industrial municipalities like Soacha and Cota, this estimate increases to 90,000 tons a year. The study found that the most common form of disposal was incineration. In Bogotá, there are six incinerator kilns, each with a capacity of 200 kg per hour. Some factories specialize in treating wastes such as solvents, spent oils, and PCBs (polychlorinated biphenyls), which are often exported to other countries for disposal.

Several developed countries dispose of hazardous wastes by incinerating them in kilns used in cement production. In Colombia, MAVDT's efforts have been limited to initial attempts at using cement-making kilns to incinerate fungicide containers, contaminated soils, spent oils, and tires. The ashes produced from incineration are added to the cement without affecting cement quality. Bogotá does not have the capacity to safely dispose of the hazardous wastes it generates. Consequently, more than half of the hazardous wastes generated are inadequately disposed of in open-air landfills and dumps.

More recently, Bogotá developed a master plan for integrated waste management that defines various waste streams, including hazardous waste. On the basis of data from 1999, the Office of the Mayor of Bogotá reported that 41 tons of hazardous waste were disposed of at the Doña Juana landfill, while 9 tons of waste were reused, presumably as fuel in an unidentified facility.

The Global Environmental Fund has granted the MAVDT US$727,000 (Col$1.527 million) to design and implement a program to manage POPs. In Cali, of the total amount of medical wastes and hazardous wastes generated, 1 percent is sterilized and buried in the open-air dump of Navarro. The other municipalities deactivate and burn these wastes and dispose of their ashes in dump sites or landfills.

With respect to medical wastes, Sánchez-Triana and Oppaluch (1996) reported that pathogenic waste generated at five hospitals in Bogotá varied from 0.13 kg per bed per day to 0.18 kg per bed per day in 1992.

A recent document developed by the CAR of the Sinú and San Jorge Valleys (*Corporación Autónoma Regional de las Valles del Sinú y San Jorge,* CVS) identified nine issues associated with the management of medical wastes (CVS 2004):

- Atmospheric pollution caused by open burning of medical waste
- Technically inadequate incineration—the institutions lack the proper permit for atmospheric emissions for stationary sources
- Uncertainty about the reliability of the microbiological sterilization procedure
- Untreated medical waste
- Ignorance about waste types produced by clinic laboratories
- Ignorance about environmental and sanitary risks
- Absence of emergency planning
- Contamination through mixing of hazardous and nonhazardous wastes, and disposal of medical wastes by burial on hospital premises
- Inappropriate disposal sites and systems.

Clean Production Agreements

The strategy of developing and promulgating regulatory standards and guidelines that are not strictly mandatory or that are voluntary has been a key focus of both the Ministry of Environment and some CARs, virtually since the passage of Law 99 in 1993 (see chapter 3).[14] As an illustration, the last three Ministers of the Environment, in particular, have emphasized the use of voluntary regulations. Voluntary schemes are popular in Colombia. They come about as a result of negotiating clean production agreements (*convenios de producción limpia*) with polluters. The agreements target either specific productive sectors (for example, transportation or agriculture) or specific regions. Typically, they involve a two-way understanding: polluters pledge to improve environmental performance over a specified period, and in exchange, the regulator declares a certain grace period during which existing command-and-control standards are not enforced. The ostensible purpose of such agreements is to mitigate the problem of chronic noncompliance in certain sectors and certain regions by promoting consensus building among polluters on the need for compliance and by providing polluters with guidance on how to achieve compliance.

Notwithstanding some potential benefits, documentary data suggest that clean production agreements typically have not succeeded in improving environmental performance. During the grace period specified in the agreement—that is, the period during which polluters have committed to investing in pollution control and prevention and during which regulators have promised not to enforce regulations—polluters do not actually make any significant new investments. In any case, regulators typically have no means of assessing environmental performance because the clean production agreements do not include indicators or establish a baseline. Thus, the agreements end up legitimizing inaction on the part of both polluters and regulators. This seems to have been the pattern for most national-level sectoral clean production agreements.

Esterling (2003) evaluated a sample of 13 voluntary clean production agreements, including both single-sector and multisector agreements and agreements at the national and regional levels. The study found that many of the agreements suffered from weaknesses that rendered them ineffective. For example, commitments made by the signatories to the agreements—and moreover, the consequences of failing to keep these commitments—were typically vague and ill-defined. In addition, the agreements did not identify sources of financing for costly pollution abatement and prevention investments. Finally, the legal status of the agreements was unclear. These conditions created incentives for stakeholders to sign these agreements even if they had no real intentional of meeting their commitments.

Other Selected Issues Related to Waste Management

Total waste generation continues to rise, although only modestly, on a per capita basis. Most of the per capita waste generation growth appears to be occurring outside the large cities. Efforts to manage solid wastes have met with varying levels of success across the country. Although they are not codified in formal regulations, guidelines for integrated waste management have been issued and significant programs exist in large cities. In some CARs, presumably the wealthier ones, smaller municipalities also have programs in place. In other CARs, basic solid waste management programs are nonexistent in many municipalities. Even in those municipalities that have programs, little is known about the technical and qualitative aspects of the programs. This problem is exacerbated by the lack of enforceable regulations for waste management.

Recycling shows some promise as an element of a wider approach to waste management. For more valuable materials such as metals and some types of paper, recycling rates are substantial and, according to data for 1998 to 1999, appear to be growing rapidly. With respect to the management of hazardous wastes, Colombia is a signatory to the Basel Convention. In this context, a few large firms and at least one large city (Bogotá) have developed modest programs. Lack of a national hazardous waste program hinders compliance with the Basel Convention. Clean production agreements are in place with many enterprises throughout the country. Little is known, however, about the performance of the agreements. The limited information that is available leaves doubt as to whether such agreements encourage environmental behavior beyond business as usual.

The following observations are also pertinent:

- Salamanca (2004) highlights the absence of regulation for the management of solid wastes, and lack of institutional planning and coordination among governmental entities. Illustrating these deficiencies is the fact that municipalities and governmental entities have been unable to reach decisions on siting of landfills, despite the fact that POTs exist and have established environmental zoning rules.
- The current regulations do not specify the appropriate type of landfill relative to the size and characteristics of the municipalities they serve; they do not define any technical specifications with respect to soil permeability, collection of gases, and treatment of rainwater and leachates; and they are silent on issues relating to management and technical supervision of companies in charge of the operation.
- As in many other developing countries, the largely unregulated recycling industry—dominated by scavengers—plays an important role in waste management in Colombia. Scavengers have worked independently in landfill and dump sites from as early as 1986, eking out a living from selling scrap or other waste with some resale value. In 1986, the nongovernmental organization *Fundación Social* was established and made efforts to encourage scavengers to form cooperatives by providing legal, administrative, and business assistance. The *Fundación Social* has nearly 100 member cooperatives. In 1997, the foundation established a program that provided donations and loans, estimated at approximately US$700,000 (Col$1,470 million) to the cooperatives. The organizational structure for the program included national, regional, and local associations of cooperatives. Through the program, affiliated cooperatives were allowed to sell recyclables in large volume to fetch higher incomes, but figures on the volumes of waste reused by these cooperatives are not available.
- Inadequate financing continues to present challenges to adequate solid waste management. Sánchez-Triana and Oppaluch (1996) report that larger cities are usually able to cover costs by imposing direct charges. In small and medium-sized municipalities, however, charges are often

not collected. Thus, financing of waste management services in those municipalities must be done through other sources such as other municipal income or the National Treasury.
- There is a growing emphasis on economic incentive mechanisms such as targeted charge systems or deposit-refund schemes. Sánchez-Triana and Oppaluch (1996) review such schemes as applied to waste management.

Conclusions and Recommendations—Waste Management and Urban Development

Colombia has made some advances in solid waste management, especially in urban centers. The fact that 65 percent of waste is disposed of in sanitary landfills is an important indication of progress. Similarly, there appears to be some progress in the area of recycling. Notwithstanding these advances, it is clear that Colombia needs a more effective policy on waste management. The operation and management of the limited number of landfills that do exist is often substandard. Clear regulations for control of leachates, groundwater pollution, and disease vectors do not exist, nor do specific regulations for the control and regulation of landfill gases and soil-type analyses. In addition, over half of all municipalities in the country continue to dispose of their waste in open-air and uncontrolled dump sites without any prior treatment, or directly into bodies of water. Systems for separation and management of hazardous and special wastes, including medical waste, are nonexistent or grossly inadequate where they do exist. These practices present significant health risks to the public.

The government is aware of many of the problems associated with waste management and has considered several alternatives to overcome the problems identified. The following suggested alternatives are intended to support future reforms:

- *Establishment of legally binding standards for landfills in urban areas*. The obvious starting point for these standards is the 2002 Integrated Waste Management Guidelines. Lack of a comprehensive set of standards for landfills has resulted in wide differences in operating practices for landfills across urban areas where they exist. Development of a common standard will establish a minimum requirement that landfill operators must meet to mitigate risks to the environment and public health.
- *Development of recommendations appropriate for smaller municipalities*. Sanitary landfills are expensive to build and operate, and they involve substantial investments in capital and infrastructure, which smaller

municipalities may not be able to afford. Thus, construction of state-of-the-art landfills in small municipalities may not be cost-effective. Nonetheless, a need remains for adequate management of waste generated from small and remote municipalities. Instead of applying standards for urban landfills to such municipalities, it is recommended that the government issue regulations that include the development of criteria and standards for waste management solutions appropriate for smaller municipalities. Such regulations should also include incentives for waste disposal in regional landfills.

- *Enforcement of territorial management plans that address the siting of landfills*. The territorial management plans contain some zoning regulations regarding siting of landfills, but they are not adequately taken into account in decision making on where to put landfills.
- *Adoption of a decentralized approach to waste disposal*. Transfer stations should be designed and constructed and located throughout urban areas so that transport costs can be reduced.
- *Better articulation of legal requirements for hazardous waste management*. Despite the existence of regulations for hazardous waste, noncompliance continues to be a serious problem. It is recommended that the current regulations be evaluated with the goal of simplifying definitions and requirements, and improving monitoring and enforcement of regulations, including penalties.
- *Better articulation of the role of environmental authorities in the enforcement of waste management regulations*. The inclusion of provisions in waste management regulations that require CARs and AAUs to enforce such regulations will contribute considerably to enhancing compliance. Implications for nonenforcement of regulations by the AAUs and CARs might be articulated, including provisions for ensuring accountability. In addition, such regulations might specify that the MAVDT monitor the performance of the enforcement programs conducted by the AAUs and CARs.
- *Improved monitoring of final disposal of medical wastes*. Decree 2676 of 2000 regulates medical wastes and establishes stringent standards for their disposal by incineration. However, monitoring of this program is less than optimal. It would be advisable that a special evaluation be carried out for medical wastes with the goal of simplifying the regulations and improving monitoring and enforcement.

Recommendations for urban planning and waste management are summarized in table 9.8.

Table 9.8 Summary of Recommendations for Addressing Problems Associated with Accelerated Urban Growth

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Institutional and regulatory framework for urban planning		
Define priorities that will be addressed in technical assistance programs to cities for drafting and revising POTs, based on the capacities of the municipalities	M–L	MAVDT
Establish legal and regulatory framework and oversight mechanisms to ensure compatibility among POTs, development plans, and annual budget procedures at the municipal level	S	MAVDT, Municipalities
Use POTs (articulated with municipal development plans) and municipal development plans as basis for elaboration of budgets	M–L	Municipalities
Coordinate planning and urban management functions at the local level through		
• adjusting institutional settings such as establishment of metropolitan areas	M–L	Municipalities
• formalizing modes of horizontal cooperation among cities	M–L	Municipalities
• creating regional entities for management of integrated urban operations in charge of coordinating interventions in various sectors	M–L	MAVDT, Municipalities
• establishing and allocating to appropriate institutions functions of support to and monitoring of urban development, for environmental issues the scope of which is broader than the municipal or aggregate level	M–L	MAVDT, Municipalities, CARs
Articulate environmental and urban legislation through		
• review of legal and regulatory framework, starting from sector perspective	S–M	MAVDT
• integrating environment into urban planning	S–M	MAVDT, CARs, AAUs
Prevention of informal housing		
Conduct studies to improve understanding of how and why informal settlements are formed	S	MAVDT, AAUs, CARs
Address structural land supply problems and thus lower costs of formalization	S	MAVDT

(*continued*)

Table 9.8 Summary of Recommendations for Addressing Problems Associated with Accelerated Urban Growth (*continued*)

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Housing subsidies		
Evaluate the actual VIS to ensure its compliance with habitability standards per provisions of Decree 975	S	MAVDT
Define and include environmental criteria that minimize natural risks and ensure ventilation and indoor air quality in the eligibility criteria of VIS projects	S	MAVDT
Provide alternative subsidies		
• revise eligibility criteria of VIS scheme to broaden the scope of the VIS and encompass rehabilitation incentives to locate in "void" pockets of land within existing urban perimeters (for example, old industrial zones), and multifamily housing	S	MAVDT
• shift from subsidies for new construction toward subsidies for amelioration and upgrading, with emphasis on basic services and infrastructure	S	MAVDT
Waste management		
Establish legally binding technical standards for landfills in urban areas	S	MAVDT, CARs
Develop criteria and standards for waste management solutions, including incentives for waste disposal in regional landfills	M	MAVDT
Enforce land use plans (POTs) so that decisions on siting of landfills are consistent with zoning regulations contained in POTs	S	MAVDT, CARs
Waste management regulations		
• better articulate the role of environmental authorities in enforcement of waste management regulations	S	Congress, MAVDT
• include provisions in waste management regulations that require that CARs and AAUs enforce such regulations	S–M	Congress, MAVDT, *Comisión de Regulación de Agua*
• include regulations that specify that the MAVDT monitor the performance of enforcement programs conducted by the AAUs and CARs	S	Congress
Conduct evaluation of final disposal of medical wastes with the goal of simplifying regulations for medical waste disposal and improving monitoring and enforcement	S–M	MAVDT

Source: Authors.

Notes

1. Richard Morgenstern and Ernesto Sánchez-Triana are the authors of this chapter, which draws heavily from background documents prepared for this study by Le Blanc (2005) and Blackman and others (2005).
2. They are predominantly urban regions including adjacent towns and suburbs.
3. The figures from the Department of National Planning on informal or substandard housing include units that cannot be brought up to normal standards and units located in zones of natural risks, and units with "qualitative deficit" (insufficiencies in construction, deficient access to utilities or services, and so forth). These two types of units do not call for the same types of intervention (dwellings pertaining to the second category are subject to upgrading, improvement of access, and so forth, which would bring them out of the slum category). Thus, the two categories should be distinguished.
4. However, in many smaller municipalities, the formulation of the POT constituted the first process of territorial planning and contributed to the building of institutional capacity.
5. International experience shows that the costs of preventing informal development, in terms of servicing and bringing utilities, are far lower than the cost of dealing with them after construction is completed. Moreover, the two cases translate into a different balance between private and public costs. Early enforcement ensures that a larger portion of the costs is borne by the private sector. Ex post regularization usually puts the financial burden entirely on the public sector.
6. The regional and departmental repartition, which is based on transparent criteria, should not be changed.
7. A serious obstacle to this strategy is the high price of land in central zones of urban agglomerations.
8. This could be justified by the need for the state to contribute to welfare increases in regions facing particular types of problems linked with housing conditions (for example, subsidies for toilets or sanitation to priority areas where lack of sanitation causes health problems).
9. For example, one-to-one matching subsidies could be instituted for land titling the first year, accompanied by a change in the law; then the following year two-to-one subsidies could be offered for sanitation in priority areas, and so forth.
10. The Ministry of Health issued Decree 1669 of 2002, which regulates medical and related wastes (*Gestión Integral de Residuos Hospitalarios y Similares*, GIRHYS). It establishes standards concerning pharmaceutical laboratories, defines a number of key terms in the field, establishes new responsibilities for Health and Environmental Authorities, and determines that waste incineration should be done after that waste's deactivation at incineration plants or cement factories where an environmental license has been granted for this particular use.

11. See http://www.pops.int/.
12. Col$2,510 = US$1.
13. Office of the Superintendent of Public Services, the MAVDT, and the National Statistical Administration Department.
14. Much of the information contained in this subsection is derived from interviews conducted by the Resources for the Future consultants in March 2004 (see Blackman, Morgenstern, and Topping [2004]).

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CHAPTER 10

Living with Natural Disasters

In Colombia, natural disasters constitute a threat to the livelihood and very existence of a significant percentage of the population. Natural disasters, mainly floods and landslides, have been responsible for substantial loss of life and for damage and destruction of property. During 1999 to 2003, natural disasters affected an estimated 533,000 people and 18,000 houses and resulted in 142 deaths. The government of Colombia has made considerable progress in managing disasters, particularly in the creation of institutions. Efforts have focused principally on disaster management rather than disaster prevention. This chapter identifies structural deficiencies in the institutional framework, inadequate funding, scarce and poorly articulated information on risks and vulnerability to disasters, and absence of natural disaster prevention in planning efforts. These shortcoming must be addressed by strengthening natural disaster prevention policy implementation at the local and national levels, increasing involvement of regional and national environmental authorities in the reduction of vulnerability to natural disasters, and strengthening disaster information through improved monitoring and alert systems and comparative risk assessments. Doing so will enable Colombia to mitigate the consequences of natural disasters in a sustainable manner. The role of the Autonomous Regional Corporations is particularly crucial in local disaster prevention and management because they are the principal repositories of knowledge about the characteristics of the areas under their jurisdiction.

Colombia is extremely vulnerable to natural disasters for three main reasons.[1] A mountainous topography with high rainfall creates flood and landslide risks that are greatly exacerbated by deforestation and unsustainable agricultural practices. Much of Colombia is located on the Andean fault line where several tectonic plates meet, which puts it in a position of great risk of earthquakes, volcanic eruptions, and tsunamis. Finally, the country is affected by the El Niño weather system, which periodically causes severe drought and flooding.

This chapter discusses the issues associated with the occurrence of natural disasters in Colombia and evaluates the adequacy of existing policies to manage natural disasters. It presents background information on the nature, frequency, and geographical distribution of natural disasters in Colombia; discusses the policy and institutional alternatives for preventing and mitigating natural disasters; and offers conclusions and recommendations.

Natural Disasters in Colombia: Occurrence and Impacts

Major natural disasters[2] in recent Colombian history include earthquakes in Cúcuta (1875), Caldas (1979), Popayán (1983), Atrato (1992), Tauramena, Pereira, and Pasto (1995), and Armenia (1999); repeated volcanic activity in the Nevado del Ruiz and Galeras volcanoes; and tsunamis in Tumaco (1906 and 1979).

Damage to property and loss of life caused by natural disasters is costly. Table 10.1 presents information on the incidence of natural disasters and their costs in Central and South America during 1970 to 1999. During this period, Colombia experienced on average 2.97 natural disasters per year, the third-highest annual rate among the 19 countries in the two regions. In addition, an estimated 30,000 deaths were caused by these natural disasters, the third-largest number for the two regions. These events resulted in losses of more than Col$9,450 billion (US$4,500 million), or 11.5 percent of the country's 1995 gross domestic product (GDP). The high frequency of occurrence of natural disasters, the toll these events have taken on human lives, and the additional constraints that the economic losses impose on the country's budgetary resources underscore the need to develop more robust institutional responses.

Figure 10.1 shows the distribution of major natural disaster threats by region in Colombia. According to the figure, the Pacific, Andean, Amazon, Orinoquia, and Caribbean regions are threatened by floods, and the Pacific, Andean, and Caribbean regions are threatened by landslides.

While individual earthquakes and volcanic eruptions cause the most dramatic damage and greatest loss of life, rainfall and climatic events are

Table 10.1 Disaster Exposure Indicators in Central and South America, 1970–99

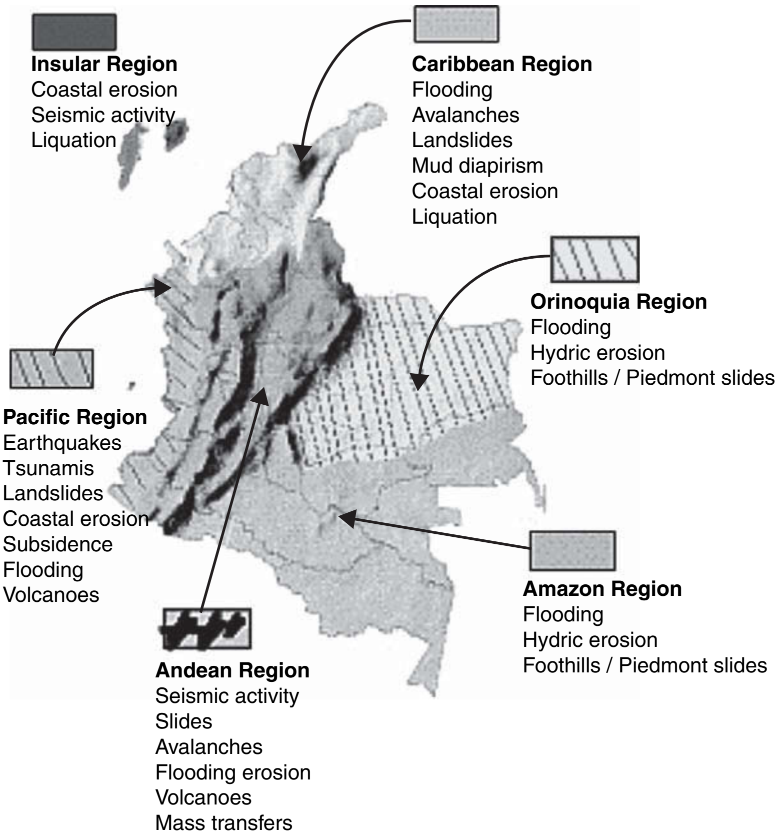
	Disaster occurrence			*Fatalities*		*Economic losses*	
Country	*Total*	*Per year*	*Per km²*	*Total*	*Per 1,000 inhabitants*	*1998 US$ million*	*% 1995 GDP*
Central America							
Belize	6	0.2	0.30	5	0.02	33.8	5.4
Costa Rica	33	1.1	0.70	287	0.08	1,117.5	13.4
El Salvador	16	0.5	0.80	2,880	0.50	2,713.9	22.9
Guatemala	28	0.9	0.06	24,139	2.20	3,062.5	17.3
Honduras	28	0.9	0.30	17,347	2.90	4,239.5	82.0
Mexico	117	3.9	0.06	15,594	0.20	13,822.5	3.6
Nicaragua	26	0.9	0.20	13,067	2.90	5,780.5	338.4
Panama	15	0.5	0.20	152	0.06	170.0	1.8
South America							
Argentina	48	1.60	0.02	685	0.02	11,201.0	3.8
Bolivia	31	1.03	0.03	787	0.10	4,919.9	21.0
Brazil	102	3.40	0.01	4,462	0.03	1,756.7	2.2
Chile	47	1.57	0.06	997	0.07	16,238.1	6.3
Colombia	89	2.97	0.09	29,857	0.80	4,457.8	11.5
Ecuador	46	1.53	0.20	7,091	0.61	6,824.5	42.5
Guyana	5	0.17	0.10	0	0.00	29.8	4.6
Paraguay	16	0.53	0.04	109	0.02	116.1	1.4
Peru	78	2.60	0.06	72,475	2.98	5,988.7	10.3
Uruguay	7	0.20	0.04	2	0.00	30.0	0.2
Venezuela, R. B. de	19	0.63	0.02	30,446	1.40	2,055.2	2.2
Average	40	1.32	0.17	11,599	0.78	4,450.0	31.0

Source: Charvériat 2000.
Note: GDP = gross domestic product; km² = square kilometer.

more frequent and widespread. Floods and landslides, which occur most frequently during the rainy months of May, June, October, and November, account for two-thirds of all disasters (figure 10.2).

Larsen (2004) estimates that during 1999 to 2003, 142 people per year were killed in natural disasters, and 533,000 people and 18,000 houses per year were affected in some way (tables 10.2, 10.3 and 10.4). In the same period, earthquakes accounted for a majority of deaths, injuries, and houses destroyed, and floods affected the greatest number of people. Earthquakes—not including the earthquake that devastated Armenia in 1999—accounted for 63 percent of deaths, 76 percent of injuries, 56 percent of houses destroyed, and 13 percent of people affected by natural disasters. In comparison, floods accounted for 8 percent of deaths, 3 percent of injuries, 20 percent of houses destroyed, and 71 percent of the people affected by natural disasters. Avalanches and landslides, mainly related to heavy rainfall, accounted for another 4 percent of people affected by natural disasters.

Figure 10.1 Geographical Distribution of Natural Disaster Threats in Colombia



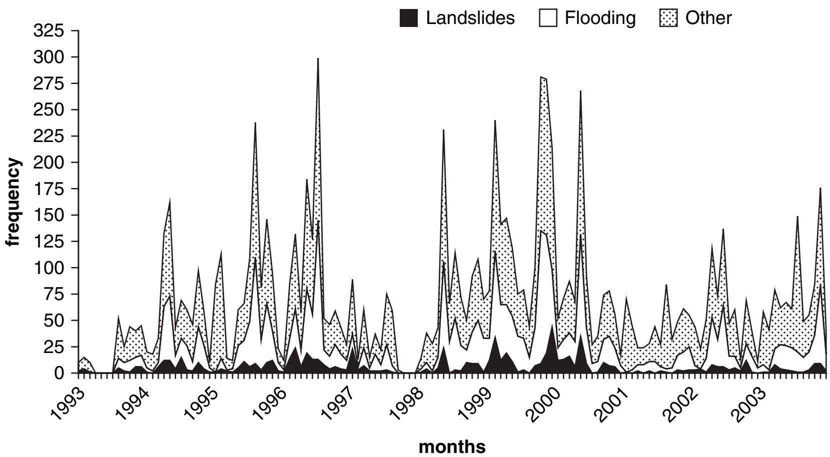
Source: Red de Desarrollo Sostenible Web Site (June 2005). http://www.rds.org.co/reducir.

During 1999 to 2003, nearly 2 million people were affected by floods, not including impacts caused by landslides and storms. In 2003 alone, 390,977 people were affected by floods, landslides, and storms (floods 328,304 people; landslides 6,279 people; and storms 55,944 people) (table 10.5).

Effectiveness of Policy Design

This section discusses and evaluates the existing policy and legal framework for addressing natural disasters in Colombia.

Figure 10.2 Cumulative Monthly Occurrence of Flooding, Landslides, and Other Disasters



Source: INGEOMINAS 2005.

Table 10.2 Percentage of Disaster Impacts by Type of Disaster, 1999–2003

Event	*Deaths persons*	*Injured affected*	*Persons*	*Houses destroyed*	*Houses damaged*
Landslides	18	6	3	6	5
Floods	9	4	71	21	35
Storms	0	5	7	5	25
Droughts	0	0	3	0	0
Fires, buildings	1	2	0	8	0
Fires, forest	0	0	1	0	0
Avalanches	3	1	1	4	2
Earthquakes	63	76	13	56	32
Contamination	0	4	0	0	0
Other	6	2	1	0	1
Total	100	100	100	100	100

Source: Larsen (2004), derived from General Directorate for Disaster Relief and Prevention database.
Note: Data do not include the 1999 Armenia earthquake.

Natural Disaster Law

Law 9 of 1979 created national-, regional-, and local-level disaster management institutions known as Emergency Management Committees, and established disaster preparedness and management procedures. At the national level, the National Emergencies Committee (*Comité Nacional de Emergencias,* CNE) is responsible for, among other functions, declaring the

Table 10.3 Impacts of Natural Disasters, 1999–2003

Impact	*2003*	*2002*	*2001*	*2000*	*1999*
Deaths	122	142	74	96	276
Injured persons	420	39	379	111	351
Missing persons	18	52	28	15	60
Number of people affected (thousands)	436	343	205	468	1,214
Families affected (thousands)	88	67	40	94	240
Houses destroyed (thousands)	2.1	1.3	1.6	2.5	5.5
Houses damaged (thousands)	16.8	10.2	14.5	10.9	26.2
Roads damaged	31	83	66	135	375
Bridges damaged	8	13	14	61	123
Pedestrian overpasses and bridges damaged	10	22	20	57	126
Water supply systems affected	6	119	21	91	136
Sewerage systems affected	1	1	1	5	30
Health centers affected	6	8	8	11	7
Schools and education centers affected	45	65	64	76	89
Community centers affected	31	62	40	31	62

Source: Larsen (2004) derived from General Directorate for Disaster Relief and Prevention database.
Note: Data do not include the 1999 Armenia earthquake.

Table 10.4 Annual Average Impacts of Natural Disasters, 1999–2003

Impact	*1999–2003*
Deaths	142
Number of people affected (thousands)	533
Houses affected (thousands)	18

Source: Larsen (2004) derived from General Directorate for Disaster Relief and Prevention database.
Note: Data do not include the Armenia earthquake.

beginning and end of an emergency and for coordinating disaster response activities. Local Emergency Management Committees are required to prepare a contingency plan for each of the different types of disasters that threaten their communities. The contingency plans are to be based on a vulnerability assessment and a disaster planning exercise. The CNE is responsible for presenting such plans to the Ministry of Health for approval and for requesting foreign assistance for disasters. In accordance with the law, the Ministry of Health is responsible for coordinating training programs needed to facilitate the contingency plans and for providing care to injured people, managing corpses, and implementing waste disposal and other sanitary measures.

Law 46 of 1988, the country's main national disaster regulation, created the National Disaster Preparedness and Response System (*Sistema*

Table 10.5 Number of People Affected by Landslides, Floods, and Storms, 2003

Department	*Total*	*Landslides*	*Floods*	*Storms*
Chocó	116,502	96	113,896	2,510
Bolívar	46,607	374	44,813	1,420
Antioquía	30,878	30	25,273	5,575
Boyacá	30,685	1,830	28,100	755
Magdalena	25,105	0	24,355	750
Córdoba	24,570	0	17,010	7,560
Sucre	18,770	0	15,369	3,401
Amazonas	9,955	0	9,955	0
Santander	9,480	530	8,950	0
Atlántico	8,376	0	346	8,030
Putumayo	6,445	0	4,935	1,510
Cauca	6,393	85	356	5,952
Cesar	6,319	0	3,516	2,803
Caquetá	6,165	95	4,040	2,030
Casanare	5,786	0	5,786	0
Tolima	5,518	573	1,410	3,535
Valle	5,505	280	4,850	375
Norte de Santander	5,421	1,762	3,213	446
Quindío	4,527	35	60	4,432
Risaralda	4,020	438	0	3,582
Caldas	3,839	390	3,106	343
Arauca	3,155	0	3,155	0
Guainía	2,000	0	2,000	0
Cundinamarca	1,409	189	1,220	0
La Guajira	1,180	0	245	935
Guaviare	1,025	0	1,025	0
Vichada	790	0	790	0
Meta	325	0	325	0
San Andrés y Prov.	105	0	105	0
Nariño	100	0	100	0
Huila	22	22	0	0
Vaupés	0	0	0	0
Total	390,977	6,729	328,304	55,944

Source: Blackman and others 2005.

Nacional de Prevención y Atención de Desastres, SNPAD). It gave SNPAD responsibility for defining the functions of all public and private institutions related to disaster prevention and management; integrating public and private efforts for disaster prevention and management; and guaranteeing timely and efficient management of the human, technical, administrative, and economic resources necessary for preventing and managing disasters. At the national level, the two most important institutions in SNPAD are the National Disaster Preparedness and Response Committee (*Comité Nacional para la Prevención y Atención de Desastres*, CNPAD) and the National Disaster Preparedness and Response Office (*Oficina Nacional para la Prevención y Atención de Desastres*, ONPAD), now known as the General Directorate for Disaster Relief and Prevention (*Dirección General para la Prevención y Atención de Desastres*, DGPAD) and located in the Ministry of Interior and Justice.[3] CNPAD is a high-level committee, presided over by the President; the committee heads SNPAD and coordinates its activities through the DGPAD.

DGPAD. The DGPAD is responsible for coordinating day-to-day disaster response planning and management. Funding for the DGPAD is provided by the National Disaster Fund (*Fondo Nacional de Calamidades*, FNC). The DGPAD is also responsible for organizing an integrated information system that facilitates the identification of disaster risks. Law 46 of 1988 assigns to the DGPAD the responsibility of promulgating (by presidential decree) a National Disaster Preparedness and Response Plan (*Plan Nacional para la Prevención y Atención de Desastres*, PNPAD). By law, PNPAD is required to address, through national, regional, and local planning offices, a wide range of issues including (a) disaster prevention, immediate management, and reconstruction; (b) all relevant technical, scientific, economic, funding, community, judiciary, and institutional topics; (c) educational and participatory issues; (d) integrated information and communication systems; (e) the role of mass media; (f) interinstitutional and intersectoral coordination; and (g) identification of needs for research or technical studies.

CREPAD and COLPAD. Law 46 of 1988 created regional- and local-level disaster prevention and management institutions: the Regional Disaster Preparedness and Response Committee (*Comité Regional para la Prevención y Atención de Desastres*, CREPAD) and the Local Disaster Preparedness and Response Committee (*Comité Local para la Prevención y Atención de Desastres*, COLPAD). Each department is required to have a CREPAD and each municipality a COLPAD.

Decree-Law 919 of 1989 implements the provisions of Law 46 of 1988. The decree-law identifies the members of SNPAD and defines their responsibilities and functions; proposes general guidelines for managing disasters and procedures to be followed by each institution for prevention and management of potential and actual disasters; requires that the recommendations of PNPAD be included in any POT; mandates both the prioritization of risk mitigation activities in key economic sectors and the creation of a National Disaster Information System—a repository of data on risks and vulnerabilities and of guidance on disaster prevention and risk mitigation measures—and clarifies the criteria for declaration of a state of emergency and for its termination. When a situation does not qualify as a state of emergency, it is to be considered a *public calamity* and is eligible to be upgraded to a state of emergency during the three months after the event.

While Law 46 of 1988 mandated the newly created DGPAD to prepare a PNPAD, Decree 93 of 1988 states that the main goal of the PNPAD is to guide the actions of the government and civil society to prevent and mitigate disaster risks and to attend to and restore areas that have suffered a disaster.

Programs. Decree 93 of 1998 stipulates that research on and the knowledge of risks should be the basis of the decision-making and planning processes. Toward that end, SNPAD develops programs in four areas: (a) identifying and characterizing sources of risk, (b) incorporating risk reduction and prevention in planning mechanisms, (c) strengthening the SNPAD's institutions, and (d) promoting information disclosure. The decree describes specific activities meant to further these programs. These include installing a surveillance, detection, and alert network; developing an inventory of risks and threats; including disaster prevention criteria in development plans; conducting inventories of settlements located in high-risk areas; supporting relocation activities; defining housing standards; preparing a communication network among SNPAD institutions; strengthening SNPAD's agencies; preparing contingency plans for the rehabilitation of utilities in case of disaster; establishing temporary management facilities for social housing and infrastructure reconstruction and relocation; designing an integrated information system and a documentation center network; and developing a national capacity-building system for government employees and community leaders.

Coordination between the National Environmental System and SNPAD. Decree 93 of 1998 states that the National Environmental System (*Sistema Nacional Ambiental*, SINA) and SNPAD should coordinate their activities in areas such as (a) vulnerability, threats, and risks at the national, regional, and local levels; (b) the inclusion of risk mitigation and disaster prevention in environmental impact assessments and environmental management plans; and (c) the inclusion of risk as a trigger for the prohibition of certain land uses.

The Relationship between the National Environmental System and the National Disaster Response and Prevention System

Law 99 of 1993 established the SINA and created the Ministry of the Environment (*Ministerio del Medio Ambiente*, MMA) to head the SINA. Several provisions of the law relate to disaster prevention and relief. One of the law's basic principles is that disaster prevention and attention are matters of collective interest and, as a result, SINA is required to promote them. In addition, among the many functions assigned to the MMA is the evaluation, follow-up, and control of natural disaster risks. Law 99 of 1993 directs the MMA to coordinate actions aimed at anticipating and preventing emergencies, and stipulates that the Ministry of Government and the MMA must effectively coordinate the activities of SINA and SNPAD.

Law 99 of 1993 assigns Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs)—the regional authorities within the SINA—principal responsibility for implementing a wide range of environmental and natural resource policies, including disaster prevention and management. The law establishes that one of the functions of CARs is to organize activities for the analysis, follow-up, prevention, and control of disasters, in coordination with other competent authorities. It also stipulates that CARs are to provide assistance to such authorities on the environmental aspects of disaster prevention and relief. CARs are directed to work jointly with the local and regional institutions to improve the safety of urban areas located in high-risk zones.

Laws Relating to Funding of the National Disaster Prevention and Relief System

SNPAD comprises a variety of institutions, and they are funded from different sources. As such, they allocate their funding between disaster prevention and management and their other tasks and responsibilities. The DGPAD, located within the Ministry of Interior and Justice, is unique in that it is allocated a budget from a single source—general revenues—and consequently focuses solely on disaster prevention and mitigation.

Decree 1547 of 1983 created the FNC as a national account with administrative, accounting, and statistical independence. The decree stipulates that the FNC's funds are to be used to (a) provide financial support for disaster relief; (b) control the effects of catastrophes, especially those involving epidemics; (c) support rehabilitation and restructuring of basic sanitation facilities; (d) finance information systems and other equipment necessary to diagnose and manage catastrophic situations; and (e) take actions to prevent or attenuate the effects of disasters.

Law 60 of 1993 deals with the allocation of financial resources among municipalities and states that these resources are to be used for stabilizing high-risk zones, relocating households at risk, and preventing and addressing disasters (in addition to funding education, health, housing, and utilities).

Law 715 of 2001 replaced Law 60 of 1993. It creates the General Participation System (*Sistema General de Participaciones*) for municipalities to use to promote, fund, or cofund projects of municipal interest, including those related to natural disasters. Law 715 mandates that the municipalities, the national government, and the departments cofinance projects to prevent and address natural disasters within their jurisdictions, including relocation of households in high-risk zones.

Institutions and Activities Involved in the Design and Implementation of Colombia's Natural Disaster Policy

Like SINA, SNPAD is an all-encompassing set of institutions spanning the public and private sectors and the national and regional levels. The disaster prevention policies of SNPAD entail four types of activities: (a) developing information on disaster risks, (b) incorporating disaster prevention and mitigation into planning activities and construction codes, (c) strengthening SNPAD institutions, and (d) promoting education on disaster prevention and mitigation.

Developing information on disaster risks. The DGPAD is responsible for building an Integrated Disaster Information System that includes data on risks and vulnerabilities and networks for surveillance, detection, and early warning. Many networks that are supposed to make up the system are run by entities that specialize in related functions. For example, the Colombian Institute of Geology and Mines (*Instituto Colombiano de Geología y Minería*, INGEOMINAS) is responsible for the seismological and vulcanological network; the Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) manages the hydrometeorology network; and mayors' and governors' offices are responsible for the disaster alert networks. The DGPAD, CREPADs, and COLPADs are in charge of building documentation centers that cover their management levels—national, departmental, and municipal, respectively. Risk and threat inventories are a central component of the effort to build knowledge about disaster risks.

Law 9 of 1989 originally mandated such inventories and gave the territorial entities responsibility for carrying them out. Subsequent decrees and policies spread responsibility for these inventories among various institutions with relevant expertise. For example, INGEOMINAS is charged with preparing seismological and volcanic risk maps, and IDEAM is responsible for hydrometeorology risk maps.

Incorporating disaster prevention into planning and construction. According to Colombian law, disaster prevention and mitigation considerations are supposed to be incorporated into land use, contingency, and development planning and into construction codes.

Municipalities and CARs share responsibility for incorporating disaster considerations into Land Use Plans (*Planes de Ordenamiento Territorial*, POTs). Municipalities are responsible for including in their POTs detailed inventories of areas at high risk of natural disaster. CARs are responsible for verifying that high-risk areas are clearly identified in POTs. Once an area has been classified as high risk, either the mayor's office or the CAR can make a determination that the area is unfit for infrastructure or occupation. In such cases, by law households in these areas should be relocated to alternate areas that have been identified by the municipality. National subsidies can finance some of the relocation, which falls under the responsibility of the Ministry of Environment, Housing and Regional Development *(Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT). In addition to identifying areas suitable for resettlement, municipalities are also responsible for identifying locations to be used as temporary housing and shelter facilities in the event of a disaster. When disaster actually strikes, the mayor's office is required to publish a request for the temporary (up to one year) occupation of these locations. These locations can be purchased or even expropriated by force if necessary. In consideration for this use, the municipality must compensate the (public or private) owner.

For national-level disaster risks, contingency plans are the responsibility of the National Technical Committee in association with the DGPAD. For regional- and local-level risks, contingency plans are to be prepared by CREPADs and COLPADs and approved by the governor's or mayor's office. In addition, municipalities are responsible for ensuring that public services companies (utilities) conduct a vulnerability assessment of the existing utilities and prepare contingency plans. Municipalities are required to request that any public service company planning to construct new facilities carry out a risk and vulnerability assessment to prevent the building of facilities in high-risk areas.

It is important to incorporate prevention and mitigation considerations into planning activities for economic and social development at the national, departmental, and municipal levels. The Department of National Planning (*Departamento Nacional de Planeación*, DNP) at the national level is uniquely positioned to incorporate disaster prevention and relief into its Development Plan.

Another planning-related mechanism to complete disaster prevention concerns construction codes. The PNPAD assigned the responsibility for defining housing standards to the Colombian Construction Chamber of Commerce and to the Colombian Society of Construction Engineers, both of which are part of the Permanent Advisory Commission for Seismic Resistant Construction. Territorial entities enforce compliance with these guidelines.

Strengthening SNPAD institutions. DGPAD and the MAVDT share responsibility for strengthening SNPAD institutions at the national level. Strengthening of regional and local entities is to be carried out mainly by the DGPAD and the MAVDT together with CARs and territorial entities. For assistance institutions such as the Red Cross and the army, responsibility for capacity building is shared among the Ministry of Interior and Justice, the army, the police, and the Ministry of Health.

Providing Education. Disseminating information about disaster prevention and management to public and private sector officials and the public at large is the responsibility of the National Learning Service, the Ministries of Education and Environment, DGPAD, CREPADs, and COLPADs.

Assessment of Natural Disaster Policies

Blackman and others (2005) examined various sources of information including data from interviews and written reports that evaluated the performance of SNPAD. These sources indicate that SNPAD's disaster prevention efforts are not sufficient to meet the demands of disaster risk management. Similarly, the generation, management, and dissemination of information on disaster risks, and financing of prevention activities, need to be strengthened.

Insufficient attention to disaster prevention. Stakeholders interviewed by Blackman and others (2005) stated that SNPAD's design is partly to blame for weak performance in disaster prevention. They stated that, in the spirit of the 1991 Constitution, one of SNPAD's defining characteristics is decentralization. A related key characteristic is that many of

SNPAD's top institutions—including the National Technical Committee, the CREPADs, and the COLPADs—are composed of preexisting institutions. These characteristics have presented advantages and disadvantages. Decentralization has enabled SNPAD to rely on local and regional resources in addition to those provided by the national government. Moreover, SNPAD's reliance on existing institutions has enabled key institutions to be constituted expeditiously. However, because most of the members of important disaster committees work in other capacities that do not involve disaster prevention and management, they often have limited time to tend to their day-to-day responsibilities within SNPAD. Stakeholders interviewed for this study recognized that key disaster committees typically do not actively engage until an actual disaster strikes (Blackman and others 2005).

CONPES 3146 (2001), Freeman and others (2003), and Pollner, Codato, and García (2002) all concurred with the views of the stakeholders interviewed—that SNPAD had failed to devote sufficient resources to disaster prevention. The main observation given by Pollner, Codato, and García (2002) to SNPAD is that it focuses disproportionately on disaster management instead of prevention. They note that the principal areas in need of improvement include SNPAD's ability to (a) assess risks and vulnerabilities, (b) build capacity for disaster management and prevention at the local level, and (c) generate nonemergency financing. A document of the National Council on Economic and Social Policy (*Consejo Nacional de Política Económica y Social*, CONPES) CONPES 3146, 2001 states that disaster management (versus prevention) is typically considered the main responsibility of the national, regional, and local disaster committees despite PNPAD and other norms that mandate prevention. That analysis concurs with the assessment of stakeholders interviewed for this study that SNPAD's constituent members are typically not focused on participation in the system. According to the CONPES document, the majority of national entities in SNPAD have not incorporated this participation into their programs and statutes, a fact that limits their commitment to it. According to Freeman and others (2003, p. 8), "… mitigation activities tend to relate to reconstruction rather than to risk reduction and trying to avoid the perpetuation of vulnerability has been a challenge."

Poor information and communication. A second set of crosscutting problems within SNPAD includes poor information on disaster risks, poor communication about such risks, and poor coordination among constituent members of the system. As noted, Decree 919 of 1989 mandates that the

DGPAD create a National Disaster Information System. Unfortunately, this information system remains incomplete and suboptimal. Several entities possess information that could be incorporated into the system. For example, the DGPAD has information on past disasters, IDEAM has hydrometeorological information, the Maritime General Directorate has oceanographic information, and the National Institute of Health has sanitation information. However, these information systems are not linked or integrated. The DGPAD personnel interviewed for this study stressed the need to gather in a single place all the disaster-related data contained in existing information systems in Colombia, including those containing environmental, hydrographic, sanitation, mining, and oceanographic data. A related concern repeatedly expressed by a variety of interviewees was the need for an improved system to allow for effective and timely communications among the different members and levels of SNPAD (Blackman and others 2005).

According to Pollner, Codato, and García (2002), Colombia's information on disaster risks and vulnerabilities needs strengthening.[4] A number of factors are suggested. For instance, funding for studies and scientific instruments is inadequate. Many of the studies that do exist contain reasonably good scientific and technical information, but do not do a good job of using it to assess risk and vulnerability. Moreover, the studies often use inconsistent methodologies and are not technically rigorous. Furthermore, an integrated information system containing, for example, data on costs, death tolls, injuries, damages, and risks does not exist.

CONPES 3146 (2001) supports the overall assessment of SNPAD's information and systems by Pollner, Codato, and García (2002). According to CONPES 3146 (2001), at the national level SNPAD has knowledge about disaster threats because it comprises several scientific institutions. However, SNPAD has limited knowledge about physical, social, economic, and cultural vulnerabilities to these threats. For example, SNPAD may have good seismic maps, but poor information about what these maps imply for populations living in earthquake-prone areas. As a result, modeling or quantification of the impact of potential disaster risks is difficult. CONPES 3146 (2001) also states that, for the National Disaster Information System to be developed adequately, links among SNPAD, the National System of Science and Technology, and SINA need to be strengthened. Specifically, the new system would need to integrate the following existing information systems and sources: (a) MAVDT; (b) the *Sistema Nacional de Información Oceanográfica*; (c) the *Sistema de Información de Agua Potable y Saneamiento Básico*; (d) the *Sistema de Potencialidades y Restricciones para el Desarrollo*

Minero-Energético; (e) regional and local systems such as the *Sistema de Información para la Gestión de Riesgos y Atención de Emergencias, Alcaldía de Bogotá*, and INGEOMINAS; (f) information kept by CARs; and (g) the SNPAD information center.

In addition, CONPES 3146 (2001) cites SNPAD's lack of an integrated system of communication among far-flung constituent institutions, and weak coordination among these members at the national, regional, and local levels. According to CONPES 3146, among the most urgent communication issues is strengthening the natural disaster monitoring and alert systems (Pollner, Codato, and García 2002). There is also a need for coordination protocols depending on level of risk.

Both CONPES 3146 (2001) and Pollner, Codato, and García (2002) recommend that SNPAD devote sufficient attention to awareness raising and public education on disaster risk mitigation. Although some education efforts exist, a national public education campaign strategy is needed.

Poor coordination. The DGPAD implements policies set by SNPAD and is responsible for its day-to-day operation, including disseminating plans and actions to CREPADs and COLPADs, designing policies and presenting draft laws and decrees, receiving and directing petitions for declaration of emergencies and disasters, executing agreements and contracts with entities that will respond to disasters or emergencies, budget assignment, and technical support for disaster prevention and relief.

Several of the stakeholders interviewed for this study by Resources for the Future researchers at both the national and the regional levels stated that of the many institutions that make up SNPAD, the DGPAD has the best understanding of its role and of the procedures that are to be followed during a disaster. Despite these positive informal evaluations, according to CONPES 3146 (2001), the DGPAD has faced a number of obstacles in recent years. For example, it has been reformed and restructured repeatedly, generating considerable political, financial, and institutional instability; as a part of the Administrative Department of the Presidency, it had significantly greater resources and autonomy than it has today as part of the Ministry of Interior and Justice; and while the DGPAD was originally allocated a budget from general national revenues, its budget now comes from the Ministry of Interior and Justice. According to CONPES 3146 (2001), the reduction in the DGPAD's budget and cuts in personnel have affected its performance.

The National Technical Committee comprises entities with considerable technical and scientific expertise. Nevertheless, according to

CONPES 3146 (2001), committee members do not always have the most appropriate expertise, and sometimes have little influence.

The National Operations Committee is composed of institutions that focus primarily on natural disasters, emergencies, and calamities, such as the Civil Defense, Red Cross, Ministry of Health, and National Firefighting Board. According to CONPES 3146 (2001), the National Operations Committee has severe financial difficulties because the entities assigned to it typically have minimal operating budgets.

As noted, Pollner, Codato, and García (2002) identify limited local-level capacity for risk prevention and mitigation as one of SNPAD's key deficiencies. There is no centralized repository of information on CREPADs and COLPADs, and in fact, according to CONPES 3146 (2001), no evaluation of Colombia's over 900 CREPADs and COLPADs has ever been conducted. Therefore, much of the performance data in this study are derived from interviews with stakeholders in selected areas, including coordinators of CREPADs in the Cauca Valley, San Andrés, and Córdoba. Following is a discussion of some of the issues that the CREPADs and COLPADs face, thus affecting SINA's performance.

Funding for CREPADs and COLPADS, including salaries of support staff members, comes directly from departments and municipalities, respectively. According to stakeholders interviewed for this report, these funds are almost always insufficient. Further details on funding are included in the next section.

As with many institutions in SNPAD, CREPADs and COLPADs are staffed by representatives of existing institutions related to natural disasters. This staffing situation has important disadvantages, perhaps the most important of which, according to stakeholders interviewed for this report, is that local disaster committee members typically focus on responsibilities other than disaster prevention and management. For example, the CREPAD coordinators interviewed for this study all had high-ranking positions in the governors' administration, including Department Secretaries and Department Planning Secretaries. While this ranking no doubt imbues disaster committee directors with more power and influence than they would otherwise have, it also implies that their day-to-day responsibilities tend to crowd out their natural-disaster-related responsibilities.

Interviews with CREPAD directors conducted for this study confirmed this disadvantage. The directors did not appear to be particularly well informed about disaster prevention—most did not have information on prevention activities or projects under way in their departments, which could reflect a paucity of ongoing prevention activities. Notwithstanding their poor knowledge of disaster prevention activities, the CREPAD directors interviewed for this study generally had good information on the budgetary resources allocated for the management of actual disasters.

In principle, CARs should play a vital role in local disaster prevention and management because they are the principal repositories of knowledge about the natural, physical, geographical, climatological, and geological characteristics of the areas under their jurisdiction. However, the actual role of CARs in local disaster prevention and management appears to be limited. Many of the CAR staff members interviewed for this study (from the Autonomous Regional Corporation of Cundinamarca [*Corporación Autónoma Regional de Cundinamarca*, CAR Cundinamarca], the Corporation for Sustainable Development of the Archipelago of San Andrés, Providencia and Santa Catalina [*Corporacíon para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina*, CORALINA], the Autonomous Regional Corporation of the Sinú and San Jorge Valleys [*Corporación Autónoma Regional de los Valles del Sinú y San Jorge*, CVC]), were unaware that Law 99 of 1993 assigns the CARs responsibilities for disaster prevention and risk assessment.

According to stakeholders interviewed for this report, although there is sometimes a delay in convening CREPADs and COLPADs after an actual disaster, the committees generally operate according to previously defined procedures. The governor of the department as head of the CREPAD, or the mayor of the municipality as head of the COLPAD, coordinate the different prevention and management activities and institutions so that the emergency is managed expeditiously.

Evaluation of Funding Requirements and Arrangements

Cost implications of natural disasters in Colombia are daunting. Table 10.6 presents estimates from Freeman and others (2003) of economic losses attributable to natural disasters in Colombia and three other countries in Latin America, and financing needs (assuming that countries must cover half of the costs of managing natural disasters). They estimate the cost to Colombia of each 20-year event at US$2 billion, each 50-year event at US$5 billion, and each 100-year event at US$8 billion. As mentioned, Colombia is exceptionally vulnerable to natural disasters, a fact that supports the high cost for Colombia relative to the other countries examined by Freeman and others.

Table 10.7 presents estimates from Freeman and others (2003) of the annualized losses from 20-year to 100-year natural disasters for the study countries. The annualized loss is defined as the amount of money that the country would need to set aside each year to cover the cost of

Table 10.6 Projected Economic Loss from Disasters and Government Financing Needs
US$ million

Country	*20-year event*	*50-year event*	*100-year event*
Projected loss			
Bolivia	200	600	1,000
Colombia	2,000	5,000	8,000
Dominican Republic	1,250	3,000	6,000
El Salvador	900	3,000	4,500
Financing needs (50% of loss)			
Bolivia	100	300	500
Colombia	1,000	2,500	4,000
Dominican Republic	625	1,500	3,000
El Salvador	450	1,500	2,250

Source: Freeman and others 2003.
Note: US$1 = Col$2,150.

Table 10.7 Expected Annualized Loss from 20-Year to 100-Year Natural Disasters

Country	*Million US$*	*As % GDP*	*As % govt. expenditures*
Bolivia	10	12	40
Colombia	85	8	60
Dominican Republic	54	34	180
El Salvador	48	40	220

Source: Freeman and others 2003.
Note: US$1 = Col$2,150.

these disasters. For Colombia, the annualized loss represents 8 percent of GDP, or 60 percent of annual government expenditures.

The FNC is clearly the principal domestic source of disaster management funding (table 10.8). Of the Col$49 million spent on disaster management during 1993 to 2003, 93 percent was provided by the FNC, 5 percent by COLPADs and CREPADs, 1 percent by other entities such as municipalities and private foundations, and less than 1 percent by aid organizations, including the Red Cross, Civil Defense, and army. Because COLPADs and CREPADs do not have their own resources, their contributions must come from the entities that comprise them.

Reactive instead of proactive funding. The FNC was initially capitalized with direct appropriations from the national budget. The intention was to create a reliable, stable reserve fund that could be used expeditiously in the event of a natural disaster. Recently, however, the FNC's funding

Table 10.8 Disaster Funding by Source and Year
million 2004 pesos

Year	*FNC*	*COLPADs and CREPADs*	*Aid organizations*	*Mixed aid (CREPAD, COLPAD, FNC)*	*Other entities*	*Total*
1993	737	38	0	120	0	158
1994	1,511	825	2	14	75	916
1995	3,142	915	0	26	449	1,390
1996	2,456	471	21	149	0	641
1997	252	118	0	52	0	170
1998	6742	22	0	0	0	22
1999	14,065	0	0	23	0	23
2000	4,305	0	0	0	0	0
2001	3,179	29	0	0	0	29
2002	2,902	0	0	0	0	0
2003	6,273	0	0	0	0	0
Total	45,564	2,418	23	384	524	48,913
Percentage of total	93	5	0	1	1	100

Source: DGPAD 2004.
Note: US$1 = Col$2,150.

arrangements have changed. Instead of a constant infusion of funds aimed at building up a reserve, the FNC now receives major infusions of funding only after a disaster has occurred. CONPES 3146 (2001) notes that the new mode of funding generates sudden fiscal destabilizations and slows response time during major catastrophes. Pollner, Codato, and García (2003, p. 466) agree with this observation and identify "cyclical and sometimes politically driven funding" as one of SNPAD's major weaknesses. Table 10.9 shows total budget allocations to the FNC. By far the largest allocations occurred in 1995 and 1999. However, in 1995 roughly 50 percent of the total allocation was additional (following an actual natural disaster).

CONPES 3146 (2001), Freeman and others (2003), and Pollner, Codato, and García (2002) all agree that one important potential source of funding—natural disaster insurance programs—has not been explored in sufficient depth. The main reason is that SNPAD's efforts have been primarily focused on responding to emergencies.

Inadequate funding for prevention. Allocation of SNPAD resources has been disproportionately focused on disaster management instead of prevention. According to CONPES 3146 (2001), roughly 80 percent of the total budget of the FNC is devoted to disaster management and only 20 percent to prevention. For the period from 2001 to 2004, resources used

Table 10.9 Initial, Additional, and Total Budget Allocation to FNC

Year	*Initial %*	*Additional %[a]*	*Total (million pesos)*
1995	50	50	17,500
1996	90	10	7,000
1997	100	0	5,000
1998	80	20	5,000
1999	95	5	28,154
2000	100	0	15,000
2001	—	—	10,449
2002	—	—	12,500
2003	—	—	—
2004	—	—	3,800
Average	86	14	11,600

Sources: Blackman and others 2005; CONPES 3146, 2001.
Note: US$1 = Col$2,150, — = not available
a. This occured following an actual natural disaster estimated from CONPES 3146 (2001) figures.

for prevention totaled roughly Col$250 million (US$116,000), less than 2 percent of the Col$12,850 million (US$6 million) requested by the DGPAD for the 2002 Disaster Prevention Program. Pollner, Codato, and García (2002) decry the lack of funding for the development of disaster prevention and contingency planning. They report that funds are rarely designated for this purpose—especially at the local level—and even when they are, they are often diverted to emergencies.

The problem of inadequate funding for prevention is partly structural. One of the motivations for SNPAD's decentralized design was to give the organization access to resources from the general budget of the various entities that constitute the system, including departments, municipalities, and the Red Cross. Although disaster planning and management was to be mainstreamed into the normal planning and investment activities of SNPAD's constituent institutions, this has not happened. SNPAD's decentralized resources have been devoted almost exclusively to disaster management, not prevention. For example, of the Col$187,412 million (US$89.1 million) in investments made by municipalities during 1997 to 2000, less than 1 percent was directed to disaster prevention and management (CONPES 3146, 2001).

Evaluation of Disaster Planning

Decree 93 of 1998—the PNPAD—mandates that both national and local institutions develop detailed disaster contingency plans. Several sectoral disaster plans—that is, plans, laws, or regulations covering specific economic sectors—have been adopted. According to CONPES 3146 (2001), however, many have been difficult to develop. For example, the plan for dealing with the impact of El Niño has not been developed or monitored adequately; there has been considerable difficulty implementing the farm insurance law; the law regarding earthquake resistance mandated vulnerability studies in various sectors, but only 20 percent of health care institutions have completed these studies; and the regulation of the transportation of hazardous substances is inadequate.

Development of local contingency plans has also been inadequate. By law, Territorial Development Plans are supposed to contain Local Emergency and Contingency Plans (*Planes Locales de Emergencias y Contingencias*, PLECs). Table 10.10 presents data on the number of municipalities that have been offered capacity-building services by the DGPAD to develop PLECs; unfortunately, only one-fourth of all municipalities had adopted plans, or were in the process of doing so. Table 10.11 presents data reported by the CARs on their adoption of PLECs. These data are not consistent with those collected by the DGPAD. According to these data, 30.2 percent of municipalities in the country have adopted PLECs, not 25 percent. Nevertheless, both figures are quite low.

Evaluation of Land Use Plans and Construction Standards

Besides PLECs, Colombian law mandates that different municipal, regional, and national planning mechanisms incorporate disaster prevention and management plans. Chief among these are POTs, which must include policies, directives, and regulations regarding the prevention of natural disasters, the location of human settlements in high-risk areas, and management strategies for zones in high-risk areas. A preliminary analysis conducted by the DGPAD indicated that most of the municipalities incorporate some disaster planning in the POTs, but a high percentage do so in a deficient way. Reasons include lack of capacity in disaster issues among the staff responsible for POTs.

CARs staff members are responsible for supervising municipal POTs. Among the CARs staff members interviewed for this study, there was a consensus that disaster planning and management are not appropriately addressed in POTs. Often, the POTs are guided more by political considerations than technical ones. Moreover, even when POTs identify areas as high risk, households and businesses in these areas are rarely relocated. In some cases, the mayor's office has relocated some of the families living in high-risk areas—typically poor families that do not have the wherewithal to buy property—but new families have moved into

Table 10.10 Implementation of PLECs, 1998–2004

Department	*Year training offered*	*Number of municipalities*	*PLECs*					*% municipalities*
			M	*I*	*EP*	*CR*	*Total*	
Amazonas	2002	2	n.a.	n.a.	1	n.a.	1	50
Antioquía	1999	125	6	n.a.	6	39	51	41
Arauca	2002	7	n.a.	n.a.	1	n.a.	1	14
Atlántico	2002	23	n.a.	n.a.	n.a.	n.a.	0	0
Bolívar	1999, 2002	45	5	n.a.	1	n.a.	6	13
Boyacá	1998, 2000, 2002	123	n.a.	15	10	n.a.	25	20
Caldas	2002	27	n.a.	n.a.	10	4	14	52
Caquetá	None	16	n.a.	n.a.	n.a	1	1	6
Casanare	2002	19	n.a.	1	1	n.a.	2	11
Cauca	2000	41	1	n.a.	n.a.	n.a.	1	2
Cesar	1998, 2001	25	n.a.	n.a.	n.a.	1	1	4
Córdoba	2001	28	n.a.	n.a.	n.a.	n.a.	0	0
Cundinamarca	1998	117	n.a.	n.a.	n.a.	n.a.	0	0
Chocó	2001	26	1	1	n.a.	4	6	23
La Guajira	1998, 2002	15	n.a.	n.a.	n.a.	n.a.	0	0
Guaviare	None	4	n.a.	n.a.	n.a.	4	4	100
Guianía	2001	1	n.a.	n.a.	n.a.	n.a.	0	0
Huila	2001	37	n.a.	n.a.	n.a.	n.a.	0	0
Magdalena	2002	30	17	10	n.a.	n.a.	27	90
Meta	2002	29	6	n.a.	2	n.a.	8	28
Nariño	2000	63	n.a.	n.a.	n.a.	37	37	59
Norte de Santander	2002	40	1	n.a.	1	n.a.	2	5
Putumayo	2001	13	n.a.	n.a.	n.a.	2	2	15
Quindío	2002	12	n.a.	5	n.a.	6	11	92
Risaralda	2000, 2002	14	n.a.	1	n.a.	13	14	100
San Andrés	2002	2	n.a.	n.a.	1	n.a.	1	50
Santander	1999	87	n.a.	n.a.	n.a.	n.a.	0	0
Sucre	2002	25	2	n.a.	1	n.a.	3	12
Tolima	None	47	1	n.a.	n.a.	1	2	4
Valle del Cauca	1999	42	n.a.	n.a.	n.a.	n.a.	0	0
Vaupés	None	3	n.a.	n.a.	n.a.	n.a.	0	0
Vichada	None	4	n.a.	n.a.	n.a.	n.a.	0	0
Total		1,092	40	33	35	112	220	25

Source: DGPAD 2003.
Note: n.a. = not applicable; M = electronic version; I = paper version; EP = in process; CR = found in CREPAD.

informal (unlicensed, substandard) dwellings in the high-risk areas. According to MAVDT staff members, a percentage of the total subsidies budget is allocated to people affected by disasters. This percentage is small, however, and is only intended for people who have already been affected by a disaster, not for relocating those in high-risk areas.

Table 10.11 Implementation of PLECs by CAR and Municipality, 2002

Entity	*Number of municipalities*	*Municipalities with PLEC*	
		Number	*Percent*
CAM	37	0	0
CAR Cundinamarca	104	0	0
CARDER	14	12	86
CARDIQUE	21	0	0
CARSUCRE	19	3	16
CAS	74	0	0
CDA	8	8	100
CDMB	13	11	85
CODECHOCO	31	0	0
CORALINA	2	0	0
CORANTIOQUIA	80	80	100
CORMACARENA	10	0	0
CORNARE	26	0	0
CORPAMAG	30	33	110
CORPOAMAZONIA	31	5	16
CORPOBOYACA	87	0	0
CORPOCALDAS	27	27	100
CORPOCESAR	25	0	0
CORPOCHIVOR	25	0	0
CORPOGUAJIRA	15	0	0
CORPOGUAVIO	8	7	88
CORPOMOJANA	7	7	100
CORPONARIÑO	64	33	52
CORPONOR	40	40	100
CORPORINOQUIA	64	0	0
CORPOURABA	19	0	0
CORTOLIMA	47	47	100
CRA	23	0	0
CRC	41	0	0
CRQ	12	12	100
CSB	24	7	29
CVC	42	0	0
CVS	28	0	0
TOTAL	1,098	332	30.2

Source: Self-reported by CARs to the MAVDT.

Finally, both the Colombian Construction Chamber of Commerce and the Construction Engineering Society have already produced basic earthquake-resistant standards for housing and infrastructure. Municipal offices that issue construction permits (*Curadurías Urbanas*) are charged with enforcing these standards. According to interviewees at DGPAD, however, little monitoring occurs after a license has been issued.

Challenges to Disaster Prevention

As noted, natural disasters have significant impacts on human health, the environment, and the economy in Colombia. Colombian law creates a wide-ranging system of institutions—the SNPAD—to manage disasters. Although this legal foundation is not without weaknesses, the most important deficiencies in Colombian natural disaster policy clearly arise more from poor implementation than from flaws in policy design. Without exception, all of the evidence reviewed for this report suggests that the most important general problem in implementing natural disaster policy is insufficient emphasis on disaster prevention, as opposed to disaster management. This problem has a number of causes and manifestations.

Structural characteristics of the SNPAD. Three basic structural characteristics of the SNPAD contribute to a lack of emphasis on disaster prevention. First, because SNPAD has a decentralized organizational structure, the regional and local disaster committees—CREPADs and COLPADs, respectively—bear most of the burden for implementing natural disaster policy. Inevitably, given regional disparities in overall levels of institutional capacity within Colombia, some CREPADs and COLPADs are performing at a lower level than others. In general, the low-performing committees fail to give adequate attention to natural disaster issues except in the event of actual disasters. For example, they are unlikely to develop disaster contingency plans, to incorporate disaster considerations into POTs, to relocate households in high-risk areas, to enforce construction codes mandating earthquake resistance, or to help raise public awareness about disaster prevention.

Second, SNPAD is composed of all the institutions in Colombia at the national, regional, and local levels that have a bearing on natural disasters. This characteristic, along with decentralization, implies that communication and coordination among the various CREPADs and COLPADs, and among these institutions and national-level SNPAD entities, are complex and costly, contributing to inadequate attention to disaster prevention.

Third, the leading institutions in SNPAD—CNPAD, DGPAD, the National Technical Committee, and the National Operation Committee at the national level; CREPADs at the departmental level; and COLPADs at the local level—are composed of representatives from existing institutions. The main responsibility of these representatives is not disaster prevention and management, and apparently, they make their disaster responsibilities a priority only in the event of an actual disaster. The result is that key SNPAD institutions tend to be reactive rather than proactive.

Funding. Historically, the FNC has provided over 90 percent of funding for disaster prevention and management. However, only 20 percent of this funding has been devoted to prevention. Although the original intention of the framers of the FNC was to create a reserve fund with a stable level of funding, in practice, this reserve has been depleted and is only replenished in the event of an actual disaster. This mode of operation limits resources available for disaster prevention. An alternative to such reactive funding is to rely on insurance mechanisms. This strategy has received limited attention, however.

Information. Colombian disaster law recognizes that sound, readily available information on disaster risks and on vulnerabilities to these risks is essential to promoting disaster prevention. However, implementation of information-related mandates has been inadequate. By all accounts, pockets of information on various risks and vulnerabilities exist, but overall existing data are incomplete, poorly managed and maintained, poorly integrated, and not readily available. In addition, the disaster alert and monitoring system is inadequate, as are efforts to disseminate information to key institutions (such as COLPADs and CREPADs) and to the public at large. In sum, Colombia lacks the integrated national disaster information system mandated by law.

Planning. A key mechanism for promoting natural disaster prevention is to mandate the inclusion of natural disaster considerations into Colombia's extensive planning process. Municipalities must incorporate disaster contingencies into their development plans and POTs. In addition, national authorities are charged with developing disaster contingency plans for key economic sectors such as health care and transportation. Implementation of this strategy has been woefully incomplete, however.

Furthermore, the new Water Resources Management Law should ensure that the hydrography is maintained by CARs and Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs), particularly in urban areas, and that the recurrence period of the flow rate for flood-prone areas is increased in a cost-effective manner.

Parallels between SNPAD and SINA

In many respects, SNPAD and the SINA are cut from the same cloth. Both were created within three years of the 1991 Constitution, and both reflect an emphasis on inclusiveness, participation, and decentralization. More specifically, SNPAD and SINA each comprise a system of far-flung institutions at the national, regional, and local levels. Each system is led by a set of national-level institutions that set policy; coordinate and monitor interactions of local institutions; allocate national funds; generate, manage, and disseminate scientific information; and attempt to raise public awareness about risks of natural disasters. Furthermore, in each system, semiautonomous regional and local institutions with their own sources of funding are principally responsible for policy implementation. In both systems, decentralization was implemented in part as an effort to relieve the national government of the financial and administrative burden associated with central control.

Given these common characteristics, it is not surprising that SNPAD and SINA also share a number of other qualities. In both systems, capacity and performance vary markedly across autonomous regional and local institutions; coordination among the members of the systems needs improvement; and generation, management, and dissemination of critical information need strengthening. Finally, in both systems, the potential strategies for addressing these challenges are similar: collection of reliable indicators of institutional performance is necessary to improve coordination and performance.

Conclusions and Recommendations

This section summarizes the main conclusions of this chapter and provides recommendations to strengthen natural disaster prevention in Colombia.

Improve Implementation of Natural Disaster Prevention Policies at the Local and National Levels

Several of Colombia's COLPADs and CREPADs do an insufficient job of implementing disaster prevention mandates, such as developing contingency plans and incorporating disaster considerations into POTs. To address this weakness, reliable, detailed, up-to-date information on this problem is needed. Toward that end, the study recommends that DGPAD, supported by a research institute, consider conducting a study of the performance of CREPADs and COLPADs. Even more important, DGPAD could develop a permanent system of performance indicators for CREPADs and COLPADS. Local disaster committees would be required to annually report the data needed to make this system operational. It would be advisable that self-reports be subject to verification.

Once new data on performance are obtained, several measures might be undertaken to improve implementation of natural disaster prevention policies at the local level. The DGPAD can publicly disclose reference indicators to raise public scrutiny and accountability. Allocations of funds should conform to priorities established by a risk assessment. The DGPAD can continue to help build capacity in disaster prevention at CREPADs and COLPADs by developing instructional materials and offering training and technical assistance. Colombia's control organizations charged with ensuring government entities perform their assigned functions can step up pressure on departments and municipalities to ensure that CREPADs and COLPADs are fulfilling their disaster prevention mandates. The executive branch can investigate legal requirements that municipalities and departments spend a certain percentage of their tax revenue on disaster prevention, and might consider promulgating regulations that enable it to withhold transfers of national funds to departments and municipalities that are not fulfilling their obligations to implement natural disaster prevention policies.

Implementation of natural disaster prevention policies could also be enhanced at the national level. As discussed, SNPAD comprises a large number of different types of institutions, a feature that makes communication and coordination difficult. One means of mitigating this problem would be to more clearly define (through new laws, decrees, regulations, or directives) the specific roles of each of the national-level members of SNPAD. Moreover, as with CREPADs and COLPADs, efforts could be made to develop data on how well national-level members of SNPAD are performing their functions, to publicize these data, and to use them to create incentives for more effective disaster prevention.

Increase Participation of CARs and Coordination with the SNPAD in Local Disaster Prevention

In principle, CARs should play a vital role in local disaster prevention and management because they are the principal repositories of knowledge about the natural, physical, geographical, climatological, and geological characteristics of the areas under their jurisdiction. Furthermore, Law 99 of 1993 assigns CARs the responsibilities for disaster prevention and risk assessment. To improve enforcement of natural disaster management policies, coordination between the CARs that are responsible for environmental enforcement and the SNPAD needs to be strengthened. In particular, increased efforts should be directed at prevention of natural disasters, especially floods and landslides, which have been shown in this report to occur with highest frequency and to affect the greatest number of people. Preventive activities might focus on incorporation of prevention considerations in POTs, improvements in urban drainage, resettlement of populations from areas that are prone to natural disasters, strengthening of early alert and information systems, and strengthening of regulations prohibiting human settlement in areas prone to the risk of natural disasters. In addition, synergies between key members of the SNPAD, particularly CARs and regional disaster committees, are underexploited. To mitigate the problem, the DGPAD, the MAVDT, and the control organizations might strengthen enforcement of mandates that CARs participate in disaster prevention and might create stronger incentives for inclusion of disaster considerations in environmental impact assessments and environmental licensing.

Implement an Integrated Disaster Information System

Colombian lawmakers have long recognized that reliable, up-to-date, readily available data on disaster risks and vulnerabilities, strategies for mitigating these risks, and strategies for managing disasters are absolutely essential for disaster policies to be effective. Yet, despite specific mandates, Colombia still lacks a well-functioning, integrated disaster information system. This gap needs to be filled as quickly as possible. The system might integrate oceanographic, hydrological, climatological, and seismographic data systems and other systems deemed appropriate. Data systems most relevant to areas judged to be high priority by the risk assessment described above might be integrated first. To the extent possible, data in the system could be made available on the Internet. Subcomponents of the system could be made available as quickly as possible instead of waiting for the entire system to be completed. Adequate resources and effort could be provided to ensure that the system is well managed and maintained. Protocols might be developed to ensure the quality and standardization of data collection. Finally, user-friendly guidance documents on the interpretation, use, and application of the data might be made available.

Conduct Comparative Risk Assessments

Although SNPAD has developed detailed information on various disaster risks, only limited efforts have been made to compare the human and economic impacts of different types of risks. Given that resources available for disaster prevention are quite scarce, such comparative risk assessments are urgently needed to ensure that investments in disaster prevention have the greatest possible impact. Risk assessments are needed at the national, regional, and local levels. The DGPAD can periodically perform national risk assessments, and CREPADs and COLPADs can periodically perform similar assessments of the disaster risks in their territories. The DGPAD, departments, and municipalities should be required to use such comparative risk assessments to guide their allocations of financial, human, and technical resources. The DGPAD can take a number of specific steps to make these requirements feasible: it might improve data collection and management; it might develop a standard methodology for comparative risk assessments that is practical, given the capacity for data collection and analysis that will prevail among CREPADs and COLPADs in the medium term; it might provide technical assistance and training in comparative risk assessment by, among other things, developing user-friendly training manuals and holding workshops; and it might certify third parties to assist CREPADs and COLPADs in carrying out risk assessments.

Strengthen the Disaster Monitoring and Alert Systems

Efforts to integrate and strengthen disaster alert and monitoring systems, including those for seismic activity, volcanoes, flooding, and tsunamis, might be expedited. The comparative risk assessment discussed earlier should be used to establish priorities for this project. Adequate resources and effort could be provided to ensure that the system is well managed and maintained.

Enhance Funding for Disaster Prevention

Lack of funding for disaster prevention at the national and local levels is an important barrier to adequate prevention. At the national level, it is critical that the DGPAD and other key entities be assured a reliable source of nonemergency funding to support the DGPAD's disaster prevention efforts. Options for achieving this goal include reinstating direct allocations to the DGPAD from the national budget, possibly entailing repositioning the DGPAD within the national-level bureaucracy; changing the operating guidelines of the FNC to ensure that it provides sufficient funding for prevention activities; mandating that the various members of SNPAD's national-level entities, such as ministries and national services, guarantee funding for the participation of their representatives in the SNPAD; and encouraging the DGPAD to make better use of the National Royalty Fund (*Fondo Nacional de Regalías*, FNR), international sources, and other sources of funding. If needed, the regulations governing the FNR's allocation of funds could be amended to facilitate funding for disaster prevention activities.

At the local level, CREPADs and COLPADs also must have the resources they need to meet regularly—that is, in nonemergency situations—and to undertake disaster prevention. Measures that might advance this goal include encouraging the DGPAD, CREPADs, and COLPADs to make better use of the FNR, international sources, and other sources of funding—the DGPAD could provide guidance to CREPADs and COLPADs on how to raise funds for prevention activities—and directing or encouraging the institutions comprising CREPADs and COLPADs to guarantee funding for the participation of their representatives in disaster committees.

Investigate Better Use of Insurance to Provide Disaster Management Financing

Colombia's use of insurance and other market instruments to finance disaster management is incipient. The DGPAD might investigate the feasibility of making better use of such instruments at both the local and the national levels.

Develop a Prioritized Agenda for Scientific Research on Disaster Risks and Vulnerabilities and Promote Priority Research Areas

The integrated disaster information system needs to be supported by solid scientific information. To ensure that required data are generated, the DGPAD, in consultation with relevant scientific institutions, might undertake a study to identify gaps in and priorities for scientific research on disaster risks and vulnerabilities. The results from this study should be combined with those from the comparative risk assessments to develop a prioritized agenda for research. To promote the items on this agenda, targeted funding can be made available through existing funding channels or new ones if the existing ones are deemed inadequate. In addition, the National System of Science and Technology can be better integrated into the SNPAD. Finally, lines of communication between universities and other SNPAD institutions can be strengthened.

Enhance Sectoral Contingency Planning

The DGPAD might commission a study of progress on sectoral contingency planning and use the results in combination with those from the comparative risk assessments discussed earlier to develop a prioritized agenda for developing and strengthening sectoral disaster contingency plans. It could also ensure that sufficient resources are made available, and sufficient incentives are provided, so that planning in key sectors is expedited.

Create Stronger Incentives for Enforcing Construction Codes

The DGPAD should explore ways to strengthen enforcement of disaster prevention provisions in construction codes.

Raise Public Awareness About Disaster Prevention and Management

Raising public awareness of disaster prevention will not only advance prevention directly; it can also generate the political will to pressure SNPAD to reduce vulnerability to natural disasters. Tools for achieving this goal include mass media campaigns and ensuring that disaster prevention and management are included in educational curricula.

Table 10.12 summarizes the recommendation made in this chapter.

Table 10.12 Summary of Recommendations for Strengthening Prevention of Natural Disasters

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Improve implementation of natural disaster prevention policies at the local and national levels		
Annually report the data needed to put the system of performance indicators for disaster prevention into operation	S	Local disaster committees, DGPAD, MAVDT, CARs, AAUs, IDEAM
Build capacity in disaster prevention by developing instructional materials and offering training and technical assistance	S	MAVDT, CREPADs, COLPADs, CARs, AAUs, IDEAM
Increase enforcement of regulations for departments and municipalities to ensure that disaster prevention mandates are fulfilled	S	Contraloría, Procuraduría, MAVDT, DGPAD, CARs
Establish regulatory mandates that municipalities and departments spend a percentage of their tax revenues on disaster prevention	S	Congress, MHCP, MAVDT
Promulgate regulations that allow the executive branch to withhold transfers of national funds to departments and municipalities that are not fulfilling their obligations to implement natural disaster prevention policies	S	Congress, MAVDT, MHCP
Clarify the specific roles of each national-level member of the SNPAD	S	Congress, DNP

Table 10.12 Summary of Recommendations for Strengthening Prevention of Natural Disasters *(continued)*

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Develop data on performance of national-level SNPAD members and make it public	S–M	MAVDT
Coordinate actions between CARs and SNPAD		
Increase efforts in natural disaster prevention, especially floods and landslides, through activities that focus on incorporation of disaster prevention in POTs, urban drainage improvements, resettlement of populations from areas prone to natural disasters, strengthening of early warning and information systems, and strengthening of regulations prohibiting human settlement in areas prone to risks of natural disasters	S	Congress, MAVDT, DNP
Strengthen the role of CARs in disaster prevention	S	DGPAD, MAVDT Contraloría, Procuraduría
Create incentives for inclusion of disaster considerations in environmental impact assessments and environmental licensing	S	Congress, MAVDT
Complete an integrated disaster information system		
Complete integrated disaster information system	M–L DGPAD, IDEAM	MAVDT, CARs,
Conduct comparative risk assessments		
Periodically conduct risk assessments at regional and local levels	S–M	MAVDT, DGPAD, CREPAD, COLPAD, CARs
Require the use of comparative risk assessment to guide allocations of financial, human, and technical resources by		
• Improving data collection and management	L	DGPAD, MAVDT
• Developing a standard methodology for comparative risk assessments	L	DGPAD, MAVDT
• Providing technical assistance and training in comparative risk assessment by developing user friendly training manuals and holding workshops	L	DGPAD, MAVDT, CARs
• Certifying third parties to assist CREPADs and COLPADs in conducting risk assessments	L	DGPAD, MAVDT

(continued)

Table 10.12 Summary of Recommendations for Strengthening Prevention of Natural Disasters *(continued)*

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Responsible government agencies*
Integrate and strengthen disaster monitoring and alert systems		
Expedite integration and strengthening of disaster alert and monitoring systems (seismic activity, volcanoes, floods, and tsunamis)	S	MAVDT, DGPAD, IDEAM
Establish priorities for disaster monitoring and alert systems based on comparative risk assessment	S	MAVDT, DGPAD, IDEAM
Provide adequate funding for management and maintenance of system	S	MHCP
Enhance funding for disaster prevention		
Enhance funding for disaster prevention by		
• Changing operating guidelines of the FNC to ensure that it provides sufficient funding for prevention activities	S	Congress, MHCP, DNP, MAVDT
• Encouraging use of FNR, international sources, and other sources of funding for disaster prevention	M	MHCP, DNP
Expedite sectoral contingency planning		
Undertake comparative risk assessments to develop prioritized agenda for developing and strengthening sectoral disaster contingency plans	S–M	MAVDT, DGPP

Source: Authors.
Note: DGPP = *Dirección General del Personal Público;* DNP = *Departamento Nacional de Planeación;* MHCP = *Ministerio de Hacienda y Crédito Público.*

Notes

1. Allan Blackman, Yewande Awe, Peter Brandriss, and Carolina Urrutia are the authors of this chapter, which draws heavily from background documents prepared for this study by Blackman and others (2005) and Larsen (2005), and from the Program Document for the Disaster Vulnerability Reduction First Phase Adaptable Program–Loan Number 72930-CO.
2. Colombia's National Disaster Preparedness and Response Plan (*Plan Nacional para la Prevención y Atención de Desastres*, PNPAD) defines key terms as follows: A *disaster* is a situation caused by a natural, technological, or human-caused phenomenon that results in intense alteration in people, goods, services, or the environment. *Prevention* is a set of measures put in place to avoid or reduce

an anticipated event's impact on people, goods, services, and the environment. *Mitigation* consists of measures intended to reduce or diminish risk to an *acceptable* level when it is not possible to eliminate it.

3. ONPAD was originally located in the Administrative Department of the Presidency of the Republic. It was moved to the Ministry of Government by Decree 1680 of 1991. Decree 2035 of 1991 and Decree 372 of 1996 changed the Ministry of Government into the Ministry of Interior, and Decree 2546 of 1999 merged the Ministry of Interior with the Ministry of Justice to create the Ministry of Interior and Justice.
4. Pollner, Codato, and García (2002) list five areas where information on disaster risk is relatively strong:
   - Detailed seismic maps and preliminary seismic vulnerability studies have been developed for Bogotá.
   - The *Normas de Diseño y Construcción Sismo Resistente* (NSR-98) mandated seismic studies aimed at identifying zones across the country where the probability of a seismic incident is greater than 10 percent over the next 50 years. Accordingly, detailed seismic maps have been developed for the cities of Armenia, Bogotá, and Pereira.
   - The cities of Manizales and Tumasco have incorporated risk mitigation into their political agendas.
   - INURBE has commissioned housing condition evaluations that can be used to assess risk and vulnerability to natural disasters.
   - The Ministry of Development has prepared maps of areas that are susceptible to floods, volcanoes, landslides, and earthquakes in 1,054 municipalities (with the help of IDEAM, INGEOMINAS, and Augustín Codazzi Geographic Institute).

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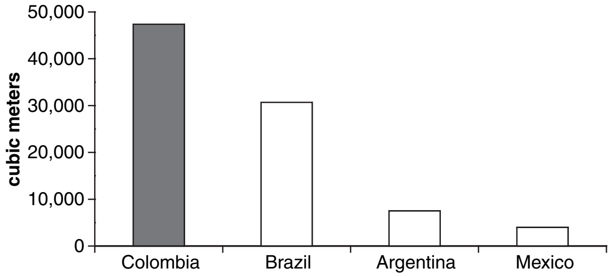
CHAPTER 11

Water Management in a Water-Rich Country

Colombia is endowed with abundant water resources. Responsibilities for water policy design and implementation are distributed between the Ministry of Environment, Housing and Regional Development (MAVDT) and local authorities, but because of the abundance of water, water allocation regulations have not been modified since 1978. The current legal and institutional framework does not facilitate access to water by small water users or vulnerable groups such as indigenous peoples and Afro-Colombian communities. Although information on groundwater is scarce, the resource is used inefficiently and overexploited in some areas. The most important sources of water pollution are hazardous substances, including toxins and pathogens. The water pollution control regulations and the effluents charge system address only organic matter and suspended solids discharged from point sources to surface waters, and thus need to be broadened.

Colombia is endowed with abundant water resources.[1] It has a national average freshwater supply of more than 2,100 cubic kilometers, equivalent to a supply of about 50,000 cubic meters per capita, a figure that is several times larger than that of other Latin American countries such as Mexico and Argentina. Figure 11.1 compares the per capita availability of freshwater among these countries, highlighting the wealth of Colombia's

Figure 11.1 Internal Freshwater Resources Per Capita



Source: World Bank 2005.

water resources. Regional and seasonal flow variations and environmental vulnerability differ considerably among river basins.

In the past two decades, the agricultural zones of a few river basins have been affected by water deficits. The Institute of Hydrology, Meteorology and Environmental Studies (*Instituto de Hidrología, Meteorología y Estudios Ambientales*, IDEAM) estimates that by 2030, if watersheds are mismanaged, vulnerability to surface water shortages may pose a significant problem in the Andes and Caribbean regions of the country.

There are over 2.5 million hectares of wetlands and almost 2 million hectares of floodplains in Colombia. They serve an important role in recharging and discharging aquifers, controlling floods, retaining nutrients and sediments, filtering contaminants, producing biomass, maintaining fauna and flora, stabilizing coastlines and microclimates, facilitating aquatic transport, and providing recreation and tourist attractions. They are a vital element in drinking water production, agriculture, fisheries and other biological resources, forests, and wildlife.

These environmental benefits have diminished with time as a result of years of poor management of the wetlands, which have been affected by problems such as draining of marshes and contamination. In addition, construction of infrastructure and effluents from agriculture, fishing, and domestic sources have contributed to altering important wetland ecosystems, including the Ciénaga Grande de Santa Marta, the Zapatosa and Teca Systems, the Ciénaga Virgen, Tota Lake, and the small lakes of Cocha and Fúquene. However, Colombia has achieved considerable progress in restoring its wetland ecosystems, as shown in Ciénaga Grande de Santa Marta and the Juan Amarillo and Salitre wetlands.

Water pollution is another important problem that affects Colombia's water resources and limits their use for water supply and recreation, and their ecological benefits. Many important rivers, such as Bogotá, Cali, Combeima, Otún, Pamplonita, and Pasto, are highly contaminated as a result of direct discharge of untreated effluents, primarily from industrial centers. To address the problem of water pollution, wastewater treatment plants have been constructed in cities such as Medellín and Bucaramanga.

This chapter addresses the issues of allocation of water quantity and water pollution control, discusses the effectiveness of the policy design for water allocation and of the design and implementation of water pollution control policy,[2] and draws a series of conclusions.

Water Quantity

There are five first-order watersheds in Colombia—Caribe, Magdalena-Cauca, Orinoco, Amazonas, and Pacífico. A recent inventory of watersheds identified nearly 27,000 watersheds larger than 10 square kilometers (km^2) and more than 700,000 smaller than 10 km^2 (IDEAM 2004). In the past two decades, several watersheds have been affected by water deficits, including the Bogotá River (Cundinamarca Department), the Cesar and Ariguaní Rivers (Cesar Department), the Zulia River (Norte de Santander Department), the Tapias and Rancheria Rivers (La Guajira Department), the Coello-Totare River system (Tolima Department), and the Palo-Juanchito River system (Valle del Cauca Department) (IDEAM 2004; Mejía, Millan, and Perry 1985).

According to IDEAM (2004), water demand in 2003 was 7,435 million cubic meters. Of this amount, 54.5 percent was for agriculture, 28.8 percent for household use, 12.7 percent for industry, 3.1 percent for livestock, and 0.9 percent for the services sector. The municipalities with greatest demand were those with substantial rice production: Ambalema, Espinal, and Lérida in the department of Tolima. It is estimated that 14 watersheds currently have very high vulnerability to water shortages, and that by 2030 the situation will worsen in the Andes and the Caribbean regions because of inadequate watershed planning and management, diminished availability resulting from contamination, rising demand, and climate change impacts (IDEAM 2004).

Over 30 percent of Colombia's freshwater is contained in aquifers, making groundwater an important potential supply source. According to the 2004 IDEAM report, 40 percent of municipalities rely exclusively on groundwater for their drinking water. Although systematic information on groundwater is lacking, in general it is used inefficiently, and in a few areas it is overexploited, including in the Bogotá Savanna, La Guajira, and Córdoba.

Main Actors in Water Resources Management Policy Design

The main entities responsible for water resources management are regional authorities, including departments, municipalities, Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs), and Urban Environmental Authorities (*Autoridades Ambientales Urbanas*, AAUs), which can formulate regulations that are more restrictive than those required under national law, but not less.[3]

The basic legal structure for water regulation is established in Decree-Law 2811 of 1974, which created the National Code for Renewable Natural Resources and Environmental Protection (*Código Nacional de Recursos Naturales y de Protección al Medio Ambiente*, CNRN), and which remained the main environmental law for many years. Part III of the CNRN governs issues related to water. Specific regulations are defined and implemented through subsequent decrees. According to the CNRN, virtually all bodies of water belong to the public domain. Therefore, water is considered private property only when it originates and terminates on the same piece of private property. In this context, companies and individuals can obtain rights to use surface and groundwater only by law or by concession. When ground or surface waters are in danger of depletion or pollution, pending concessions in that basin or zone can be suspended and existing concessions can be circumscribed.

Decree 1541, approved in 1978, established regulations related to ownership and use of all water resources, including some water quantity provisions, and established the framework for the national system of water concessions. The decree states that all water users must hold water concessions issued by the National Institute of Renewable Natural Resources (*Instituto Nacional de los Recursos Naturales Renovables*, INDERENA). This authority was later transferred to the CARs and AAUs.

Law 99 of 1993 established the Ministry of Environment (*Ministerio del Medio Ambiente*, MMA) and assigned to it some responsibilities relevant to water management. However, the law did not modify regulations for the water sector or management of water resources. Law 99 also increased the number of CARs and extended and redefined their purview by giving them principal responsibility for monitoring and enforcing water regulations, including discharge standards and fees. It also established AAUs in cities with populations greater than 1 million and gave them responsibilities analogous to those of the CARs.

The Ministry of Environment became the Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT) in 2003. The MAVDT is the supreme regulatory authority for water resources. Its responsibilities include formulating, managing, and coordinating policies, regulations, and programs on drinking water, water resources management, wastewater discharges, and sanitation. In collaboration with the Ministry of Foreign Affairs, it is also responsible for international cooperation on water-related issues.

The CARs and AAUs are responsible for monitoring and enforcing national water policies, granting concessions for water rights, and reviewing environmental impact assessments. Departmental and municipal governments help the CARs monitor and enforce water pollution regulations and develop sanitation and wastewater treatment infrastructure. As owners of wastewater treatment plants, municipalities must comply with the discharge criteria established by law.

Analysis of Water Resources Management Policy Design

According to the CNRN and Decree 1541 of 1978, water should be allocated according to the following order of decreasing priority: human consumption, preservation of fauna and flora, agriculture, animal husbandry, recreation, industry, and transportation. The CNRN does not take into account that the economic value of water, social preferences, and water allocation priorities can vary substantially from one region to another.

Decree 1541 of 1978 regulates the procedures for obtaining water permits and their associated rights and conditions. According to this regulation, rights to divert surface water or to draw water from aquifers are granted by the local environmental authorities through water concessions. Obtaining a water concession can take several years, largely because of the cumbersome procedures established in Decree 1541 (Amado 2004). In rural areas and most municipalities, water concessions are granted by the CARs. However, in the largest cities—Bogotá, Medellín, Cali, and Barranquilla—they are granted by the AAUs. These can be granted for up to 10 years,[4] and may be transferred to another beneficiary only if authorized by the CAR or AAU, and without changes to the original conditions of the concession.

Because the CNRN and Decree 1541 of 1978 do not spell out how to apply in practice the legally determined order of priorities for water use, government officials responsible for water allocation are left to make their own interpretations (Amado and Niño 2004). When users in different sectors demand the same water resource, the allocation among them ultimately becomes a discretionary decision by the responsible government official. Often, the most powerful local stakeholders drive local water policy or simply use the resource as they see fit, regardless of its opportunity cost.

Decrees 2857 of 1981, 1933 of 1994, and 1729 of 2002 mandate CARs to create Watershed Administration and Management Plans (*Planes de Ordenamientos y Manejos de Cuencas Hidrográficas*, POMCAs). These plans must include provisions regarding land use zoning, development of water resources infrastructure, allocation of water resources, water pollution control, and conservation of water bodies.

Some CARs charge fees for water use based on the legal authority of Article 159 of the CNRN and subsequent laws and decrees. Because these legal instruments do not provide specific criteria, the CARs decide who to charge and how to set the fees, resulting in inconsistency across the country. For example, since 1999 the CAR Cundinamarca charged Bogotá Water and Sewer Company (*Empresa Acueducto y Alcantarillado de Bogotá*, EAAB) and some small agricultural irrigation systems of the region for using water (Amado 2004), but did not charge the beneficiaries of the La Ramada Irrigation District, which was under the administration of the CAR. In 2003, the CAR Cundinamarca collected about Col$11,100 million (US$5.2 million) in water fees, about 83 percent of which was paid by EAAB alone. EAAB sued the CAR Cundinamarca to recover all its payments related to water fees, and challenged some of that CAR's decisions related to water allocation (Niño 2004).

Water fees are correlated with socioeconomic conditions and water availability. In the municipality of Subachoque, the water fee for irrigation purposes was Col$12 (US$0.006) per cubic meter, while the fee paid by EAAB varied between Col$72 (US$0.033) for water taken from the Bogotá River to Col$127 (US$0.059) for water taken from the Teusacá River (Niño 2004), which represents between 10 and 18 percent of the price of drinking water.

Until December 2003, based on Resolution 259 of 1997, the Environmental Administration Department (*Departamento Administrativo del Medio Ambiente, Bogotá*, DAMA) charged a fee for the use of groundwater within the Bogotá city limits. Like the water fees charged by CAR Cundinamarca, this fee had its legal origin in the CNRN, and varied between Col$148 (US$0.07) and Col$305 (US$0.14), depending on the depth of the water table.[5] Water fees collected by DAMA in 2003 amounted to US$700,000.[6]

In 2003, the Colombian Farmers Society sued over the water fees that some CARs had been charging since 1984 based on Articles 159 and 160 of the CNRN. In December 2003, the Constitutional Court declared that those articles of the CNRN had been replaced by Article 43 of Law 99 of 1993, and that therefore the water fees could no longer be charged until specific regulations based on Law 99 were approved.

During 2002 and 2003, the MMA held a series of meetings in which government and industry stakeholders discussed proposals for new regulations to implement Article 43 of Law 99 on water fees. The meetings produced feedback and proposals from representatives of the mining and manufacturing industries, aquaculture, water utilities, hydropower, petroleum, agriculture, CARs, and the National Parks Unit (Universidad de los Andes 2004), but did not include participation by civil society groups, communities, and nongovernmental organizations. Based on the proposals made by the participating stakeholders, the MMA drafted and issued new regulations through Decree 155 of 2003 and Resolution 240 of 2004. Quantitative studies of the social value of water were not taken into account by the MMA, and the new fees were set so low that the CARs were unconvinced that it was financially justifiable to even collect them (Alvarez 2004).

According to the new regulations, the minimum price for a cubic meter of water in Colombia was set at Col$0.5 and the maximum price was set at Col$3.5, less than 3 percent of what the CAR Cundinamarca had been charging for water from the Teusacá River and about 1.5 percent of what DAMA had been charging for groundwater. This new fee is less than 1 percent of the marginal value of water for the industrial sector of Colombia (Cruz, Uribe, and Coronado 2003), and between 1.5 and 6.5 percent of the marginal contribution of water to production of potatoes and peas in one municipality of the Bogotá Savanna (Ersulien 2003).

Effectiveness of Policy Implementation

The case study of the allocation of water resources in the Bogotá Savanna presented in box 11.1 illustrates the effectiveness of the implementation of the water resources management policy in one of the most vulnerable watersheds in the country. Although this is by far the largest population affected by limited water supply, and is not typical of most areas where water quantity is not an immediate concern, the same institutional dynamics are at work throughout the country: for all water resources, small farmers do not have access to the allocation of water rights—they go instead to the big, powerful users—and this calls for a major modernization effort.

Although the CNRN made human consumption and ecosystem conservation the highest priorities for water allocation, neither the CNRN nor Decree 1541 of 1978 created guidelines or procedures for balancing competing priorities and resolving conflicts. Therefore, government officials responsible for water allocation, mainly in the CAR Cundinamarca, were left to make their own interpretations and decisions (Amado and Niño 2004), with limited opportunity for administrative or legal appeal.

Box 11.1

Case Study of the Allocation of Water Resources in the Bogotá Savanna

This case study analyzes the allocation of water resources among different stakeholders in the Bogotá Savanna, and corresponding policy and institutional implications. Although the government was able to prevent water scarcity for large users—primarily through a series of supply-side engineering solutions—in general, current institutions and regulations do not respond to the realities and needs of small water users such as farmers, and cannot guarantee them equitable access to water, protection of their formal water concessions, participation in decision making, or access to mechanisms for resolving conflicts.

The watershed. The Bogotá Savanna covers 4,200 square kilometers on a plateau 2,560 meters above sea level in the Andes. The main waterway in the savanna is the Bogotá River, which provides water for irrigation and domestic consumption and is used for electricity generation as it leaves the high savanna and descends toward the lowlands of the Magdalena watershed. The savanna is the most industrialized and densely populated region of Colombia, generating 27 percent of gross national product, including 72 percent of industrial output.

The city of Bogotá has a population of about 6.8 million (roughly 15 percent of the national total), and is growing at more than 2 percent per year (DANE 2004). The other 19 municipalities in the savannah have a combined population of nearly 900,000, and their industrial production is growing at a rate of 4.4 percent per year, compared to a rate of 2.3 percent per year for Bogotá itself.

The savanna is also an important agricultural region. It produces 2.2 million liters of milk a day, worth US$136 million per year; accounts for 85 percent of national flower production, with an annual value of US$600 million; and is the country's main producer of fresh vegetables (Asocolflores 2005; CEDE of Universidad de los Andes 2003; DANE 2002). The average annual precipitation in the savanna varies from as little as 700 millimeters (mm) in some areas to more than 1,900 mm in the municipalities with the heaviest rainfall (Rodríguez 2003; SGC 1998). Water yields in the Bogotá River watershed vary between 10 liters per second per square kilometer (l/s/km^2) and 25 l/s/km^2. Water scarcity in rural areas of the savanna is most severe during January, February, July, and August.

There are two main aquifers in the Bogotá savanna, the *Acuífero de la Sabana* (Savanna Aquifer) and the *Acuífero Guadalupe* (Guadalupe Aquifer). The Savanna Aquifer water table lies at about 400 meters, yields about 5 liters per second per well, and supplies nearly 80 percent of the region's consumption of groundwater. The Guadalupe Aquifer lies between 800 meters and 1,300 meters and can yield 20 liters per second per well.

Historical perspective. By the late 1940s, Bogotá officials were becoming concerned about possible water shortages and decided to build an aqueduct and treatment plant in the upper basin of the Bogotá River (Rodríguez 2003). The new infrastructure, brought on line in 1959, gave the EAAB the capacity to deliver an additional 3 cubic meters per second (m^3/s) of drinking water (eventually expanded to 6 m^3/s).

With the population of the Bogotá Savanna at 1.4 million and growing, EAAB foresaw that water demand by 1970 could not be met solely with the resources available from the Bogotá River watershed. To meet the anticipated demand, EAAB built the Chingaza system to divert water to the Bogotá Savanna from several rivers across the continental divide in the upper reaches of the Orinoco River basin. This system began operation in 1985 and currently supplies 14 m^3/s (Ingetec 2003). The two main sources of demand, besides domestic and commercial consumption handled by EAAB, were for generation of hydroelectric power for the Bogotá Energy Utility (*Empresa de Energía de Bogotá,* EMGESA) and for agricultural use in the La Ramada irrigation district.

EMGESA generates electricity through a series of power plants on the lower Bogotá River, downstream from the savanna. In 1967, the energy company built the Tominé reservoir in the upper basin of the Bogotá River to regulate water flow to the downstream power plants. The economy of the Bogotá Savanna was critically dependent on this energy until the mid-1990s, when a national electricity market was created that allowed energy to be transferred to Bogotá from the Guavio hydroelectric complex (inaugurated in 1985) in the Orinoco watershed.

The La Ramada irrigation district covers 6,215 hectares on the west bank of the Bogotá River opposite Bogotá, and mainly serves dairy farms and vegetable growers. It was created in 1961 and is administered by the CAR Cundinamarca, which is responsible for allocating water among the irrigation district's members. La Ramada takes 0.6 m^3/s from the Bogotá River upstream of the convergence with the El Salitre River (CAR 1995). The flower industry is not included in the irrigation district because it mainly uses water from underground sources.

Surface water balance. A complex system of water reservoirs, tunnels, gates, canals, aqueducts, and valves in the Bogotá Savanna allocates water among various major users. The flow of water to different parts of the system and for different uses is controlled by releasing water from a series of reservoirs. The final

(*continued*)

outflow from the Bogotá Savanna is used to generate electricity along the lower watershed as the river descends toward the lower Magdalena Valley. In some cases the water can be used more than once (for example, domestic consumption and hydropower generation), but some uses exclude reuse (irrigation).

The table below summarizes information on surface and groundwater consumption in the Bogotá Savanna provided to Universidad de Los Andes researchers by the EAAB, the CAR Cundinamarca, and the DAMA. The table shows that the largest water user in the region is EAAB and that there are significant gaps in the information available about water supply and use in the region, particularly regarding water consumption by small users. Information on groundwater and smaller surface water resources is also incomplete. CAR information on the hydrology of small streams and creeks is inadequate or nonexistent, and information on the number of water permits granted and the amount of water allocated by CAR Cundinamarca in the Bogotá Savanna has not been consolidated.

As for groundwater, the CAR Cundinamarca estimates that there were about 3,500 wells in the Bogotá Savanna in 1990 (the most recent year for which data

Main Sources and Demands for Water in the Bogotá Savanna

Source	*Mean flow (m^3/s)*	*User*	*Uptake (m^3/s)*
Tunjuelito River (Bogotá watershed)	4.4	EAAB	1.1
		Small users[a]	Unknown
		Mining	Unknown
Bogotá River	9	EAAB[b]	4.5
		La Ramada Irrigation District	0.6
		Small users[a]	Up to 4.7
Guaitiquía, Chuza, and Frio Rivers (Orinoco watershed)	14	EAAB	11
		Other users	0
Other tributaries of the Bogotá River	Unknown	Small users[a]	Unknown
		Municipalities	Less than 1.5
Groundwater in Bogotá	Unknown	Large industry	0.14
		Small industries and services	0.02
Groundwater in rural areas	Unknown	Flower industry	0.84
		Municipalities	Unknown
		Others	Unknown

Sources: Information provided to Universidad de los Andes researchers by EAAB, CAR Cundinamarca and DAMA in written materials and interviews.
a. Agriculture, livestock, fisheries.
b. The amount includes 0.6 m^3 sold by the EAAB to municipalities in the Bogotá Savanna.

are available) and that aquifer levels are falling between 0.36 meters and 1.97 meters per year because of overexploitation. In addition, CAR Cundinamarca has detected traces of pesticides in some groundwater sources.

DAMA has an inventory of 306 active or potentially active wells in Bogotá. It is estimated that large industrial users account for 85 percent of the groundwater consumed in Bogotá (DAMA 2002). The remaining 15 percent is allocated to small industries and services such as car washes. According to DAMA, the aquifer underneath the city is not overexploited, but it is contaminated with fecal coliform.

The total demand for drinking water in the Bogotá region has declined by 16 percent since 1998 as a result of the increase of water tariff rates and an education campaign by the EAAB (Molina 2002).

The table below summarizes the current roles of the main institutional actors in water allocation and use in the Bogotá River watershed. Water allocation has traditionally been the responsibility of the CAR Cundinamarca. In 1967, the Board of Directors of the CAR Cundinamarca created the Hydrological Committee of the Bogotá Savanna as an advisory and consultative group to coordinate decisions on water allocation among large users and on management of the water storage and distribution system. The committee does not have a legal basis in current national legislation and the CAR Cundinamarca still has sole decision-making power.

Institutional Actors in the Water Sector for the Bogotá Savanna

Institution	*Functions*
CAR Cundinamarca	• Allocates water among different users in the Bogotá watershed • Manages and controls use of the region's natural resources • Charges fees for water consumption • Grants environmental licenses and permits for water use • Administers the La Ramada irrigation district
DAMA	• Allocates underground water in the urban area of Bogotá • Manages and controls use of the city's natural resources • Charges fees for water consumption • Grants environmental licenses and permits for use of underground water resources
EAAB	• Provides drinking water to Bogotá and 11 municipalities in the Bogotá Savanna • Administers the sewerage system of Bogotá

(*continued*)

	• Conserves ecosystems critical for water supply and regional hydrological functions (*páramos*, wetlands, and watersheds) • Provides flood prevention and control in the city of Bogotá
EMGESA	• Generates and buys energy, mainly for Bogotá and its neighboring municipalities
Municipalities around Bogotá	• Buy services and resources from the water and energy utilities
La Ramada Irrigation District	• Uses water from Bogotá River, mainly for dairy production and vegetable growing
Other rural users	• Use water from surface and underground sources for aquaculture, cattle ranching, recreation, and so forth
National Parks Unit and EAAB	• Administer Chingaza National Park (site of Chuza reservoir)

Source: Universidad de los Andes 2004.

The creation of the Hydrological Committee, at a time when there was not sufficient water and infrastructure available to satisfy the needs of large users in the region (Rodríguez 2003), illustrates how institutions emerge when there is a social need for them. The solutions implemented reflect initiatives by local institutions to develop forward-looking strategies supported by technical information. However, the committee included only the three major water users. Communities, municipalities, small farmers, and other stakeholders were, and continue to be, excluded from the committee.

Source: This case study is largely drawn from a background paper prepared for this report by the of Universidad de los Andes (CEDE of Universidad de los Andes 2003).

The Bogotá Hydrological Committee has resolved many short-term water shortage issues, and reforms in the mid-1990s created a national electricity market. Perhaps the most important remaining function of the committee is to coordinate reservoir and water flow management to prevent flooding during extreme rainfalls (Niño 2004).

The Hydrological Committee has not traditionally dealt with the water needs of small users in rural areas of the Bogotá Savanna, which is the responsibility of the CAR. While it is estimated that more than 70 percent of small users do not hold water permits and there is no information on their actual water consumption, occasionally the sum of the permits held is greater than the available flow (Amado 2004). The low number of permits and the lack of links between concessions and actual water supply could be attributable to the cumbersome procedures established by Decree 1541 of 1978, centralization of the concession process, insufficient human resources in the CAR Cundinamarca, limited enforcement and control capacity, and the fact that water fees are charged only to legal users (permit holders).

As a result of measures to address water supply concerns over the past 25 years, the industrial sector does not consider water availability, price, or quality to be limiting factors in its development and investment plans in the Bogotá Savanna. However, small rural water users face scarcity every year during the dry months (January, February, July, and August), particularly in the center and the far north and south of the Bogotá Savanna, where annual precipitation is less than 800 millimeters (mm). Small users also lack the allocation mechanisms and access to judicial appeal enjoyed by large water users.

Finding long-term solutions to the problems of small water users has not been a priority for local, regional, or national environmental authorities, and information on water supply and demand in the region's smaller watersheds is generally nonexistent. Obtaining a legal water concession is a long, cumbersome, centralized, and costly process for small users at the local level (Camargo 2004), and there is no public participation in water allocation policy for small users. In addition, for small users, the current legal and institutional framework does not provide transparent and equitable access to water, protection of rights, or resolution of disputes. Without a decentralized institution that can ensure efficient allocation, monitoring, and enforcement at the community level, water conflicts among farmers will remain common.

Watershed Administration and Management

Although CARs throughout Colombia are required by law to create POMCAs, the degree of compliance is difficult to evaluate. Available information suggests that only a few watersheds have such plans, there is no clear rationale for which watersheds have them, and there is no effective monitoring or enforcement of the plans. According to IDEAM, between 1998 and 2002, 21 of the 33 CARs formulated 145 new POMCAs covering 20,000 square kilometers, or less than 2 percent of the national territory. Of these plans, 49 were for watersheds that supply municipal drinking water systems.

Of the 40,672 new water concessions reported to IDEAM for the period from 1998 to 2002 by 30 of the CARs, nearly 60 percent were for human consumption, about 23 percent were for agriculture and livestock, 2.4 percent for hydropower, 1.9 percent for industry, 1.4 percent

Table 11.1 New Water Concessions by Sector, 1998–2002

Sector	*Number of concessions*
Domestic	24,119
Agriculture and livestock	9,333
Other sectors	4,805
Hydroelectric generation	978
Industry	777
Mining	660
Total	40,672

Source: IDEAM 2004.

for mining, and 11.0 percent for other sectors (table 11.1). The great majority were in Antioquía and the Cauca Valley, which together granted about 60 percent of the concessions; Cundinamarca accounted for another 12 percent. Because few parts of the country face water shortages, this concentration likely reflects the level of economic development and institutional capacity more than the need to promote rational water allocation or conservation in a particular area or sector. In any case, nationwide or region-specific data that could help assess the implementation and impacts of water concessions remains elusive, thwarting attempts to incorporate lessons and experience from water concessions into effective planning, analysis, and policy formulation.

Degradation of Water Bodies

Degradation of wetlands through poor management and lack of knowledge about their function and services has led to reductions in the environmental benefits they provide. Degradation of water bodies; draining of marshes; and contamination from industry, agriculture, fishing, and domestic sources have altered important wetland ecosystems. In the Colombian Pacific, which has the country's largest areas of land covered by mangroves, a net reduction of 5 percent (nearly 14,000 hectares) of mangrove coverage is estimated to have occurred between 1969 and 1996 (INVEMAR 2002).

Yellow fin tuna accounts for an estimated 80 percent of the national fish capture, and for almost Col$172,000 million (US$80 million) in income generated in 2005 (IDEAM 2005). Most fish captures originate from the Pacific coast. However, overfishing of other marine species such as white, tiger, and red shrimp; lobster; and queen conch continues to be a problem and has led to declines in captures. In addition, coastal water ecosystem interventions contribute to the observed decline. Furthermore, degradation of water quality from the discharge of ballast and bilge water from ships, accidental petroleum and toxic substance spills, the dumping of domestic wastewater, and sediment transport from rivers and canals such as the Dique have also contributed to the observed decline in captures. In the Ciénaga Grande de Santa Marta, fish captures decreased from 8,000 tons in 1972 to 1,800 tons in 1989.

During the 1960s, fish captures in the Magdalena-Cauca basin were estimated at about 100,000 tons per year, but decreased in the 1990s to almost 9,000 tons per year (Colorado State University 2004; Escobar 2004). The decrease of fish capture in inland areas, especially the Magdalena and Cauca River basins, is attributable to a variety of reasons including drainage of wetlands and marshes, use of inadequate fishing equipment, channel blockages, salinity changes in mangrove ecosystems, and water pollution. The main wetlands and rivers associated with fish production are located principally in the Caribbean region and in the bottoms and high plains of the Orinoquía.

Policy Design

The main tools provided in Colombia's policy to control degradation of bodies of water are the POMCAs, established by Decrees 2857 of 1981, 1933 of 1994, and 1729 of 2002, and the environmental licensing process. To obtain a license, projects that have potentially negative environmental impacts are required to conduct an environmental impact assessment and hold a public hearing. Licenses specify the manner in which water users will control water degradation. The licensing process, however, does not capture the degradation of bodies of water as a result of non-project-related activities such as urban and rural runoff, urban expansion and encroachment, and unsustainable agricultural practices incorporating the use of fertilizers and pesticides.

At the national level, one of the few political instruments aimed at conservation of wetlands is the Wetlands Convention (Ramsar) ratified by the Colombian Congress. The objective of the convention is to promote the conservation and rational management of wetlands. To this end, the government established the following Ramsar areas: 400,000 hectares of the Delta Estuarino of the Magdalena River, Ciénaga Grande de Santa Marta in 1998; 39,000 hectares of the La Cocha lagoon in 2001; and 8,888 hectares in the delta of the Baudó River in 2004. In 2001, the MMA issued the National Interior Wetlands Guideline, which established a framework for the management of wetland ecosystems at the national, regional, and local levels. This guideline suggests generic approaches for the management of wetlands and introduces concepts such as the creation of social criteria and community participation in wetland management.

Governmental Agencies Responsible for Controlling the Degradation of Bodies of Water

The MMA is responsible (under Law 99 of 1993) for defining policies for water resources management, including the control of wetland degradation. Law 99 also assigns the ministry the task of setting fishery quotas and total allowable catch from a fish stock. In addition, it assigns the CARs the function of authorizing the use (including recreational use) of renewable natural resources and the practice of activities that can affect the environment; the concessions for water usage and sport fishing seasons; and the application of corresponding sanctions. According to Law 99 of 1993, the entities within the National Environmental System responsible for implementing the policies previously defined by the national government are the governmental environmental authorities (MAVDT 2006, p 10).

Policy Implementation

Several CARs have established POMCAs that include wetland restoration and conservation activities.[7] An example is the restoration of urban wetlands in the Bogotá metropolitan area. In 1900, there were over 50,000 hectares of wetlands[8] in Bogotá. By 1998, wetlands had decreased to a mere 800 hectares (Rodríguez 2003). Among those 800 hectares, the Juan Amarillo wetland alone retains 40 percent of the city's storm waters (Rodríguez 2003). Other environmental services provided by these wetlands include sediment retention; aquifer replenishment; nutrient recycling; and habitat provision for endemic, resident, and migratory species.

Innovative approaches for the restoration of Bogotá's wetlands were implemented through a World Bank–funded water and sewerage project. The objective of the project was to reestablish the ecological and physical corridors of the most important ecosystems of the savanna. The project covered the San Rafael ecological park; the Molinos, Córdoba, Rionegro, and Salitre canals; the Córdoba, Juan Amarillo, and Jaboque wetlands; and the riparian zone of the Bogotá River. Through the project, public space was increased by the addition of over 400 hectares of green areas. In addition, 43 kilometers of pedestrian paths and 37 kilometers of bike paths were constructed, and 228 hectares of wetlands were restored (Rodríguez 2003). Two green areas stand out: the Humedal de Juan Amarillo and the Paseo Río Salitre, which the Chief Executive Officer of the Bogotá Water Utility considers one of the longest urban environmental corridors in Latin America (Alvarez 2004).

The Ciénaga Grande de Santa Marta (CGSM) is located in the delta of the Magdalena River and is inhabited by 30,000 people whose main livelihood is fishing. During 1956–95, the area of land covered by mangrove forests fell from 511 km^2 to 225 km^2 (IDEAM 2002). In 1995, the government implemented a project to reestablish water flows in the CGSM by opening the Aguas Negras, Alimentador, Almendro, Clarín, Renegado, and Torno channels with a view to connect the Magdalena River with the wetland. These efforts led to an increase of almost 53 km^2 in mangrove-covered areas during 1995 to 2001. Furthermore, the implementation of hydraulic works in the Aguas Negras, Clarín, and Renegado channels has lessened the pace of deterioration of the ecosystems, evident in reduced salinity of marshes and recovery of vegetation.

Water Pollution Control

IDEAM (2004) has recognized that information collection on and management of ambient water quality in Colombia is insufficient. Although monitoring stations do exist for selected rivers and aquifers, coverage is limited and data collection and management are not standardized. As a result, assessment of the state of water quality at a national level is incomplete. Water pollution is evident in several rivers: Bogotá, Cali, Combeima, Medellín, de Oro, Otún, Pamplonita, and Pasto. Water pollution from toxic substances and pathogens is deleterious for drinking water and for water used in recreation, biodiversity, and agriculture.

Toxic and Pathogenic Pollution

The discharge of toxic substances, pathogens, and other hazardous wastes into bodies of water is the main cause of water pollution. Most toxic and hazardous pollutants come from agricultural and industrial discharges, which may have cumulative and persistent consequences. Hospital, livestock, and agroindustrial wastes contain bacteria, protozoa, and other pathogenic microorganisms that pose severe health risks to anyone consuming the water directly or through agricultural products irrigated with it. Key causal factors in groundwater pollution include agricultural runoff, septic tanks, and landfills.

The agricultural sector discharges large amounts of pesticide pollutants. Even though problems of nonpoint-source water pollution are generalized worldwide, preliminary estimates suggest that the application of pesticides on the 1.2 million hectares in Colombia dedicated to agriculture are two to three times greater than the amounts recommended by the manufacturers and used in other regions, suggesting that in these areas the problems of runoff pollution and agricultural percolation are critical (DNP 1995).

Most toxic wastewater discharges in Colombia come from the improper disposal of solid waste and hospital waste and from runoff from fertilizers, pesticides, and industrial waste, particularly from petroleum refineries, the chemical industry, and leather tanneries. The inadequate disposal of solid waste results in leachates with high concentrations of toxic residues such as phenol, chromium, lead, and mercury. Sanitary landfills in Bogotá and Medellín are illustrative. In Bogotá's Doña Juana landfill, for example, high concentrations of toxic compounds have been registered, such as phenol (3.91 milligrams per liter [mg/l]), chromium (1.12 mg/l), lead (0.41 mg/l), and mercury (0.004 mg/l) (DNP 1995).

The use of polluting technologies in the manufacturing industry—such as those traditionally used in tanneries, electroplating, metal smelting, palm oil extraction, distilleries, chlorine and soda ash production, oil refineries, and petrochemical plants—or in slaughterhouses and freezers promote the waste of prime material and high production of residual waste. The chemical, electroplating, paper processing, and tannery industries also dump toxic substances such as cadmium, chrome, lead, mercury, nickel, and organic chloride compound wastes in uncontrolled conditions.

Crude oil spills from acts of sabotage by terrorists have become another cause of water pollution in the country. The most affected ecosystems have been slow-moving bodies of water such as wetlands and low-flowing creeks. The areas damaged by these oil spills are located mainly in the Araucana high plains area of the Catatumbo River basin region, which is very steep and rich in streams, ravines, and tributary rivers; the mid-valley and low-valley plains of the Magdalena River (primarily in the departments of Santander, Cesar, and Sucre); and in the departments of Putumayo and Nariño, where the mountainous conditions have hindered efforts to control the oil spills effectively.

In the Catatumbo basin, as in most cases, the spills have reached larger bodies of water such as the Sardinata, Tarra, and Catatumbo rivers. The most difficult spills to control and manage have occurred in the Magdalena plain. The expansion of crude oil has compromised as much as 1,000 hectares of lentic (still) water, nearly 40 kilometers of less important rivers (such as the Simaña River), and some 150 kilometers of canals and secondary or seasonal streams, in which groundwater contamination becomes more relevant than that of surface water.

In the cities, inadequate management and disposal of substances used for the operation and maintenance of vehicles also contributes to water contamination. By 1995, the major portion of the 650 million barrels of oil lubricants used annually for automobiles had been dumped into sewers and bodies of water without prior treatment or control. By 1990, the Cundinamarca CAR estimated that close to 250,000 barrels of motor oil had been dumped into the sewers of the city of Bogotá and ended up in the Bogotá River. Organic material wastes from agricultural, livestock, and domestic and industrial sources that reduce or eliminate the dissolved oxygen in streams negatively affect aquatic life and water aesthetics. According to the *Contraloría General de la República*, there is no reliable analysis of water pollution at the national level (Garay 2002). Carrasquilla and Morillo (1994) estimated that the three largest contributors to biochemical oxygen demand (BOD) discharged into surface waters in Colombia were, in order of importance, agricultural and livestock nonpoint sources, 84 percent; domestic wastewater from large urban centers such as Bogotá, Medellín, Cali, Barranquilla, Manizales, and Cartagena, 10 percent; and industrial point sources, 6 percent (table 11.2).

Among point sources, urban wastewater is the major source of discharges with high BOD. According to IDEAM (2002), in 1999, the total BOD discharged from point sources was 624,746 metric tons, of which 74 percent came from the domestic sector and 26 percent from industry. IDEAM (2002) identifies industrial centers of Barranquilla, Bogotá, Bucaramanga, Cali, Cartagena, Manizales, and Medellín as the greatest contributors. Among industrial activities, Carrasquilla and Morillo (1994) identified the production of alcoholic and nonalcoholic beverages, industrial chemicals, and the cardboard and paper industry as key contributors of organic pollution.

Table 11.2 Daily BOD Production by Sector

Sector	*Tons*	*Percent*
Agriculture and livestock	7,100	84
Domestic wastewater	800	10
Industrial wastewater	520	6
Total	8,420	100

Source: Carrasquilla and Morillo 1994.

Agencies Responsible for the Design and Implementation of Water Pollution Control Regulations

Law 99 of 1993 gave responsibility for the design and implementation of environmental policy to the MAVDT, CARs, and AAUs, and made the MAVDT the supreme regulatory authority for water pollution control. The MAVDT is responsible for both setting general policies and developing specific programs related to water. In conjunction with the Ministry of Social Protection, it is responsible for defining the acceptable quality standards and uses for water and for developing a resource classification plan that includes existing uses, projections of water use needs, quality simulation models, quality criteria, and discharge procedures. The Ministry of Social Protection alone is responsible for approving water treatment, storage, and transportation when the water is for human consumption. Law 99 also assigned CARs and AAUs responsibility for enforcing the water policies set at the national level.

Implementation of Water Pollution Policy

The main water pollution problems in Colombia are associated with toxic substances, pathogens, and other hazardous substances, but no policies address these problems. Furthermore, Colombia's water pollution policy omits nonpoint discharges, which are significantly more damaging to the environment than point discharges of organic matter (BOD). However, a handful of regulations establish the basic structure of regulation of organic matter and suspended solids.

Water quality regulations for BOD and total suspended solids (TSS) have three main elements: (a) a set of quality standards for various beneficial uses, including human and domestic consumption, preservation of flora and fauna, agriculture (including irrigation), animal production, and recreation (including swimming); (b) a system of registration and permitting, associated with a set of discharge standards; and (c) a system of discharge fees. Decree 1594 of 1984 and Law 09 of 1979 contain the details of standards and requirements regarding environmental quality, treatment of wastewater, and compliance standards. CARs and AAUs are responsible for enforcing the discharge standards, and to do so, they can inspect discharging facilities at any time to sample effluents and inspect equipment.

Water pollution charges have been used in Colombia at least since the late 1970s. The design of the fee system, established in the CNRN of 1974 and developed by the Autonomous Regional Corporation of the Cauca Valley (*Corporación Autónoma Regional del Valle del Cauca*, CVC) in 1978, has been changed several times by several decrees and laws.[9] As envisioned in Law 99 of 1993, discharge fees were applied only to those discharges remaining *after* the discharge standards had been met. For example, for new facilities (established after Decree 1594 of 1984) that achieved 80 percent BOD removal, the discharge fees applied only to the 20 percent BOD content of their discharges. CARs are entitled to charge-generated revenues; to provide incentives for the application of the charges, the national government determined that many of the agencies' operational expenses, including staff compensation, could be financed only by charge revenues and a few other instruments.

In addition to the obstacles to expanding water supply and sewerage services with participation of the private sector (explained in chapter 6), the charge design contains the following serious flaws with respect to ecological improvement goals:

- The selection of BOD and TSS as charge parameters, which are associated with aesthetic characteristics and not with the most significant problems such as impacts to human health, ecosystem conservation, or beneficial uses of bodies of water, such as recreation.
- Reliance on voluntary declarations to determine discharges of pollutants, without a system to verify the accuracy of the declarations and penalize false reporting.
- The possibility of revising environmental goals once they are met, which reduces the incentives to invest in pollution-abatement technologies. Experiences in other countries show that polluters tend not to meet environmental goals because doing so would invite the setting of more stringent goals. Instead, polluters tend to adopt a strategy of reluctant compliance to increase the probability of more lenient goals in subsequent periods.[10]
- Absence of a quality-assurance mechanism to ensure the precision, sensitivity, and accuracy of environmental monitoring, and therefore lack of a reliable system to assess progress.

The total national generation of wastewater in urban centers is 67 cubic meters per second (Carrasquilla and Morillo 1994), the vast majority of which is not treated. In addition, a significant percentage of wastewater is not collected because many households are not served by municipal sewerage systems. Even when wastewater is collected it is generally not treated, and many of the existing wastewater treatment plants operate inefficiently or not at all.

Approximately 75 percent of the population living in urban areas in 2001 (31,339,130 inhabitants) had access to sewerage systems. This means that 7,803,000 people lacked access to this service. As of 1999, 16 percent of Colombia's 1,089 municipalities had operating treatment plants (Contraloría 1999). The Ministry of Development estimated that Colombia's treatment plants treat less than 1 percent of total urban wastewater. In the sample of 40 municipal wastewater treatment plants in table 11.3, 60 percent were not in compliance with Decree 1594 of 1984 standards for the removal of 80 percent of BOD and 65 percent of TSS (Contraloría 1999).

Another urban wastewater treatment issue is its high cost, estimated to be Col$5,250 billion (US$2.5 billion), or 72 percent of the total cost of all water infrastructure (table 11.4). An important contributor to the cost of treating urban wastewater is the predominance of high-cost, high-technology conventional treatment plants and the limited use of low-technology, low-cost solutions, including lagoons, anaerobic processes and filters, and seasonal stabilization reservoirs for agricultural reuse (Libhaber and Foster 2003). Table 11.5 presents data on actual expenditures on urban wastewater treatment plants in seven cities during 1998 to 2001.

The MMA (2002) has reported that in 66 percent of the cities studied, no industries treated wastewater as mandated by Decree 1594 of 1984. In 23 percent of the cities, fewer than 50 percent did; in 7.5 percent, 50 to 100 percent did; and in only 3.1 percent did 100 percent of the industries treat their wastewater.

The fact that CARs and AAUs have built municipal wastewater treatment plants and are still operating them also has led municipalities to avoid compliance with the regulations. For example, the CAR Cundinamarca built 23 municipal wastewater treatment plants during the 1990s and exempted municipalities from their water pollution control responsibilities. The CAR Cundinamarca still operates those wastewater treatment plants, and the municipalities have been reluctant to accept the financing of their operation.[11]

Bogotá's Wastewater Treatment Plant

The lessons from the Bogotá Wastewater Treatment Plant programs illustrate policy changes needed in wastewater treatment. In September 1994,

Table 11.3 Efficiency of Organic Load Removal in Municipal Wastewater Treatment Plants

		Load removal (percent)		
Municipality	*Flow (l/s)*	*BOD5*	*COD*	*TSS*
Alvarado	4.8	78.1	71.8	70.1
Anapoima	8.1	72.4	88.2	90.0
Barrancas	14.0	38.2	30.0	80.0
Becerril	50.9	58.1	83.3	83.9
Cajicá	105.4	79.0	78.0	92.0
Chía	41.8	73.0	71.0	82.5
Chiriguaná	52.8	32.9	48.3	62.7
Chocontá	13.2	65.2	70.0	43.0
Concepción	26.9	55.8	85.9	46.7
Cota	9.0	81.0	77.0	91.0
El Paso	16.5	41.8	30.2	65.9
Espinal	84.1	85.0	81.0	90.0
Facatativa	86.0	77.0	82.0	80.0
Fonseca	123.2	40.9	20.4	21.5
Funza	145.0	88.0	90.0	92.0
Gachancipá	6.1	25.0	38.0	40.0
Ginebra	51.9	81.1	71.4	84.2
Guacarí	40.0	81.1	65.7	94.4
Guamal	46.4	75.0	78.0	89.0
Guatapé	7.6	85.0	80.0	88.0
Hato Nuevo	54.4	70.0	80.2	83.4
Icononzo	7.4	60.0	56.0	80.0
La Unión	20.0	83.7	81.0	98.5
Maicao	133.0	77.5	77.7	82.2
Mosquera	83.6	86.0	85.0	91.0
Roldanillo	40.0	80.5	81.3	88.7
Sesquilé	4.7	74.7	78.4	82.0
Sopó	7.9	90.0	80.1	78.4
Suesca	68.0	46.2	92.0	50.0
San Francisco	59.0	80.0	78.0	82.0
Tenjo	11.0	65.0	80.0	74.0
Tocancipá	9.7	81.3	82.3	90.0
Toro	20.0	83.0	72.8	97.8
Ubaté	3.7	78.0	94.0	85.0
Urumita	8.2	53.4	68.4	65.2
Villanueva	135.0	74.1	61.0	88.0
Zipaquirá I	44.1	97.0	83.4	20.0
Zipaquirá II	167.8	93.0	74.1	83.3

Source: Ministry of Development (1999) as reported in Contraloría (1999).
Note: l/s = liters per second; BOD = biochemical oxygen demand; COD = chemical oxygen demand.

Table 11.4 Estimated Costs of Required Aqueducts and Sewers in Urban Areas, 2001–10

Type of expenditure	*Cost (US$ thousand)*
New aqueducts	461.3
Rehabilitation of potable water plants	3.1
New potable water plants	17.2
New sewers	515.2
New wastewater treatment plants	2,568.5
Total	3,565.3

Source: MMA 2002.

Table 11.5 Investment in Wastewater Treatment Systems, 1998–2001

City	*Investment (million pesos)*
Bogotá	229,120
Medellín	354,200
Pereira	18,330
Cartagena	21,000
Santa Marta	35,970
Manizales	8,661
Conhydra[a]	4,468
Total	671,749

Source: Blackman and others 2005.
Note: US$1 = Col$2,150.
a. Marinilla/Santafé de Antioquía.

the city government adopted a strategy that consisted of the construction of three activated sludge (secondary treatment) plants along the Bogotá River within the city limits, to be located at the confluences of the Salitre, Fucha, and Tunjuelo tributaries. The plants would dispose of their treated effluents into the Bogotá River. The investment cost of the three plants was estimated at about US$1.4 billion.

The first stage of the strategy has been completed and is being implemented. It consists of the first primary treatment plant at Salitre, constructed under a 30-year build-own-transfer agreement with a private operator. According to public information, the investment in the primary Salitre plant amounted to Col$26,250 million (US$125 million) and the monthly fee the Bogotá City paid the operator was Col$6,300 million (US$3 million). These expenditures were financed with resources earmarked by Law 99 of 1993 to the Bogotá AAU (DAMA). As reported by the Universidad de los Andes (2004, p. 8), "acting as a developer and as a regulator DAMA has not had a free capacity to question the benefits of a project that was promoted by the Administration." Libhaber and

Foster (2003) estimated that the total amount Bogotá City would have paid during the 30-year contract period, just for the first stage of the first plant, would amount to about Col$1,075 billion (US$500 million).

After it went into operation, the plant was found to have no detectable positive impact on the water quality of the Bogotá River. At the time, neither the national government nor the World Bank supported the adopted strategy on the grounds that it was too costly and that it would not achieve meaningful benefits even upon completion of the construction of the three secondary plants (Libhaber and Foster 2003).

As a result of the high costs associated with the primary Salitre plant, in 2003 the Bogotá Water Supply Utility questioned the adopted strategy and initiated a process of revising past decisions and searching for an alternative strategy. On December 31, 2003, after the plant had been in operation for nearly three years, the city's mayor terminated the contract and made provisions to pay Col$157,500 million (US$75 million) to the contractor.[12] This sum included the value of the infrastructure and compensation. The mayor's decision to terminate the contract was supported by a range of financial, legal, and technical studies and evaluations conducted during 2002 and 2003.[13] In essence, those evaluations found that the project did not produce social benefits, that the contract was economically disadvantageous to the city, and that the plant had technical deficiencies.

Cartagena

A comprehensive set of alternatives for wastewater treatment and disposal for Cartagena were identified and analyzed, including the areas of Cartagena Bay, the Ciénaga de la Virgen Wetland, and the Caribbean Sea, as well as alternatives for reuse and irrigation. The analysis included five treatment options (from preliminary to tertiary), four sites for sea outfalls, five types of pipe materials, and nine land conveyance routes in four corridors. Overall, 15 alternatives combining different treatment levels and final disposal sites were considered. All alternatives were analyzed according to their technical, environmental, social, economic, and financial merits. Effluent quality, initial investment costs, operation and maintenance costs, and land uptake were the main comparison criteria.

Based on extensive, highly technical modeling of water quality, the analysis concluded that the most environmentally and socially sound, and economically and financially feasible, alternative for the treatment and disposal of wastewater in Cartagena would consist of a scheme of preliminary treatment and disposal into the Caribbean Sea through a long outfall with diffusers at a 20-meter depth. It was envisioned beyond any doubt that the proposed scheme in Cartagena would be one of the most cost-effective environmental investments in the country. In addition to providing a cost-effective solution to the disposal of wastewater from Cartagena, the sub-marine outfall will provide a minimum dilution factor of 1:100 and an average of 1:500 at the outlet of the diffusers.

The Cartagena case illustrates the need to reform the wastewater regulations to allow a more rational approach to wastewater treatment and disposal in Colombia. The costs of enforcing the current wastewater discharge standards are extremely high, and obviously beyond the country's reach. Such standards, established in 1984, have induced a strategy of no action, which, in turn, has caused significant environmental and health impacts in the country. This has led to situations in which cities with low water and sewerage coverage insist on constructing wastewater treatment plants, or towns insist on building wastewater treatment plants when they are located next to rivers with ample assimilation capacity. As in the case of the Bogotá watershed, treatment plants that were subsidized by the national government are not being accepted by municipalities.

Conclusions

Colombia possesses abundant water resources. However, by 2025 a few of the country's basins could become vulnerable and, if left unattended, could generate potential water deficits for the following decades. Despite the abundance of water, the current legal and institutional framework does not facilitate water access to small water users such as small farmers, indigenous peoples, and recreational users, or for ecological needs. Nor does the current regulatory framework secure the maintenance of water rights or provide effective mechanisms for the resolution of water disputes.

In recent decades, a variety of uncoordinated efforts, managed by various ministries (for example, public works, health, and economic development), have been carried out with respect to integrated water resource management, potable water, and basic sanitation services. As a result, departments, municipalities, and environmental authorities have made dispersed investments in water basin management with little correlation to water supply needs, and significant investments have been made in wastewater treatment with little improvement in water quality. In addition, conflicts of interest arise in the allocation of water management responsibilities to CARs.

Current water legislation (mainly the CNRN and Decree 1541 of 1978) ranks the priorities for water use but does not indicate what the practical implications of that ranking should be in cases of water conflicts. This legal void has been at the origin of several legal disputes between large water users and needs to be addressed.

In addition, current water pollution control regulations (particularly Decree 1594 of 1984) do not regulate the discharge of priority pollutants (pathogens and other hazardous wastes) or the largest polluters—nonpoint sources, such as agricultural runoff, which contribute an estimated nine times as much BOD as municipal wastewater (CONPES 3177, 2002). Nonpoint sources also contribute the largest amount of pesticide and fertilizer waste. Even if reducing BOD remains a priority, an amendment of Decree 1594 of 1984 to control discharges from nonpoint sources is urgently needed.

The current water pollution control framework focuses solely on the quality of surface waters, ignoring groundwater issues. However, the quality of groundwater should also be protected because it supplies an estimated 25 percent of the country's population, and the restoration of polluted aquifers is more difficult than of surface waters.

A CAR's efforts to improve water quality could be undermined if it receives polluted water from the jurisdiction of another CAR located upstream. However, the current water pollution control regulatory framework does not contemplate clear mechanisms for addressing this issue, nor are there provisions to efficiently regulate wastewater discharges into the sea.

The effluents charge system needs to evolve, because it addresses organic pollutants discharged from point sources to surface waters, but not the impacts of other substances, the contributions of the largest polluters, and the contamination of aquifers and marine waters. Nor does the current design of the charge system[14] address the impacts of the individual sewerage bills of the poorest segments of the population. Implementation of wetland restoration and conservation actions has shown positive impacts, particularly in the Juan Amarillo and CGSM wetlands, and these best practices, including the incorporation of incentives for wetland restoration and standards for the environmental management of urban storm water and urban wetlands in the regulatory framework, could be exported to other locations in Colombia.

Several studies (Colorado State University 2004; Universidad de los Andes 2004) have recommended amending the water regulations to mandate institutional responsibilities among numerous governmental agencies (for example, the AAUs, CARs, IDEAM, MAVDT, and Ministry of Agriculture), drinking water quality standards, control of nonpoint sources of water pollution, management of water runoff and urban drainage, reduction of vulnerability to natural disasters associated with flooding and landslides, management of marine and coastal resources, and conservation of important water ecosystems. Other stakeholders maintain that the legal framework needs to be amended to fully incorporate the environmental considerations of water resources management (IUCN 2005).[15]

Water resources management is a national priority for the government of Colombia. A draft law prepared by the MAVDT was presented to Congress in 2005 to reform the national legal framework for water resources management, particularly addressing issues related to allocation of water rights; promotion of public participation in water resources management; establishment of a users registry; regulations on management of water runoff and urban drainage; control of hazardous wastewater discharges; definition of the ecological flow rate; and redesign of economic instruments, such as water pollution fees (MAVDT 2006, p. 10).

Regarding the roles and responsibilities pertaining to the allocation of water rights and the integrated management of water resources, the draft law presented to Congress "establishes in Article 11 the modes of access, use, and exploitation of water resources and establishes the procedures for access to water resources, and defines the responsibilities of users as well as the appropriate environmental authority. The draft law provides incentives for public participation, allowing for each of the administrative procedures proposed in the law that those interested put forward their observations and concerns" (MAVDT 2006, p. 10).

Concerning the recommendation of establishing a users registry, the water law proposed by the government "establishes in Article 48 that a public registry of national concessions should be administered by IDEAM. It also recommends that efficient and transparent procedures be developed to facilitate access to water resources; in particular, Article 29 establishes the requirements and procedures for authorizing concessions as well as wastewater discharge permits" (MAVDT 2006, p. 10).

With respect to the definition of ecological flow rate, Article 21 of Law 365 proposed by the government defines the flow rate for surface waters as the minimum flow rate that each section of a waterway should maintain to guarantee conservation of hydrobiological resources and associated ecosystems. The same law "proposes that variations in flow rates over time be considered so that water availability is not exceeded.

Article 13 of the law establishes that the appropriate environmental authorities should determine the available water supply to avoid authorizing concessions for a larger flow than is available, after evaluating previous concessions, the ecological flow rate, and ministerial uses required by law" (MAVDT 2006, p. 10).

On the subject of designing a system to control water pollution (given that regulations of Decree 3100 of 2003 consider only BOD and TSS for charging effluent fees), Article 42 of the draft law "establishes among the factors that comprise the formula for effluent fees, the factors of water supply, absorption capacity, dilution, and the autopurification capacity of receiving bodies" (MAVDT 2006, p. 10).

Recommendations

In accordance with the draft law presented to Congress, it is appropriate to define the roles and responsibilities of the different institutions as they relate to allocation and enforcement of water rights. Such a law might articulate the handling of water rights that were allocated in the past and provide mechanisms that allow people to give up previously awarded rights (to arrive at a more socially equitable distribution) and to ensure that users pay arrears on water charges. The law might consider efforts to strengthen water resources and clarify the roles of agencies responsible for water resources management; ensure appropriate stakeholder participation; and establish a registry of users and create efficient and transparent procedures to facilitate access to water rights, including groundwater, by small users. Strengthening the capacity of control agencies such as the Attorney General's Office and of other local agencies and communities to ensure the enforcement of water regulations might also be considered for inclusion in the new legal framework.[16]

The water law proposed by the government reflects the economic value of water in water fees. Those fees might include the costs associated with the conservation of the natural ecosystems that regulate water flows and the protection of the wetlands and riparian ecosystems that control floods. An amended legal framework might also include the definition of a minimum ecological flow rate. It is also important that water allocations take into account the variability of the peak flow rate and its corresponding probability, to ensure that water allocations do not exceed water availability.

With respect to water pollution control, the draft law presented to Congress modifies Law 99 of 1993 by establishing clear water quality

Table 11.6 Recommendations to Improve Water Resources Management

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Participating institutions*
Create efficient and transparent procedures to facilitate access to water rights, including groundwater, especially by small users	M	Congress, MAVDT
Ensure the collection and public disclosure of information related to water availability and water demands	M	Congress, MAVDT
Clearly define the roles and responsibilities of different institutions and create appropriate coordination mechanisms	S	Congress, MAVDT
Strengthen the capacity of control agencies such as the Attorney General's Office and of other local agencies and communities	M–L	Congress, MAVDT
Create local mechanisms for the enforcement of water regulations	M–L	Congress, MAVDT
Ensure that the economic value of water is adequately reflected in water fees	S–M	MAVDT, CARs, AAUs
Create a water rights registry	L	MAVDT, CARs
Provide guidance on allocation of water from aquifers	M	MAVDT
Define minimum ecological flow rate and minimum flow rate required to meet the basic needs of the population	M–L	MAVDT
Issue regulations to establish water quality standards and establish a system of authorizations aimed at reducing pollution	M–L	MAVD, CARs, AAUs
Introduce phased approaches and differentiated treatment and disposal schemes according to regional conditions and priorities, and reform wastewater discharge regulations to allow for a more rational approach to wastewater treatment	L	MAVDT, CARs, AAUs
Conduct analytical work to modernize the effluent charge system in Decree 3100 of 2004	S	Congress, MAVDT
Spread best practices for wetland restoration and conservation	L	MAVDT, CARs, AAUs

Source: Authors.

regulations. In addition, a system of authorizations aimed at reducing pollution by toxic substances, pathogens, and other dangerous residues with potential adverse health impacts might be designed. In particular, the provision of guidelines for the development of national-level primary discharge standards linked with health effects or impacts for regional-level secondary standards might be developed on the basis of analytical work. An amended regulatory framework on water resources management might clearly outline the institutions responsible for developing and enforcing such standards.

The most troubling aspects of the effluents charge system stem from its design in Law 99 of 1993. As of 2006, the effluent fee system addresses only BOD and TSS discharged from point sources to surface waters, neglecting the impacts of other substances, the contributions of the largest polluters, and the contamination of aquifers and marine waters. The current design of the charge, embodied in Decree 3100 of 2004, also fails to address the disproportionate impacts of sewerage bill increases on the poorest segments of the population. The draft water law presented to Congress redresses the shortcomings of Decree 3100 of 2004 by including the identification of interventions that enhance social welfare and the development of policies that are efficient, effective, and equitable.

A new regulatory framework might also introduce the concept of phased approaches, starting with the optimization of discharges by using the assimilation capacity of receiving bodies. The new framework might also allow for differentiated treatment and disposal schemes according to regional conditions and priorities. For coastal cities, the alternative of preliminary treatment and disposal through ocean outfalls might be promoted.

Table 11.6 summarizes the recommendations made in this chapter.

Notes

1. Ernesto Sánchez-Triana, Peter Brandriss, and Yewande Awe are the authors of this chapter, which draws on reports prepared by Blackman and others (2005); Colorado State University (2004); Enríquez (2004); and Universidad de los Andes (2004).
2. Water quality for human consumption is discussed in chapter 6. This chapter discusses the problems of surface and groundwater pollution, which are not related to the water-related illnesses prevalent in Colombia.
3. According to MAVDT (2006, p. 9), "the Constitution and Law 99 of 1993 establish that the definition, design, and issuance of national water resources policy are the exclusive responsibility of the Ministry of Environment, Housing, and Territorial Development."

4. In cases of public interest, such as aqueducts or public infrastructure, concessions could be granted for up to 50 years.
5. The fee decreased as the depth of the resource increased. This is related to the increasing availability of groundwater with increasing depth, and with the higher risk of groundwater pollution caused by extraction at lower depths.
6. Information provided by DAMA to Universidad de Los Andes researchers.
7. For instance, the joint effort by the Autonomous Regional Corporation of Dique (*Corporación Autónoma Regional del Dique*, CARDIQUE) and the Autonomous Regional Corporation of Atlántico (*Corporación Autónoma Regional del Atlántico*, CRA) for the "Environmental Management Plan for the Wetlands of El Totumo, El Guajaro and El Jobo in the Canal del Dique Ecoregion," and the "Integrated Management Plan for the Wetlands of the Mompox Area and the Sinú River Watershed," a joint effort of five regional corporations (the Autonomous Regional Corporation of Central Antioquía (*Corporación Autónoma Regional del Centro di Antioquía*, CORANTIOQUIA), the Autonomous Regional Corporation of Magdalena (*Corporación Autónoma Regional del Magdalena*, CORPAMAG), the Autonomous Regional Corporation of the South of Bolívar (*Corporación Autónoma Regional del Sur de Bolívar*, CSB), the Automous Regional Corporation of the Sinú and San Jorge Valleys (*Corporacíon Autónoma Regional de los Valles del Sinú y San Jorge*, CVS), and the Sustainable Development Corporation for the Mojana and San Jorge (*Corporación para el Desarrollo Sostenible de la Mojana y San Jorge*, CORPOMOJANA)) in 2002. Both initiatives were financed by the Inter-American Development Bank.
8. The Ramsar Convention considers wetlands as "water reserves of great economic, cultural, scientific and recreational value," and they are defined "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (RAMSAR Information Paper No.1 at http://www.ramsar.org/about/about_infopack_1e.htm).
9. These decrees and laws include Decree 1594 of 1984, Law 99 of 1993, Decree 901 of 1997, Decree 3100 of 2003, and Decree 3440 of 2004.
10. As explained in chapter 6, private investors had no means of knowing how the charge would ultimately affect the utility's finances.
11. Interview by consultants of the Universidad de los Andes with Mrs. Gloria Lucía Alvares, Director of CAR, July 2004.
12. See resolution 2036 of December 31, 2003, for that decision.
13. Taller de Estrategia conducted financial evaluations. The Instituto Quinaxi, Carlos Alberto Giraldo, the Water Research Center of England, and the Unión Temporal Saneamiento Río Bogotá conducted technical evaluations. The firm Arodríguez-Azuero conducted the legal analysis.

14. The current design is embodied in Decree 3100 of 2004.
15. The World Conservation Union (IUCN) has stated its concern about the need for better articulation of stakeholder participation in water resources management. http://www.sur.iucn.org/wani/notdetalle.cfm?passcodnot=1009.
16. According to MAVDT (2006, p. 9), with "respect to wastewater treatment, Resolution 1433 of 2004 establishes that providers of sewerage services and complementary activities, such as wastewater treatment, should formulate sanitation and effluent management plans (PSMV) and present them to the appropriate environmental authority for approval. The PSMV should be presented no later than four months after the quality objectives are defined by means of an administrative act issued by the environmental authority. The PSMV contains the required programs, projects, timetables, and investments to advance basic sanitation and wastewater treatment, in which the municipality determines the period for constructing the treatment plant(s) considering, among other factors, the financial capacity of the municipality, the capacity of users to pay for sewerage services, and the desired quality objectives."

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CHAPTER 12

Land Degradation and Deforestation

Data on soil erosion and salinization in Colombia are limited, and discrepancies exist among the studies that are available because of differences in methodology, terminology, and coverage. Available data suggest that both erosion and salinization are significant problems—between 4 percent and 23 percent of the soil is seriously eroded. The mean annual cost of soil degradation (erosion and salinization) measured as lost crop productivity is estimated at Col$1,440 billion (US$670 million). Despite evidence of land degradation in Colombia, few national laws or regulations specifically target soil erosion and salinization. Given the dearth of land degradation policies, and the general lack of performance indicators for environmental regulation in Colombia, assessing the extent of the problem and finding solutions is difficult. Existing data suggest that present efforts by Autonomous Regional Corporations to prevent, control, and mitigate land degradation need to be strengthened. Forestry policy has been effective in reducing deforestation rates from 600,000 hectares per year in the 1970s and 1980s to 90,000 hectares in 2004. A forestry bill currently under discussion offers an opportunity to promote the development of income-generating activities and employment for forest dwellers and indigenous peoples living in buffer zones of conservation areas.

Land degradation has a variety of causes, including depletion of soil nutrients, invasion of salts (salinization), agrochemical pollution, soil erosion, and vegetative degradation as a result of overgrazing. All of these processes result in a decline in ecosystem services and potential agricultural yields.[1] To compensate, farmers may increase fertilizer application, leave land fallow, or convert land to uses that are more compatible with lower soil quality. Reduced agricultural productivity aside, land degradation can also have negative off-site consequences, including siltation of low-lying dams and irrigation infrastructure, contamination of drinking water by agrochemicals, and loss of biodiversity and ecosystem health.

Recent global studies suggest that in the past 50 years, 22 percent of the world's cropland, pasture, forest, and woodland has been degraded, and 4 percent of it has been degraded so severely that the damage is virtually irreversible. Most of the degradation is caused by wind and water erosion resulting from poor land-use practices, deforestation, and inadequate watershed management. Latin America and Africa have the highest proportion of degraded agricultural land. Although the economic impacts of soil erosion are hotly debated, cumulative productivity loss from soil degradation over the past 50 years is estimated to be about 13 percent for cropland and 4 percent for pastureland (Scherr and Yadav 1996).

This chapter discusses land degradation and deforestation in Colombia and the policies designed to prevent, control, and mitigate them. The section on land degradation focuses on two specific issues: salinization and soil erosion, with soil erosion defined as "physical loss of topsoil, reduction in rooting depth, removal of plant nutrients, and loss of water" (Lal 1990, p. 77). The section on deforestation analyzes current forest cover, the main forces driving deforestation, and costs of deforestation.

Soil Erosion and Salinization: Magnitude and Dimensions of the Problem

The main contributors to soil degradation in Colombia at the national level include natural factors such as geologic erosion, earthquakes, landslides, and weather changes, and anthropogenic factors[2] such as agricultural activities, urban expansion, mining, road construction, and logging (IGAC 1988). Anthropogenic factors are particularly important from a policy perspective because they are more easily controlled by government initiatives.

As discussed in detail as follows, salinization and different types of soil erosion are more severe in some parts of the country than in others. Salinization, which is mainly caused by irrigation, is most common in the Caribbean, Andean, and Pacific regions. Erosion from water (hydraulic) is most severe in the Andean and Caribbean regions. Erosion caused by wind (eolic) is most common in the Caribbean region.

Soil Erosion

There are few studies of soil erosion at the national level. To the authors' knowledge, in the past 25 years only three national erosion maps have been created, one by the Institute of Hydrology, Meteorology, and Environmental Studies (*Instituto de Hidrologío, Meterología y Estudios Ambientales*, IDEAM) in 2004 and two by the Agustín Codazzi Geographical Institute (*Instituto Geográfico Agustín Codazzi*, IGAC) in 1988 and 2000.[3] However, these maps do not use consistent methodologies and criteria. For example, they do not include all the same causes of erosion—landslides and sedimentation are included in only two of the maps. According to IDEAM (2002), the two most recent erosion maps were both generated using remote sensing techniques, but yielded significantly different results. The discrepancy was due to differences in the type of images used, the season in which the images were obtained, and the methodology used to interpret them. Whatever the causes, these discrepancies make the evolution of soil erosion over time difficult to assess.

The tables in this section present information derived from these maps and their corresponding studies. Table 12.1 shows the percentage of very high or high soil erosion by department. In 12 of Colombia's 32 departments, one-third or more of all land is highly eroded, including some of the most populated and productive areas in the country. In seven of those departments (Atlántico, Casanare, Cesar, Córdoba, La Guajira, Meta, and Sucre) more than half of all land is highly eroded.

The 1988 study of soil erosion by the IGAC used criteria established by the U.S. Department of Agriculture in 1981 that provide a qualitative determination of the damage inflicted by hydraulic and eolic erosion, salinization, sodification, and compaction. The study found that about half of Colombia's land area suffers from some degree of erosion and that 23 percent had moderate to very severe erosion (table 12.2). Although moderate and mild erosion could still be controlled through soil and water conservation measures, the lands classified as having severe erosion (7.8 percent) were considered impossible or very expensive to restore.

Table 12.1 High or Very High Soil Erosion, by Department

Department	*Total area (km²)*	*High or very high soil erosion (%)*	*Department*	*Total area (km²)*	*High or very high soil erosion (%)*
Amazonas	110,213	0	Guaviare	55,080	5
Antioquía	63,307	12	Huila	19,240	32
Arauca	23,784	48	La Guajira	20,506	81
Atlántico	3,324	73	Magdalena	23,076	33
Bogotá	1,642	8	Meta	86,047	50
Bolívar	26,644	17	Nariño	30,832	9
Boyacá	23,076	29	Norte de Santander	21,995	15
Caldas	7,444	6	Putumayo	26,011	4
Caquetá	89,645	13	Quindío	1,948	3
Casanare	44,435	66	Risaralda	3,599	7
Cauca	29,883	16	Santander	30,475	20
Cesar	22,614	50	Sucre	10,719	54
Chocó	47,321	1	Tolima	24,061	24
Córdoba	25,061	55	Valle del Cauca	21,277	23
Cundinamarca	22,490	32	Vaupés	53,546	1
Guainía	70,679	1	Vichada	99,874	41
		Total land area: 1,139,848 km²		*Total with high or very high soil erosion: 23 percent*	

Source: Larsen (2004) based on IDEAM (2004).
Note: km^2 = square kilometer.

Table 12.2 Soil Erosion in Colombia by Level of Severity, 1988 Study

Level	*Hectares affected*	*Percentage of country affected*
Severe	8,875,575	7.79
Moderate	14,706,795	12.90
Mild	26,337,546	23.11
Very mild	5,657,950	4.96
No erosion	55,508,310	48.53
Other areas	2,259,049	1.98
Total	114,174,800	

Source: IGAC 1988.

Table 12.3 Principal Regions Affected by High and Very High Erosion

	Very high erosion		*High erosion*		*Total*	
Region	*Hectares*	*Percent*	*Hectares*	*Percent*	*Hectares*	*Percent*
Caribbean	625,725	6.2	844,175	8.3	1,469,900	14.5
Andean	203,850	0.6	3,206,275	9.3	3,410,125	9.9
Orinoquía	n.a.	n.a.	4,825,125	20.9	4,825,125	20.9
Total	829,575		8,875,575		9,705,150	

Source: IGAC 1988.

Note: n.a. = not applicable. The table is based on division of Colombia into five hydrographic regions: Caribbean, Andean, Orinoquía, Amazon, and Pacific.

The study found that high levels of erosion mainly affect the Caribbean, Orinoquía, and the Andes regions, in areas where rains are intense and irregularly distributed. Very high erosion was found to occur in regions where there is low annual precipitation that is concentrated in only a few months of the year. These regions include some of the most populated and economically active parts of the country, particularly in the Caribbean and the Andes (table 12.3).

The 1988 IGAC study also found moderate erosion on nearly 14.7 million additional hectares, particularly in the Andes (10.4 million hectares) and the Amazon (1.7 million hectares). Weather, topography, and human activities—particularly landslides resulting from roads, dams, and human settlements—have been key causes of this type of erosion. There was mild erosion in many colonized areas (particularly in the Andes, the Amazon, and Orinoquía) and very mild erosion in Orinoquía and the Andes. The areas with the least erosion were the Amazon and the Pacific, which have favorable biophysical conditions, low population density, and no identified erosion in most of their territory. By contrast, in the mountainous Andean region, where most of the

Colombian population is settled, 86.5 percent of all land had some degree of erosion.

On the basis of landscape satellite images, the 2000 IGAC study found that 4.4 million hectares, or about 3.8 percent of Colombia, was characterized by severe or very severe erosion (table 12.4). This figure is much lower than in the 1988 IGAC study (8.5 percent) and the 2004 IDEAM study (23 percent). This discrepancy could be the result of inconsistent methodologies and classifications between the studies or a rapid increase in serious land degradation by the time of the 2004 IDEAM study.

Even though the 1988 and 2004 data just summarized are not necessarily comparable, they provide some indication of how erosion has changed during the past 16 years, including the 1993–2003 study period of the present report. Table 12.5 compares the findings of the two studies.

Table 12.4 Soil Erosion in Colombia by Level of Severity, 2000 Study

	Area affected	
Level	*Hectares*	*Percent*
Without erosion	16,602,050	14.7
Not apparent[a]	50,863,505	44.9
Mild	22,132,483	19.5
Moderate	18,851,787	11.3
Severe	3,748,585	3.3
Very severe	615,453	0.5
Areas of active sedimentation	2,258,549	2.0
Rocky outcrops	1,405,984	1.2

Source: IGAC 2000.

a. Erosion was not apparent according to landscape satellite images, but was empirically identified in field.

Table 12.5 Change in High and Very High Erosion, 1988–2004

		High and very high erosion					
		Hectares			*Percent*		
Region	*Total area (hectares)*	*1988 (IGAC)*	*2004 (IDEAM)*	*Change*	*1988 (IGAC)*	*2004 (IDEAM)*	*Change percentage points)*
Amazon	18,977,000	0	157,590	157,590	0.0	0.8	0.8
Andean	21,927,700	3,410,125	4,369,974	959,849	15.6	19.9	4.3
Caribbean	13,194,400	1,469,900	6,205,975	4,736,075	11.1	47.0	35.9
Orinoquía	46,954,400	4,825,125	13,982,990	9,157,865	10.3	29.8	19.5
Pacific	12,931,300	0	1,292,308	1,292,308	0.0	10.0	10.0
Total	113,984,800	9,705,150	26,008,837	16,303,687	8.5	22.8	14.3

Sources: IGAC 1988; IDEAM` 2004.

This exercise suggests that areas classified as having high or very high erosion in Colombia expanded significantly during 1988 to 2004. The total of such areas increased by over 16 million hectares, representing 14 percent of the country's area. This statistic indicates that existing soil degradation policies are inadequate.

It would be particularly useful to devote more attention to the Caribbean and Orinoquía regions, because they appear to have experienced the greatest increase in affected areas. One would also be interested in considering the Andean region because it is the most populated and economically active region of the country, and the Pacific region because it serves as a natural resources and biodiversity reservoir.

Salinization

Soil salinization is principally caused by irrigation. Although salinization has various adverse economic and ecological consequences, it has not received the attention from Colombian policy makers that erosion has received. In fact, it is difficult to find studies, policies, plans, or activities that directly mention salinization prevention or control.

A 1983 soil map produced by IGAC indicates that 9 percent of Colombia's land is "susceptible" to salinization. These areas are mainly located in dry ecosystems such as the Inter-Andean valleys, the Bogotá Savanna, and the Caribbean. According to IDEAM (2004), approximately 10 percent of Colombia suffers from high or moderate levels of salinity in the soil that can affect crops and rangeland. Problem areas are mainly located in the Caribbean region (the Atlántico, Bolívar, Cesar, Córdoba, La Guajira, Magdalena, and Sucre departments). In addition, salinization is a problem in Cundinamarca, Huila, Tolima, and Valle del Cauca (tables 12.6 and 12.7). Tables 12.8, 12.9, and 12.10 present the results of regional studies done for the Atlantic Coast (2002), the Cauca Valley (CVC 2002), and the Bogotá Savanna (1982, 1983), respectively.

Cost of soil degradation. Soil erosion generates significant economic costs. Larsen (2004) estimates the mean annual cost of soil degradation (erosion and salinization) measured by lost crop productivity at Col$1,440 billion (US$670 million). He attributes 56 to 67 percent of these costs to erosion, and 35 to 42 percent to salinization. These estimates are very conservative because they do not include lost productivity of pastures and rangeland, which represent about 88 percent of total agricultural land in Colombia. Even so, in Larsen's study land degradation incurs a higher cost for rural areas than does any other type of environmental

Table 12.6 High or Moderate Soil Salinity, by Department

Department	*Total area (km^2)*	*High or moderate soil salinity (%)*	*Department*	*Total area (km^2)*	*High or moderate soil salinity (%)*
Amazonas	110,213	0	Guaviare	55,080	0
Antioquía	63,307	10	Huila	19,240	20
Arauca	23,784	0	La Guajira	20,506	79
Atlántico	3,324	74	Magdalena	23,076	84
Bogotá	1,642	0	Meta	86,047	0
Bolívar	26,644	45	Nariño	30,832	3
Boyacá	23,076	5	Norte de Santander	21,995	6
Caldas	7,444	13	Putumayo	26,011	0
Caquetá	89,645	0	Quindío	1,948	0
Casanare	44,435	0	Risaralda	3,599	5
Cauca	29,883	2	Santander	30,475	8
Cesar	22,614	63	Sucre	10,719	80
Chocó	47,321	2	Tolima	24,061	32
Córdoba	25,061	44	Valle del Cauca	21,277	18
Cundinamarca	22,490	16	Vaupés	53,546	0
Guainía	70,679	0	Vichada	99,874	0
	Total land area: 1,139,848 km^2			*Total with high or moderate soil salinity: 10 percent*	

Source: Larsen (2004) based on IDEAM (2004).
Note: km^2 = square kilometer.

Table 12.7 High or Moderate Soil Salinity, by Region

Hydrographic region	*Total area (hectares)*	*High or moderate soil salinity*	
		Hectares	*Percent*
Amazon	18,977,000	0	0.0
Andean	21,927,700	2,753,579	12.6
Caribbean	13,194,400	8,388,200	63.6
Orinoquía	46,954,400	0	0.0
Pacific	12,931,300	629,890	4.9
Total	113,984,800	11,771,669	10.3

Source: Larsen (2004) based on IDEAM (2004).

Table 12.8 Salinization in Three Key Geographic Areas

Geographic area	*Soil salinization (hectares)*
Atlantic Coast	2,500,000
Cauca Valley	120,000
Bogotá Savanna	5,060

Sources: Atlantic Coast: Universidad del Valle (2002); Cauca Valley: Alvaro García (2004), Universidad del Valle (2002); Savanna of Bogotá: CAR (1982–83), as cited in Blackman and others (2005).

Table 12.9 Salinization in the Cauca Valley

Study area		*Salinity*		*Salinity and other problems*	
Municipality	*Hectares*	*Hectares*	*Percent*	*Hectares*	*Percent*
Candelaria	30,000	2,027	6.7	2,832	9.4
Palmira	41,200	13,153	31.9	20,830	50.6
Cerrito	14,818	2,853	19.3	3,880	26.2
Guacari	6,048	280	4.6	610	10.1
Buga	8,303	1,022	12.3	2,159	26.0
Buga–San Pedro	9,990	1,268	12.7	2,519	25.2
San Pedro–Tulua	13,200	1,300	9.8	1,623	12.3
Roldanillo–La Unión–Toro	10,000	2,351	23.5	3,872	38.7
Tulua–Andalucía–Bugalagrande	14,331	845	5.9	1,382	9.6
Bugalagrande–Zarzal	10,094	2,126	21.1	2,982	29.5
Zarzal–La Victoria	14,370	4,744	33.0	4,984	34.7
Obando–Cartago	25,130	8,407	33.5	8,932	35.5
Total	197,484	40,376	20.5	56,605	28.7

Source: CVC 2002.

problem (including water and sanitation). Baquero and others (2000) estimate the costs of soil erosion for the departments of Caquetá, Santander, and Tolima (table 12.11). The results suggest considerable variation in the cost per hectare of eroded land.

Table 12.10 Salinization in Selected Areas of the Bogotá Savanna

		Area affected	
Municipality	*Degree of soil salinity*	*Hectares*	*Percent*
Mosquera (La Ramada irrigation district)	Slightly saline	2,739	43.5
	Slightly saline and slightly to moderately sodaic	464	7.3
	Slightly to moderately saline and slightly sodaic	765	12.0
	Moderately saline and moderately sodaic to sodaic	12	0.2
	Very strongly saline and moderately sodaic to sodaic	4	0.1
Cota–Zipaquira (zone of influence of Bogotá River)	Slightly saline	180	3.5
	Slightly saline and slightly sodaic	554	10.9
	Slightly saline and slightly to moderately sodaic	341	6.7

Source: CAR 1982, 1983.

Table 12.11 Estimated Erosion Costs for Three Departments

Department	*Average cost of erosion (pesos/hectare)*
Caquetá	638,673
Santander	178,593
Tolima	978,440

Source: Baquero 2000.
Note: Costs were estimated using the hedonic pricing methods. US$1 = Col$2,150.

Table 12.12 Most Suitable Land Use and Actual Land Use

	Most suitable use	*Actual use (hectares)*	
Activity	*(hectares)*	*1997*	*1999*
Agriculture	14,363	5,318	4,445
Cattle ranching	19,251	40,083	41,223
Forest	78,301	58,854	63,052
Water and urban	2,259	1,430	3,156
Without use		8,490	2,298

Source: MAVDT 2003.

Causes of soil degradation. As noted, the human causes of soil erosion are particularly important from a policy perspective. Human causes typically stem from use of land for purposes that are not appropriate to the land's natural characteristics. Table 12.12 provides aggregate national information based on data from the Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT) on whether total land used for different purposes exceeds the amount of land naturally suited to these purposes. The table makes clear that in certain cases the answer is yes. For example, the amount of land being used for cattle ranching, which mainly displaced agriculture and forestry, is more than twice the amount suitable for this use. Ranching is associated with soil compaction, erosion, and sometimes (depending on parallel land management issues such as irrigation and drainage) with salinization.

Table 12.13, which is derived from IGAC, Ministry of Agriculture, and Corpoica (2002), presents similar data on land use conflicts. The table indicates that 17 percent of the country's land is being overused, that is, the current use is above capacity.

Table 12.14 presents the main agricultural uses that have been present since 1980. Total area devoted to agriculture has increased by about 2 percent since 1980. Total irrigated area, a key contributor to salinization, has increased by over 100 percent during that time.

Table 12.13 Suitable Land Use and Land Use Conflicts

		Area	
Type of conflict	*Description*	*Hectares*	*Percent*
None	Current use is compatible with capacity	22,669,659	19.9
Underuse (total)		17,790,116	15.7
Mild	Current use is near its productive capacity	5,192,717	4.6
Moderate	Current use is below its productive capacity	7,829,533	6.9
Severe	Current use is considerably below its productive capacity	4,767,866	4.2
Overuse (total)		19,652,641	17.2
Mild	Current use is near its capacity	6,303,463	5.5
Moderate	Current use is above its capacity; productive processes are unsustainable	5,635,580	4.9
Severe	Current use is considerably above its capacity; cause of accelerated soil degradation	7,713,598	6.8
Soils in conservation	Natural forests, vegetation of moors, mangroves, and so forth	65,538,892	47.2
Total national		125,651,308	100.0

Source: IGAC, Ministry of Agriculture, and Corpoica 2002.

Table 12.14 Land Use and Irrigated Areas in Colombia, 1980–2001
(thousand hectares)

Land use	*1980*	*1990*	*1999*	*2000*	*2001*
Arable land (1)	3,712	3,305	2,536	2,818	2,516
Permanent crops (2)	1,480	1,695	1,828	1,727	1,733
Arable land and permanent crops (1 + 2)	5,192	5,000	4,364	4,545	4,249
Permanent pasture (3)	40,100	40,083	41,304	40,920	41,800
Total agricultural area (1 + 2 + 3)	45,292	45,083	45,668	45,465	46,049
Irrigated area	400	650	850	900	900

Source: Blackman and others (2005) using data from FAO, http://www.fao.org.

Deforestation is also a major contributor to soil degradation. Table 12.15 provides data on the most common activities that result in deforestation. It shows that deforestation in Colombia is mainly due to expansion of the agricultural border (mostly for livestock production) and colonization (for cattle ranching and small-scale agricultural activities).

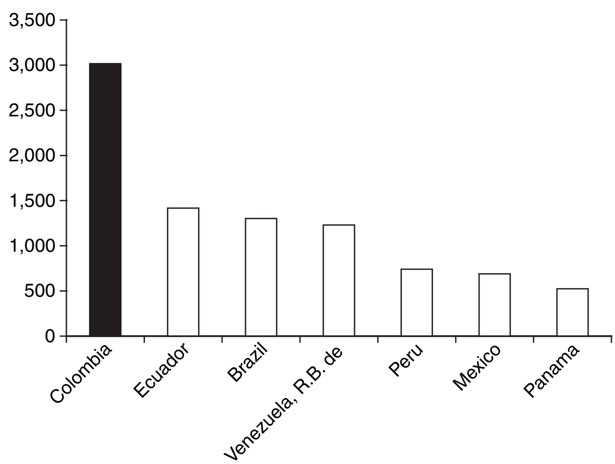
Fertilizer consumption in Colombia is high relative to the other countries in the region. The data in figure 12.1 indicate that the use of fertilizer per hectare of arable land in Colombia is more than double that of Brazil, Ecuador, and República Bolivariana de Venezuela, and even higher when compared with Mexico, Panama, and Peru. Although a further assessment would be necessary to identify the economic incentives and other determinants of fertilizer use in each country, Colombia's more-intensive fertilizer consumption has evident negative environmental impacts, as described in chapter 11, and may also be associated with the loss of soil fertility resulting from erosion and salinization, and with

Table 12.15 Causes of Deforestation in Colombia

Causes	*Percentage of total deforestation*
Expansion of agricultural frontier and colonization	73
Lumber production	12
Firewood consumption	11
Forest fires	2
Illegal crops	2

Source: MMA 1997.

Figure 12.1 Fertilizer Consumption



Source: World Bank 2005.

the agricultural use of soils with a natural inclination toward different economic activities and ecological functions.

Soil Erosion and Salinization: Policy Design

This section summarizes the legal and regulatory framework for policies designed to prevent, control, and mitigate soil erosion and salinization. These problems affect a wide variety of economic and policy sectors. Therefore, this chapter reviews laws and regulations in three areas: environment, land use planning, and forestry and agriculture. As the discussion makes clear, the relevant legal and regulatory framework is quite limited; few laws and regulations in any of these areas deal explicitly with these problems.

Environmental regulation. Neither Law 99 of 1993 nor Decree 2811 of 1974—two of the pillars of environmental law in Colombia—cover soil erosion or salinization in detail. They simply state that soil erosion and salinization are environmental problems and that public authorities should be in charge of addressing them. However, no mechanisms or specific responsibilities are mentioned.

Decree 2811 of 1974 states that soil erosion and salinization, among other factors, degrade the environment. It also states that public authorities should endeavor to mitigate these problems.

Decree 1541 of 1978 regulates the water sector. It states that water users who are granted concessions for agricultural water must build and maintain a drainage system to prevent soil erosion and salinization.

Soil erosion and salinization appear in Law 99 of 1993 only in lists of topics that various environmental regulatory authorities are charged with addressing. The Ministry of Environment (*Ministerio del Medio Ambiente*, MMA) is charged with regulating the environmental matters associated with land use, while the Autonomous Regional Corporations (C*orporaciónes Autónomas Regionales*, CARs) are charged with preventing natural disasters by, among other things, controlling soil erosion. In urban areas, this responsibility may be carried out in concert with municipal environmental authorities. Finally, Law 99 establishes that IDEAM must obtain, analyze, study, and process information regarding, among other things, land degradation.

Land-use planning. Law 388 of 1997 is Colombia's key land-use planning law. However, the relationships between land use and land degradation are not clearly defined. Land use plans are supposed to ensure that land is used only for purposes compatible with the land's natural characteristics. Hence, a good land-use plan should prevent erosion and salinization. Nevertheless, no such requirement is explicitly established either by the regulation itself or by subsequent clarifications promulgated by different environmental authorities, a limitation that may be due to the fact that these regulations were written by the development sector, not the environmental sector.

The objective of the land use plan proposed in Law 388 of 1997 is to rationalize the development and exploitation of land. According to the law, municipalities must formulate Land Use Plans (*Planes de Ordenamiento Territorial*, POTs) in both urban and rural areas. With regard to conservation and protection of land and the environment, Law 388 establishes that all POTs should consider the territory's characteristics and potential when defining permissible land uses, and establishes that municipalities should consider long-run consequences of this use, including the impacts on natural resources.

Decree 879 of 1999 regulates Law 388 of 1997 and establishes specific guidelines for POTs. It mandates that all municipalities with more than 30,000 inhabitants should prepare a POT that contains rural and urban components. The POTs are required to ensure harmonious interaction between the designated land use and the environment, conserve and protect the environment and natural resources, prevent natural disasters, and designate certain areas for conservation and protection. Although several other issues (mostly operational) are covered by the decree, these are the only ones relevant to soil degradation and salinization.

Forestry and agricultural legislation and policies make almost no explicit mention of soil erosion and salinization.

Soil Erosion and Salinization: Policy Implementation

Availability of data. Assessment of the performance of soil degradation policies is difficult for two reasons. First, environmental law and regulation in Colombia does not contain specific goals and objectives regarding soil erosion and salinization. Control and prevention of soil erosion is frequently mentioned in various planning documents, including those for environmental, disaster control, and economic development plans. For example, the topic of soil erosion appears often in CARs' Regional Environmental Management Plans (*Planes de Gestion Ambiental Regional*, PGARs) and Three-Year Action Plans (*Planes de Acción Trienal*, PATs). However, these plans almost always lack specific and quantifiable goals and indicators. Second, implementing institutions typically do not generate performance indicators. For example, in the Management Reports (*Informes de Gestión*) for the years covered in the plan, performance indicators generally focus on the amount of money invested in different areas, not on the actual results or effects of these investments.[4]

Investment data. Canal (2004) presents data on total investment in land quality by each CAR. Such investment by all CARs represented just 2.8 percent of all CAR investments in environmental activities (tables 12.16 and 12.17). Environmental activities totaled 58.8 percent of all CAR expenditures during this period. Hence, investment in land quality constituted just 1.8 percent of total CAR expenditures. However, the information presented by Canal has important gaps—data for many CARs are not available. These data also omit investments by farmers and other public and private entities that may overshadow CARs' investments in land quality. Notwithstanding its limitations, the Canal (2004) data indicate that land degradation is not an investment priority for most CARs.

Figure 12.2 presents the time trend of total CAR investment in land quality from 1995 to 2003. Total investment in land issues increased approximately 104 percent between 1995 and 2000, and declined 33 percent between 2000 and 2003.

Do individual CARs underinvest in soil conservation? Blackman, Morgenstern, and Topping (2004) analyzed 2001 CAR-level investment and roughly concurrent environmental quality data to determine whether individual CARs allocate their investment funds to the most pressing environmental problems. Soil degradation was among the six different types of environmental risks considered in this analysis. This section briefly recapitulates the soil degradation component of the analysis from Blackman, Morgenstern, and Topping (2004).

For each CAR, Blackman, Morgenstern, and Topping (2004) compared the severity of soil degradation risk with the extent to which the CAR focused its 2001 investment funds on this risk. If CARs were allocating investment spending rationally, that is, based on an assessment of the severity of different risks, there should be a correlation between severity of soil degradation and investment devoted to it—where soil degradation is relatively serious, CARs should be spending a relatively high percentage of their investment funds on soil conservation, and vice versa.

This analysis is limited by the availability of appropriate data. Blackman, Morgenstern, and Topping (2004) did not have data on soil degradation risk that exactly matched their categories of investment

Table 12.16 CAR Investments in Land Quality by CAR, 1995–2003

thousand pesos

CAR	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*Total*
CAM	168,446	292,141	—	168,255	186,726	310,826	207,612	126,300	120,000	1,580,306
CAR Cundinamarca	54,672	48,815	47,002	3,261,005	3,097,518	3,681,623	3,197,924	1,395,615	543,000	15,327,174
CARDER	—	—	—	—	—	—	—	—	—	—
CARDIQUE	10,262	49,781	19,861	—	—	181,063	—	—	—	260,967
CARSUCRE	179,406	511,929	442,144	—	—	—	360,859	384,583	397,510	2,276,431
CAS	18,639	43,909	50,770	—	147,170	350,056	—	—	—	610,544
CDA	—	—	—	—	—	—	—	—	—	—
CDMB	3,586,902	3,192,086	2,744,274	4,216,555	4,149,980	4,473,975	4,050,197	4,767,598	4,878,167	36,059,734
CODECHOCO	—	—	—	—	—	—	—	—	—	—
CORALINA	—	—	—	—	—	—	—	—	—	—
CORANTIOQUIA	252,006	367,338	333,691	877,893	—	—	1,509,607	1,545,912	1,586,304	6,472,750
CORMACARENA	2,394	3,598	6,838	—	—	—	24,920	—	—	37,750
CORNARE	713,119	813,587	870,408	657,256	583,590	523,073	159,100	150,858	143,334	4,614,325
CORPAMAG	—	—	—	—	—	—	—	—	—	—
CORPOAMAZONIA	—	—	—	—	—	—	—	—	—	—
CORPOBOYACA	—	—	—	—	—	—	—	—	—	—
CORPOCALDAS	7,588	10,989	9,845	60,670	107,740	120,709	—	—	—	317,541
CORPOCESAR	—	—	—	—	—	—	—	—	—	—
CORPOCHIVOR	—	—	—	—	—	—	—	—	—	—
CORPOGUAJIRA	—	—	—	—	—	—	—	—	—	—
CORPOGUAVIO	11,186	66,375	58,766	91,005	134,675	96,567	—	—	—	458,574
CORPOMOJANA	—	—	—	—	—	—	—	—	—	—
CORPONARIÑO	—	—	—	—	—	—	—	—	—	—
CORPONOR	144,330	117,410	77,280	151,675	130,723	211,241	—	—	—	832,659

CORPORINOQUIA	4,354	20,266	20,987	30,335	—	—	—	—	—	75,942
CORPOURABA	—	—	—	—	—	—	—	—	—	—
CORTOLIMA	376,622	472,591	1,678,147	—	363,172	362,127	178,095	105,250	100,000	3,636,004
CRA	12,000	17,782	15,556	—	—	—	—	73,675	75,320	194,333
CRC	158,198	132,112	245,683	—	—	—	774,783	210,500	200,000	1,721,276
CRQ	597,053	719,408	763,701	—	1,149,528	3,118,153	901,518	—	—	7,249,360
CSB	—	—	—	—	—	—	—	—	—	—
CVC	619,439	372,349	831,258	2,009,082	848,181	697,698	1,529,975	1,450,713	1,378,350	9,737,045
CVS	—	—	—	—	—	—	—	—	—	—
Total	6,916,616	7,252,466	8,216,211	11,523,730	10,899,003	14,127,109	12,894,589	10,211,003	9,421,985	91,462,714

Source: Canal 2004.

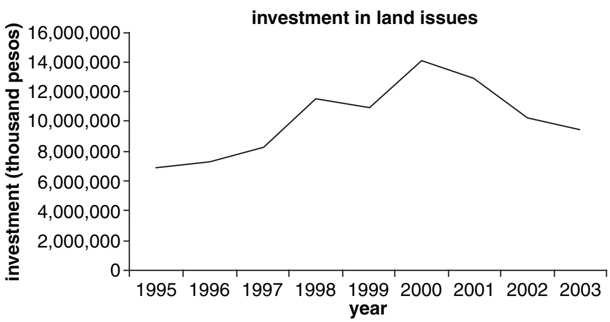
Note: US$1 = Col$2,150. — = not available.

Table 12.17 CAR Investment in Land Quality, by Type of Project
thousand pesos

	Type of project			
Year	*Studies and diagnoses*	*Erosion, salinization, landslide control*	*Others*	*Total*
1995	200,162	6,576,365	140,089	6,916,616
1996	276,311	6,766,484	209,671	7,252,466
1997	350,758	7,797,464	67,989	8,216,211
1998	91,005	11,321,420	111,306	11,523,730
1999	134,675	10,577,602	186,726	10,899,003
2000	277,631	13,538,653	310,826	14,127,109
2001	995,489	11,649,349	249,751	12,894,589
2002	435,033	9,539,158	236,812	10,211,003
2003	418,654	8,778,331	225,000	9,421,985
Total	3,179,718	86,544,826	1,738,171	91,462,714

Source: Canal 2004.
Note: US$1 = Col$2,150.

Figure 12.2 CAR Investment in Land Issues



Source: Canal 2004.
Note: US$1 = Col$2,150.

spending. The proxy used for the risk of soil degradation was the cost of salinization and erosion for each CAR as estimated by Larsen (2004), and the investment data included all types of soil conservation measures, not just those targeting erosion and salinization. This problem aside, the categorization of spending was based on the names of investment projects reported by CARs and, therefore, was somewhat imprecise.

Blackman, Morgenstern, and Topping (2004) used a simple method to compare the severity of different soil degradation risks in each CAR with the extent to which CARs focused their investment funds on these risks. They ranked the severity of the soil degradation risks posed in each CAR as high, medium, or low, depending on whether the CAR ranked in the top, middle, or bottom third of the distribution of the soil-degradation risks measure (economic costs from Larsen [2004]) across all 33 CARs. A similar method was used for ranking the extent to which CARs focused their investment funds on soil degradation. They ranked the percentage of investment funds allocated to soil conservation in each CAR as high, medium, or low, depending on whether the percentage of investment funds spent on that risk ranked in the top, middle, or bottom third of the distribution of these percentages across all 33 CARs.

Having ranked the severity of soil degradation risk and the extent to which CARs focused their investment funds on this risk, Blackman, Morgenstern, and Topping (2004) compared these two rankings to determine whether CARs overinvested or underinvested in soil conservation. They determined that a CAR underinvested in soil conservation when the risk of degradation was ranked either high or medium but the CAR investment spending was ranked low. Similarly, they determined that a CAR overinvested in soil conservation when the degradation risk was ranked low but investment spending was ranked medium or high.

Blackman, Morgenstern, and Topping's (2004) measures of soil degradation risk and spending are detailed in table 12.18. The first data column presents a ranking of the risk of soil degradation in each CAR. The right-hand column presents a ranking of the percentage of investment funds devoted to this risk in 2001. The last two rows of the third column indicate the percentage of all 33 CARs that underinvest and overinvest in that risk. The data presented in table 12.18 suggest that CARs' allocations of investment spending to soil conservation do not correlate particularly well with the severity of risk: 54 percent of CARs underinvest in this risk, while no CARs overinvest.

Planning data. By law, POTs are one of the principal tools policy makers are supposed to use to prevent soil degradation. Such plans, however, are often not used to promote soil conservation and other environmental objectives. Table 12.19 presents self-reported information on the percentage of municipalities in each CAR with POTs that contain an environmental component approved by the CAR. On average, 81 percent of the municipalities in each CAR have approved environmental components in their POTs. However, the existence of these components clearly does not guarantee that they are implemented or enforced.

Table 12.19 also presents information on the percentage of municipalities in each CAR that have basic soil zoning that would enable them to incorporate soil conservation considerations into their POTs. On average, only 60 percent of the municipalities in each CAR have such zoning.

Table 12.18 Soil Degradation Risk Compared with CAR Investment in Soil Conservation

CAR	*Cost of soil degradation*	*Percentage of total investment in soil conservation*
CAM	High	Low
CAR Cundinamarca	High	Low
CARDER	Low	Low
CARDIQUE	Low	Low
CARSUCRE	Low	Low
CAS	High	Low
CDA	n.a.	Low
CDMB	Medium	High
CODECHOCO	n.a.	Low
CORALINA	n.a.	Low
CORANTIOQUIA	High	High
CORMACARENA	High	Low
CORNARE	High	Low
CORPAMAG	Medium	Low
CORPOAMAZONIA	n.a.	Low
CORPOBOYACA	High	High
CORPOCALDAS	Medium	Low
CORPOCESAR	Low	Low
CORPOCHIVOR	Medium	Low
CORPOGUAJIRA	Low	Low
CORPOGUAVIO	Medium	Low
CORPOMOJANA	Low	Low
CORPONARIÑO	Medium	Low
CORPONOR	n.a.	Low
CORPORINOQUIA	n.a.	Low
CORPOURABA	Medium	Low
CORTOLIMA	High	Low
CRA	n.a.	Low
CRC	Medium	Low
CRQ	Low	Low
CSB	Low	Low
CVC	High	High
CVS	n.a.	Low
Percentage of CARS that underinvest		54
Percentage of CARS that overinvest		0

Source: Blackman and others 2005.
Note: n.a = not available. Percentage of underinvestment or overinvestment is based on estimate of public expenditures in CAR for CARs with no cost of soil degradation.

Table 12.19 Land-Use Planning and Soil Zoning by CAR
(*percent*)

CAR	*Municipalities with environmental component in POT*	*Municipalities with soil zoning*
CAM	97	97
CAR Cundinamarca	90	97
CARDER	100	100
CARDIQUE	81	48
CARSUCRE	79	72
CAS	58	0
CDA	63	0
CDMB	85	62
CODECHOCO	39	29
CORALINA	50	0
CORANTIOQUIA	86	83
CORMACARENA	100	47
CORNARE	96	96
CORPAMAG	80	97
CORPOAMAZONIA	90	58
CORPOBOYACA	79	75
CORPOCALDAS	89	81
CORPOCESAR	80	40
CORPOCHIVOR	96	72
CORPOGUAJIRA	73	27
CORPOGUAVIO	100	100
CORPOMOJANA	71	43
CORPONARIÑO	73	5
CORPONOR	85	63
CORPORINOQUIA	70	0
CORPOURABA	100	89
CORTOLIMA	53	64
CRA	91	87
CRC	56	2
CRQ	100	100
CSB	67	75
CVC	95	100
CVS	89	79
Average	81	60

Source: Blackman and others (2005), using data from ASOCAR (2002).

Forests

In 2004, Colombia's forestry sector—dedicated primarily to furniture manufacturing, pulp, paper, and timber production—accounted for less than 1 percent of gross domestic product and provided almost 30,000 permanent jobs (Orozco 2004). The current deforestation rate is estimated at 0.18 percent per year, significantly lower than that in neighboring Panama and Ecuador (IDEAM 2004; SIAC 2002, p. 290). This loss of forest cover causes a variety of environmental problems, including loss of biodiversity, destabilization of aquifer sources, and soil erosion. Such consequences notably affect the poorest population groups, including a large percentage of the 800,000 indigenous people and other highly marginalized and disproportionately poor groups that inhabit forested areas.

Forest cover in Colombia is estimated to have been 90 percent before human settlement (WRI 2003). Today, forest cover is about 47 percent of total land area. Although this is still above the world average of 30 percent, forest cover in Colombia is distributed extremely unevenly across the country.[5] Despite the relatively high forest cover, a significant percentage of the national territory has been drastically altered by human action, with varying impacts across regions. Relatively deforested areas extend over large sections east of the mountains and in high population density areas, with the most affected ones found primarily along the arid peri-Caribbean belt, the Sierra Nevada, and the North Andean regions.

Of the country's five largest watershed basins, the East Caribbean watershed has been almost completely transformed, with only 4 percent of forest cover remaining. The Caribbean region includes some small but important industrial forest plantations. The Andean and Orinoquía regions are more heavily devoted to nonforestland uses. The Andean region is highly settled and has the densest population in the country. The Orinoquía region is less densely settled—and more heavily allocated to cattle ranching. Human pressures on the forest for fuelwood and poles are important in this region.

In contrast, the Amazon and Pacific regions are the most important forest regions. The Amazon basin is the best preserved, most of its original cover still remains (table 12.20), and it has the largest forest coverage of any of the five natural regions. Its forest products represent a significant share of all wood consumed in Colombia, especially for furniture, and the region contains the majority of Colombia's forest plantations. Approximately 14 percent of the region's forest is indigenous peoples' territory under the collective management of *resguardos* (indigenous homelands). The Pacific region has a smaller total area of forest cover than the Amazon region, but the Pacific contains vast areas of commercial species and provides the largest share of Colombia's industrial harvests from natural forest. Between 60 and 80 percent of total industrial timber harvests come from this region. The Amazon region's population is largely

Table 12.20 Forest Cover

	Total area		Forest cover	
Region	*Hectares*	*Percent*	*Hectares*	*Percentage of region that is forested*
Andean	29,997	23	7,727	25.8
Amazon	39,726	35	32,349	81.4
Caribbean	18,817	16	530	4.1
Orinoquía	23,405	20	7,151	30.6
Pacific	7,211	6	5,423	75.2

Source: IDEAM 2002.

composed of Afro-Colombian communities, which will benefit from improved forest land titles.

A review of the level of deforestation in each department shows two-thirds of the remaining forest area is located within those six departments located in the southeastern part of Colombia, east of the mountain chains (Amazon region).[6] The forest cover in these departments averages almost 85 percent. Together, they represent one-third of the national territory and have a very low population density, holding less than 2.5 percent of the total population.

Four departments occupy the northeast area lying east of the mountain chains.[7] Only 3 percent of the total population lives here; despite the low population density, the forest cover averages only 17 percent, representing 8 percent of Colombia's total forest area. West of the mountains, four coastal departments besides Bolívar and Antioquía (Choco, Valle, Cauca, and Narino) hold 18 percent of the total forest areas; these departments average 42 percent forest cover.

All the other 17 departments, including Bogotá, hold the remaining 10 percent of the country's forest area, averaging 18 percent forest cover, except for the seven departments in the East Caribbean, which have less than 10 percent forest cover. The entire area of these 17 departments harbors two-thirds of the total population and 60 percent of the agricultural cropped land, comprising 23 percent of the national territory. Rural population density is significantly higher than east of the mountains: 25 inhabitants per square kilometer compared with 2 inhabitants per square kilometer in the east.

The variation in forest cover across departments seems to be largely explained by the amount of land under cultivation and the size of rural populations. It is clear, however, that other factors have contributed substantially to forest losses in some specific parts of the country.

Cost of Deforestation

The cost of deforestation is difficult to assess; some of the effects of deforestation are included in the cost of natural disasters, because deforestation is believed to contribute to the increased frequency and severity of flooding and landslides. Deforestation, however, is likely also contributing to agricultural land erosion and decreased quality in water resources, two processes in which isolation of deforestation is not possible. Anthropological processes, conversely, are easier to quantify. Following are some perspectives on the historic processes of deforestation in Colombia resulting from a statistical analysis.

To shed some light on the long-term historic processes of forest loss in Colombia, a regression analysis was conducted by Larsen (2004). The analysis is based on department-specific data on amount of forest area (1996), total land area, land area under cultivation (1991), and estimated rural population (2002). The results are presented in table 12.21. As expected, the coefficient for land area is highly significant, implying that larger departments in general have larger forest area (although not necessarily higher forest cover). The coefficient for land under cultivation indicates that for each additional hectare devoted to agriculture, 4.1 hectares of forest area are lost. Similarly, the forest loss associated with total rural population is 1.5 hectares per capita. An intercept dummy was included to prevent bias because the five most northern departments east of the mountains[8] had a particularly low forest cover.

The difference between actual and estimated forest areas in the northeast region totals 18 million hectares fewer than expected, based on the size of the rural population and land under cultivation. This would indicate additional forces of deforestation. In the northwest, Atlántico, Boyacá, La Guajira, Magdalena, Norte de Santander, and Santander also have significantly less forested area than expected. In contrast, some departments

Table 12.21 Regression Analysis of Forest Cover

	Coefficient	*t-statistics*
Land area (km^2)	87.7	18.2
Land under cultivation (hectare)	–4.1	–2.6
Rural population	–1.5	–2.6
Dummy	–2594237.0	–6.7
Constant	214755.0	0.8
R^2	0.94	

Source: Larsen 2004.
Note: km^2 = square kilometer.

have a larger forest area than expected by rural population size and land area under cultivation; most notably, Bolívar has close to 50 percent forest cover, compared with the 30 percent expected.

Sources of Deforestation

The most important factor contributing to deforestation is illicit crop production (coca and poppy). Other causes include agricultural expansion, lumber production, firewood consumption, ranching and settlements, and forest fires (IDEAM 2004). However, lack of reliable information and database systems preclude accurate assessment of deforestation and other indicators of forest conditions.

It is estimated that during 1980 to 1990, coca crops went from negligible (traditional crops by indigenous people) to 25,000 hectares. By 1994, the official estimate of land used for commercial coca crops was 70,000 to 83,000 hectares (Escobar Ramírez 2004). In 1999, Carlos Cesar Perafán (1999, referenced in Davis and Sánchez 2003) estimated that 17 percent of the country's illicit crops were being cultivated within indigenous territories. These illicit crops have had a negative impact on the indigenous community of Putumayo and on Afro-Colombians of the Patía River in the department of Nariño (Davis and Sánchez 2003). The MMA indicates that during 1974 to 1998, illegal crops destroyed 850,000 hectares of forests in Colombia (Contraloría 2002). Eradication of illegal crops through fumigation is also considered to be a significant threat to forests and to biodiversity and human health. The debate over fumigation in Colombia is polemic, and has even resulted in repeated requests from the *Defensoría del Pueblo* (the public institution in charge of human rights enforcement) to the government for the suspension of all chemical aerial fumigation in light of its potential negative effects on health and the environment (Defensoría del Pueblo 2002).

In addition to illicit crop production, both sprawl and changes in land use have negative effects, resulting in additional settlers moving to areas adjacent to the forest to avoid the violence in other areas. In essence, this means local land use issues are more important to sustainable forestry than industrial timber harvests. It also suggests that local rights to the use of the forest are critical when concerns related either to deforestation or to long-term, sustainable forest management are addressed. Under current conditions, large areas of forest have greater value when converted to agriculture, because local stumpage values are most often derived from fuelwood, which is a low-value product. Because most of the higher commercial timber values go to transportation costs, leaving little benefit to local populations, forests and trees that are more valuable for industrial uses are also under pressure from human settlement.

Furthermore, because the forest's agricultural and fuelwood users are geographically dispersed, their dominance as sources of deforestation and forest degradation cause difficulties for the CARs that have forestry responsibility. These agencies can only hope to lead by good example and good reason. They can periodically review the forest condition and enforce easily managed requirements of forest use, but they can never expect to control all forest use by extensive populations of dispersed subsistence users of the forest.

Policy Design

Law 2 of 1959 declared as forest reserves a total of 58,162,950 hectares, corresponding to over 50 percent of the national territory. Most of these lands are owned by the government. In 1961, Law 35 required two-thirds of any colonized parcel to be cleared to entitle ownership, thus fostering extensive deforestation practices throughout Colombia.

As in other areas of environmental protection in Colombia, the most important legislation to date is the 1974 National Code for Renewable Natural Resources and Environmental Protection (*Código Nacional de Recursos Naturales Renovables y de Protección al Medio Ambiente*, CNRN). As discussed in chapter 13, the CNRN regulates the conservation and use of forestry resources and sets out the objectives of a National Parks System. By 2005, the National Natural Parks System (NNPS) (Sistema de Pargues Nacionales Naturales) comprised 46 areas with a total of about 9.6 million hectares, approximately 9 percent of the country's land area. The system is highly representative of Colombia's different marine and inland forests ecosystems.[9]

The incentives for deforestation established in Law 35 of 1961 have been reversed since 1988 by Law 30 on land tenure and by the law on forestry incentives, aimed at controlling degradation and deforestation. Law 30 of 1988 established that proof of both occupancy and economic exploitation of two-thirds of the land were required for land titling. Conservation of protective vegetation and rational use of forests were included as economic activities.

As elaborated in chapter 13, most indigenous reserves are located in natural forests containing a significant share of the country's biodiversity. Nearly all indigenous Colombians live in collective territories legally known as *resguardos*. The 1991 Constitution allowed the country to set apart about 30 million hectares, or nearly 26 percent of its area, as indigenous reserves. According to the 1991 Constitution, these *resguardos* are inalienable (that is, the title to these lands cannot be acquired merely through uninterrupted possession of specific duration). However, the indigenous reserves overlap with the National Parks, occupying some 30 percent of the NNPS area.

The 1991 Constitution and Law 70 of 1993 allocated approximately 3 million hectares—about 2.5 percent of the country—to Afro-Colombian communities settled in the Biogeopraphical Chocó region. This area comprises forests representative of one of the world's most important conservation hot spots, home to great biodiversity and a high level of endemism.[10]

Law 99 of 1993 contains provisions to establish Forest Protection Reserves and Forest Protection–Production Reserves. By 2003, these provisions had resulted in more than 2.1 million hectares demarcated and with management plans in place. Integrated Management Districts comprise another 2.8 million hectares, and 500,000 hectares of land are officially protected by municipalities and departments (Ruiz and Vergara 2003).

In 1993, Congress issued a law to create Forestry Incentive Certificates, by which forest owners who undertake reforestation or forestry plantations of a protective nature can receive a partial reimbursement of reforestation costs derived from either direct investment or maintenance (70 percent of costs for native species, 50 percent for introduced species). In addition, Colombia has introduced tax deductions for investments in forestry plantations. This mechanism has been less successful than direct subsidy. The use of subsidies signifies a transfer of financial resources from taxpayers to reforesters. These subsidies have been justified by the argument that reforestation practices are beneficial to the environment, particularly for soil conservation and erosion control, and as a buffer against climate change.

The forestry regulations currently in place control the use and exploitation of forests and oil-nut palms and prohibit the destruction of oil-nut palms when located in natural forests. Exceptions to this prohibition must be approved by the Ministry of Finance. The regulations also establish that any attempt to use forest resources for private gain (in private or public areas) is illegal. All such illegal actions are subject to a fine—between Col$1 (US$0.005) and Col$100 (US$0.05)—or prison.

The CNRN and forestry regulations issued in the 1970s and 1980s establish that the National Institute of Renewable Natural Resources (*Instituto Nacional de los Recursos Naturales Renovables*, INDERENA—the MAVDT's predecessor) is responsible for granting permits to exploit and use public forests. For areas smaller than 20,000 hectares, such permits are assigned for a maximum of 10 years. To obtain a permit, the agent must undertake an environmental impact assessment. For areas larger than 20,000 hectares this right must be assigned by public bidding.

By law, all agents that exploit public forests must restore them. Regulations establish that all reforestation programs must be approved by the responsible local authority, except for forests developed on untilled, uncultivated, or inappropriate land by private agents who retain full control of the forest.

Forestry regulations also provide economic incentives for the conservation of water and land in the upper Magdalena River basin.[11] The one-time, lump-sum economic incentive is to be given to individuals or groups of farmers who invest in agricultural improvements, including labor practices (crop rotation, intercropping, and plantation on alternate rows), reforestation, pasture improvement, the use of natural resources such as live barriers, and mechanical practices for erosion control and water conservation. Forestry regulations also state that the incentives will be prioritized in the following order: establishment of new farms; maintenance of new farms; and erosion control.

In the 1990s, a Forest Conservation Certificate (*Certificado de Incentivo Forestal*) was established for private owners of virtually undisturbed forest areas, in recognition of and as compensation for the costs of protecting the forest. The National Council for Economic and Social Policy is responsible for assigning these financial resources. The areas eligible to receive the incentive are forests more than 2,500 meters above sea level, those near water sources, those in natural parks, and those in areas that provide water resources to municipalities. The local environmental authority is to monitor and evaluate use of the forest. The economic incentive in the first year is equivalent to seven times annual minimum wages (as calculated annually by the national government) per hectare, and in subsequent years it will be adapted using the following equation:

$$VA = VB + FAR$$

where

VA = the adjusted value every year
VB = the base value established by the environmental authority
FAR = the regional factor.

Furthermore,

$$FAR = FTP \times FPT$$

where

FTP is an altitude factor assigned as follows:

Altitude	*FTP*
Less than 1,000 meters	0.63
1,001 to 2,000 meters	0.77
2,001 to 2,500 meters	0.89
More than 2,500 meters	1.00

FPT is an area factor assigned as follows:

Area	*FPT*
Less than 3 hectares	2.0
3 to 10 hectares	1.6
11 to 20 hectares	1.4
21 to 30 hectares	1.2
More than 30 hectares	1.0

Within the development plans of the 1990–98 administrations, and based on the analysis by USAID-Colciencias (1989) and the World Bank (1989), the government made deforestation control a priority for government agencies. By 1990, the main driving forces of deforestation were found to be human settlement, use of firewood, lumber production, furniture manufacture, and pulp and paper production. Deforestation control was made a joint responsibility of the MMA and the CARs. The government designed the Forestry Action Plan for Colombia and financed it through loans from the Inter-American Development Bank and the World Bank. The policies for investing in reforestation and watershed basin management have had significant financial support from the government since 1993.

Nevertheless, several authors (Andrade 2005; Orozco 2004; Ponce de León 2005; Rodríguez Becerra 2005) argue that the priorities of the forestry policy should include

- creating a reliable and publicly accessible forest information system to facilitate planning and decision making

- increasing employment and income-generating options for forest dwellers, reducing negative environmental impacts on water basins and soils, and conserving biodiversity
- generating alternatives to diversify nontimber forest products and improve the livelihood of forest communities
- promoting sustainable exploitation of forest resources
- building consensus by involving the government and the public on creation of an environmental services market, improved basin management, and decentralization of forest management.

Ruiz and Vergara (2003) argue that the valuation and capture of revenues from environmental services represent potential revenue for rural communities. These revenues may help illegal crop eradication and indirectly assist with the peace process.

Effectiveness of Policy Implementation

Colombia has competitive sectoral advantages stemming from its biogeographical diversity, which provides a wide variety of species with economic potential. In addition, the productivity of Colombia's forestry plantations has increased from 16 cubic meters per hectare per year in 1980 to 25 cubic meters per hectare per year in 1990, which are national levels comparable with those in Chile.

Despite the shortcomings in primary information sources, it seems that the policies designed to control deforestation have been quite effective. Estimates of deforestation rates in the 1970s and 1980s amounted to 600,000 hectares per year (INDERENA 1978; World Bank 1989). Currently, deforestation estimates are 91,932 hectares per year (IDEAM 2004).[12] Law 30 of 1988 and Laws 70 and 99 of 1993, and enforcement by INDERENA and the CARs, have contributed to decreasing the rate of deforestation. It is also probable that other causes reduced new settlement areas significantly throughout Colombia, to the point that according to IDEAM (1998, p. 295), the country "lost about 145,000 hectares of forest and recovered secondary forest cover in some 3,445,000 hectares, resulting in a net gain of 3,300,000 hectares of forest cover in 10 years, or 330,000 hectares per year."

A 2004 report by IDEAM (table 12.22) showed the largest increases in green cover during 1994 to 2001 were those in agroecosystems (57,873 hectares per year [ha/yr], average growth rate 0.2 percent), forestry plantations (15,777 ha/yr; average growth rate 7.7 percent), and human settlements (urban and artificial—3,011 ha/yr, average growth rate 2.3 percent). Covers showing significant surface reduction for the same

Table 12.22 Changes in Green Cover in Colombia, 1986–94 and 1994–2001

	Forest cover (thousand hectares)						
			1986–94 change			*1994–2001 change*	
Region	*1986*	*1994*	*Total*	*Annual average*	*2001*	*Total*	*Annual average*
Urban and artificial	92	125	33	4	144	19	3
Agroecosystems	33,382	34,367	985	122	34,749	381	58
Forests	56,902	56,280	–622	–77	55,613	–667	–101
Forestry plantations	107	165	58	7	269	104	16
Moors	1,725	1,614	–111	–14	1,627	13	2
Savanna	15,525	15,531	6	1	15,556	25	4
Snow	54	40	–14	–2	29	–11	–2
Wetlands	2,991	2,848	–143	–18	3,006	158	24
Scarce vegetation cover	3,124	2,958	–166	–20	2,949	–9	–1
Without natural cover	57	54	–3	0	56	2	0

Source: IDEAM 2004.

Table 12.23 Protective Reforestation in Colombia, 1991–2002

Year	*Area planted (hectares)*
1991	1,100
1992	739
1993	105
1994	3,691
1995	17,951
1996	16,777
1997	21,277
1998	13,815
1999	7,204
2000	14,949
2001	19,109
2002	64,810
Total	181,527

Source: Blackman and others (2005), using data from IDEAM (2003).

period include forests (101,303 ha/yr) and Andean highlands (snow) (1,765 ha/yr).

Reforestation Data

The reforestation policy has been very effective. Approximately 180,000 hectares were reforested during 1991 to 2002 (table 12.23). However, according to MAVDT (2003), approximately 15 million hectares that should be used for forests and forestry activities have been devoted to other uses. Thus, only about 1 percent of the forest deficit was reforested during 1991 to 2002.

Bill on Forestry Resources Management

At the time this chapter was completed (June 2005), Colombia's National Congress was discussing a forestry bill. The objective of the bill is to foster development of the Colombian forest sector and regulate the activities related to the management, exploitation, and sustainable use of forest resources, and the transformation, transport, and commercialization of derived goods and services. Although various stakeholders agree that a solid legal framework is needed to unify the current statutes and laws, the bill has been controversial. Some of the main criticisms are that it does not clearly support the timber industry, and has little in-depth treatment of conservation, protection, and restoration issues; it lacks a way to pay for the environmental services approach; it undermines and is inconsistent with the goals of the *Plan Verde* and the National Forestry Development Plan (2000), Law 99 of 1993, Law 70 of 1994, and the Forest Policy of 1997, among others; it does not acknowledge indigenous peoples and Afro-Colombian communities as owners of the forests in their lands; and it does not incorporate the principles and recommendations of international agreements and conventions that Colombia has ratified, such as the Convention on Biological Diversity, the International Timber Agreement, the Ramsar Convention, the United Nations Convention to Combat Desertification and Drought, and the Framework Convention on Climate Change (Andrade 2005; Galán 2005; Ponce de León 2005; Roldán 2005). A general criticism of the bill is that it promotes a different perspective from the one established in the current policy and institutional framework. The perspective established in the existing policy stems from the perception of forests as complex ecosystems that produce goods and supply multiple services and that are a basis of biological and cultural diversity. The bill, according to some of its critics, implies that conservation is solely a tool for production, rather than an end in itself.

Several stakeholders (Andrade 2005; Ponce de León 2005; Rodríguez Becerra 2005) have suggested modifications to the proposed forestry bill to move it toward sustainable development in the sector, defined as the process to reach optimal and sustained production of forestry resources for society's benefit and to improve the quality of life, without affecting the equilibrium and integrity of forest ecosystems. The forestry bill could include provisions to

- reduce rural poverty through job creation, increased profitability of forest activity, and implementation of payments for environmental services
- reduce adverse environmental impacts associated with the sector, including further reduction of deforestation rates, recovery of degraded

land through reforestation, and reconversion of marginal agricultural zones for productive use
- reduce pressure on key areas of biodiversity
- reduce forest fires and increase carbon dioxide collection
- strengthen national security through reductions in illegal activities
- promote public participation in protection and restoration programs.

Conclusions and Recommendations

Soil Erosion and Salinization

Data on soil erosion and salinization in Colombia are limited, and discrepancies exist among the available studies as a result of differences in methodology, terminology, and coverage. Nevertheless, existing data suggest that both erosion and salinization are significant problems. They indicate that between 4 percent and 23 percent of the country's soil is seriously eroded and that the problem appears to have worsened over the past 15 years. Serious soil erosion is most prevalent in the Caribbean, Andean, and Orinoquía natural regions, which are among the most populated or productive regions in the country. Existing salinization studies suggest that soils in approximately 10 percent of the country now have levels of salinity high enough to adversely affect crop and rangeland productivity. Problem areas are located primarily in the Caribbean natural region.

Soil erosion and salinity generate significant economic costs. Larsen (2004) estimated the annual costs stemming solely from lost crop productivity at Col$1,440 billion (US$670 million) and attributed 60 percent of these costs to erosion and the remaining 40 percent to salinization. Salinization is mainly a result of irrigation, while a key driver of erosion is the expansion of agricultural activities, particularly cattle ranching.

Few national laws or regulations specifically target soil erosion and salinization. Most of the existing legislation and regulations concern broader problems such as land use planning and deforestation, and do not explicitly contemplate the link between these issues and soil erosion and salinization.

Given the dearth of specific policies addressing land degradation and the lack of performance indicators for environmental regulation in Colombia, assessing the extent of the problem and finding solutions is difficult. Nevertheless, existing data suggest that efforts to prevent, control, and mitigate land degradation by CARs have been minimal. CARs' investments in land quality during 1995 to 2003 were less than 2 percent of total CAR investment. A comparison across the 33 CARs of the severity of

Table 12.24 Recommendations

Recommendation	*Priority: short (S), medium (M), and long term (L)*	*Participating institutions*
Create a reliable and publicly accessible forest, soil erosion, and soil salinization information system to facilitate planning and decision making	L	Congress, Ministry of Agriculture
Develop analytical work to identify the costs and benefits of alternative interventions to control soil erosion and soil salinization	M– L	Ministry of Agriculture
Generate alternatives to diversify nontimber forest products and improve the livelihoods of forest-dwelling communities	L	Congress, Ministry of Agriculture
Foster the capacity of forest-dwelling and indigenous communities and cooperatives to profit from the sustainable and productive uses of forest areas	M– L	Congress, Ministry of Agriculture
Reduce rural poverty through job creation, increased profitability of forest activity, and implementation of payments for environmental services	M– L	Congress, Ministry of Agriculture
Establish specific mechanisms for cost recovery, nontimber forest production, ecological services valuation, small-scale user permits, and intellectual property rights	M– L	Congress, Ministry of Agriculture
Ensure public participation in sectoral decision making regarding soil degradation control and forestry management, especially for communities, small farms, and local civil society organizations	S	Congress, Ministry of Agriculture

Source: Authors.

soil degradation risk with the extent to which CARs focus their investment funds on this risk suggests that CARs systematically underinvest in addressing this risk. Finally, data on land use planning suggest that this mechanism for preventing soil degradation has significant limitations. About 20 percent of municipalities have no environmental component in their POT, and 40 percent do not have the soil zoning needed to ensure that the environmental components are effective in preventing soil degradation.

Forestry Policy

Forestry policy has been effective in reducing deforestation rates from 600,000 hectares annually in the 1970s and 1980s to 90,000 hectares in 2004. During 1988 to 1998, recovered secondary forest amounted to 3,445,000 hectares. The net gain in forest cover was thus estimated at 330,000 hectares per year. In addition, reforestation activities during 1991 to 2002 accounted for 180,000 hectares.

The proposed forestry bill is a chance to promote increased opportunities for the development of income-generating activities and for generation of employment for forest dwellers and indigenous peoples living in buffer zones of conservation areas. The bill could provide an opportunity to strengthen the capacity of these communities and cooperatives that so far have been unable to take greater advantage of sustainable and productive uses of forest areas. The forestry bill also provides an opportunity to put in place specific mechanisms for cost recovery, nontimber forest production, ecological services valuation, small-scale user permits, and intellectual property rights. All these mechanisms could be effectively applied to indigenous communities and help foster accountability by ensuring stronger involvement of local communities, small farmers, and local civil society organizations in sectoral decision making.

Table 12.24 summarizes the recommendations made in this chapter.

Notes

1. Allen Blackman and Ernesto Sánchez-Triana are the authors of this chapter, which draws heavily from a background document prepared for this study by Blackman and others (2005).
2. They are factors of, relating to, or resulting from the influence of human beings on nature.
3. Future studies of soil degradation are planned. According to an employee at IGAC's Agrology Section, IGAC is currently in the process of establishing

an agreement with the Ministry of Environment, Housing and Regional Development to design studies evaluating the current state of erosion and salinization in the country.

4. This is likely to change under the new PAT formulation methodology adopted by the government and CARs in 2004.
5. The following discussion and analysis is based on forest cover data from IDEAM (2002).
6. The southeastern departments include Amazonas, Caquetá, Guainía, Guaviare, Putumayo, and Vaupés.
7. The northeastern departments include Arauca, Casanare, Meta, and Vichada.
8. Those departments include Arauca, Casanare, Guainía, Meta, and Vichada.
9. Within the system are tropical rainforests, dry forests, and subhumid tropical forests; xerophytic and desert scrublands; Andean and cloud forests; moors; natural savannas; alluvial forests near rivers; and mangroves, among other types of vegetation.
10. Endemism includes biological species found only within a physically narrow habitat.
11. The upper Magdalena River basin includes the area surrounding the Combeima River in the departments of Huila and Tolima.
12. The Contraloría (2002, p. 7) reports that "Colombia does not have a baseline that allows for determination of the state of, and changes in, the quality and quantity of natural resources and the environment over time; for example, reliable statistics do not exist on the state of natural resources, the pressure exerted on them and the subsequent response, which hinders follow-up and evaluation of national and state management in preserving it".

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CHAPTER 13

Biodiversity Loss and Other Global Environmental Problems

By several measures, Colombia is among the world's five most ecologically diverse countries. With an area of 1.14 million square kilometers, Colombia represents only 0.8 percent of the world's surface area, yet it is home to 15 percent of all known terrestrial species. Although protected areas and indigenous reserves cover 34 percent of Colombia's national territory—among the highest levels of biodiversity in the world—the findings of this chapter suggest that the measures to create protected areas do not accurately reflect the social concerns of inhabitants of those areas. Greater involvement of local stakeholders has already begun to show positive results and could significantly benefit biodiversity use and conservation.

Although Colombia's contribution to global greenhouse gas (GHG) emissions is less than 0.3 percent of the world's total, it has taken advantage of international financial mechanisms to develop renewable energy projects aimed at reducing GHG emissions. Likewise, Colombia contributes less than 0.45 percent of the total ozone-depleting substances (ODS) emitted globally and has reduced the amount of ODS with grants from the Montreal Protocol.

Colombia is one of the world's five most ecologically diverse countries (IDEAM 2003).[1] With an area of 1.14 million square kilometers, Colombia occupies only 0.8 percent of the world's surface area, yet it houses 15 percent of all known terrestrial species. It has 10 percent of the world's flora and fauna, 20 percent of the planet's bird species, one-third of the primate species in tropical America, and more than 56,000 registered flowering plant species, including 15 percent of the world's total orchid species. The country is first in the world in the number of bird and amphibian species and second in vascular plants. The country possesses 18 ecological regions (IDEAM 2003), the second highest of any country in Latin America. Indeed, Colombia's ecosystem map (IDEAM 2003) identifies 65 ecosystem types. Colombia encompasses 12 percent of the continent's humid and dry hotspots and two of the world's most important areas for biodiversity: the Biogeographical Chocó corridor and the Amazon Basin (IDEAM 2003). Protected areas and indigenous reserves account for 34 percent of Colombia's national territory and enjoy some of the highest levels of biodiversity in the world.

Colombia's cultural and ethnic diversity is also exceptional. The United Nations Educational, Scientific and Cultural Organization (UNESCO) has declared five sites in the country to be of important historical and cultural heritage to humanity. Some 84 indigenous groups recognized by the government have a total population of 800,000 (2 percent of the national population). These groups live in 1,500 communities and are located in 27 of the country's 33 departments. Indigenous communities generally inhabit areas rich in biodiversity (UAESPNN 1999). Local indigenous cultures have developed ways of living based on centuries of experimenting with the balance between the needs of human communities and the needs of local ecosystems.[2] Their ancestral land-management practices have largely preserved diverse ecosystems, and large regions within their territories remain relatively intact.

Regarding other global environmental problems, Colombia has taken advantage of international financial mechanisms to develop renewable energy to reduce the amount of ozone-depleting substances (ODS). Emissions of ODS in Colombia add up to less than 0.45 percent of global emissions, and global greenhouse gas (GHG) emissions are between 0.2 and 0.3 percent. Colombia emits very small amounts of carbon dioxide (CO_2); 1990 emissions were equivalent to about 1 percent of U.S. emissions.

This chapter discusses the problems associated with biodiversity loss and the actions implemented in Colombia to tackle the problems associated with climate change and ozone depletion.

Biodiversity

Although an extensive literature examines biodiversity, it displays little consensus on estimating the potential value of biodiversity conservation. Areas that could receive benefits from such conservation include ecotourism, genetic prospecting for pharmaceuticals, harvesting of renewable resources, and the intrinsic values of species. Limited work has been done on how the value of biodiversity conservation should be captured to give local communities or national governments an incentive to conserve (Polasky and others 2000). According to a study prepared by Fedesarrollo in 2002, global benefits associated with the biodiversity in Colombia's National Natural Parks System are valued at US$3.2 million (Col$6,720 million). A study on green markets will be conducted in the medium term to evaluate the contribution of biodiversity to the Colombian economy. Following is a review of the existing empirical literature that attempts to estimate the value of various aspects of biodiversity.

A current trend in global tourism is for travelers to select their destinations based on the flora and fauna of the location, also known as nature-based tourism or ecotourism. For some countries, such as Costa Rica and Kenya, this type of tourism generates a significant flow of income. A study conducted in Costa Rica places an estimated annual value of US$2 million on income derived from the Monteverde Reserve (Echeverria, Hanrahan, and Solorzano 1995). In Madagascar, ecotourism-generated benefits were estimated to be between US$2 million and US$3 million annually, as measured in 1987 dollars (Maille and Mendelsohn 1991).

These estimates are for the total value of the travel. The destination country does not receive the full amount of this revenue (Polasky 1996). As an example, one study estimates that of approximately US$1,300 spent by a typical tourist to the Galapagos Islands, a mere US$100 of that amount actually ends up in the local economy (Southgate 1996 citing de Miras 1994). Other concerns regarding ecotourism stem from questions about its capacity to generate well-paid local jobs and serve as a catalyst for the development and growth of local economies, and the possibility that it might cause greater environmental degradation to the habitats visited by the ecotourists (Polasky 1996).

Adequate flora and fauna are not the only criteria for a successful ecotourism site; it must also provide potential visitors with assurances of their personal security. Colombia's situation is a prime example of this: despite its richly diverse ecosystems, many North American and European travelers perceive the country to be an unsafe destination because of the regional drug trade, guerilla activity, and metropolitan crime. If the actual and perceived situations do not improve, Colombia will be overlooked as a favorable destination, with travelers visiting Costa Rica or Belize instead (Polasky 1996).

Genetic prospecting is the systematic search for new sources of chemical compounds, genes, proteins, microorganisms, and other products that have potential economic value and that can be found in natural biological wealth. Therefore, promoting the conservation of animal and plant species provides a strategic long-term benefit because species that do not have a current use may prove valuable as research technologies develop. This is known as an *option value,* because the estimated value of the species can be realized only if its extinction is prevented (Polasky 1996). Experts, however, have a difficult time arriving at a consensus on the monetary value that should be placed on land (per hectare) to estimate the genetic prospecting value for pharmaceutical companies. One study determined that the land held a value of US$1 per hectare for the firm doing the actual genetic prospecting, but that the public benefit of these efforts placed the value at US$50 per hectare, indicating that subsidies to encourage conservation and genetic prospecting would be justified (Mendelsohn and Balick 1995).

Resource harvesting is the harvesting of biological resources for the purpose of subsistence or economic gain. A prominent example of this is the commercial fish market. Advocates of resource harvesting argue that, if done in a sustainable manner, the harvesting of a biological resource will yield the highest current value for that resource. This argument is valid, however, only when the biological growth rate of the harvested resource is greater than the social discount rate. When the reverse is true, the course of action that will yield the maximum present value of the harvest, even as the resource stock approaches zero, is to make the resource extinct (Clark 1973). Obviously this is not a responsible approach for resource managers.

One study addressing tropical deforestation issues determined that the value of nontimber products harvested on a sustainable basis would yield much greater financial returns than a one-time sale of timber from clear cutting followed by nonforestry uses of the land (Peters, Gentry, and Mendelsohn 1989). Another study, however, argues that this premise is unfounded given the unique characteristics of any site, such as soil type and access to markets (Southgate 1996).

Existence value refers to the intrinsic value of an asset, usually natural or environmental. It is the value of the benefits derived from the asset's existence alone and is separate from the value accruing from any use or potential use of the asset. Because there are no observable prices for these values, nor perhaps any observable behavioral trail, most economic methods for estimating value are not applicable. Perhaps the only method by which economists can estimate existence values is contingent valuation. In general, more charismatic species (for example, large mammals) tend to have higher willingness-to-pay values than species lacking in charisma (for example, the striped shiner—a small bait fish). However, the range of reported values across different studies, even for studies on the same species, is often quite large. Economists are unable to estimate the value of biodiversity conservation with much precision.

Along with the usual problems associated with implementing and interpreting a contingent valuation study, several facets of the species conservation issue present special difficulties. For example, as in many settings, lack of information or familiarity may make it difficult for people to accurately assess value. Conserving species is viewed as a moral imperative by a fraction of the population. Asking them about their willingness to pay to conserve a species may be viewed similarly to asking them about their willingness to pay to avoid having a murder committed (Polasky 1996). Even for people with less extreme views, there are various ethical and emotional commitments that might cause responses to survey questions to be highly variable. In addition, analytical work on diversity measures focuses on the relationships among species. The value of conserving any particular species is a function of the set of species that is conserved (Solow and Polasky 1994; Weitzman 1992). This factor is typically ignored in contingent valuation studies that focus primarily on the value of a single species.

These factors illustrate the special challenges associated with the formal economic valuation of biodiversity. Nonetheless, from the livelihood and cultural perspective of local indigenous groups coexisting in national parks, the value is potentially immeasurable.

The National Protected Areas System

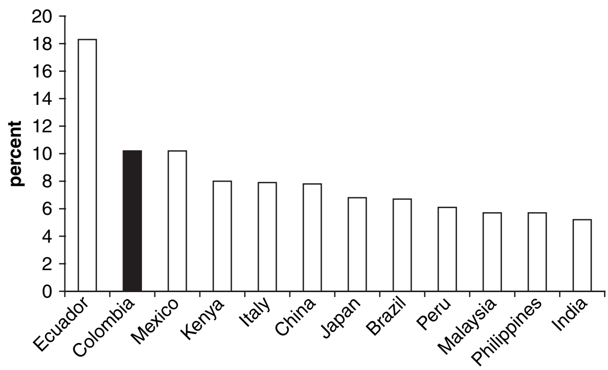
Colombia's significant natural endowment is conserved within the National Protected Areas System (NPAS), which includes public and privately owned lands throughout the country (table 13.1). The NPAS contains the National Natural Parks System (NNPS) consisting of 49 National Parks spanning close to 10 million hectares. The area covered by the national parks occupies close to 10 percent of the national territory, which is slightly below the average of 11.2 percent for the Latin American region (figure 13.1). Compared with the other four highly diverse Latin American countries, the percentage of land that is protected is larger than that of Brazil and Peru, and similar to that of Mexico, but smaller than that of Ecuador. Colombia protects an area larger than that protected by most biodiverse countries outside the region, including China, India, Kenya, and Malaysia. Protected areas in higher income countries such as Canada, Italy, and Japan cover similar or smaller shares of their territory. The NNPS constitutes the

Table 13.1 The National Protected Areas System

Protection categories	*Hectares*
National Natural Parks System: 49 areas under 5 management categories	10,320,865
Civil Society Natural Reserves: 205 reserves; approximately 324 properties, 111 of which are registered in the NPAS; 183 reserves are part of a National Reserves Network.	40,335
Territorial Protected Areas: 247 areas in 46 management categories; includes 79 municipal areas, 108 regional areas managed by CARs, and 17 departmental areas	243,825
Regional Protected Areas (without forest reserves)	3,439,452
National Forest Reserves (Law 2 of 1959)	1,371,940
Indigenous Territories: 30 million hectares (protected areas to be defined)	30,000,000
Ethnic Afro-Colombian Community Territories: 3 million hectares (protected areas to be defined)	3,000,000

Source: IDEAM 2004.

Figure 13.1 National Protected Areas



Source: World Bank 2005.

country's principal biodiversity conservation strategy. The NNPS encompasses 50 of Colombia's 108 biogeographical districts (Biocolombia 2000) and includes 12 percent of Latin America's humid and dry wilderness refuges and two of the most biodiverse regions in the world: the Biogeographical Chocó and the Amazon Forest (IDEAM 2003).

The NPAS also includes 5 million additional hectares of land under conservation. This system contains two internationally declared wetlands through the Wetlands Convention (Ramsar) and five World Biosphere Reserves: the Sierra Nevada de Santa Marta, the Ciénaga Grande de Santa Marta, the San Andrés and Providencia Archipelago, the Tuparro

National Park, and the Colombian Massif. In addition, the United Nations Educational, Scientific and Cultural Organization declared the Katíos National Park a World Heritage Site because it exhibits the most interesting natural regeneration and recovery capabilities among all of Colombia's national parks (Ruiz and Vergara 2003). Under Law 99 of 1993, the National Parks Authority (NPA) is the environmental regulatory agency for the areas within the NNPA.

The total area under effective conservation and protection has been increasing as a result of the decentralization and organizational strengthening process led by the Colombian government aimed at increasing the number of effective management categories and conservation strategies. Law 99 of 1993 assigns to Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs) the task of establishing regional protected areas and creating management categories for reserves promoted by civil society, thus promoting active public participation in conservation. CARs also exercise authority in national park buffer zones. Over 200 natural areas are protected under municipal, departmental, and regional conservation categories. These categories include the following:

- *Private Reserves*. The Civil Society Reserves Network represents landowners who, through their own initiative, provide part or all of their lands for conservation purposes. In 1993, Law 99 (which created the National Environmental System) officially recognized civil society natural reserves. According to IDEAM (2003), by 2005 over 200 reserves had been created.
- *Forest Protection Reserves and Forest Protection–Production Reserves.* Management plans are in place for 2.1 million demarcated hectares. An additional 2.8 million hectares are considered Integrated Management Districts, created by Decree 1974 of 1989, and another 500,000 hectares are officially protected by municipalities and departments (UAESPNN 1999). There are also 1.37 million hectares of Forest Reserves created by Law 02 of 1959, representing about 15 percent of national lands.

Furthermore, territories collectively owned by Afro-Colombian and indigenous communities hold significant conservation and environmental management potential. These groups have traditionally supported conservation objectives through their ancestral natural resource management practices. Indigenous territories, known as *resguardos*, comprise 30 million hectares and represent 26 percent of the national territory. Likewise, close to 3 million hectares (2.5 percent of the country's area) are collectively owned Afro-Colombian territories located primarily in the Biogeographical Chocó region (Ruiz and Vergara 2003). Generally, zones of high ethnic diversity coincide with ecologically strategic regions endowed with high biodiversity levels. Such is the case with the Sierra Nevada de Santa Marta, the Amazon, the Colombian Massif, and the Biogeographical Chocó. Additionally, indigenous *resguardos* overlap 18 protected areas within the NNPS, while Afro-Colombian communities overlap 5 such areas.

High mountain, or *páramo*, regions critical to the regulation of water resources span approximately 1.4 million hectares and represent 1.3 percent of national territory (IDEAM 2003). Buffer zones surrounding protected areas must be effectively incorporated into the NPAS. Preliminary data collected during 2004, in support of the Regional and Integrated Silvopastoral Approaches to the Ecosystem Management Global Environment Facility (GEF) Project, underscore the importance of the link between biodiversity and sustainable production systems. Data collected during the Silvopastoral project and the proposed GEF Andes project are expected to provide information on the rural productive landscapes that should be included in the NPAS. Environmentally sustainable livelihoods will improve the quality of life of buffer zone inhabitants and contribute to social and economic development in these regions, improving protected areas' social and economic sustainability.

Although the total land area in the parks system is fairly large, the NNPS does not adequately represent all of the important habitat types in the country (Polasky 1996). The national parks are concentrated in the Andes region with 18 units that include 2 million hectares. The Orinoquía region, however, has only one park, Parque El Tuparro. The Caribbean coast and marine areas are similarly underrepresented within the NNPS.

Despite the large number of newly created protected areas, deterioration of existing protected areas continues. This can be attributed to large-scale population displacement and colonization, illicit crop cultivation, lack of economic alternatives for people inhabiting the parks' surrounding buffer zones, lack of win-win agreements that provide incentives for the provision of environmental services, and weak institutional presence. Inadequate land use and the expansion of the agricultural frontier have also contributed to the occupation of protected areas.

Poverty and the lack of economic alternatives generate pressures on protected area conservation. Suboptimal resource use leads to soil degradation, ecosystem fragmentation, changes in ecosystem structure and functionality, and social and economic conflict over resource privileges. About 60 percent of the country's territory is used for unsustainable cattle ranching, creating degraded pastures where lands are suited for forests or agricultural use (IGAC 1988). Lack of benefits to local populations has led individuals and local communities to resist conservation efforts and to perceive national parks in their territories as illegitimate.

Illicit crop production leads to increasing environmental impacts in the country's natural forests and strategic ecosystems as follows: forest clearing to establish such crops, population displacement to vulnerable ecosystems because of the high expectations generated by illicit crop production, the arriving population's expansion of the agricultural frontier, investment of the economic surplus generated by illicit crop production into unsustainable cattle ranching, and water contamination from chemicals used during illicit crop planting and processing.

A lack of institutional coordination and long-term financial resources and mechanisms to consolidate the NPAS has also affected the scope of conservation initiatives carried out by national and regional institutions. While the NPA is the environmental regulatory agency in the areas within the NNPS, the CARs exercise their authority in the remaining national territory, including national park buffer zones. The NPAS legal framework still needs to be defined and its institutional and financial capabilities strengthened for it to effectively coordinate public and private conservation initiatives. Such initiatives include those promoted by the NNPS, local and regional protected areas, ethnic territories, and other private sector conservation and sustainable management strategies. Anthropogenic activities and their implications for the connectivity of the country's protected areas pose challenges that would need to be addressed by public and private sector groups committed to in situ conservation. Advances in this direction are described in the next section.

The Policy for Social Participation in Conservation

As noted, Colombian law created the national parks in 1959.[3] Regulations for the creation and administration of national parks were approved during the 1970s, but without public participation. In addition, these regulations did not include mechanisms to balance conservation interests with economic and development priorities. Under these circumstances, the implementation of conservation strategies with the participation of local stakeholders becomes a major challenge.

Although the 1991 Constitution recognizes the right of citizens to participate in decisions of environmental consequence, regulations written before that date remain in place. Before 2003, 47 national parks were created in areas overlapping traditional indigenous, Afro-Colombian, and peasant (*campesino*) communities. Although the creation of the parks affected the economies of those communities because the parks restricted the traditional uses of natural resources, there was no compensation.

In 2002, after wide consultations, the national government approved the Policy for Social Participation in Conservation.[4] This policy seeks to promote the design and implementation of conservation strategies in national parks with the broad participation of local stakeholders, including indigenous organizations and Afro-Colombian and *campesino* communities. This policy is not a legal instrument, however, and therefore is not legally binding or enforceable.

Using a case study approach, the following describes the process that led to the creation of the Corales del Rosario and Alto Fragua Indi Wasi National Parks and the mechanisms in place to balance stakeholder interests, before and after approval of the Policy for Social Participation in Conservation. The final section presents and analyzes the information discussed in the case studies and draws a series of lessons and recommendations.

In 1959, the Colombian Congress approved Law 02, the main objective of which was "promoting the forest economy and protecting the soils, waters and wildlife of the Nation." This law presented the concept of national natural parks for the "conservation of fauna and flora" that could be created by the Ministry of Agriculture, with technical support from the Colombian Academy of Sciences. Consistent with the thinking at the time, Law 02 of 1959 made no reference to the rights of the traditional local communities in the areas to be declared as national parks, or to their participation in the processes of creation and administration. Economic activities, other than tourism, were prohibited in those areas.

Following the enactment of Law 02 of 1959, six national parks were created between 1960 and 1968. Although all those parks were then inhabited by indigenous, Afro-Colombian, and *campesino* communities, and despite the severe restrictions imposed on the use of their natural resources, no consultations with local stakeholders were conducted. According to Law 02 of 1959, such consultations were not required.

During the 1960s and 1970s, the National Institute of Renewable Natural Resources (*Instituto Nacional de los Recursos Naturales Renovables*, INDERENA), the Agustín Codazzi Geographic Institute, and the Natural Resources Institute of the Universidad Nacional published information on the nature of Colombia's ecosystems and natural resources. Until 1993, the information gathered by those institutions provided the basis for the declaration of most of Colombia's national parks.[5]

The creation of the NNPS in 1974 by the National Code for Renewable Natural Resources and Environmental Protection (*Código Nacional de Rescursos Naturales Renovables y de Protección al Medio Ambiente*, CNRN) responded to the view of the director and employees of INDERENA who believed that national parks should not be perceived as separate units but rather as parts of a system, and that the government should administer them under coherent and unified criteria.[6]

According to Decree 2811 of 1974, the objectives of the NNPS are to "conserve the outstanding natural values of fauna, flora, landscapes; and historic, cultural and archeological relics . . ."; to "perpetuate the wild state of biological communities of physiographical and biogeographical regions, genetic resources and threatened species"; and to "protect natural, cultural, and historic phenomena and others of international interest to contribute to the preservation of the common patrimony of humankind."

In accordance with Law 02 of 1959, the CNRN made no reference to the rights of traditional local communities inhabiting areas to be declared national parks or to their participation in the process of the parks' creation and administration. Nor did the CNRN include provisions to secure the consideration of interests such as regional economic development and social equity.

Decree 622 of 1977 regulates the administration of the NNPS in greater detail. This decree prohibits the development of economic activities inside the areas of the park, including wood extraction, fishing, agriculture, cattle ranching, industry, oil production, and mining. However, this regulation notes that "the declaration of a national park is not incompatible with indigenous reserves . . . ." Consequently, Decree 622 allows national parks to be created over the traditional territories of indigenous communities. However, as in the case of Law 02 of 1959 and the CNRN, Decree 622 does not include provisions to ensure the participation of indigenous communities in the processes of declaration and administration of national parks.

The 1991 Constitution includes a series of economic, ethnic, and cultural rights (in its Chapters I and II) and the right of all citizens to participate in decisions of environmental relevance. In addition, the Constitution stipulates that the use of natural resources in the territories of indigenous communities must not harm the integrity of those cultures and that all citizens have the right to participate in decisions of environmental relevance. Clearly, prevailing regulations in relation to the creation and management of national parks are not always consistent with these constitutional precepts.

Law 99 of 1993 created the National Parks Unit within the Ministry of Environment with the mandate of administering the NNPS. Law 99 did not change prevailing regulations for the administration of national parks, namely Law 02 of 1959, the CNRN of 1974, and Decree 622 of 1977.

According to Law 02 of 1959, the CNRN, and Decree 622 of 1977, before creation of a national park the National Parks Unit must conduct scientific studies. Those regulations do not include the participation or representation of local communities (indigenous peoples, *campesinos*, fisher, miners, and so forth) during the process that leads to the creation of national parks. The content of the required studies has not been regulated, and the criteria for the definition of a park's boundaries have not been established. The required scientific studies must be reviewed by the Colombian Academy for Exact Physical and Natural Sciences (*Academia Colombiana de Ciencias Exactas Físicas y Naturales*) before a park is formally created by a Presidential Decree. If the areas to be included in the NNPS overlap with indigenous reserves, the relevant studies must be conducted jointly with the Colombian Institute for Agrarian Reform (*Instituto Colombiano de la Reforma Agraria*).

Colombia's 462 indigenous reserves (*resguardos indígenas*) occupy 30 million hectares covering approximately 26 percent of the country (Giugale 2003). Some 24 percent of the total area of indigenous reserves overlaps national parks. Of the 49 parks within that system, 33 are inhabited by indigenous groups (Unidad de Parques Nacionales 2001). In addition, there are 23 collective Afro-Colombian territories in approximately 3 million hectares of the Colombian Pacific Biogeographical region. They correspond to approximately 2.5 percent of the country's total area (Unidad de Parques Nacionales 2001). Traditional indigenous, Afro-Colombian, and *campesino* communities inhabit 47 of Colombia's 49 national parks.[7]

However, as noted, Colombian legislation does not include provisions to secure the participation of these communities during the creation and administration of the parks. According to several officials of the National Parks Unit, none of the parks that created overlapping traditional territories of indigenous, Afro-Colombian, and *campesino* peoples underwent a consultation process with local communities before 2003.[8] During 1960 to 1968 those decisions were made by the Ministry of Agriculture, during 1968 to 1994 by INDERENA, and during 1994 to 2002 by the National Parks Unit and the Ministry of Environment. The areas to be declared national parks, and their boundaries, were autonomously defined by the technical staff members of those institutions, on the basis of their own judgment. In most cases, the existence of a national park within traditional territories took communities by surprise. In cases such as the Catatumbo National Park, which was created in 1989, the communities did not find out or understand that they were part of a park until very recently.[9]

The regulations in place since Law 02 of 1959, which impose severe restrictions on the economic use of natural resources in the areas of the national parks, also limit the economic activities of indigenous communities. In addition, they make no reference to other poor communities (*campesinos*, Afro-Colombians, and so forth) that have traditionally lived in the national parks. A strict interpretation of the prevailing legislation leads to the conclusion that the economic use of natural resources by these communities, even for subsistence purposes, is illegal.[10] Consequently, they cannot benefit from government programs such as agricultural technology transfers and credits. Nor does the prevailing legislation include mechanisms to compensate local communities affected by the creation of national parks.

Implementation of conservation strategies in protected areas, created without taking into account the social and economic realities of the local stakeholders, seems challenging. At the heart of this challenge are the very severe restrictions that Colombian law has imposed on the economic use of natural resources inside the limits of national parks.

Several conflicts have arisen between the NNPS and indigenous, Afro-Colombian, and *campesino* communities whose territories overlap national parks.[11] Those conflicts arose from the restrictions imposed by Law 02 of 1959, the CNRN of 1974, and Decree 622 of 1977, in relation to the economic and commercial use and exploitation of natural resources in national parks. These communities, however, have not used the judicial system to defend the economic use of their traditional territories. The limited use of the judicial system by poor communities results from their lack of familiarity with their legal rights and their lack of access to the system (Quintero and Iguarán 2001).

Some of these conflicts have occurred with fishing communities in the Corales del Rosario, Flamencos, Salamanca, and Tayrona National Parks on the Caribbean Coast, and in the Utria and Sanquianga National Parks on the Pacific Coast, the latter created with over 10,000 inhabitants of traditional Afro-Colombian communities. Conflicts have also occurred with agricultural communities in the Chingaza, Galeras, and Los Nevados National Parks in the Andean Region and with miners and indigenous communities in the Cahuinarí National Park in the Amazon.

These conflicts have recently been documented in films and interviews with community leaders.[12] In these reports, community leaders have argued that the parks were not only created overlapping their traditional and sacred territories, but that measures and norms adopted by the National Parks Unit affected them economically by restricting their traditional use of and commerce in natural resources. More recently, indigenous and Afro-Colombian communities have argued that they are also authorities, vested by law, to manage these territories, with attributes similar to those of the government.[13]

In contrast with the national parks legislation, which predates the 1991 Constitution, the Colombian legislation relative to the rights of indigenous communities underwent important developments during the 1990–2000 decade. The 1991 Constitution recognized the right of indigenous communities to organize autonomous institutions for the administration of their traditional territories and public affairs. In 1993, the Colombian government approved Convention 169 of the 76th meeting of the International Labor Organization held in 1989. This convention protects the ethnic rights of indigenous communities, including their territorial rights and traditional cultures. By Decree 1088 of 1993, the government regulated the creation of Associations of Indian Reserves and of Traditional Indigenous Authorities. These are autonomous forms of government recognized by the Colombian government. They can undertake social programs with resources transferred by the national government. Currently, indigenous authorities claim the same authority as the National Parks Unit in the overlapping territories.[14]

The case of the extension of the Corales del Rosario National Park is a typical example. Since the mid-1950s, the islands of the El Rosario archipelago in the Colombian Caribbean have been a recreation site for affluent visitors from Barranquilla, Bogotá, Cali, Cartagena, and Medellín.[15] Its surrounding waters have been a fishing area for traditional communities of the region. In May 1977, the board of directors of INDERENA created the Corales del Rosario National Park. Today, there are 120 vacation homes in the islands of the archipelago. The park has an area of 19,500 hectares over the coral reefs and other marine ecosystems that surround the 30 small islands of the archipelago. However, the park included only 2 of the 30 islands; therefore, it is largely an underwater park.[16]

The San Bernando archipelago is located south of the El Rosario archipelago and includes seven small islands, their associated mangroves and coral reefs, and other underwater ecosystems (Díaz 1998). The area has been traditionally inhabited or visited by local Afro-Colombian fishing communities (Sierra 2002) whose main traditional economic activity has been lung diving for lobsters and snails. As with the Rosario Islands, the beauty of the San Bernardo islands also attracted the interest of affluent vacationers who, to date, have built 60 houses on those islands. The San Bernando archipelago was not originally included in the national park created in 1977.

The San Bernardo islands and their associated coral reefs and marine ecosystems have severely deteriorated since the beginning of the 1980s (Díaz 1998). The bleaching of coral reefs extended significantly (Ramirez, Miranda, and Viña 1994), and overfishing diminished the rates of capture of some species (Mora 1994). By 1995, fishing communities of the San Bernardo islands knew that the size of the fishing stocks was declining and that fishing effort had increased with time.[17] They attributed the growing scarcity of fish to overexploitation by commercial fishing boats from Cartagena, the closest city on the mainland.

Ecological information gathered by the National Parks Unit in 1996 provided evidence that the El Rosario and San Bernardo archipelagos are not independent. According to that information, there are functional relations between the two archipelagos and the conservation of both areas is important for the maintenance of their ecological processes. Aware of the deterioration of the San Bernardo archipelago and of its ecological importance, the Minister of the Environment decided to extend the area of the Corales del Rosario National Park to include the San Bernardo archipelago.

The new extended park was created in December 1996 during the inauguration ceremony of the new headquarters of the Ministry of Environment. As with the park's original islands (El Rosario islands), the decision was based solely on ecological information. No social evaluation or consultation preceded the creation of the new extended park (established by Decree 1425 of 1996). The decision again negatively affected the traditional rights of the local fishing communities. The new extended park was called the Corales del Rosario and San Bernardo National Park. Its original area was increased from 19,500 hectares to 120,000 hectares, including the original areas of the Corales del Rosario National Park and the associated underwater ecosystems of the San Bernardo archipelago. It also includes two of the seven emerged islands of this archipelago.[18] Close to five years passed before the traditional inhabitants of the San Bernardo archipelago gradually became aware of the existence of a national park in their traditional fishing areas.[19]

The Ministry of Environment, through its National Parks Unit, has jurisdiction over the areas included in the Corales del Rosario and San

Bernardo National Park—that is, 4 of the 37 islands of the 2 archipelagos and their underwater ecosystems. The National Parks Unit has no authority over the activities that take place on the 33 remaining islands. The municipality of Cartagena has control over construction activities that take place on those islands.

To this day, the presence of the National Parks Unit in the San Bernardo archipelago has been "limited and sporadic."[20] It was not until 2000 that the National Parks Unit sent personnel to this archipelago. Today, four people are assigned to the San Bernardo archipelago. The processes of deterioration that motivated the creation of the new extended park are still in place[21]: overfishing, fishing with explosives by native communities, and illegal construction of houses and docks on the islands.

The prevailing tensions between the National Parks Authorities in parks such as Utría, where native Afro-Colombian communities occupied the park to protest their lack of participation in the park's creation and management in 1994, led the National Parks Unit to rethink its strategy with communities.[22] A factor that facilitated the development of a new policy for national parks was that Juan Mayer and Juan Carlos Riascos, Minister of the Environment and Director of the National Parks Unit, respectively, during 1998 to 2002, were traditional leaders of the environmental movement in Colombia. They had directed important national nongovernmental organizations (NGOs)[23] and had developed community work in protected areas. Their experience with local communities in protected areas gave them a clear vision of the role of social participation in conservation.[24]

The Policy for Social Participation in Conservation was approved in August 1999 by the National Environmental Council.[25] The council, headed by the Minister of the Environment, comprises representatives of different economic sectors, including minority groups, and is responsible for the approval of national environmental policies.[26]

The policies approved by the National Environmental Council do not have legal status and are consequently not enforceable or legally binding. It is possible that the policies approved by the council are not always in harmony with the content of existing regulations, and in some cases, the implementation of those policies may require changes in regulations or approval of new regulations. In fact, the Policy for Social Participation in Conservation values community participation in conservation and contains a set of good-practice principles for consultation with the local community on diverse issues related to a protected area, whereas prevailing national park regulations completely ignore this issue. Full implementation of this policy would require regulatory changes to secure community participation in conservation.

The Policy for Social Participation in Conservation was the result of a wide, democratic process of consultation with government officials, NGOs, indigenous communities, members of Congress, multilateral agencies, and the national government. The active participation of indigenous communities in the consultation processes led to the approval of this policy (Correa 2002), which is more consistent with the 1991 Constitution than existing national park regulations on matters of social participation. However, the traditional national park regulations remain enforceable, while the policy has no legal status.

The Policy for Social Participation in Conservation seeks to protect NNPS areas by designing and implementing conservation strategies with the broad participation of local stakeholders, including indigenous organizations and Afro-Colombian and *campesino* communities. "This new policy is based on the recognition that there is a close and inseparable interdependence between the conservation of biological diversity and the protection of the cultural wealth of the nation."[27]

More than defining specific strategies for conservation, the Policy for Social Participation in Conservation is an agreement on the principles to build and adjust these strategies at the local level (Unidad de Parques Nacionales 2001). The policy includes a mix of objectives that seek to strengthen the capacity of social organizations and communities to participate in the implementation of conservation strategies. It also aims at strengthening the institutional capacities of the National Parks Unit and at increasing public awareness of the social value of national parks at the local and national levels. Coordinated implementation of the policy is the responsibility of the National Parks Unit of the Ministry of Environment.

The Policy for Social Participation in Conservation does not include provisions related to the criteria for the selection of new national parks. It indicates that, in all cases, local stakeholders should participate in the selection of the areas and in their administration. Because this policy is not legally binding, however, the right of local stakeholders to participate in the conservation of national parks is not guaranteed. Only a reform of prevailing regulations, mainly the CNRN approved in 1974 and Decree 622 of 1977, could guarantee such participation.

After the Policy of Social Participation in Conservation was approved, two new areas were added to the National Parks System through consultation processes and agreements with local indigenous communities. One of these was the Alto Fragua Indi Wasi National Park, created in 2002 after a broad participation process with local indigenous communities (Zuluaga 2002). In fact, the park was created in response to an initiative by those communities (Jiménez 2002).

Since the National Parks Unit began to implement the Policy for Social Participation in Conservation, almost 80 agreements have been reached with local communities throughout the country.[28] These agreements seek to define management schemes with local and native communities, develop life plans (*Planes de Vida*) of indigenous communities in a simultaneous process with the parks' Management Plans, create consultative boards for different parks with the participation of communities and the National Parks Unit, develop sustainable economic alternatives for communities, and, in some cases, define internal rules regarding the use of natural resources by communities.[29]

Implementation of this policy has been effective in securing greater support from local and native communities in the conservation and sustainable management of different parks, and for helping to solve historic conflicts with local stakeholders, including indigenous groups, and the Afro-Colombian, fishing, and *campesino* communities:

- In the Corales del Rosario National Park, traditional Afro-Colombian fishing communities are now working with the National Parks Unit on restricting overexploitation of lobster and other fish stock and promoting the participation of local communities in ecotourism. As a result of this participatory management strategy, during 2001 to 2002 there was a 70 percent reduction in the capture of undersized lobsters.[30]

- In the Galeras National Park, the park administrator recently recognized that peasant communities, which used to receive park employees with machetes before the implementation of the policy, are now working with the unit in the development of sustainable agricultural systems in buffer zones. Since 2001, no forest fires have occurred in those sectors of the park where 1,200 families work with the unit.[31] In contrast, in those sectors of the park where the National Parks Unit is not yet working with communities, forest fires are frequent.

- Several parks, including the Cahuinarí and the Alto Fragua Indi Wasi, in the Amazonian region, have co-management schemes with indigenous communities. In the Cahuinarí National Park, where the Bora-Miraña community leaders traditionally opposed the creation of a national park on their territories, a consultative body currently makes joint decisions regarding the park's management. In this case, the indigenous communities have undertaken zoning processes and have constructed maps where they have "helped the National Parks Unit to understand what we have always thought of our territories."[32] In this case, the traditional indigenous authority oversees compliance with fishing quotas and applies sanctions when a member of the community defies the established rules. In 2003, the indigenous communities of this park drove away 23 illegal (Brazilian-Colombian) gold mining operations (*dragas*). This occurred in coordination with the local staff of the National Parks Unit, and without the intervention of the armed forces.

- In 2003, in the Amacayacu National Park, located in the Amazonian flood plains, the indigenous communities that inhabit the area confiscated a shipment with 28,000 pieces of precious wood that had been illegally extracted from the park. This was a result of coordinated and agreed actions between the National Parks Unit and local communities.[33]

Although in several parks the participation of local communities in conservation efforts has increased, most of these communities derive their livelihood from the economic use of the parks' natural resources. As indicated, strict interpretation of Law 02 of 1959, of the CNRN, and of Decree 622 of 1977 would lead to the conclusion that, in most cases, such economic activities are illegal.[34] For these regions, the Policy of Social Participation in Conservation has concentrated sustainable production processes and land zoning in buffer zones of the national parks.

Toward the southeastern part of Colombia, in an area where the Andes descend rapidly from the cloud forest to the Amazonian forests, there is a region of large biological diversity (Etter 1998). This region has traditionally been inhabited by various indigenous groups of the Ingano family. The biological and cultural values of this region are threatened by colonization, deforestation, [and] illicit crops that could ". . . lead to severe environmental deterioration and to the disappearance of indigenous cultures" (Zuluaga 2002 as cited in Universidad de los Andes 2004, p. 25).

The 1991 Constitution and Law 21 of 1991 recognized organizations of indigenous communities as public authorities. As such they had to design and undertake development plans. The Tandachiridu Inganocuna Association of Indian Reserves of the Inganos adopted their plan in 1998. It is called a Life Plan (*Plan de Vida*),[35] and has three components: conservation of their ancestral territory and its resources, protection of their cultural identity and traditions, and strengthening of their traditional medicine.

Since 1983, Germán Zuluaga, a medical doctor and current director of the Ethnobiological Institute—an organization dedicated to promoting the conservation of traditional territories and medicinal plants—has maintained close relations with the Ingano communities as he investigated and published information related to their medical traditions (Zuluaga 1994). He communicated the interest of the Ingano communities in securing protection of their traditional territories to the director of the National Parks Unit. This initiated conversations and a negotiation process, which led to the creation of the Alto Fragua Indi Wasi National Park.

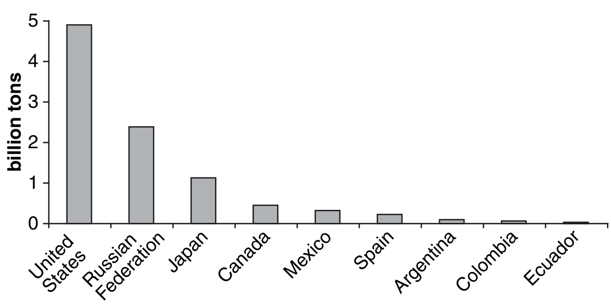
To conduct the technical studies required by law, the Von Humboldt Institute, the National Parks Unit, and the Tandachiridu Inganocuna Association conducted an evaluation of the biological resources of the La Fragua region during 2000 (Instituto Von Humboldt and others 2001). Those studies reported that there were extensive and well-preserved forests with little intervention in that region. Their indexes of biological diversity were among the highest ever reported in Colombia. Threatened species and potentially new species were found. Highly diverse insects and birds and a high frequency of endemism[36] were reported. The importance of the biological and ecological resources of the area was related to its geographical position in the transition between the highlands of the Andean region and the low Amazonian forests. The Von Humboldt Institute, the National Parks Unit, and the Tandachiridu Inganocuna Association complemented their biological evaluation with a cultural survey of the area, and identified sacred places, traditional paths, and areas where medicinal and sacred plants are endemic (Instituto Von Humboldt and others 2001).

Through those studies, the Inganos and the national government found common reasons to protect the natural and biological resources of the La Fragua region. In the conservation of La Fragua, the Inganos saw an opportunity to advance their *Plan de Vida* for the reconstruction of their culture. An important element of the plan is their increased control over the traditional forest territories, where some of their medicinal and sacred plants are endemic. Neither *campesinos* nor other communities were in the territories included within the boundaries of the Alto Fragua Indi Wasi National Park, nor were permanent dwellings of the Ingano communities within the area; the Inganos did not develop agriculture, economic, or any other productive activities in the area and were interested in preventing the advance of colonization. Consequently, they had little or nothing to give up with the creation of the national park. Those territories, however, were visited regularly by the members of the Ingano communities because they include sacred sites and harbor endemic plants that are part of their traditional medicine. The government has not granted formal property rights (*resguardos*) to the Ingano communities over those territories, but the Ingano have gained the more active involvement of the Colombian government in the protection of a region that they consider strategic for the conservation of their culture.

Climate Change

Colombia's contribution to GHG emissions is less than 0.3 percent; its CO_2 emissions in 1990 were the equivalent to 1 percent of U.S. emissions and 5 percent of Japan's, and were significantly less than other Latin American countries such as Mexico and Argentina. For example, Colombian CO_2 emissions in the transport sector are about one-fifth as much as the comparable emissions of Mexico and about two-thirds as much as those of Argentina. Figure 13.2 compares total CO_2 emissions in Colombia with those of selected developed and developing nations. In 2002, the National Inventory of GHGs was drawn up by IDEAM, covering the period from 1990 to 1994. Table 13.2 displays GHG emission estimates by gas and by sector.

Figure 13.2 Total CO_2 Emissions in Colombia Compared with Other Countries, 1990



Source: Colombia's First National Communication to the United Nations Framework Convention on Climate Change.

Table 13.2 Colombia's GHG Emissions by Gas and Sector, 1994

	Emissions (gigagrams of CO_2 equivalents)			
Sectors	*CO_2*	*CH_4*	*N_2O*	*Total*
Energy	55,351.7	5,972.4	476.6	61,800.7
Industrial processes	5,212.3	8.2	77.5	5,298.0
Agriculture	n.a.	34,319.5	27,126.6	61,445.1
Land-use change and forestry	16,540.0	88.7	9.0	16,637.7
Waste	n.a.	4,601.4	625.0	4,686.4
Total	77,103.9	44,450.1	28,313.7	149,867.8

Source: IDEAM referenced by Blackman and others (2005).
Note: n.a. = not applicable; CH_4 = methane; N_2O = nitrous oxide.

Overall, Colombia emitted 129.4 million gigagrams of GHGs (expressed as CO_2 equivalents) in 1990. In 1994, emissions rose to 149.9 million gigagrams (also expressed as CO_2 equivalents), an increase of about 16 percent over the four-year period. In both 1990 and 1994, emissions from the energy and industrial process sectors accounted for almost 45 percent of total emissions. In 1990, emissions from the agricultural sector accounted for almost 43 percent of total emissions, in the form of methane (CH_4) and nitrous oxide (N_2O). In 1994, that proportion fell slightly to 41 percent. The land-use change and forestry sector accounted for 9.3 percent of total emissions in 1990, almost entirely in the form of CO_2. In 1994, that proportion rose to 11.1 percent. The waste sector accounted for the remaining 3 percent of emissions, in the form of CH_4 and N_2O. In 1994, the rate of capture (sequestration) in Colombia was almost 40 times greater than the annual emissions (Blackman and others 2005).

Colombia adopted the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it on March 2, 1995. Under the convention, Colombia agreed to conduct an inventory of its contributions to global warming, an initial assessment of domestic vulnerabilities to climate change, and a preliminary examination of policy options for both adaptation and mitigation. The convention also established an ongoing process for developing and updating international commitments through regular Conference of the Parties assemblies.

In December 1997, Colombia signed the Kyoto Protocol, which establishes national emissions targets for developed country signatories and contains several incentives for international cooperation to promote cost-effective GHG abatement in the developing world. Among the incentives is the Clean Development Mechanism (CDM), which is designed to generate both cost-effective GHG reductions and sustainable development benefits for host developing countries.

Pursuant to its obligations under the UNFCCC, Colombia prepared its First National Communication (March 2002). The First National Communication identified potential vulnerabilities to climate change across the country, including coastal zones, water resources, high plateau zones, glaciers, and other ecosystems, soils, and land affected by desertification, vegetation covers, and agricultural and health impacts. By 2005, the Second National Communication had been completed. Colombia has also taken steps to organize a range of domestic activities to address issues relating to both mitigation and adaptation.

The First National Communication describes economic opportunities in a number of sectors, including the evolving market for CO_2 sequestration credits in the forestry products sector. The First National Communication also indicates a capacity for expansion in relatively high-value products such as cocoa, exotic oils, flowers, processed food, and shrimp breeding. To assess the nation's potential vulnerability to climate change and the opportunities for adaptation, Colombia has undertaken a number of broad-ranging scientific, economic, and engineering studies. Individual analyses focused on impacts associated with sea-level rise, desertification, vulnerability of the hydrological regime, vulnerability of high mountain ecosystems, and impacts on agriculture and on human health.

Since 1994, Colombia has undertaken a number of actions to reduce GHG emissions, and has taken advantage of the CDM established by the Kyoto Protocol. The principal goal of the CDM is to support project-based GHG reductions in developing nations to be transformed into Certified Emission Reductions (CERs). In turn, these CERs become available to countries or companies as credits that can be used as a means of meeting individual Kyoto emission control commitments. Because many abatement opportunities are less expensive in developing nations, the CDM can help reduce the overall cost of achieving global GHG reductions.

By April 2005, a number of projects were under development in Colombia: Jepirachi (wind power), Agua Fresca (small hydro/renewables), La Vuelta and La Herradura (large hydro), and TransMilenio (transport). In addition to the projects reported by CDM Watch, two others are also under development: Amoya (run-of-river hydro) and Furatena (energy efficiency).[37]

The Jepirachi Wind Farm project was developed by the Medellín Public Utilities (*Empresas Públicas de Medellín*, ESP). ESP signed an agreement with the Prototype Carbon Fund to sell 800,000 metric tons of GHG emission reductions from the 19.5 megawatt Jepirachi Wind Power Project, in the department of La Guajira. This is the first project to be carried out in Colombia within the CDM framework. Once completed, it is expected that the 15 windmills will deliver 68.3 gigawatt hours per year to the national grid. Over a 21-year period, the project will reduce emissions by 1.168 million tons. The Prototype Carbon Fund has agreed to pay a premium of US$0.50 (Col$1,075) per ton of emission reductions upon implementation of the plan. This purchase agreement contains a clause that lays out the conditions under which the premium will be paid, namely upon delivery of the emission reductions and upon verification that the social plan has been implemented.

The La Vuelta and La Herradura project is designed to harness the capacity of La Herradura River by means of two subprojects in a chain

(La Herradura and La Vuelta). With a total installed capacity of 31.5 megawatts, the project will improve electricity service in western Antioquía, contribute to regional development, improve security by means of distributed generation, and reduce CO_2 emissions. ESP is the developer. The project will generate revenues of about Col$420 million (US$200,000) per year for the municipalities in the area.

The Agua Fresca Hydroelectric Project is a small-scale, run-of-river generating facility that aims to generate 420,200 CERs in the first seven years of operation. It is expected that 208,000 CERs will be generated by 2012. Participants include *Aguas de la Cabaña Generadora Unión SA*, and *Va Tech Bouvier Hydro Empresas Públicas de Medellín*.

The Furatena Energy Efficiency Project will support improvements through the use of improved high-efficiency burners at about 120 small family-owned plants, enabling them to process *panela* (raw sugarcane juice) into molasses. This improves energy efficiency and enables the communities to use *bagasse*[38] as fuel instead of old tires. Total project cost is estimated to be Col$2,100 million (US$1 million). Farmers and the town will provide 20 percent of the equity. The balance is to be secured by the Financial Fund for Agriculture and Cattle Ranching. A contribution from the Community Development Carbon Fund is sought for about Col$1,470 million (US$0.7 million) over 14 years. Expected emission reductions are about 127,000 tons of CO_2 equivalent.

In addition to these projects, the Colombia Climate Change Office reported that eight more projects for reduction and sequestration of GHGs were being considered as of March 2004. In addition to the specific project activities reported earlier, other activities are also underway to promote GHG abatement and sequestration. For example, a report issued by German Agency for International Technical Cooperation proposes a method for formulating CDM projects and preparing a generic portfolio of CDM-eligible projects for Colombia's energy sector.

Ozone Depletion

The ozone layer shields the earth from ultraviolet radiation from the sun, serving as a shield at the stratosphere level. Chlorofluorocarbons (CFCs), chemical substances used particularly in refrigerators, freezers, air-conditioning equipment, aerosols, and plastics, are substances causing the most depletion of the ozone layer. Although 90 percent of global emissions are generated in industrial countries of the northern hemisphere, they are displaced by the wind to the southern hemisphere during springtime. The U.S. Environmental Protection Agency has stated that every 1 percent decrease in ozone could result in a 2 percent increase in skin cancer and in related health problems, particularly in countries in the southern hemisphere close to the Antarctic.

Following the discovery of the Antarctic ozone hole in late 1985, governments recognized the need for stronger measures to reduce the production and consumption of ozone-depleting substances (ODS). To this end, the Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in 1987.

The Montreal Protocol

Colombia ratified the Montreal Protocol in 1989 and it was approved by Congress through Law 29 of 1992. Colombia's participation in the protocol was defined by a country program submitted to the Multilateral Fund on January 18, 1994 (DNP 1995). The Country Program Document assessed the consumption levels of ODS in different industrial sectors and included the design of an action plan to phase out the consumption of these substances. Simultaneously, the government established an implementing unit, the Ozone Technical Unit (*Unidad Tecnica de Ozono*, UTO).

Total consumption of ODS in Colombia accounts for less than 0.45 percent of global consumption. According to the country program, the most significant levels of ODS consumption resulted from domestic, commercial, and industrial refrigeration maintenance, with 43 percent of the total, followed by commercial refrigeration (16 percent), foams (12 percent), and halon consumption (11 percent each).

Implementation of the Protocol

Although its contribution to this global problem is minimal, Colombia has made significant advances and has become one of the leading countries in the region in eliminating ODS. Colombia is committed to a gradual elimination of ODS with respect to its baseline, with a scheduled reduction in ODS imports of 50 percent by 2005, 85 percent by 2007, and 100 percent by 2010. To fulfill its voluntary commitments, the UTO has designed a National Elimination Plan based on CFC substitution in the commercial refrigeration sector, CFC reduction in the maintenance sector, and elimination of halon imports.

Colombia reached a 60 percent reduction of ODS in 2005, beyond the agreed commitment of 50 percent. Since 2001, vehicular assembly in Colombia has not used CFCs for air conditioning, and there is no reported use of halons and aerosols. In 1998, the country implemented a manufacturing standard for household and commercial refrigerators. Today, 100 percent of household refrigeration equipment and 90 percent of commercial refrigeration has been reconverted. In 2003, a second phase of the National Elimination Plan totaling Col$9,450 million (US$4.5 million) was submitted and approved by the Executive Committee of the Montreal Protocol to be carried out by 2010.

External assistance has been provided by the United Nations Development Programme, the United Nations Environment Programme, the United Nations Industrial Development Organization, and the World Bank. Since the creation of the UTO in 1994, 51 industry projects have been approved to eliminate ODS. Nearly 70 percent of the resources have been assigned to individual projects in large companies in the refrigeration and polyurethane foam sectors, followed by umbrella projects in small and medium companies with similar productive processes.

Conclusions and Recommendations

Biodiversity

Most national parks in Colombia were selected solely on the basis of ecological considerations. Other factors such as cultural diversity, traditional productive processes, economic expectations, and property rights of inhabitants were not taken into account, nor were broader considerations such as regional and economic development.

Decisions about creating Colombia's national parks have been made on the basis of recommendations of the technical and scientific staff members of the different institutions responsible for administering the parks over the years. Other stakeholders at the local, regional, and national levels have not been able to express their views regarding the creation of these protected areas. Consequently, most of Colombia's national parks have not resulted from balanced and equitable agreement processes.

The creation of national parks by the government, without taking into account local economic, cultural, and social realities and expectations, has been detrimental to the rights of local stakeholders. Protected areas legislation, which is still in effect, has severely limited the use of traditional production systems and natural resources by local inhabitants, allowed parks to be created without compensation, and made many traditional economic activities illegal.

The implementation of conservation plans in protected areas that were created solely on the basis of ecological information, ignoring local social and economic realities and broader regional and national priorities, poses significant challenges. At the local level, those challenges derive from the very severe restrictions that Colombian law has imposed on the economic use of natural resources within the limits of the national parks.

To harmonize national park regulations with the 1991 Constitution, the Universidad de los Andes (2004) has suggested a potential amendment to Law 02 of 1959, the CNRN of 1974, and Decree 622 of 1977. Future regulations could ensure the effective participation of all relevant actors and interests at the local, regional, and national levels. In addition, special consideration might be given to the inclusion of the most vulnerable stakeholders (instead of being limited to the indigenous communities) in these processes.

Greater involvement of local stakeholders through application of the Policy for Social Participation in Conservation has already begun to show positive results, even though this policy has only recently been applied. Since the adoption of this policy in 1999, several agreements have been reached between the government and traditional communities in the national parks. These agreements include the creation of coordinating mechanisms for the conservation and sustainable economic use of the protected areas. The support and involvement of local communities in the implementation of conservation strategies have increased in several parks. This is true even in those cases where there had been conflicts in the past between local communities and the responsible governmental agencies (Universidad de Los Andes 2004).

Since the Policy for Social Participation in Conservation does not have legal status and is contradictory to prevailing regulations, reform of the existing legal framework might align current regulations and the policy. Future reform of the regulatory framework might take into consideration the good-practice principles of that policy and fully recognize the constitutional rights of the local *campesino*, indigenous, and Afro-Colombian communities. A reformed regulatory framework should also ensure the equitable participation of all relevant actors, including the most vulnerable and the poor, in decisions related to the conservation and economic use of protected areas (Universidad de Los Andes 2004).

Although an Intercultural Coordination Committee was created for administering the Alto Fragua Indi Wasi National Park, and for preventing and addressing potential conflicts between indigenous communities and the national government, no provisions have been made to deal with the potential conflicts that could arise with the *campesino* communities that are colonizing and advancing with forest clearings toward this national park in particular or national parks in general. Future regulations might also include provisions to prevent and to deal with those potential conflicts, and might include development of institutional mechanisms to prevent and solve conflicts between conservation interests and other social priorities such as regional, social, and economic development (Universidad de Los Andes 2004).

Future regulations might consider efforts to define with greater precision the criteria for the selection and delimitation of national parks, the conditions that justify their creation, the consultation processes required, and the coordination mechanisms for their administration. Those regulations might consider ensuring that in the process of creating a national park and in the definition of its boundaries, special attention is given to the potential implications for regional and local economies. In particular, this might be the case when poor communities are involved. Future regulations might also consider ensuring that fair compensation is provided (Universidad de Los Andes 2004).

Future regulations should allow for the development of ecologically sustainable production processes by local communities within national parks, and for the protection of property rights in those protected areas. For these purposes, Law 02 of 1959 and the CNRN should be reformed (Universidad de Los Andes 2004).

Climate Change

Colombia has undertaken diverse activities to address the issue of climate change, and based on the information presented in this chapter, it might consider continuing current efforts on the long-term aspects of the problem. The main priority with respect to climate change might include the design and implementation of an adaptation strategy. By its very nature, climate change is a cross-cutting issue that involves many levels of government and many agencies. Additional capacity building and strong management direction at the national level are needed to ensure the most effective and cost-effective management response. Suggestions include the establishment of an information clearinghouse and the designation of one national-level entity to coordinate efforts to this end. Regarding mitigation activities, it is clear there are many opportunities to advance the twin objectives of economic development and GHG mitigation in Colombia. The Climate Change Mitigation Office is already promoting the CDM and providing support to developers on specific projects. For the continuation of activities in this area, it would be advisable that enhanced support be offered to project developers.

Table 13.3 Recommendations to Control Biodiversity Loss and Other Global Environmental Problems

Recommendations	*Priority: short (S), medium (M), and long term (L)*	*Participating institutions*
Develop an evaluation of the NNPS that incorporates cultural, regional, and economic considerations and involves stakeholders through participation processes; institute reforms for the development of ecologically sustainable production processes by local communities within national parks	M	MAVDT
Reform Law 02 of 1959, the CNRN of 1974, and Decree 622 of 1977 to harmonize them with the precepts of the 1991 Constitution	L	Congress, MAVDT
Reform the existing legal framework to solve the inconsistencies with the Policy for Social Participation in Conservation	L	Congress, MAVDT
Conduct a valuation of current and potential economic surplus generated as a result of the sustainable use of biodiversity	L	Donors, development partners
Continue taking advantage of financing opportunities posed by the Montreal Protocol	M	Montreal Protocol, Private sector

Source: Authors.
Note: MAVDT = *Ministerio de Ambiente, Vivienda y Desarrollo Territorial*.

Ozone Depletion

Colombia has taken significant regulatory and implementation actions to reduce ODS under the Montreal Protocol and the Vienna Convention. It might also consider continuing its efforts in this area, with priority assigned to expanding current efforts to small companies, particularly in the refrigeration maintenance sector where controlling and eliminating ODS is most difficult, strengthening the legal framework by establishing mandatory certification for maintenance technicians; and completing the design and further implementation of regional strategies.

Table 13.3 provides a summary of the recommendations made in this chapter.

Notes

1. Kulsum Ahmed, Richard Morgenstern, and Carolina Urrutia are the authors of this chapter.
2. Tropical forests present a complex landscape, the product of relationships, practices, techniques, fears, and preferences of the societies that inhabit them. The "reserve of biodiversity" is in part the cultural result of the daily, economic, and material practices of the groups that have traditionally inhabited the region.
3. This section draws heavily from a 2004 case study prepared by the Universidad de Los Andes for this report.
4. Unidad de Parques Nacionales de Colombia–Política de Participación Social en la Conservación, 2001.
5. Information is also provided from an Universidad de los Andes case study consultants with Julio Carrizosa, Margarita Botero, and Manuel Rodríguez, former INDERENA directors (March 2004, Bogotá).
6. See the interview by Universidad de los Andes case study consultants with Julio Carrizosa, INDERENA's director during 1973 to 1978 (July 2004, Bogotá).
7. The exceptions are Gorgona National Park (an island on the Pacific coast) and the Chiribiquete National Park in the center of the Colombian Amazonian Region.
8. See the interview by Universidad de los Andes case study consultants with Carlos Acosta, adviser to the director of the National Parks Unit responsible for coordinating participation processes with Afro-Colombian and indigenous communities (Bogotá, March 2004).
9. See the interview of Universidad de los Andes case study consultants with Carlos Acosta and Lavinia Fiori, Coordinators of the Environmental Component of the Dutch Institutional Strengthening Program of the National Parks Unit (Bogotá, March 2004).
10. See the interview of Universidad de los Andes case study consultants with Eugenia Ponce, expert on national park regulations (March 2004, Bogotá).
11. See the interview of Universidad de los Andes case study consultants with Sandra Valenzuela, legal advisor to the director of the National Parks Unit; Carlos Acosta, Coordinator of Participation Processes; and Lavinia Fiori, Coordinator of Environmental Education and Communication for the Dutch Institutional Strengthening Program of the National Parks Unit (Bogotá, March 2004).
12. See the interview of Universidad de los Andes case study consultants with Lavinia Fiori, Coordinator of the Environmental Component of the Dutch Institutional Strengthening Program of the National Parks Unit, who has filmed these testimonies (Bogotá, March 2004).
13. See the interview of Universidad de los Andes case study consultants with Arregocés Conchacalá, Cabildo Gobernador and leader of the Kogui

Indigenous group. This indigenous group inhabits the Sierra Nevada of Santa Marta, which includes two national parks (Santa Marta, April 2004).

14. See the interview with the Legal Group of the National Parks Unit (Bogotá, March 2004).
15. See the interview of Universidad de los Andes case study consultants with Clara Sierra, manager of the park during 2002 to 2004 (Bogotá, April 2004).
16. These two islands, El Tesoro and El Rosario, were included as a part of the national park by INDERENA Agreement 093 of 1987.
17. See the interviews by Universidad de los Andes case study consultants with Clara Sierra and Clara Osorio, managers of the park during 2002 to 2004 and 1992 to 1994, respectively (Bogotá, April 2004).
18. These are the islands of Maravilla and Mangle.
19. See the interviews of Universidad de los Andes case study consultants with Clara Sierra and with Clara Osorio, managers of the park during 2002 to 2004 and 1992 to 1994, respectively (Bogotá, April 2004).
20. See the interviews of Universidad de los Andes case study consultants with Clara Sierra and with Clara Osorio, managers of the park during 2002 to 2004 and 1992 to 1994, respectively (Bogotá, April 2004).
21. See the interview of Universidad de los Andes case study consultants with Clara Sierra, manager of the park during 2002 to 2004 (Bogotá, April 2004).
22. See the interview of Universidad de los Andes case study consultants with Juan Carlos Riascos, director of the National Parks Unit (January 2004).
23. Mr. Mayer was director of the Prosierra Foundation, which developed activities in the Sierra Nevada National Park. Mr. Riascos was director of Fundación Herencia Verde, which developed community conservation activities in the buffer zones of the Los Nevados National Park.
24. See the interviews of Universidad de los Andes case study consultants with Juan Mayer and Juan Carlos Riascos (Bogotá, July 2004).
25. The policy was created by Article 13 of Law 99 of 1993.
26. Council members include representatives of municipal and regional governments (Gobernaciones) and of indigenous and Afro-Colombian communities; producers' associations (agricultural, mining, forest, and manufacturing) and exporters; NGOs; universities; and the Ministries of Agriculture, Defense, Education, Foreign Trade, Mines and Energy, National Planning, Social Protection, and Transportation.
27. See the interview of Universidad de los Andes case study consultants with Juan Carlos Riascos, director of the National Parks Unit during 1998 to 2004 (Bogotá, December 2003).

28. See the interview of Universidad de los Andes case study consultants with Carlos Acosta, advisor to the director of the National Parks Unit on issues related to participation of local groups (Bogotá, February 2004).
29. See the interviews of Universidad de los Andes case study consultants with Carlos Acosta, advisor to the director of the National Parks Unit on issues related to participation of local groups with the National Parks Unit and current director of the Dutch Program for Parks in the Pacific, and with Lavinia Fiori, Coordinator of Environmental Education for the Dutch Program for Institutional Strengthening of the National Parks System (Bogotá, April 2004).
30. See the interview of Universidad de los Andes case study consultants with Lavinia Fiori who coordinated a project funded by The Nature Conservancy with native communities in the islands of the Corales del Rosario National Park (Cartagena, February 2004).
31. See the interview of Universidad de los Andes case study consultants with Nancy Builes, director of the Galeras National Park (Bogotá, February 2004).
32. See the interview of Universidad de los Andes case study consultants with Lavinia Fiori of the National Parks Unit in a documentary currently under production.
33. See the interview of Universidad de los Andes case study consultants with Juan Carlos Riascos, director of the National Parks Unit (Bogotá, December 2003).
34. See the interview of Universidad de los Andes case study consultants with Eugenia Ponce de León, expert in national parks regulations (Bogotá, March 2004).
35. See the interview of Universidad de los Andes case study consultants with Germán Zuluaga (Bogotá, December 2003).
36. Endemism means biological species found only within a physically narrow habitat.
37. The Amoya River run-of-river power generation facility involves construction of a 78-megawatt run-of-river facility on the Amoya River to replace existing generation sources. The project developer is HIDROGER S.A. E.S.P., a subsidiary of Generadora Unión S.A. E.S.P. CO_2 mitigation is expected to be 1.87 million tons by 2012 and 2.69 million tons by 2019.
38. *Bagasse* is biomass as a by-product of sugarcane production.

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CHAPTER 14

Conclusions and Recommendations

Colombia's environmental management framework has evolved into a decentralized and innovative environmental management system.[1] The National Environmental System (*Sistema Nacional Ambiental, SINA*) defines roles for different stakeholders, including financially independent regional environmental agencies, a central-level ministry responsible for overall policy formulation and coordination, and research institutes responsible for collecting and disseminating environmental data. The SINA also defines a role for nongovernmental organizations through their involvement on the boards of regional agencies and for the private sector through its significant involvement in a Technical Advisory Council, which advises on policy formulation. Intersectoral coordination is promoted through the National Environmental Council, which comprises representatives from 25 organizations, including nine ministers (Agriculture, Commerce, Defense, Education, Environment and Housing, Health, Mines and Energy, Planning, Transport) and six business and industry association leaders (agriculture, export, forestry, manufacturing, mining, and oil and gas).

The 1991 Constitution and Law 99 of 1993, which established the SINA, reinforced the rights of every citizen to a clean and healthy environment. The new legislation reflected the evolution of the SINA from

Water Basin Authorities in select watersheds to a Natural Resource Division as part of the Ministry of Agriculture and subsequently to a Ministry of Environment coordinating the SINA entities, which included the previously established Water Basin Authorities. Law 99 also added several new regional authorities and incorporated urban authorities for cities with populations over 1 million, reflecting Colombia's transition from a highly rural economy to a largely urbanized economy.

This chapter summarizes the conclusions of the Country Environmental Analysis and provides recommendations to assist the government of Colombia in revising policies to address priority environmental problems. It also outlines a program of policy and institutional reform and complementary investment directed toward areas that impose a high cost on the economy, but that have not yet been tackled (table 14.1). Increased focus is needed on improving the quality of life for the growing number of poor people living in and around urban areas in a country in which over 70 percent of the population is urban. The goal of the recommendations presented in this chapter is to support the country's efforts to move toward more equitable and sustainable economic growth.

Colombia's growth from a largely rural economy to a highly urbanized country occurred rapidly over the past 50 years. Despite a strong planning tradition, environmental priorities have been driven by historical factors. The creation of the Regional Autonomous Corporation of the Cauca Valley (CVC) in 1954 as a river basin agency along the model of the Tennessee Valley Authority, the original placement of the National Institute of Renewable Natural Resources within the Ministry of Agriculture, and the large number of officials with a water or natural resources background produced a primary emphasis only on water resources management, national parks, and forestry issues. This emphasis yielded considerable dividends in the water resources management and conservation programs. These include the establishment of a National Natural Parks System (8.5 percent of the national territory) and forestry reserves (more than 15 percent of the national territory), and a reversal in deforestation rates from 600,000 hectares per year in the 1970s and early 1980s to 90,000 hectares per year in 2004.

Given Colombia's economic growth and development over the past decades and the green environmental agenda's progress, environmental priorities appear to have expanded. The environmental management agenda, however, has not caught up with this change. The analysis shows that the greatest costs now borne by the country, amounting to more than 3.7 percent of gross domestic product per year, are associated with the following categories of environmental problems: waterborne diseases,

Table 14.1 Main Policy Options of the Report

Key issue	*Main policy options*
Need for strategic and systematic tools for priority setting	• Design and implement a policy (through laws and regulations) to set environmental priorities at the national, regional, and local levels based on learning mechanisms to periodically review and learn from the experiences of implementing environmental policies • Install and implement systems to monitor and evaluate environmental management and the extent to which the objectives of environmental priorities are efficiently met • Periodically evaluate progress on the implementation of policies to tackle environmental priorities with the support of the accumulation of data, results, and experiences achieved through intersectoral coordination and learning
Need for strengthening institutions' capacity to address environmental priorities, particularly in environmental health	• Mainstream environmental considerations in policy formulation by strengthening SINA institutions' capacity in priority areas through, for example, strategic environmental assessments in (a) environmental health, (b) vulnerability to natural disasters, and (c) sustainable urban development
High cost of environmental degradation associated with waterborne diseases	• Design and implement a safe water program that includes components dealing with handwashing and point-of-use disinfection of drinking water • Facilitate private sector participation in water supply and sanitation • Modify water pollution fee system (*tasas retributivas*) to promote the construction of sewerage collection systems • Formulate and implement actions to promote compliance with drinking water quality standards • Modify laws and regulations on parameters of effluent standards so that pathogens and toxic and hazardous substances are regulated
High cost of environmental degradation associated with air pollution	• Revise and establish national standards for $PM_{2.5}$ and PM_{10} in priority urban areas and update major emission standards for mobile and nonpoint sources to reflect new scientific and technological advances • Implement air pollution control interventions, such as promoting the improvement of fuel quality in transport and industry sectors expanding the use of natural gas to replace coal and oil and establishing emissions control for stationary, mobile, and nonpoint sources • Implement an air quality monitoring program to monitor $PM_{2.5}$ and PM_{10} in priority urban areas • Implement and enforce regulations (including Resolution 0532 of 2005) to control air pollution emissions and appropriate monitoring methods for *green cut* of sugarcane, which uses manual or mechanical methods to remove sugarcane instead of burning out the fields for planting

(*continued*)

Table 14.1 Main Policy Options of the Report *(continued)*

Key issue	*Main policy options*
	• Reform compliance and enforcement systems, including the adoption of a more severe penalty system • Introduce more rigorous approaches to vehicle emissions testing
Morbidity and premature deaths associated with indoor air pollution	• Promote the use of cleaner fuels in an accessible, safe, and cost-effective manner in areas that predominantly use fuelwood • Implement a program to promote improved stoves • Extend the coverage of rural electrification programs • In subsidy programs for rural low-income housing, include requirements for building codes and housing design in poor communities to allow for improved ventilation and optimal chimney design
Vulnerability to natural disasters	• Increase efforts to prevent natural disasters, especially floods and landslides, through activities that focus on incorporating disaster prevention in land use plans, drainage improvements, warning systems, and regulations prohibiting informal settlement in areas prone to risks of natural disasters • Develop a permanent system of performance indicators for reduction of vulnerability to natural disasters • Define the specific roles of each national- and regional-level member of the National Disaster Preparedness and Response System and SINA, particularly Autonomous Regional Corporations • Create stronger incentives for inclusion of disaster considerations in environmental impact assessments and environmental licensing • Periodically conduct national, regional, and local risk assessments • Require all levels of government to use comparative risk assessment to guide allocations of financial, human, and technical resources • Establish priorities for disaster monitoring and alert systems based on comparative risk assessment
Requirements for improved urban environmental conditions	• Devise concrete ways of integrating environmental considerations into urban planning and management tools after reviewing the legal and regulatory framework of environmental and urban legislation • Define and include environmental criteria in the eligibility criteria of Social Interest Housing projects • Address structural land supply problems and reduce costs of formality • Enforce existing regulations and planning documents earlier to prevent occupation of hazardous sites • Enforce land use plans so that decisions on siting of landfills are consistent with zoning regulations contained in the plans

Table 14.1 Main Policy Options of the Report *(continued)*

Key issue	*Main policy options*
Need for improved water resource management	• Reexamine the roles of government bodies, and create more efficient cooperative mechanisms • Find an economically efficient approach to wastewater treatment, and control discharges of pathogens and hazardous wastes • Ensure the collection and public disclosure of information related to water availability and water demands • Ensure that the economic value of water is adequately reflected in water fees
Land degradation and deforestation	• Identify the costs and benefits of alternative interventions to control soil erosion and soil salinization • Generate alternatives to non-timber forest products and improve the livelihoods of forest-dwelling communities • Establish the analytical mechanisms to foster the capacity for both indigenous communities and the rural poor to profit from the sustainable and productive uses of forest areas and the implementation of payments for environmental services

Source: Authors.
Note: $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter.

urban air pollution, indoor air pollution, land degradation, and natural disasters. This suggests SINA's activities need to be refocused. Efforts need to be made to build capacity to carry out related quantitative analyses on a periodic basis as an input to the government's plans.

As shown in chapter 5, a number of methods in addition to quantitative analysis can be used to identify priorities. Consistent with the quantitative study, a survey of public perceptions of Colombia's environmental problems, covering more than 2,600 Colombians throughout the country, showed that air pollution was the main environmental problem identified by 79 percent of the people surveyed. The same survey, however, illustrated significant differences in perceptions of priorities among income groups. Whereas low-income groups identified air pollution, noise pollution, and vulnerability to natural disasters as major problems, upper-income groups perceived the loss of global environmental resources (for example, biodiversity and global warming) and inappropriate land use in urban areas as principal problems.

Finally, drawing on the discussion of environmental expenditures presented in chapter 2, it is evident that current expenditures are not well aligned with the priorities of the lower-income groups or with the environmental problems associated with the highest costs of damage. For example, in chapter 4, available data suggest that Autonomous Regional Corporations (*Corporaciones Autónomas Regionales*, CARs) might consider strengthening efforts to prioritize risks and allocate investment funds accordingly. In 2001, CARs as a group allocated 28 percent of their investment funds to projects involving the protection of flora and fauna, but only 5 percent to industrial pollution control projects other than wastewater treatment plants. Although these statistics are based on limited data and must be interpreted cautiously, they do suggest that, given the severity of Colombia's environmental problems, CAR investments may focus disproportionately on constructing wastewater treatment plants. In addition, examination of individual CAR allocations of 2001 investment funds suggests that CARs' allocations of investment spending across different risks do not comport well with the severity of those risks.

The results of the analysis support the view that the segments of the population that bear the heaviest burden of the costs of environmental degradation have not traditionally been taken into account in policy decisions, largely because they are not a vocal constituency. In particular, the poor and children often are disproportionately affected by environmental degradation. The discussions on air pollution, water resources management, and biodiversity indicate that in Colombia, as in most countries, stakeholders affected by environmental degradation have less of a voice to address environmental issues when priorities are set, decisions are made, and human and financial resources are allocated. In the case of indoor air pollution, typically children under age 5 suffer the most from acute respiratory infections and pneumonia. Other examples include the case study of water resources management in the Bogotá Savanna. Water scarcity is an issue for small farmers living in the savanna, whereas the larger stakeholders, such as the irrigation district, the regional environmental corporation, and the energy company, have all secured access to a sufficient quantity of water (Universidad de Los Andes 2004). In another case study on the creation of National Protected Areas, in which, by law, all economic activity is forbidden, some of the more susceptible groups are the indigenous populations living in those areas, whose property rights have been taken away, despite their close and long association with the land (Universidad de los Andes 2004).

Colombia has made important strides in setting up an environmental management system that includes a coordination function at the central level in the ministry, and control agencies, such as the *Contraloría General* *de la República* and the Delegate Procuraduría for Environmental Affairs, (*Procuraduría Delegada para Asuntos Ambientales*) which has responsibility for oversight of all environmental authorities in Colombia within the Procuraduría General. In addition, the legal framework gives these agencies considerable responsibilities. For example, under current law, the control organizations can set in motion procedures to remove CAR directors for failure to comply with CAR action plans.

Nonetheless, the absence of reliable time-series data on the state of the environment and natural resources, and the lack of a system of homogeneous, results-focused indicators of environmental quality, have hampered the efforts of these agencies to evaluate programs. Furthermore, as noted in chapter 3, the SINA's current capacity for data collection is limited. Colombia's data collection infrastructure—including monitoring networks and measuring stations, documentation centers, and basic cartography—is inadequate. The actual performance of the control agencies and the coordinating Ministry of Environment have also fallen short, for a multitude of reasons, including weak technical and human capacity, and institutional reasons resulting from the autonomy of the CARs, their direct sources of funding, and their long history, unlike the more recently established Ministry of Environment, Housing and Regional Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial*, MAVDT).

Environmental priorities and allocation of expenditures are poorly correlated. Clarity and policy guidance are also lacking with respect to certain administrative practices, notably in the hiring of contractors by CARs. In addressing this excessive reliance on contractors, two different policy objectives create clear tensions. On the one hand, the national goal is to limit operational spending and staff size across all government agencies. On the other hand, recognition is growing of the need to limit the CARs' reliance on contractors.

To encourage a focus on the quality of environmental outcomes and to overcome the coordination problems among CARs and national and regional agencies, Presidential Decree 1200 of 2004 established a system of performance indicators to measure impact and results of environmental investments at the regional level by means of Ten-Year Regional Environmental Management Plans. Six impact indicators are included in the Three-Year Action Plan (*Plan de Acción Trienal*, PAT) to evaluate environmental management by the CARs. The results-based indicators for environmental quality cover issues including deforestation rates and forest conservation efforts, development of green markets, rationalization and optimization of renewable natural resources consumption, reduction in health impacts associated with environmental factors, and reduction in vulnerability risk associated with natural disasters. Each year, the MAVDT will review progress in achieving the goals set forth in the PATs and Regional Environmental Management Plans. The directors of CARs that do not meet the goals set forth in their own PATs are at risk of being removed by the CARs' Board of Directors. At this point, the process is so new that it cannot be evaluated.

Although Colombia has extensive environmental regulations, challenges remain. In many cases, urgently needed regulations do not exist, some regulations are incomplete and lacking in critical details, and some regulations are overly prescriptive and not adjusted for local economic and social circumstances. For example, command-and-control emissions standards have sometimes been adopted from more developed countries with little modification. These inadequacies in Colombia's regulations lead to problems. They contribute to poor coordination between the MAVDT and the CARs by making it difficult for CARs to carry out one of their basic functions—implementing regulations established at the national level. They also make it difficult for other institutions in the SINA to perform their assigned roles. For example, in 2003, the *Contraloría General de la República* noted that lack of regulation—from constitutional precepts to specific information standards—made it difficult to advance the Colombian Environmental Information System. Incomplete licensing and permitting regulations lead to inconsistent requirements and enforcement across CARs and therefore create opportunities for administrative arbitrariness. Lack of clarity in laws and regulations also burdens Colombia's judicial system. This void may have contributed to the proliferation of *acciónes de tutela* (actions for injunctive relief) brought to protect the environment.

Continuous strides forward demonstrate an organization's ability to adjust course and improve incrementally over time. Improving over time involves generating knowledge by processing information or events, then using that knowledge to cause behavioral change. It may not be an intentional process. Learning is crucial in Colombia, particularly because there seem to be few mechanisms that have allowed the country in recent years to adjust course with changing contexts and to analyze and learn from its previous experiences. Some stakeholders have shaped a continued focus on water resources management and conservation programs with great success. The government itself has few tools that allow for the setting of priorities and the development of an institutional memory.

An example of difficulties in improving over time in addressing environmental priorities is the sporadic history of air quality monitoring networks in Colombia. Such networks were first established in 1967 by the Pan American Health Organization, together with the Ministry of Health, in several cities, including Bogotá and Medellín, to monitor total suspended particles and sulfur dioxide levels. These programs lasted until 1974, when they were dismantled. Monitoring systems were again set up in many locations in response to Decree 2 of 1982. In Bogotá, the Department of Health installed and operated 12 monitoring stations during 1983 to 1989. During 1990 to 1991, the Japan International Cooperation Agency financed the installation and operation of five more monitoring stations. None of these networks operated after 1991. Furthermore, despite the existence of these stations, there is no reference to the use of data generated by them as an input to air pollution control strategies before 1991 (Universidad de los Andes 2004). During 1991 to 1997, no air quality monitoring occurred in Bogotá. Then in 1997, the Environmental Administration Department of Bogotá installed a new network of 12 monitoring stations, which included the pollutant parameters in Decree 2 of 1982, plus particulate matter of diameter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$). $PM_{2.5}$ was only monitored until 1999, when the equipment was damaged and not replaced. The story is somewhat similar in Medellín, with the installation of seven stations in 1983 by the Department of Health. Again, there is little evidence of the use of data generated by these stations as an input to air pollution control strategies, and as in Bogotá, these were superseded by a new system in the late 1990s, comprising 18 stations in the Aburrá Valley with the capacity to measure the five pollutants noted in Decree 2 of 1982, in addition to PM_{10}. The functioning of this newest network, however, has been interrupted several times by legal problems and the calibration of equipment resulting in information voids (Universidad de los Andes 2004).

Evaluation systems must not be static; they must be able to adjust to new developments in science, technology, and other fields. In the 1970s, the conventional wisdom was that high ambient concentrations of total suspended particles posed a serious health problem. More recently, with improvements in measurement technologies and analytical techniques, $PM_{2.5}$ appears to be the real culprit. This finding, in turn, has led to significant changes in air pollution control strategies in the United States and other countries. In Colombia, the importance of $PM_{2.5}$ on health impacts is increasingly recognized, and the government intends to move ahead with the installation of a monitoring system for $PM_{2.5}$ to obtain better information for decision making on air pollution control strategies.

In contrast, developments in addressing indoor air pollution are still in their infancy. As little as 10 years ago, indoor air pollution was not considered a major health threat. Today, together with waterborne diseases, it appears on the list of the top 10 causes of illness and death in the *Global Burden of Disease* 2002 report by the World Health Organization (WHO). In developing countries with high mortality rates, indoor air pollution is the fourth leading cause of illness and death (WHO 2002). Recent WHO estimates indicate that indoor smoke from solid fuels causes 1.6 million deaths annually. It is not that the problem did not exist 10 years ago. Rather, the generation of information, and the processing of that information, made it clear that this form of pollution principally affects millions of women and children in poor rural families who depend on firewood for cooking and heating. Some countries are realizing the significance of this and acting on it; many others have still not grasped the importance of placing this issue high on the policy agenda. The cost-of-degradation study shows that this is also an important issue for Colombia, affecting in particular poor women and children in rural households. It is advisable that the government consider actions to reduce the impact of indoor air pollution on these susceptible groups.

Clearly, publicly available systems for monitoring and evaluation are crucial, not only for technical learning but also for purposes of democratic legitimacy and public confidence. It is also crucial that these improvements over time take place on several fronts and that a number of stakeholders participate in the process, in particular to minimize and prevent learning traps. An example is the common misconception of the critical factors behind the success of the CVC's water pollution control program, which has led the CVC to emphasize cooperation with industry, de-emphasize strict enforcement of regulations, and experiment with effluent charges. A more thorough analysis demonstrates that important factors for the success of the program were citizen pressure, negative publicity, and policies of transnational parent companies calling for the use of environmental audits to facilitate compliance with environmental rules.

Tackling Environmental Priorities

The remainder of this chapter focuses on a program of policy and institutional reform and complementary investment directed toward areas that impose a high cost on the economy, but that have not yet been tackled (table 14.1), particularly the need to increase focus on improving the quality of life for the growing number of poor people living in and around urban areas in a country where over 70 percent of the population is urban.

Waterborne Diseases

Although Colombia has achieved substantial reductions in child mortality, including from diarrheal disease, the costs associated with diarrheal morbidity from contaminated water and inadequate hygiene in both children and adults remain high. The poorest groups often lack adequate sanitation and water supply. Approximately 9 percent of the population does not have access to an improved water source, and the lack of sewerage in 20 percent of urban centers is a serious environmental problem for the country. These poor results are largely attributable to the fact that explicit policies to address these problems do not exist. An analysis of alternative interventions to address waterborne diseases shows that the most effective intervention in Colombia would be the design and implementation of a safe water program that promotes hygienic behavior through handwashing and water quality improvement at the point of use, accompanied by the provision of potable water and sewerage services.

Urban and Indoor Air Pollution

Air pollution is one of the most widespread and serious problems in Colombia's cities and rural areas. Although air pollution levels are moderate in most cities, close to 50 percent of the population live in cities with more than 100,000 inhabitants, creating substantial aggregate health effects associated mainly with particulate matter. This results in health impacts such as cardiopulmonary diseases and lung cancers in adult segments of the population, and acute respiratory illness, particularly in children, including death from related diseases such as pneumonia. Analysis reveals that the bulk of the cost associated with urban air pollution is linked to mortality. Approximately 6,000 premature fatalities each year occur as a result of outdoor air pollution, while an estimated 1,100 fatalities are related to exposure to indoor air pollution from use of fuelwood, charcoal, and other solid fuels as primary sources of cooking fuel. Since 1993, insufficient financial and human resources have been allocated by the government to address air pollution. Furthermore, the urgency to update regulations and issue standards and economic instruments that minimize the concentration of particulate matter in the air is apparent. To achieve this, the most promising options include reduction of the sulfur content of fuels and the control of emissions from stationary sources and nonpoint sources, including control of agricultural residue burning. With respect to indoor air pollution, possible options include interventions that promote the use of cleaner fuels, technical mitigation options such as improved cook stoves, and policies that promote improved housing design.

Natural Disasters

Colombia faces numerous natural disasters such as floods, droughts, and earthquakes. The most numerous natural disasters are floods and landslides, the management of which falls under SINA's mandate. Inadequate drainage in most urban areas is an important factor linked to urban flooding. In the past quarter century, Colombia has experienced six major earthquakes, three volcanic eruptions, three landslides, and three avalanches at a significant cost to the country in terms of human and physical capital. According to a recent study, more than 4 million Colombians were affected by natural disasters during 1993 to 2000, at an annual cost of approximately Col$950 billion (US$453 million) (Echeverry 2002). The poorest and most susceptible have borne the highest costs for these disasters as measured by damage, death, and lost assets. To reduce vulnerability to natural disasters, a number of activities must be considered, particularly nonstructural measures to prevent human settlement in areas of high vulnerability to natural disasters.

Soil Degradation

The main components of land degradation in Colombia are erosion and salinization of soil and the problems associated with deforestation. The lack of interinstitutional coordination to address the problems of land degradation is pervasive. The analysis suggests that dispersed investments from states, municipalities, environmental authorities, and CARs have been made in reforestation with little or no impact on erosion control or regulation of water streams. Currently, Congress is discussing a national forestry bill. Several stakeholders have recommended incorporating in the bill provisions to secure the rights of indigenous peoples and small farmers.

Water Resources Policies

Colombia is endowed with abundant water resources, and water scarcity is a problem in a small percentage of Colombia's watersheds. As a result of degradation of water bodies, and unequal geographic distribution of water resources, if water resources are not properly managed, by 2025 more than 14 million inhabitants could suffer water shortages (IDEAM 2004).

Strengthening performance in the water sector requires improving existing regulations to control water pollution, including water pollution fee reform and the introduction of economic instruments to improve efficiency and equity, and to improve water quality standards for human consumption, recreational uses, and irrigation. This will also require strategies to formulate, socialize, and implement programs for accountability, transparency, and governance to promote compliance with water quality standards.

Urban Environmental Management

Urban environmental management problems include issues associated with housing and urban planning and with waste management. Housing and urban policies could be amended and enhanced to minimize negative environmental impacts. The three main actions suggested are the streamlining of environmental issues in the Land Use Plans, the prevention of informal housing, and the design of housing subsidy programs aimed at avoiding adverse environmental outcomes.

Statistics indicate that about 27,500 tons of solid wastes are generated daily in Colombia. There are more than 700 open-air garbage dumps located in small and medium municipalities, where public service for waste collection and disposal is deficient. Very few of the nation's registered landfills operate effectively; in the majority of cases, uncontrolled landfills threaten surface and ground water in surrounding areas. Lack of clarity regarding minimum technical specifications and deficient interinstitutional mechanisms for adequate closure of open-air dumps and construction of new landfills have resulted in weak compliance and enforcement. Typically, the poorest live closest to open-air dumps and poorly designed and operated landfills, which pose both environmental and health risks. Underscoring these challenges is the fact that an increase in shanty towns and informal housing in areas most susceptible to risks of natural disasters has resulted in increased vulnerability for greater numbers of poor people. It is advisable to design and implement policies to operate effective regional waste-disposal sites, and establish and enforce regulations to segregate and treat hazardous wastes.

Global Environmental Problems

The most salient global environmental problems evident in Colombia are loss of biodiversity, climate change, and ozone depletion. National parks cover close to 10 percent of the national territory. Compared with four other mega-diverse Latin American countries, and countries in other latitudes, the percentage of land that is protected is considerable.

The government has achieved notable progress in the creation of national parks. To further that success and guarantee its sustainability, legislation could be improved by increasing the importance of local economic, cultural, and social realities and expectations to ensure that the rights of local stakeholders are not detrimentally affected. Protected areas legislation has in some cases limited the use of traditional production systems and natural resources by local inhabitants. To overcome this weakness, the government is considering putting in place institutional mechanisms to prevent and resolve conflicts between conservation interests and other social priorities, such as regional, social, and economic development. Regarding biodiversity, climate change, and ozone-depleting substances, Colombia has taken advantage of financial mechanisms such as the Global Environment Facility, the Prototype Carbon Fund, and the Montreal Protocol to finance private investments aimed at reducing emissions of greenhouse gases and ozone-depleting substances.

Conclusions

Recent decades have brought about high levels of economic growth and urbanization in Colombia. Considerable progress has also been made in addressing the water and forestry environmental agenda. Thus, the country's main environmental problems have shifted, with an increasing emphasis on environmental health issues. However, the environmental management agenda has yet to catch up with this shift in priorities from watershed and forestry to environmental health problems because of a lack of mechanisms in the current institutional structure to signal these changes. Improved monitoring and dissemination of information on environmental outcomes, assignment of clear accountabilities for environmental actions and outcomes, and involvement of a broad range of stakeholders are three important mechanisms to allow these signals to be picked up as environmental priority issues further evolve in Colombia.

In conclusion, environmental problems associated with the highest costs of environmental degradation in Colombia are, in decreasing order of magnitude, waterborne diseases, urban air pollution, natural disasters, land degradation, and indoor air pollution. Combined, these environmental problems cost Col$7 trillion (US$3 billion) or 3.7 percent of Colombia's gross domestic product. The poor and less powerful stakeholders in Colombia bear a disproportionately high share of this cost.

To combat these problems, this report identifies a number of cost-effective interventions that could be adopted in the short and medium terms to support efforts to move toward achievement of sustainable development goals (table 14.1). To this end, the government of Colombia is considering putting in place mechanisms to identify environmental priorities based on analytical work and broad public consultations.

Note

1. Ernesto Sánchez-Triana and Kulsum Ahmed are the authors of this chapter.

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Environmental Priorities and Poverty Reduction: A Country Environmental Analysis for Colombia proposes cost-effective policy and technical interventions aimed at abating the cost of environmental degradation and supporting more equitable and sustainable economic growth.

Environmental degradation is associated with increased morbidity and mortality and decreased productivity. Urban and indoor air pollution; inadequate water supply, sanitation, and hygiene; natural disasters (mainly floods and landslides); and land degradation are the environmental problems associated with the highest social and economic costs, falling most heavily on vulnerable people, especially poor children under five years old.

Environmental Priorities and Poverty Reduction begins by exploring institutional change and environmental priorities in Colombia over the past 50 years, a time of substantial progress in environmental protection and rapid transition from a largely rural to a highly urbanized economy. Part II assesses the burden of disease rooted in inadequate water supply, sanitation, and hygiene; poor air quality; natural disasters; and environmental management practices to reduce that burden. A discussion of the environmental costs of rapid and unplanned urbanization is included. Part III assesses the sustainable management of Colombia's rich endowment of natural resources.

This book provides a wealth of information for policy decision makers, government officials, and other professionals working in environmental policy and management, poverty reduction strategies, public health, environmental economics, and civil society issues.

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