Environmental Indicators for Latin America and the Caribbean: Toward Land-Use Sustainability

- Population
- Socioeconomic Development
- Food and Agriculture
- Energy
- Ecosystems and Land Use
- Forests and Rangelands
- Biological Diversity
- Freshwater and Coastal Resources
- Atmosphere and Climate
- Information and Participation
- International Treaties and Conventions
- Projections in Land Use

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in collaboration with:

IICA-GTZ Project
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OAS
Organization of American States

WRI
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Contents

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M.W.

List of Abbreviations

AU	Animal Units
C	Carbon
CFC	Chlorofluorocarbon
CH_4	Methane
CO_2	Carbon Dioxide
D-M	Deltas and Mangroves
GDP	Gross Domestic Product
GNP	Gross National Product
ha or has	Hectare
Kg	Kilogram
Km	Kilometer
Km^2	Square Kilometer
Km^3	Cubic Kilometer
lb	Pound
m3	Cubic Meter
S	Steppe
StmF	Subtropical Moist Forests
StdF	Subtropical Dry Forests
STS	Subtropical Savannas
STtS	Subtropical Thorn Steppe
STDs	Subtropical Desert Bush
T	Metric Ton
TemmF	Temperate Moist Forests
TemS	Temperate Savannas
TOE	Ton Oil Equivalent
TmF	Tropical Moist Forests
TlmmF	Tropical Lower Montane Moist Forests
TdF	Tropical Dry Forests
TvdF	Tropical Very Dry Forests
TS-TdF	Tropical Savannas
T-STmF	Tropical and Subtropical Montane Forests
T-STD&Ds	Tropical and Subtropical Deserts and Desert Shrub
y	Year

List of Acronyms

AECI	International Spanish Cooperation Agency
CATIE	Center of Research and Education in Tropical Agriculture
CEPAL	Economic Commission for Latin America and the Caribbean
CEUR	Urban and Regional Center of Research
CIEPLAN	Corporation for Economic Research for Latin America
CIDE	WRI's Center for International Development and Environment
DANIDA	Denmark Department of International Development Cooperation
FAO	Food and Agriculture Organization of the United Nations
GASE	Ecological Systems Analysis Group
GTZ	German Agency for Technical Cooperation
ICRW	International Center for Research on Women
IDB	Inter-American Development Bank
IIASA	International Institute for Applied Systems Analysis
IICA	Inter-American Institute for Cooperation on Agriculture
IIE	Institute for Economic Investigations
IIED	International Institute for Environment and Development
ILO	International Labour Organization
INPE	Brazilian National Institute for Space Research
IUCN	The World Conservation Union
MOPU	Ministry of Public and Urban Works
NRC	National Research Council
OECD	Organization for Economic Co-operation and Development
OAS	Organization of American States
PEAL	Ecological Prospective for Latin America
SEI	Stockholm Environmental Institute
TSC	Tropical Science Center
UNCED	U.N. Conference on Environment and Development
UNDP	U.N. Development Programme
UNEP	U.N. Environment Programme
USAID	United States Agency for International Development
WCMC	World Conservation Monitoring Centre
WRI	World Resources Institute
WWF	Worldwide Fund for Nature

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I. Introduction

1. PURPOSE

Environmental indicators are needed to analyze and monitor development processes. However, development policies and strategies are elaborated and applied at different levels of society, and the effects and consequences of such policies are observed at different scales. Indicators must, therefore, be selected in relation to these characteristics and to the users' needs.

The goal of the present work is to prepare a set of indicators that might be utilized in the evaluation and design of environmental policies. Besides defining descriptive indicators that may help policy-makers quantitatively evaluate a given situation, normative indicators are needed to compare reference values and to show in what direction society must proceed. For this, we used a rational methodology for selecting retrospective and prospective environmental indicators in relation to key environment and development issues.

The model presented here is based on the elaboration of three groups of indicators at different levels and scales (countries and life-zones; regions; and localities). The first group is employed to observe the causes of environmental problems (Pressure on the Environment); the second group reflects the quality of the environment in relation to the effects of the human actions (State of the Environment); and the third refers to the measures and responses taken by society to ameliorate environmental damages (Response on the Environment). In addition, a fourth group of prospective indicators relates to the progress necessary to make land-use sustainable (Progress Toward Sustainability).

In all, some 44 Environmental Pressure Indicators, 47 Environmental State Indicators, 5 Environmental Response Indicators, and 12 Progress Toward Sustainability Indicators were selected. The indicators are presented in tables at a regional level for countries and life-zones, and in boxes at a subregional or local level for plots, basins, and ecosystems. A short analytical text accompanies each of the specific subjects, as well as the bibliographic references and data sources. Technical notes show the data sources, the choice and definition of some of the indicators, and the elaboration of data in cases where the information was calculated specifically for this work. At the same time, a series of data and indicators are presented to reveal trends. Finally, some figures illustrate the evolution of trends.

The first iteration of this work focuses on subregional and local levels, especially when analyzing peasant agricultural activities. This emphasis is due to the importance of peasant agriculture for Latin America and the Caribbean, in terms of both past and present problems, and of future opportunities. The subregional and local analyses are studies of partial cases. They illustrate the causes and solutions of the problems at different scales. However, they do not provide a complete vision of sustainability in land-use. Rather, the objective is to give examples of the type of information and indicators necessary to understand the development process and to elaborate actions and responses to related problems.

2. BACKGROUND

Latin America and the Caribbean comprise 32 countries that cover more than 20 million square kilometers. (See Map 2.1.) The areas of the region share many biophysical characteristics that are unique from a global perspective. A first-order look at the region shows large well-defined terrestrial units. Mexico represents the northern portion of the current Latin American territory. Central America bridges North and South America, with the Caribbean serving as an insular arch. If only topography and hydrography were considered, Mexico and Central America could be represented by mountains and volcanoes; the Caribbean by the sea; and South America by the huge fluvial plains and the Andes range (PNUMA, AECI, & MOPU, 1990). Adding climate (precipitation, biotemperature, and evaporation) and geography (latitude and topography) allows us to divide the region into life-zones aggregated according to current vegetation and land-use until 18 great environmental units or life-zones emerge. (See Map 2.1.) The life-zone system helps us envision the ecological and production-related features of each land-use type. We may, for example, recognize the tropical moist forests, characterized by a shifting agriculture, resource extraction, and livestock raising; the tropical lower montane moist forests, characterized by peasant agriculture based on coffee crops; the tropical dry forests, typified by livestock raising and intensive crops (sugar cane); and the subtropical savannas, with their extensive livestock raising and cereal cultivation (Winograd, 1989a).

Yet, not all the region's common features are natural resource endowments. Many shared environmental problems and unexploited opportunities exist—a consequence of the development models applied in the region. With 8.5 percent of the world population, the region includes 23 percent of potential arable lands, 12 percent of current croplands, and 17 percent of all pastures. It also accounts for 23 percent of the planet's forests (46 percent of tropical forests) and 31 percent of internal renewable water resources. Although its fossil fuel reserves amount to only 3 percent, this region has 19 percent of the world hydroelectric potential (See Table 2.1.) (Gallopín et al., 1991a). That said, the region is losing its forests at a rate of 0.7 percent to 0.8 percent per year to unstable and barely productive agroecosystems (Winograd, 1991a; WRI, 1992). Croplands are under utilized because, although 85 percent of the region can yield 2.5 annual harvests of short-cycled crops, only 65 percent of the cultivated area is harvested (FAO, 1988). In Central America and the Andean countries, 40 to 60 percent of the croplands show erosion problems, and 70 percent of the productive arid lands have suffered desertification (Leonard, 1987; Redclift, 1989; UNEP, 1991). The average carrying capacity of permanent pastures is scarcely 0.6 animals/hectare, and meat production does not exceed 13 kilograms per pasture hectare (WRI, 1992).

However, although most of the countries of the region share a common language and culture, stemming from a similar colonial past, the socioeconomic and environmental heterogeneity does not allow an easy analysis of Latin America and the Caribbean as a simple unit. From an economic standpoint, we may divide the region into countries with low-income economies (Haiti and Nicaragua), with middle-income economies (Ecuador and Colombia), and with high-income economies (Mexico and Argentina). Taking into account the socioeconomic situation, we may subdivide the region into groups of countries with high human development index (Uruguay and Costa Rica), middle human development index (Brazil and Paraguay), and low human development index (Guatemala and Bolivia). In summary, there is no single way to analyze the region. From an environmental point of view, it seems necessary to point out differences in national endowments of natural resources and their importance to economic development. In this sense, it is logical to divide the region into countries that do and do not export oil or into those countries that do or do not have great agricultural potential.

Nevertheless, to analyze and monitor development, land-use and natural resource management, we need to classify the region from a wider perspective—one that takes social and economic differences into account also. From this viewpoint, subregions (Central America, Caribbean, Southern Cone, or Andean countries) can be considered as political units of increasing integration in which development policies and strategies are elaborated at a wider level. In turn, nations can be seen as administrative units in which political decisions leading to development are taken. Life-zones are areas with common ecological and productive characteristics in which development actions and policies are performed. Finally, basins and ecosystems are where the causes and consequences of certain development policies are played out over the short term.

Socioeconomic and environmental conditions in Latin America right now make urgent changes in development models essential. These changes do not admit conventional solutions, and they must also go beyond the rhetoric on sustainable development to make real differences in real people's lives. Even as current development models are modified, the processes leading to development should be accelerated through dramatic changes in development, land-use, and natural resource policies. Applying sustainable development models poses new demands on those who formulate them. They must carefully quantify and follow the evolution of the process, the change and progress so as to elaborate the necessary actions and responses, More generally, they must recognize the causes and consequences of environmental problems and the impacts on different components of the development process.

The interest in and need for sustainable development, together with increasing consciousness of the threats menacing the environment and of the exhaustion or poor management of natural resources, have led countries, international institutions, policy-makers, and non-governmental organizations to re-examine the means they use to evaluate and safeguard the environment, natural resource-use, and development itself (Rodenburg, 1992). In this process of defining actions and strategies and analyzing costs and benefits, environmental indicators are indispensable tools (OECD, 1991).

3. INDICATORS AND SUSTAINABILITY: CONCEPTUAL FRAMEWORK

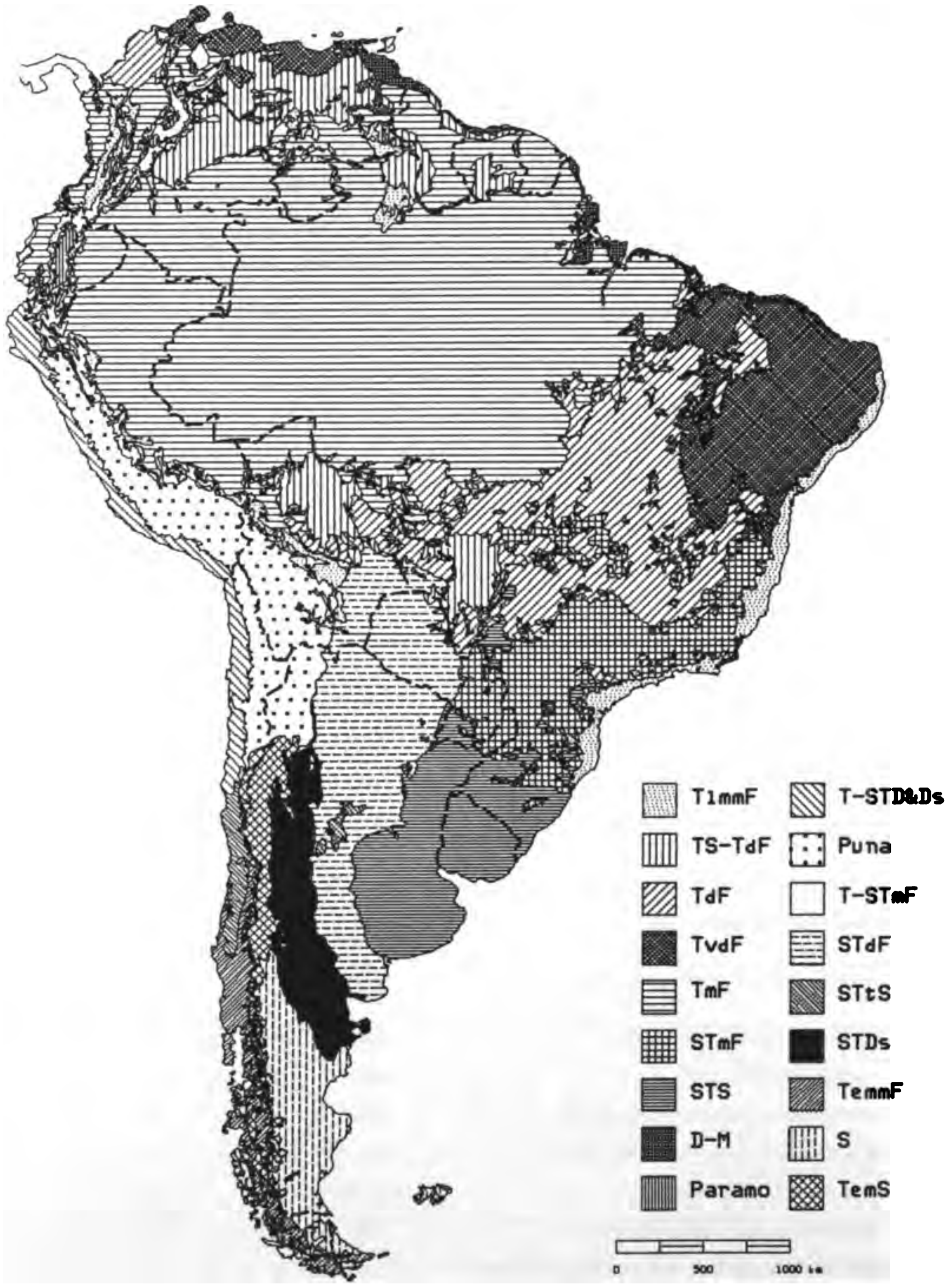
In the search for sustainable development models, tools that will allow the analysis of the evolution of the process are needed. Key among them are indicators that reflect stated development objectives and users' needs. To construct environmental indicators, researchers must define a conceptual framework to help them decide what to monitor and how. The indicators that emerge from this process must answer the needs for analysis at various levels and scales and at various stages of the development or ecological process. They must apply to separate components of the development or ecological process and be consistent with a stated definition of sustainable development.

Depending on which level analyzed (i.e., plot, basin, ecosystem or productive activity), different factors will emerge (economic, social, technological, or environmental) that influence sustainability, and therefore the necessary indicators to monitor the process. Similarly,

Table 2.1 Natural Resources in Latin America, the Caribbean, and the World

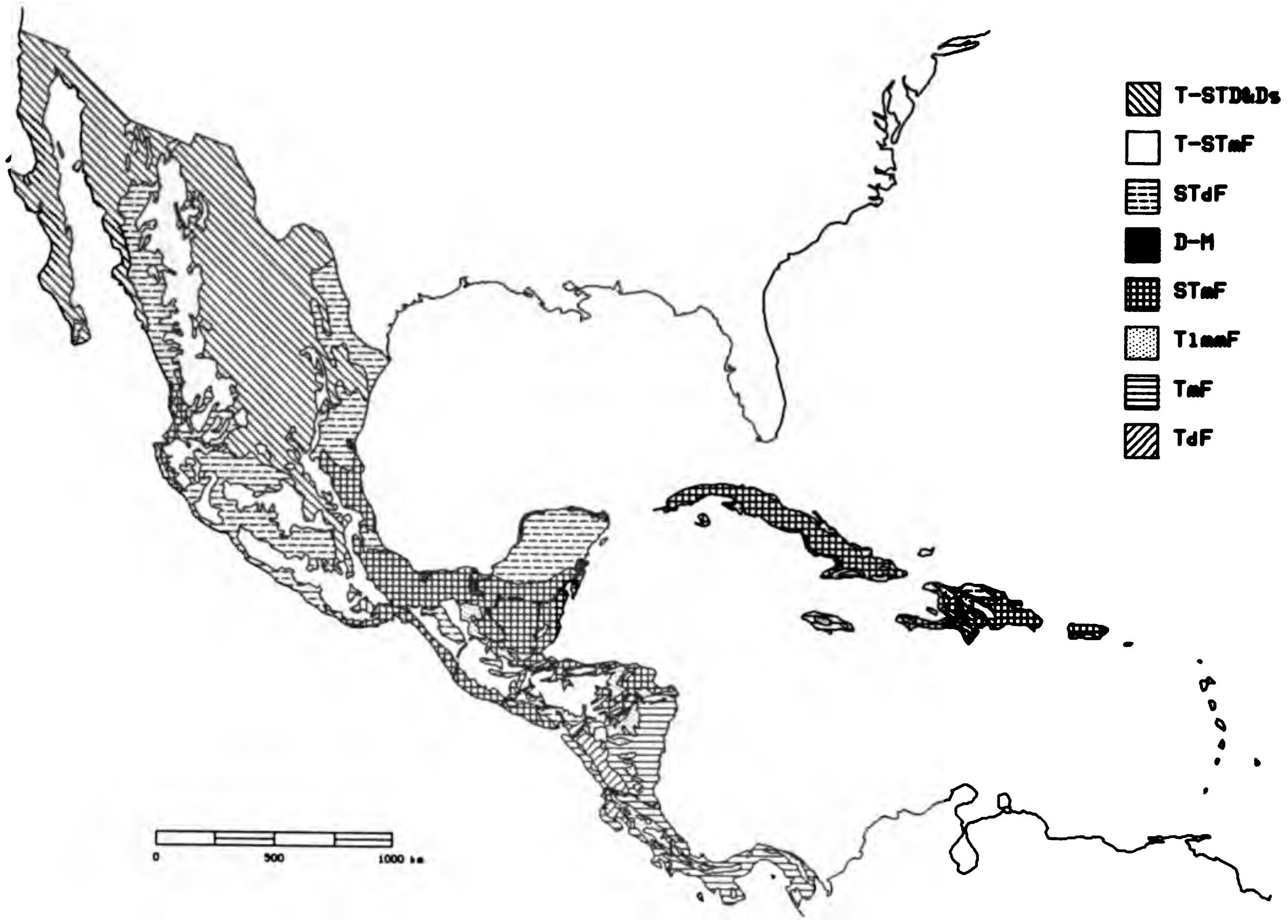
		Year	Latin America & the Caribbean		World Total
			Total	% of World	
Population	Inhabitants (millions)	1970	283	7.7	3,693
		1990	441	8.3	5,292
		2030	753	8.5	8,869
Food and Agriculture	Cropland (millions of ha)	1970	145	10.2	1,411
		1989	179	12.1	1,478
	Cropland per capita (ha)	1970	0.5	----	0.4
		1989	0.4	----	0.3
	Production of cereals (millions of T)	1970	71	5.4	1,204
		1990	100	5	1,972
	Production of Roots and Tubers (millions of T)	1970	49	8.8	561
		1990	48	8.4	574
	Production of Drugs (thousands of T)				
	Marihuana	1990	20.1	85	23.6
	Coca Leaf	1990	226	100	0
Energy	Fuelwood and Charcoal Production (millions of m3)	1970	185	15.6	1,186
		1990	289	16.1	1,796
	Installed Hydropower Capacity (gigawatts)	1970	18,718	6.4	290,652
		1989	87,761	14.2	617,101
Ecosystems and Land-use	Forested Area (% of total land)	1970	51	----	32
		1989	47	----	27
	Permanent Pasture Area (% of total land)	1970	26	----	25
		1989	28	----	25
	Cropland Area (% of total land)	1970	7	----	10.7
		1989	8.8	----	11.3
Forests and Rangelands	Extent of Forests and Woodlands (millions of ha)	1970	1,048	25	4,183
		1990	956	27	3,565
	Extent of Permanent Pastures (millions of ha)	1970	530	16	3,321
		1989	579	17	3,320
	Average Annual Deforestation (millions of ha)	1970	5.4	47	11.4
		1990	6.8	54	12.6
	Average Annual Reforestation (millions of ha)	1980-1990	0.8	5.4	14.7
	Roundwood Production (millions of m3)	1970	233	9.5	2,464
		1990	403	11.7	3,450
	Livestock Population (millions of animal units)	1970	257	17.7	1,451
		1990	362	20.8	1,746
Biological Diversity	Extent of Protected Areas (millions of ha)	1990	114	17.6	651
	Protected Area (% of total land)	1990	5.6	----	5
	Number of Species of Higher Plants (thousands)	1990	85	38	224.5
	Number of Species of Higher Plants (thousands)	1990	5.5	24	23
	Number of Animal Species Extinct	1600-1990	57	12	484
Freshwater and Coasts	Total Annual Renewable Water Resources (Km3)	1990	5,379	13.2	40,673
	Annual Renewable Water Resources per capita (thousands of m3)	1990	26.7	----	7.7
Atmosphere and Climate	CO2 Emissions from Industrial Processes (millions of T of C)	1970	142.6	3.7	3,850
		1988	266.6	4.5	5,893
	CO2 Emissions from Land-Use Change (millions of T of C)	1980	690.1	38.7	1,782.6
		1988	700.6	35.7	1,963.2
	CO2 Emissions per capita (T of C)	1980	2.6	----	1.5
		1988	2.3	----	1.5

Figure 2.1 Political and Life-Zones Map for South America



Note: TlmmF = Tropical Lower Montane Moist Forests; TS-TdF = Tropical Savannas; TdF - Tropical Dry Forests; TvdF - Tropical Very Dry Forests; TmF - Tropical Moist Forests; STmF = Subtropical Moist Forests; STS = Subtropical Savannas; D-M = Deltas and Mangroves; STdF = Subtropical Dry Forests; STtS = Subtropical Thorn Steppe; STDs = Subtropical Desert Bush; TemmF = Temperate Moist Forests; S = Steppe; TemS =Temperate Savannas

Political and Life-Zones Map for Central America



Note: T-STD&Ds = Tropical and Subtropical Deserts and Desert Shrubs; T-STmF = Tropical and Subtropical Montane Forests; StdF = Subtropical Dry Forests; D-M = Deltas and Mangroves; STmF = Subtropical Moist Forests; TlmmF = Tropical Lower Montane Moist Forests; TmF = Tropical Moist Forests; TdF = Tropical Dry Forests the scale at which sustainability is measured will influence the choice of indicators. For example, the best indicators for measuring the sustained use of wood as a resource at a forest plot level might be incremental volumetric measurements—basically, physical measurements based on biological knowledge of the resource used and on information about the technology employed to exploit it (Dixon and Fallon, 1991). If sustainability is analyzed at a higher level (ecosystem or basin)—important, since the sustainable management of an individual resource can be non-sustainable for the system—additional indicators are needed to understand the behavior and interactions of the other system components. Even if, for example, reforestation by exotic species (i.e., *Pinus sp.*) can be sustainable in terms of species productivity, erosion, pest infestations, biodiversity losses, and impacts on water cycles and soil acidification can make such reforestation efforts unsustainable, so these factors must be monitored and assessed in relation to other human activities in the zone. The right indicators will in this case help analysts evaluate the costs and benefits of the production of an individual resource in the context of overall ecosystem or basin deterioration. Similarly, the costs of mismanaging soils, watersheds, and biodiversity could be calculated. In any event, the concept of sustainability is even broader than such indicators of ecosystem performance and balance might suggest. Its objective is not only to sustain a physical reserve or ecosystem production, but also to steadily improve the quality of human life. Thus, indicators that will integrate not only physical and technological factors, but also the sustainability of the social and economic system are needed. (Dixon & Fallon, 1991). In short, indicators must help decision-makers evaluate the opportunities lost and the benefits obtained in relation to socio-economic, environmental, and political needs.

Along with level and scale, the stages of any process under analysis must be identified. What are the problems and consequences of the current policies? And how do these policies interact? What opportunities and limitations characterize alternative development models as they are applied? If indicators don't help answer these questions, development proposals will fail. In short, monitoring should provide a sense of the past as well as stimulate ideas about the future.

1.3.1 What Is Sustainable Development?

Sustainable development has many definitions, each devised for a different purpose. To minimize confusion in the context of further work on environmental indicators, sustainable development should be defined in terms of certain general sustainability objectives for the Latin America and the Caribbean region.

Essentially, sustainable development is a process of change that will allow the satisfaction of human needs without compromising the very base of development—the environment. The objectives of this kind of development are to obtain (i) an equitable economy; (ii) a fair and participatory social system; (iii) a reoriented and efficient technology base; and (iv) the optimal use and conservation of the environment. More specifically, five conditions should be met.

(1) At the economic level, it should not impoverish one group while it enriches another. In a sustainable society, all social sectors share the benefits of development. A structure characterized by increasing inequality may become sustainable in a purely biophysical sense, but not in socio-economic terms (Gallopín et al., 1989b; Saunier, 1987).

(2) At the ecological level, it should neither degrade diversity and the ecosystem's biological productivity nor the ecological processes and essential vital systems (IUCN, UNEP, & WWF, 1991). It should maintain, recuperate, and restore natural resources in areas with comparatively great productive potential, as well as deteriorated marginal zones, through sound management.

(3) At the social, cultural, and political levels, solidarity, agreement, the participation of all sectors and individuals, and international cooperation are needed to obtain sustainability. Action and respect are required from all parties, not just within the community but at global and regional levels too. Most current societies are strongly integrated into capitalist markets. But if this increasingly global system does not support sustainable practices and objectives, an isolated community or country does run the short-term risk of being penalized economically by incurring greater costs or receiving lower benefits for goods and services (Gallopín et al., 1989b; Preston, 1990).

(4) At a technological level, the ability to respond to change should increase. In a world where production is being transformed by accelerating technological innovation and expansion, where new products and markets are cropping up and both interdependence and interconnection are increasing, sustainability cannot be measured strictly in terms of an increase in productivity or sectorial self-reliance that will guarantee the production of a certain product over the long-term (Gallopín et al., 1989b). Instead, technology should be more related to efficiency in using resources and to the possibility of conserving or expanding productive options.

(5) Finally, a diversity of socio-economic, cultural, productive, and ecological systems must be considered a key to adaptability and not an impediment to development. Indeed, increasing homogeneity means decreasing cultural, social, and economic options—a trend at odds with sustainability.

1.3.2 What are Indicators?

In general, indicators are elaborated to help analysts simplify, quantify, analyze, and communicate information. By assisting analysts understand complex phenomena and to put them into context for various segments of society (Adriaanse, 1993), indicators help reduce the uncertainty level, allowing society to better define priorities and urgencies.

For the selection and development of environmental indicators a conceptual framework is needed to organize and integrate diverse and dispersed information. At base, this framework consists of three types of indicators. The first identifies the causes of environmental problems and relates them to human activities. The second assesses the quality of the environment as a result of human actions. The third gauges the success of measures taken to improve the environment—essentially, political actions and responses.

There is another type of indicators that should help forecast and anticipate unsustainable aspects of development, as well as measure progress towards sustainability. With these indicators, the objective is to present enough data to permit an analysis of how much room to maneuver various alternative development models will allow. But because these indicators are based on simulation data and land-use projections, they appear in a different section of this document.

Thus, these sets of indicators combined can help analysts diagnose a situation in relation to certain environmental thresholds, design implementable policies based on sustainable development objectives, and figure out which current policies should be reinforced or eliminated to prevent further environmental degradation.

1.3.3. How Were These Indicators Selected?

Given the diversity of situations in Latin America and the great differences in the availability of environmental information from country to country, identifying which are the most important and urgent vis-a-vis the environment and development, as well as choosing the indicators needed to monitor them, is no easy task. Any method for classifying problems and opportunities and for selecting indicators will inevitably be somewhat arbitrary. Still, a first approximation permits us to analyze the development process in terms of its dependence on the environment and natural resources.

The main studies on environment and development in Latin America (BID & PNUD, 1990; Gallopín, et al., 1991c; PNUMA, AECI, & MOPU, 1990; USAID & WRI, 1993; WRI, 1990b) identify ten principal environmental issues:

(1) erosion and the loss of soil fertility,
(2) desertification,
(3) deforestation and land utilization,
(4) forest exploitation and use,
(5) basin degradation,
(6) deterioration of marine and coastal resources,
(7) water and air pollution,
(8) loss of genetic resources and ecosystems,
(9) quality of life in human settlements, and
(10) rural migration and land tenancy.

Since these problems can be analyzed in terms of the degree of impact on natural systems, and the populations and economic activities affected, two cross-cutting issues must also be added to explain and analyze past, current, and future ecological conditions in Latin America in relation to development: land-use and urbanization.

Of course, land-use and urbanization affect natural resources and the environment, population, and economic activities in different ways. At present, though urbanization involves more than half of the region's population, its spatial impacts and effects on natural resources have been limited. In contrast, land-use affects all natural resources and is an issue in most of the region, even though it affects directly only a limited number of the population in rural areas.

Although land-use and urbanization are inextricably interrelated, it is worthwhile to separate them when elaborating and selecting indicators. Urban environmental problems (pollution, industrial activities, wastes, etc.) are related mainly to quality of life and health in cities (Linares et al., 1992). Land-use problems (deforestation, erosion and desertification, loss of ecosystems and species, etc.) reflect primarily the abuse of natural resources. Since land-use appears as the main issue in the region in terms of opportunities and alternatives for a sustainable development, it has been selected as the primary environmental indicator.

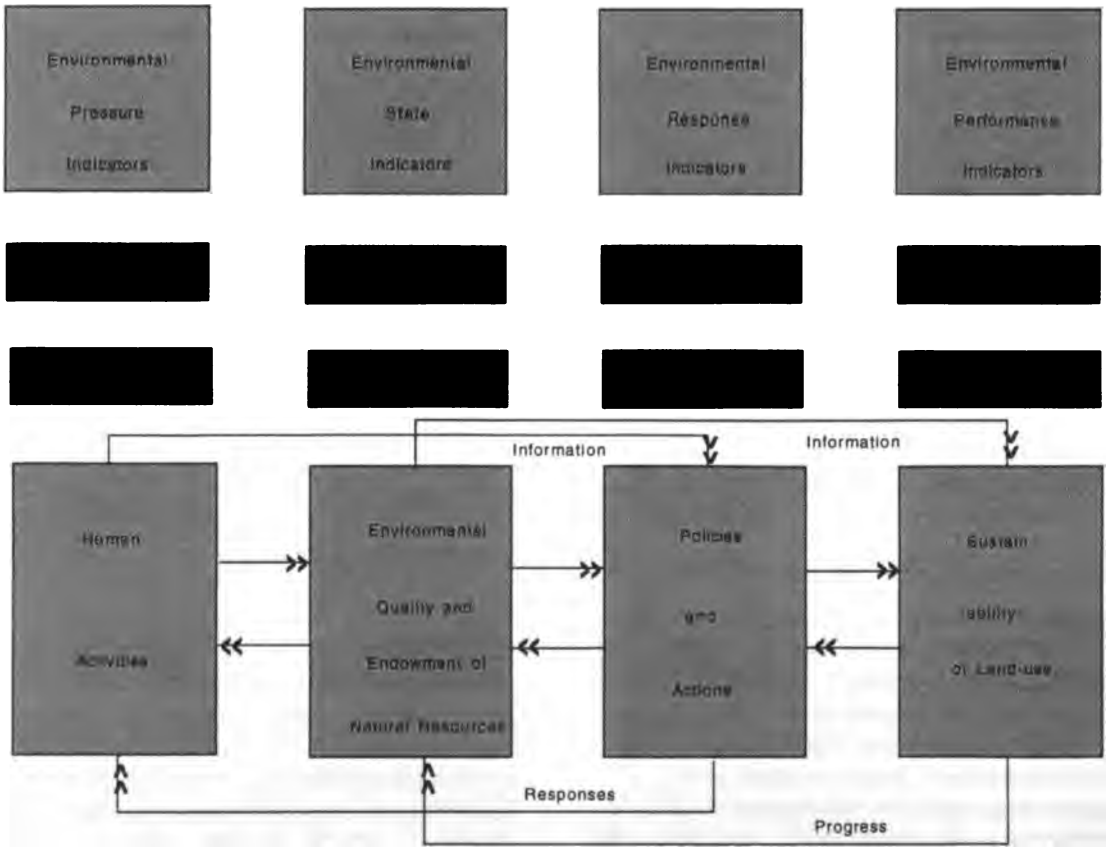
The model adopted for this project to obtain information on progress toward sustainability is a variant of the Pressure-State-Response model, initially proposed by Tony Friend, David Rapport, and others (Friend and Rapport, 1979; OECD, 1991; Adriaanse, 1993). (See Figure 3.1.) Different variables may be selected to measure how a system's sustainability is affected by land-use and natural resources management at the country and life-zones level, as well as at regional and local levels (de Camino and Muller, 1993; IIE, 1993). The variables associated with pressure on the environment are population, socioeconomic development, agriculture and food, and the use of energy resources. These pressures show up as impacts on ecosystems and land-use, forests and rangelands, freshwater and the coastal resources, and biological diversity, and as emissions stemming from human economic activities. As for societal responses, the variables are information, participation in policy-making, and global treaties and conventions. Because both problems and limitations, on the one hand and, on the other, opportunities and solutions to these problems arise as development models change, any projections stemming from this model must be viewed against more than one scenario for land-use and natural resource-use.

Within the framework of this model, indicators were selected on the basis of:

- the availability and quality of data;
- the geographical coverage;
- their relevance to the analysis;
- the possibility of relating the indicators to sustainability or non-sustainability;
- and personal judgments about how well they integrate the different levels and scales of analysis.

To elaborate the indicators, variables for each category of analysis were selected. These variables measure

Figure 3.1 Conceptual Framework for the Pressure-State-Response Model



Sources: Adriaanse, 1992 & 1993; Winograd, 1991 and describe the environmental and land-use situation and its evolution with respect to sustainability. (For example, for the Pressure on the Environment, Population, Socioeconomic Development, Food, Agriculture, and Energy were considered.) In turn, each variable is composed of different elements. (For the Population variable, for instance, the increment of population, the pressure of population on lands, and population distribution were used.) Each element has also some significant characteristics (or descriptors) related to sustainability. (For the population increment element, the measurement of the increment was used.) Finally, for each descriptor selected, one or many indicators must be defined to measure their effect on the system. (For the measurement of the increment of this effect, annual population change was selected as an indicator.) In addition, to understand the meaning of some indicators, statistical data on the future effect of the variables and elements on the system are also needed. (For instance, Projections of Population.) Tables 3.1., 3.2., and 3.3. show the variables selected, as well as the elements, descriptors, and indicators needed for each category in relation to development and the sustainability of land-use.

Table 3.1 Environmental Pressure Indicators

Variable	Element	Descriptor	Indicator	Additional Data
Population	Population Increment	Increment Measurement	Annual Population Change (R & L)	Population Projection (R)
	Pressure on the Lands	Relationship with Surface	Density (R & L)	Livestock Population (L)
	Population Distribution	Relationship between Urban & Rural	Percent Urban and Rural (R & L)	Deforestation & Desertification (L)
Socio-Economic Development	Production Increment	Increment Measurement	Annual Growth Rate (R)	Adjusted GDP (L)
	Production Increment	Relationship with Population	GNP per Capita (R)	Total GNP (R)
	Purchasing Power	Parity of Purchasing Power	GDP per Capita Real (R)	Annual Rate of Inflation (R)
	Employment	Employment Level	Percent of Unemployment (R)	
	External Debt	Relationship between External Debt & Exports	External Debt & Service as Percent of Exports (R)	Total External Debt (R)
	International Prices	Relationship between Export & Import Prices	Exchange Ratio (R)	Prices of Agricultural Products (R)
	Welfare	Human Development Level	Human Development Index (R)	
	Health Condition	Life Expectancy & Mortality	Life Expectancy at Birth & Infant Mortality Rate (R)	
	Nutrition Condition	Undernourishment & Calorie Supply	Percent of Children Undernourished & Calorie Supply (R)	
	Education Condition	Relationship between Male & Female Literacy	Percent of Adult Literacy (R)	
	Poverty	Relationship between Population & Poverty	Percent of Poverty Incidence (R)	
Food and Agriculture	Food Production	Increment Measurement	Change in Production & Yields (R)	
	Food Production	Increment Measurement	Index of Food Production (R)	
	Food Consumption	Change in Calorie Consumption	Per Capita Calories Available (R) & Percent Change of Calorie Intake (R)	Percent Change in Food Consumption (R)
	Agricultural Input	Increment of Input-Use	Annual Fertilizer & Pesticide Use (R)	
	Land Availability	Relationship between Cropland & Population	Cropland per Capita (R)	Irrigated Cropland (R)
	Land Distribution	Inequality of Distribution	Gini Coefficient (R)	
	Production Orientation	Relationship between Grain Production & Destination	Percent of Grain Fed to Livestock (R)	
	Soil Condition	Relationship with Hillside	Percent of Total & Cropland (R)	Population in Hillside (R)
	Hillside Soil Condition	Soil Limitations	Percent of Soils with Limitations (R)	
	Hillside Soil Condition	Soil Potential	Potential Cropland (R)	
	Production Potential	Relationship between Cropland, Population, & Input Level	Agricultural Land Needed (R)	
	Land Availability	Relationship between Cropland & Population	Potential Cropland per Capita (R)	Total Potential Cropland (R)
	Land Availability	Relationship between Actual & Potential Cropland	Land Expansion Potential (R)	
	Carrying Capacity	Relationship between Population & Input Level	Potential Population Supporting Capacity Ratio (R)	
	Production Orientation	Relationship between Drug Production & Employment	Drug Production (R & L)	Prices and Land-Use (L)
	Production Orientation	Changes in Food Consumption	Sources of Foods (L)	Hours Worked for Purchased Food (L)
Energy	Bioenergy Production	Relationship between Fuelwood Production & Population	Fuelwood and Charcoal Production per Capita (R)	
	Bioenergy Production	Relationship between Production & Requirements	Traditional Fuels as Percent of Total Requirements (R)	
	Production Potential	Bioenergy Production	Bioenergy Potential (R)	
	Hydroelectric Resources	Hydropower Capacity	Installed Hydropower Capacity (R)	
	Hydroelectric Production	Hydropower Capacity	Hydropower Generation as Percent of Capacity (R)	
	Hydroelectric Potential	Generation Potential	Exploitable Hydroelectric Potential (R)	
	Hydroelectric Production	Relationship between Generated & Surface	Kilowatts Generated per Hectare (L)	

Note: Brackets indicate scale
R = Regional & L = Local

Table 3.2 Environmental State Indicators

Variable	Element	Descriptor	Indicator	Additional Data
Ecosystems and Land-Use	Change in Primary Production	Production Measurement	Natural & Actual Net Primary Production (R)	Surface Patterns (R & L)
	Change in Land-Use	Change of Measurement in Use Patterns	Percent of Change (R)	Surface Patterns (R & L)
	Production & Employment	Relationship between Employment & Surface	Employment per Hectare (L)	Employment per Activity (L)
	Land Production	Economic Production	Annual Production & Value (L)	Annual Deforestation (L)
	Impact of Land-Use	Emissions Measurement & Intensity of Use	Net Emissions (L), Species Used (L), & Year of Use (L)	Type of Use (L) & Size of Production Unit (L)
	Impact of Land-Use	Relationship between Urban & Rural Emissions	Eq. Persons Using Fossil Fuels in City (L)	
Forests and Rangelands	Vegetation	Forest Types	Closed & Open Forest Surface (R)	
	Forest Depletion	Deforestation in Closed & Open Forests	Annual Deforestation (R)	
	Forest Increase	Reforestation in Closed & Open Forests	Annual Reforestation (R)	
	Change in Forest Surface	Annual Deforestation	Annual Deforestation Rate (R)	
	Change in Forest Surface	Relationship between Reforestation & Deforestation	Reforestation/Deforestation Ratio (R)	
	Forest Production	Relationship between Production & Population	Roundwood Production per Capita (R)	
	Forest Potential	Relationship between Timber Reserves & Population	Timber Reserves per Capita and per Hectare (R)	
	Forest Potential	Relationship between Production & Reserves	Production/Reserve Ratio (R)	
	Vegetation	Changes in Pasture Land	Percent of Change (R)	Permanent Pasture Surface (R)
	Livestock Population	Measurement Increment	Percent of Change in Livestock Population (R)	Livestock Population (R)
	Carrying Capacity	Measurement Increment	Carrying Capacity Index (R)	Percent of Change (R)
	Pasture Production	Measurement Increment of Meat Production	Percent of Change (R)	Meat Production (R)
	Economic Value	Relationship between Surface & Value of Exports	Dollars per ha. of Principal Agricultural Products (L)	
Biological Diversity	Decrease of Species Number	Relationship between Total & Threatened Species	Percent of Animal Species Threatened (R)	Number of Species (R)
	Decrease of Species Number	Relationship between Total & Threatened Species	Percent of Threatened Plant Taxa (R)	Number of Plant Taxa & % Endemic (R)
	Decrease of Species Number	Relationship between Threatened Species & Surface	Threatened Plant Taxa per 1,000 Km2 (R)	
	Protected System	Relationship between Protected Surface & Total	Percent of Total Surface Protected (R)	Number of Sites & Protected Area (R)
	Use of Biological Diversity	Relationship between Species Used & Total Species	Vegetation-Use Index (L)	
	Extinction Risk	Relationship between Habitat Loss & Species	Species Risk Index (R)	
	Investment in Conservation	Relationship between Investment & Surface	Dollars per 1,000 ha. (R)	Protection Financed by $US
	Economic Value	Economic Production	Value of Production (L)	Production Yields (L)
	Economic Value	Investment Profitability	Net Present Value (L)	Productive Cycle (L)
Freshwater and Coastal Resources	Coastal Resources	Relationship between Coastline and Coastal Resources	Relationship between Coastline, Mangroves, & Seagrass (R)	
	Protection of Coastal Resources	Protected Area	Number of Protected Coastal Areas (R)	
	Carrying Capacity	Increment of Population in Coastal Area	Population in Coastal Agglomeration (R)	Damages (R)
	Water Resources	Relationship between Water & Population	Renewable Water Resources per Capita (R)	Total Renewable Water Resources (R)
	Water Resources-Uses	Relationship between Total Resources & Population	Percent & per Capita Annual Withdrawals (R)	Total Annual Withdrawals (R)
	Distribution of Water-Uses	Relationship between Extraction & Activities	Percent of Sectorial Withdrawals (R)	
	Value of Coastal Resources	Relationship between Employment & Income	Employment & Income in Mangrove Forests (L)	
Atmosphere and Climate	Greenhouse Gas Emissions	Change in Greenhouse Emissions for Land-Use	Emissions CO2 Eq Carbon Total & per Capita (R)	
	Greenhouse Gas Emissions	Increment of Greenhouse Emissions	Emissions CO2 Eq. Carbon Total per Capita & per PNB (R)	Emissions of CO2, CH4, & CFC (R)
	Greenhouse Gas Emissions	Relationship between Activities & Land-Use Changes	Emissions CO2 Eq. Carbon by Activity (R)	
	Greenhouse Gas Emissions	Relationship between Actual & Cumulative Emissions	Actual & Cumulative CO2 Emissions per Capita (R)	
	Climate	Natural Disasters	Population Affected & Economic Loss (R)	Type of Event (R)

Note. Brackets indicate scale
R = Regional & L = Local

Table 3.3 Environmental Response Indicators and Progress Toward Sustainability Indicators

Variable	Element	Descriptor	Indicator	Additional Data
Information and Participation	Environmental Information	Countries with Environmental Information	Number of Environmental Profiles & Assessments (R)	INFOTERRA Member (R)
	Society Participation	Participation in Environmental Policy	Number of NGO's by Activity Area (R)	
	Public Opinion	Importance of Environment	Public Perception of Environmental Problems (R)	
Treaties and Conventions	Environmental Policy	Participation in Treaties & Conventions	Signature & Ratification of International Treaties (R)	
	Sources for Financing Conservation	Debt for Nature Swaps	Funds Generated for Conservation (R)	
Projections in Land-Uses	Potential Land-Use	Relationship between Potential Land & Population	Potential Productive Land per Capita (R)	Potential Cropland & Pasture Land (R)
	Land Needed	Relationship between Cropland Needed & Input Level	Agricultural Land Needed in 2030 (R)	Input Level (R)
	Actual & Potential Uses	Relationship between Actual & Potential Lands	Land-Use Index (R)	
	Vegetation	Relationship between Loss & Gain of Forests	Deforestation Rate & Ref./Def. Ratio (R)	Forest Surface (Def. & Ref.) (R)
	Land-Uses	Relationship between Land-Use & Population	Cropland & Forests per Capita (R)	Cropland, Pastures, & Altered & Reforested Areas (R)
	Land-Use Consequences	Greenhouse Gas Emissions	Net Additions per Capita & Total (R)	
	Costs & Investment for Development	Relationship between Land Needed & Land-Use Costs	Mean Annual Investment (R)	Land Used and Land-Use Costs (R)
	Potential Land-Use	Relationship between Actual & Potential Uses with Costs	Rehabilitation Costs & Benefits (L)	
	Mitigation Potential from Land-Use	Relationship between Potential Land-Use & Carbon Sequestration	Carbon Absorption by Reforestation & Agroforestry (R)	

Note: Brackets indicate scale
R = Regional y L = Local

II. Pressures on the Environment

The Gross National Product (GNP) and related aggregate income accounts are generally used as indicators of economic progress. However, every development process generates, to a greater or lesser extent, pressures on the environment. These economic indicators do not reflect the depletion and degradation of natural resources even in economies where they constitute the primary source of the national income. They say nothing about such key ingredients of sustainable development as welfare, quality of life, and equity. For this reason, any analysis of economic growth in relation to natural resources and the environment must be based in part on indicators of the evolution of the human dimension of development. The elaboration of indicators that will allow the evaluation of the pressures exerted by the economic and productive activities in relation to natural resources, land-use, and the environment, will provide the information necessary to analyze the factors that make development sustainable.

Population is a determining factor of environmental integrity and natural resource-use. Increased population density and uneven distribution can be related to a profusion of economic activities and natural resources-uses that can lead to environmental pressures. At the same time, population growth may also produce supplementary pressures on the environment, exhaust natural resources, or contribute to soil over-use. While population increases in developing countries generally affect natural resources, land, and the environment, in developed countries these pressures usually rise in step with consumption rather than population. In any case, indicators on trends and projections of population growth and its density and distribution at country, life-zone, and local levels, must be related to other environmental indicators. (See Socioeconomic Development; Food and Agriculture; Atmosphere and Climate; and Projections for Land-Use.)

Both population growth and economic development depend on agriculture. The way food is grown and land is used deeply affect natural resources and the environment. (See Ecosystems and Land-Use; Forests and Rangelands.) In Latin America and the Caribbean, agriculture constitutes the most important sector of national economies and agricultural products rank first among exports. Attempts to relate environmental pressures to development must thus trace the evolution of production and agricultural consumption. Similarly, the amount of agricultural land available and the level of inputs used on it indicate the state of the development—another way to view intensity of the pressure on the environment, whether measured in terms of desertification, erosion, or soil condition. To scope out the potentialities and limitations of natural resources and land, it is also necessary to know the land's production potential at country and life-zone levels in relation to population and input levels. (See Projections in Land-Uses.) Finally, in cases where local problems have regional impacts, indicators which can be adjusted to different scales are needed.

Energy production and use, besides depleting non-renewable natural resources, are essential to any development process. Good indicators of energy-related pressure on resources and the environment are measures of the available energy sources, the use of renewable energy, and polluting emissions. Also important is the region's potential to adopt policies that will promote rational energy-use. (See Atmosphere and Climate.) In assessing energy-use in relation to land-use, the use and potential of traditional forms of renewable energy are key indicators. These indicators provide information on how energy supply and consumption might change or should be changed and on how unsustainable trends or practices can be mitigated. (See Projections in Land-Uses.)

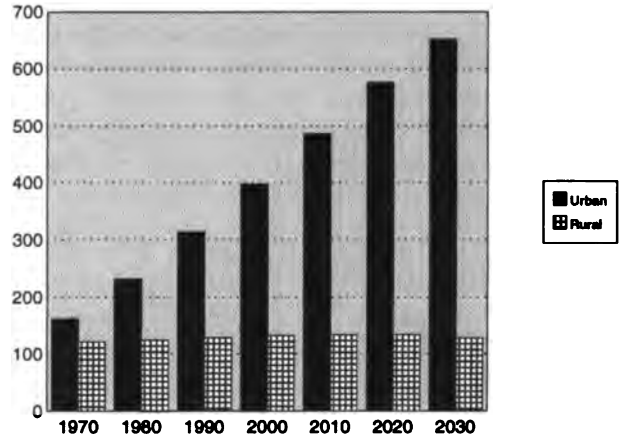
1. POPULATION

Although Latin American population has significantly increased in the last 40 years, it remains a relatively low percentage of the global figures, having risen from 6 percent of the total in 1950 to 8.5 percent of the total in 1990. Between 1950 and 1990, population growth rates were high, but the annual 3 percent rate was surpassed only in Mexico and Central America (UNEP, AECI, & MOPU, 1990). Indeed, population growth rates dropped steadily in Latin America and the Caribbean from 2.8 percent annually between 1960-70 to 2.6 percent annually between 1970-80; they are projected to be 2.4 percent between 1990-2000 and 1.2 percent between 2000-2030.

Land areas in Latin America and the Caribbean are not evenly populated. Many areas are very densely populated, while others are only minimally so. (See Tables 1.1 and 1.2.) Certain mountain regions now boast 35 percent of the total population but cover only 10 percent of the total area. Tropical moist forests are home to only 6 percent of the total population, but represent 31 percent of the total area. (See Table 1.2.)

Population dynamics in Latin America have changed greatly in the last four decades. In the 1950s, population increased significantly in traditionally occupied regions.

Figure 1.1 Population in Latin America and the Caribbean (1970–2030)
(millions of persons)



Sources: CEUR, 1988; WRI, 1992

Since the 1970s, a process of expansion of the agricultural frontier has taken place, along with efforts to integrate isolated regions into the national economies. Tropical moist forests, for instance, show an annual population growth of more than 3 percent in the period 1980-90. Other regions where the agricultural frontier advanced significantly showed annual population growth rates of between 2 and 3 percent; these include tropical dry forests, tropical savannas, and subtropical moist forests. (See Table 1.2.)

Another characteristic of the regional population dynamics in Latin America and the Caribbean is urbanization. While the total regional population grew by a factor of 3.5 in the period 1950-90, the urban population increased 6.1 times while the rural population multiplied by only 1.7. Projections for 2030 show the total population multiplying by 1.7 while the urban population doubles and the rural population remains stable. (See Tables 1.1 and 1.2; Figure 1.2.) In no country or lifezone will the rural population increase faster than the urban population. In 1980, 42 percent of the total regional population lived in cities of more than 100,000 inhabitants while 34 percent dwelled in cities of 100,000 to 1 million and 18 percent lived in cities of more than 1 million inhabitants. In 2030, eight of every ten inhabitants will live in urban zones.

In areas where the agricultural frontier is advancing, such as northern Brazil, as well as in unpopulated marginal zones, such as the Patagonian region in Argentina, urbanization is outpacing population growth. Thus, rural migration as a result of chronic agricultural and land-use problems becomes a key feature of regional population dynamics, as well as of environmental problems associated with it. (See Boxes 1.1 and 1.2.) In such areas, environmental problems stem more from land-use policies than from population pressures. In northern Brazil or Argentinean Patagonia, for instance, a growing livestock population, deforestation, and desertification are bigger environmental issues than any increase in the rural population. (See Boxes 1.1 and 1.2.)

Finally, environmental problems cannot be explained strictly in terms of population size and urban area. Such absolute values as urban or agricultural population and population density alone do not permit an understanding of the dynamic interrelationship of resources, the environment, and population growth (UNEP, AECI, & MOPU, 1990). Population density may indicate the region's carrying capacity in terms of a given technology such as mechanized agriculture, though in urban areas a density indicator is too simplistic. A more useful analysis will take into account the interaction between socio-economic factors and the environment.

Box 1.1 Population in the Northern Region of Brazil

Year	1980	1980	Percent of Change
Total Population (1,000 people)	5,880	9,095	55
Urban Population (1,000 people)	3,040	5,339	75
Rural Population (1,000 people)	2,840	3,756	32
Net Migration	766	x	x
Density (people/Km2)	1.6	2.5	56
Livestock Population (1,000 AU)	3,989	8,876	122
Annual Deforestation (1,000 ha)	650	1,512	128
Deforested Area (%)	1.8	4.6	152

Sources: Fearnside et al., 1990; World Bank, 1990

Box 1.2 Population in the Patagonian Region of Argentina

Year	1960	1980	Percent of Change
Total Population (1,000 people)	786	1,032	31
Urban Population (1,000 people)	291	766	163
Rural Population (1,000 people)	495	266	-46
Density (people/Km2)	0.01	0.013	30
Livestock Population (1,000 AU)	5.9	3.95	-33
Livestock per Rural Inhabitant	12	14.7	22.5
Desertification (%)	32	35	9

Sources: CEUR, 1988; Winograd, 1989

Table 1.1 Population by Country for Latin America and the Caribbean

Country	Population (millions of people)			Annual Population Change (%)	Density (people per Km2)			Rural Population (%)			Urban Population (%)		
	1980	1990	2030	1980-90	1980	1990	2030	1980	1990	2030	1980	1990	2030
Belize	0.15	0.2	0.3	2.2	0.7	0.9	1.3	x	x	x	x	x	x
Costa Rica	2.3	3	5.3	3	45	59	104	55	48	27	45	52	73
Cuba	9.7	10.3	12.3	0.62	87.5	93	111	33	26	14	67	74	86
Dominican Rep.	5.7	7.2	11.4	2.6	119	150	238	49	38	21	51	62	79
El Salvador	4.5	5.3	11.3	1.8	217	256	546	56	51	23	44	49	67
Guatemala	6.8	9.2	21.6	3.4	63	85	200	64	51	41	36	39	59
Haiti	5.4	6.5	11.5	2	196	236	417	77	73	53	23	27	47
Honduras	3.7	5.1	11.5	3.8	33	46	103	64	56	33	36	44	67
Jamaica	2.2	2.5	3.8	1.5	202	231	352	x	x	x	x	x	x
Mexico	69.8	88.6	150.1	2.7	36.6	46.4	79	35	29	16	65	71	84
Nicaragua	2.8	3.9	9.2	3.9	23.6	33	77.5	46	40	24	54	60	76
Paname	2	2.4	3.9	2.3	26	32	51	51	49	33	49	51	57
Argentina	28.1	32.9	47.4	1.7	10.3	12	17.3	17	14	9	83	86	91
Bolivia	5.6	7.3	18.3	3.1	5.1	6.7	16.9	55	48.5	37	45	51.5	63
Brazil	121.3	150.4	245.8	2.4	14.3	17.8	26.4	33	26	14	67	74	86
Chile	11.1	13.2	19.8	1.9	14.8	17.6	26.4	20	16	10	80	84	90
Colombia	25.8	31.8	51.7	2.3	24.8	30.6	49.8	34	28	14	66	72	86
Ecuador	8.1	10.8	22.9	3.3	30.2	39	82.7	53	45	26	47	55	74
Guyana	0.9	1	1.6	1.1	4.6	5	8	x	x	x	x	x	x
Paraguay	3.2	4.3	9.2	3.4	8	10.8	23.2	61	58	51	39	42	49
Peru	17.3	22.3	41	2.9	13.5	17.4	32	36	30	17	64	70	83
Suriname	0.32	0.4	0.6	2.5	2	2.5	3.7	x	x	x	x	x	x
Uruguay	2.9	3.1	3.9	0.7	16.6	17.7	24.2	16	14	11	84	86	89
Venezuela	15	19.7	38	3.1	17	22.3	43	24	21	13	76	79	87
Latin America & the Caribbean	355	442	753	2.4	17.4	21.6	36.9	35	29	17	65	71	83

Sources: CEUR, 1988; WRI, 1992
Note: x = not available

Table 1.2 Population by Life-Zone for Latin America and the Caribbean

Life-Zones	Population (millions of people)			Annual Population Change (%)	Density (people per Km2)			Rural Population (%)			Urban Population (%)		
	1980	1990	2030	1980-90	1980	1990	2030	1980	1990	2030	1980	1990	2030
TmF	18.6	25.6	54.3	3.8	2.8	3.8	8.2	42	35	22	58	65	78
TlmmF	87.4	106.5	166.5	2.2	187	228	357	34	27	15	66	73	85
TdF	16.5	20.4	33.9	2.4	8.7	10.8	18	35	28	13	65	72	87
TvdF	18.7	24.2	44.6	2.9	13	17	32	27	22	13	73	78	87
Ts(TdF)	2	2.6	5.8	3	1.9	2.5	5.5	40	35	32	60	65	68
Paramo	11.1	14	26.1	2.6	258	325	607	40	33	18	60	67	82
Puna	5.1	6.7	15.6	3.1	5.8	7.6	18	49	43	33	51	57	67
T-STmF	18.7	24.1	48.4	2.9	24	31	62	50	41	30	50	59	70
D-M	5.1	6.3	10.3	2.4	27	34	55	33	26	16	66	74	84
T-STD&Ds	68	86.4	149.7	2.7	59	74	129	46	38	16	54	62	84
STmF	41.5	50.5	85.1	2.2	28	34	58	45	39	25	55	61	75
STdF	17.2	21.5	35.2	2.5	12	15	24	32	27	17	68	73	83
STs	32.5	37.9	55.9	1.7	31	36	54	21	17	11	79	83	89
STtS	8.8	9.9	14.7	1.3	85	96	143	20	16	10	80	84	90
STDs	1.8	2.2	3.1	2.5	2.4	3	4.1	17	14	9	83	86	91
TemmF	1.9	2.3	3.6	2	5.8	6.9	11	28	16	10	72	84	90
S	0.3	0.32	0.5	1.9	0.6	0.6	1	19	15	9	81	85	91
TemS	0	0	0	0	0	0	0	0	0	0	0	0	0
Latin America & the Caribbean	355	442	753	2.4	17.4	21.6	36.9	35	29	17	65	71	83

Sources: CEUR. 1988: Winoarad. 1989

TECHNICAL NOTES:

Table 1.1 Population data are based on censuses and projections elaborated for the region (CEUR, 1988; WRI, 1992: Tables 16.1 and 17.2). Data on CARICOM countries with a total population of approximately 7 million were not included (Antigua and Barbuda, Bahamas, Barbados, Dominica, Grenada, St. Cristophe and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, nor the overseas territories such as Anguilla, Netherlands Antilles, Aruba, British Virgin Islands, U.S. Virgin Islands, Cayman Islands, French Guyana, Guadeloupe, Martinique, Montserrat and Puerto Rico). (See Appendix 1.1.) Country data for 1970-76 are the basis for population projections and were used to estimate population per life-zones in the same period (CEUR, 1988). Differences may exist with data from other sources.

Table 1.2 For the elaboration of life-zone population data, life-zone maps for Latin America and the Caribbean (Winograd, 1989) were used. On these maps, cities with more than 50,000 inhabitants were marked for the 1970-76 period which included 70 percent of the regional urban population (CEUR, 1988). All together, 350 cities were distributed to the different life-zones. Assuming that the rest of the urban population will be distributed in the same way as that of these 350 cities in the base year, the total urban population per life-zone was calculated for the year 1980. The urban population was then projected for 5-year periods (1980-2030) for all life-zones using U.N. data and projections at the country level. Such an approach assumes that the share of urban population will not vary (CEUR, 1988). The projections underestimate the population of agricultural frontiers and overestimates the population of stable areas. Thus, in the tropical moist forest life-zone (TmF), including part of Amazonia, the population data should be considered as a minimum hypothesis. In the case of steppes (S), including Patagonia, data should be considered as a maximum hypothesis. For this study, population totals are given per country and per life-zone at a regional level. A country breakdown by life-zone is available in CEUR, 1988.

Box 1.1 and 1.2 These data refer to specific local studies which are the source of the information. The boxes consider two regions in which population projections per life-zone present a minimum (Amazonia) and a maximum (Patagonia) hypothesis.

2. SOCIO-ECONOMIC DEVELOPMENT

In recent decades, Latin America and the Caribbean have endured great economic changes. Although basic and vital economic indicators showed continual progress between 1960-1990, the 1980s can be considered a lost decade for development. (See Tables 2.1 and 2.3.) Recession dominated the region. Real interest rates were high, the real prices of basic products fell, terms of trade deteriorated, currency exchange rates fluctuated wildly, and private voluntary financing crashed in many developing countries (World Bank, 1989). (See Box 2.1.) Coupled with deficient natural-resource management policies in many countries, these trends led to the adoption of austerity policies to pay external debts, which increased from 50 billion in 1970 to 426 billion dollars in 1990 (World Bank, 1991 & 1992). (See Table 2.2.)

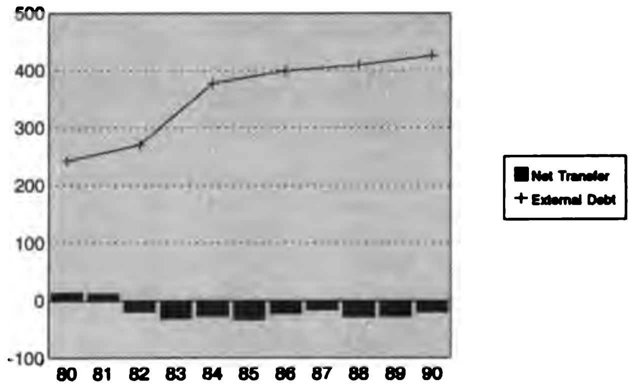
The flow of financial resources in the region changed radically with respect to the developed world. In the early 1980s, Latin America and the Caribbean received a net resource transfer of 13 billion dollars annually (average for the period 1977-1981). But this flow became negative in the 1981-1990 period, with a net cumulative transfer to the developed world of 250 billion dollars (CEPAL, 1990b). (See Figure 2.1.)

Austerity policies adopted to help repay crippling debt have struck different income groups in different ways, but low income groups have been almost universally affected by the reduction of assistance programs and public services. Meanwhile, to spur investment and high-profile development programs, much of the funding went to high-income and industrial sectors (IDB & UNDP, 1990).

The structural adjustment programs of the 1980s have backfired in many countries of the region. Although budgets do need to be balanced, public expenses decreased, and market forces liberated, adjustment policies have increased unemployment and poverty and stymied investment in "human capital." (See Table 2.3.) As just one indication, eradicated diseases have made a come-back among low-income populations as services and assistance programs have eroded. Cholera broke out in Peru and several other countries while measles re-emerged in Argentina.

As for income, distribution is increasingly regressive. Between 1980 and 1985, real per capita income dropped 14 percent, pushing high proportions of the population beneath the poverty line. At the same time, unemployment and under-employment rates rose. Public expenditures decreased in most countries (UNDP, 1989). The per capita GNP in Latin America and the Caribbean was lower in 1989 than in 1980. By 1989, the GDP had dropped 16 percent compared to that of 1980. The change in per capita GDP, which increased 4.1 percent per year on average from 1965 through 1973, became negative between 1980 and 1985 (World Bank, 1989 & 1991).

Figure 2.1 Annual Net Transfer of Resources and External Debt in Latin America and the Caribbean (1980–1990)
(billions of dollars)



Source: CEPAL, 1990

The notion that the 1980s were development's lost decade in the region is based not only on economic data (GNP, external debt, etc.). Although the human development index showed important progress in all countries from 1970 through 1985, there was no improvement in any country during the next five years. (See Table 2.4.) Moreover, the calculation of the human development index for 1990 was based on GNP data for 1985; if it is adjusted with GNP data for 1990, the decline for all countries is even more significant (Suárez, 1992).

Environmental degradation, together with poverty and low living standards, have a great influence at the regional level. Extreme poverty is advancing in the region, compelling the population to exploit fragile environments just to subsist. Migration to the cities, where rural inhabitants settle in slums, is also on the rise as rural agricultural land is exhausted.

Besides the visible urban effects of adjustment policies, forests in particular and natural resources in general are bearing the brunt of growing social and ecological impoverishment and the reduction of investment funds for development in the region. Although many macroeconomic indicators show a rebound from the crisis of the 1980s in the last years (1990-92), other indicators related to quality of life and the condition of natural resources do not. Moreover, current national income levels do not reflect the importance of natural resources in development. Indeed, most countries of the region have used up and even destroyed their wealth of natural resources in

Table 2.1 Basic Economic Indicators by Country for Latin America and the Caribbean

Country	GNP Total (10^6 dollars) 1989	GNP Per Capita (dollars) 1990	GNP Annual Growth Rate (%) 1965-90	Real GDP per Capita (PPA in dollars) 1985-88	Average Annual Rate of Inflation (%) 1980-90	Unemployment (%) 1988-89
Belize	294	1,990	2.6	x	2.3	x
Costa Rica	4,898	1,900	1.4	4,320	23.5	3.8
Cuba	20,900	x	x	x	x	x
Dominican Rep.	5,513	830	2.3	2,420	21.8	x
El Salvador	5,356	1,110	-0.4	1,950	13.2	8.3
Guatemala	8,205	900	0.7	2,430	14.6	2
Haiti	2,556	370	0.2	980	7.2	x
Honduras	4,495	590	0.5	1,490	5.4	x
Jamaica	3,011	1,500	-1.3	2,630	18.3	16.8
Mexico	170,053	2,490	2.8	5,320	70.3	3
Nicaragua	2,803	x	-3.3	2,660	432.3	8.4
Panama	4,211	1,830	1.4	3,790	2.3	16.3
Argentina	68,780	2,370	-0.3	4,360	395.2	7.3
Bolivia	4,301	630	-0.7	1,480	317.9	20
Brazil	375,146	2,680	3.3	4,620	284.3	3.9
Chile	22,910	1,940	0.4	4,720	20.5	5.3
Colombia	38,607	1,260	2.3	3,810	24.8	8.9
Ecuador	10,774	980	2.8	2,810	36.6	7.9
Guyana	248	330	-1.3	x	25.5	x
Paraguay	4,299	1,110	4.6	2,590	24.4	6.1
Peru	23,009	1,160	-0.2	3,080	233.9	7.9
Suriname	1,314	3,050	1	x	6.4	x
Uruguay	8,069	2,560	0.8	5,790	61.4	8
Venezuela	47,164	2,560	-1	5,650	19.3	9.2

Sources: ILO, 1993; UNDP, 1991; World Bank, 1992; WRI, 1992
Note: x = not available

the name of development. Although the GNP may increase, once the country's main source of wealth has been consumed, its economic future becomes very uncertain. If natural resources were included in the national accounts, both the costs and the net results of economic development would look very different from the conventional interpretation. (See Box 2.2.)

Table 2.2 External Debt and Trade by Country for Latin America and the Caribbean

Country	Total External Debt (millions of dollars)		Total External Debt as a Percent of Exports of Goods & Services		Total External Debt as Service Percent of Exports of Goods & Services		Exchange Ratio (1987=100)
	1970	1990	1980	1990	1980	1990	1990
Belize	x	x	x	x	x	x	x
Costa Rica	x	3,772	225	184	29	25	114
Cuba	x	x	x	x	x	x	x
Dominican Rep.	558	4,400	134	189	25	10	98
El Salvador	149	2,133	71	171	8	17	114
Guatemala	330	2,777	64	175	8	13	102
Haiti	x	874	73	258	6	10	97
Honduras	x	3,480	152	322	21	40	104
Jamaica	303	4,598	129	129	19	31	88
Mexico	10,295	96,810	259	222	50	28	110
Nicaragua	1,659	10,497	422	2,729	22	4	110
Panama	x	6,676	70	127	12	4	138
Argentina	8,416	61,144	242	406	37	34	112
Bolivia	302	4,276	258	429	35	40	97
Brazil	18,576	116,172	305	327	63	21	123
Chile	x	19,114	193	181	43	26	131
Colombia	1,614	17,241	117	183	16	39	92
Ecuador	1,407	12,105	202	372	34	33	109
Guyana	x	x	x	x	x	x	x
Paraguay	365	2,131	122	112	19	11	110
Peru	4,859	21,105	208	488	47	11	78
Suriname	x	x	x	x	x	x	x
Uruguay	477	3,707	104	156	19	41	104
Venezuela	2,284	33,305	132	159	27	21	164

Sources: UNDP, 1991; World Bank, 1992
Note: x = not available

Box 2.1 Commodity Prices and Commodity Exports for the Principal Products In Latin America and the Caribbean

Crop	Price (1980 dollars)			Percent of Global Trade
	1975	1982	1989	1985
Cocoa (Kg)	1.98	1.75	0.94	18
Coffee (Kg)	2.94	3.2	1.66	60
Maize (T)	190.5	110.3	84.8	9
Wheat (T)	288.7	168	153	6
Sugar (Kg)	0.72	0.19	0.21	51
Beef (Kg)	2.11	2.41	1.95	13
Banana (Kg)	0.39	0.38	0.42	x
Rubber (Kg)	10.49	10.11	8.5	x
Tobacco (T)	2,416	2,432	1,441	15
Soybeans (T)	350	247	209	x

Sources: World Bank, 1986; WRI, 1992

Table 2.3 Vital Indicators by Country for Latin America and the Caribbean

Country	Life Expectancy at Birth (years)	Infant Death Rate (deaths per 1,000 live births)		Children Undernourished (%)	Daily Calorie Supply per Capita	Adult Literacy (%)		Incidence of Poverty (% of total population)	
	1990	1970-75	1990-95	1980-88	1988	Female 1990	Male 1990	1980	1986
Belize	70	x	x	x	x	x	x	x	x
Costa Rica	75	51	17	6	2,782	93	93	22	25
Cuba	71	36	13	x	x	93	95	x	x
Dominican Rep.	67	94	57	13	2,357	82	85	x	x
El Salvador	64	110	53	15	2,415	70	76	76	x
Guatemala	63	95	48	34	2,352	47	63	84	x
Haiti	56	135	86	37	1,911	47	59	95	x
Honduras	65	110	57	21	2,164	71	76	80	x
Jamaica	73	42	14	7	2,572	99	98	x	x
Mexico	70	71	36	x	3,135	85	90	32	30
Nicaragua	65	100	50	11	2,361	x	x	80	x
Panama	72	43	21	16	2,468	88	88	67	x
Argentina	71	49	29	x	3,118	95	96	9	13
Bolivia	55	151	93	13	2,086	71	85	86	x
Brazil	66	91	57	5	2,709	80	83	39	40
Chile	72	70	19	3	2,584	93	94	56	x
Colombia	69	73	37	12	2,561	86	88	39	38
Ecuador	66	95	57	17	2,338	84	88	65	x
Guyana	65	79	48	x	x	95	98	x	x
Paraguay	67	53	39	32	2,816	88	92	63	x
Peru	63	110	76	13	2,269	79	92	46	52
Suriname	70	49	28	x	x	95	95	x	x
Uruguay	72	46	20	7	2,770	96	97	11	15
Venezuela	70	49	33	6	2,547	90	87	22	27

Sources: CEPAL, 1990; FAO, 1988; UNDP, 1991; World Bank, 1991; WRI, 1992
Note: x = not available

Box 2.2 Gross and Net Domestic Product and Adjusted Net Domestic Product in Costa Rica (millions of 1984 colones)

Year	Gross Domestic Product (GDP)	Net Domestic Product (NDP)	Natural Resources Depreciation (NRD)	Adjusted Net Domestic Product (ANDP)
1970	93,446	87,495	4,982	82,513
1975	125,393	118,738	7,583	111,155
1980	161,894	153,365	8,233	145,132
1985	169,299	164,605	11,231	153,374
1989	231,289	225,966	20,604	205,362

Source: TSC & WRI, 1991

Table 2.4 Human Development Index by Country for Latin America and the Caribbean

Country	Human 1970	Development 1985	Index 1990
Belize	x	x	0.711
Costa Rica	0.759	0.865	0.876
Cuba	x	x	0.754
Dominican Rep.	0.513	0.663	0.622
El Salvador	0.483	0.524	0.524
Guatemala	0.416	0.515	0.488
Haiti	0.2	0.349	0.296
Honduras	0.385	0.618	0.492
Jamaica	0.797	0.775	0.761
Mexico	0.675	0.864	0.838
Nicaragua	0.549	0.66	0.612
Panama	0.703	0.835	0.796
Argentina	0.784	0.902	0.854
Bolivia	0.383	0.468	0.416
Brazil	0.569	0.807	0.759
Chile	0.736	0.912	0.878
Colombia	0.617	0.786	0.757
Ecuador	0.542	0.737	0.655
Guyana	x	x	0.589
Paraguay	0.607	0.729	0.667
Peru	0.595	0.668	0.644
Suriname	x	x	0.792
Uruguay	0.799	0.924	0.905
Venezuela	0.715	0.874	0.842

Source: UNDP, 1991; Note: x = not available

TECHNICAL NOTES:

Table 2.1 Economic development data are from the World Bank (1992, Tables 1 and 28 of World Development Indicators). Real GNP per capita data are from UNDP (1991, Table 1 of Human Development Indicators). UNDP made GNP per capita data internationally comparable, by using purchasing power parity as conversion factors instead of average exchange rates.

Table 2.2 Data on external debt are from the World Bank (1992, Tables 21 and 24 of World Development Indicators). Data on exchange ratios come from UNDP (1991, Table 20) and refer to the index of average export prices of a country to the index of average import prices.

Table 2.3 Vital indicators data are based on different sources and, therefore, could not be elaborated for the same periods of time. Life expectancy and child mortality rate data are from WRI (1992, Table 16.2). Calorie supply and malnutrition data are from UNDP (1991, Tables 7, 12 and 13 of Human Development Indicators). Literacy data are from WRI (1992, Table 16.5). Poverty data are from CEPAL (1990) and FAO (1988). According to UNDP's definition, the poverty line is the income level beneath which it is impossible to guarantee a minimum nutritionally adequate diet, as well as essential non-food requirements. Data in the table refer to the percentage of total populations living below the poverty line.

Table 2.4 Data on Human Development Index are from UNDP (1991, Table 1 of Human Development Indicators). The Human Development Index is composed of three indicators: life expectancy, education, and income. This Index is constructed by defining a deprivation value for each country using these basic variables (life expectancy, literacy, and logarithm of GNP per capita). For each variable, a maximum and minimum value based on all country values in the sample, are identified. Each country is placed within a 0-1 scale, defined by its distance to the maximum and the minimum for each of the three variables (deprivation indicator). Then a deprivation average (DA) is calculated by averaging the three indicators. Finally, the Human Development Index is measured by 1-DA.

Box 2.1 Data on prices of the main agricultural products in Latin America and the Caribbean are from the WRI (1992) (Table 15.4). Data on the percentage of world trade are from the World Bank (1986).

Box 2.2 Data are from the TSC & WRI (1991, Table 1.2). The depreciation of natural resources is calculated from the depletion of forests (loss of standing timber by deforestation and loss of the production potential if forests had been managed), the loss of soil by erosion (value of nutrients lost by erosion at their commercial prices), and the depletion of fishery resources (decline in fishery asset value due to the depletion by increasing effort or by overexploitation). The Adjusted Net Domestic Product (ANDP) is calculated as the difference between the GNP and the depreciation of natural resources.

3. FOOD AND AGRICULTURE

During the last decades, attention was paid to food self-sufficiency—both to the importance of agricultural exports as a source of financial development and to balance-of-exchange terms (Redclift and Goodman, 1991). In contrast, agricultural sustainability began receiving attention for only a few years (Gallopín et al., 1991c; IICA, 1991; WRI & USAID, 1991), which somehow reflects the bias of regional development policies in favor of urbanization and industrialization.

Latin American agriculture has undergone great changes that have accentuated the gaps among peasant and modern agricultural systems. In the latter, peasants' only option is to join the non-agricultural labor force considering the economic crisis in rural areas (UNEP, AECI, & MOPU, 1991). But though peasant agriculture is the most undersupported, it continues providing cheap food for urban areas. In a region where enough food is produced to feed the entire population, and where production indexes have increased in the last decades, hunger persists. Indeed, undernourishment has even grown in many rural zones and urban marginal sectors. (See Table 2.3 Socioeconomic Development.) Obviously, policies oriented only toward increasing agroproduction yields, instead of guaranteeing the accessibility of all social classes to food, are of limited value (which means paying attention to crop varieties and consumption patterns at local levels).

In Latin America and the Caribbean, the direct consumption of agricultural crops is falling while the production of cattle feed and industrial cash crops is rising. (See Figure 3.1.) Cereal production increased 13 percent between 1980 and 1990. While the production of wheat (used in industrial products) grew by 33 percent, the production of corn, a basic staple in the region, increased only 18 percent. During the same time, root and tuber production for direct consumption increased by only 4 percent (potato, 3 percent; sweet potato, 9.5 percent; yucca, -4 percent). (See Table 3.1.) Meanwhile, the production of grain feed for cattle has grown in all countries during the last 20 years. (See Table 3.2.)

The use of agricultural inputs has grown significantly in the region in the last 40 years, especially as "green revolution" technology has been applied. However, input use is still low compared to that of developed countries. (For example, in South America, an average of 40 Kg of fertilizer per hectare cultivated is used, compared to 227 Kg/ha in Europe, 111 Kg/ha in Asia, and 95 Kg/ha in the United States. (See Table 3.3.) On the other hand, high input use occurs only in cash crops (fertilizers) and in some industrial crops such as cotton (pesticides).

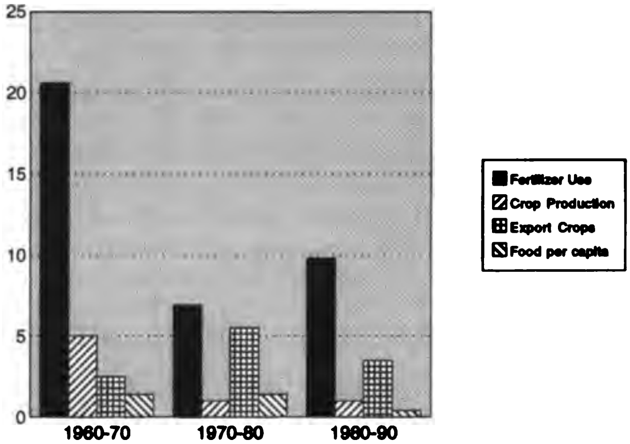
Table 3.1 Food Production by Country for Latin America and the Caribbean

	Cereals				Roots and Tubers				Index of Food Production (1979-80=100)			
Country	Production (10^6 T)		Yields (T/ha)		Production (10^6 T)		Yields (T/ha)		Total		Per Capita	
	1980	1990	1980	1990	1980	1986	1980	1990	1978-80	1988-90	1978-80	1988-90
Belize	x	0.03	x	1.7	x	x	x	x	100	115	102	92
Costa Rica	0.3	0.3	2.5	2.6	0.04	0.05	5.8	8.5	100	117	103	91
Cuba	0.5	0.6	2.4	2.5	1	1	6.5	5.3	98	109	99	101
Dominican Rep.	0.4	0.5	2.9	3.5	0.2	0.2	5.8	6.8	100	116	103	94
El Salvador	0.7	0.8	1.7	1.9	0.03	0.03	12.5	16	103	107	105	94
Guatemala	1.1	1.5	1.5	1.8	0.05	0.05	3.8	4.3	97	123	100	95
Haiti	0.4	0.4	1	0.9	0.7	0.8	3.8	4	100	110	101	93
Honduras	0.5	0.6	1.2	1.3	0.02	0.02	4.9	7	95	123	99	91
Jamaica	0	0	1.7	1.3	0.23	0.25	11.7	12.6	106	103	107	91
Mexico	20.7	22.7	2.1	2.2	1.1	1.1	129	13.9	97	118	99	96
Nicaragua	0.4	0.5	1.5	1.6	0.03	0.05	4	11.8	113	82	116	61
Panama	0.25	0.3	1.5	1.8	0.07	0.08	8.5	9.2	98	106	100	88
Argentina	24.5	19.8	2.2	2.2	2.3	2.3	14	20.7	95	107	97	95
Bolivia	0.7	0.7	1.2	1.2	1	1.1	5.2	5.8	96	136	98	107
Brazil	30.8	39.8	1.5	1.9	27.3	28.4	11.6	12.5	95	134	97	111
Chile	1.7	2.9	2.1	3.7	0.9	0.8	10.3	14.5	95	131	96	112
Colombia	3.3	3.9	2.5	2.5	4.1	3.5	11	11.9	97	131	100	109
Ecuador	0.7	1.4	1.6	1.7	0.5	0.8	9.6	6.9	97	137	100	108
Guyana	0.3	0.2	2.9	2	x	x	x	x	101	74	102	71
Paraguay	0.7	1.6	1.4	2	2.3	2.9	13.2	16.5	93	158	96	119
Peru	1.4	2.2	1.9	2.5	2.25	2.36	7.5	8.3	99	122	101	100
Suriname	0.2	0.2	3.9	3.8	x	x	x	x	91	101	91	87
Uruguay	1	1.4	1.6	2.5	0.11	0.15	5.4	6	93	120	93	113
Venezuela	1.5	2	1.9	2.2	0.6	0.7	7.9	8.3	99	121	102	94
Latin America & the Caribbean	92	104.3	x	x	44.8	46.6	x	x	x	x	x	x

Sources: FAO, 1992; WRI, 1992
Note: x = not available

Irrigation, now associated with agricultural modernization, was practiced in the region even before the Conquest. Irrigated lands currently represent 11 percent of the total cultivated area, with an expansion potential of 22 million hectares (Dourojeanni, 1982). (See Table 3.3.) In some countries, such as Mexico, Chile, and Peru, more than half of all agricultural production originates in irrigated areas. This progress aside, very often irrigation has been installed in inappropriate ecological zones where it causes salinization and desertification. Indeed, nowadays 33 percent of all irrigated areas show signs of desertification (CEPAL, 1991).

Figure 3.1 Annual Growth Rate for Agricultural Indicators in Latin America and the Caribbean
(percent)



Sources: FAO, 1992; WRI, 1992

The ownership of agricultural land in Latin America and the Caribbean has steadily grown more concentrated. (See Table 3.4.) Now the land concentration indexes are the world's highest (FAO, 1988). The number of small farmers and the area occupied have both increased, but the average size of their farms has decreased. On the other hand, wealthy landowners with large agricultural enterprises now control most agricultural and ranching lands. The number and area of intermediate-sized farms have increased as larger holdings were restructured, but mostly as a result of the expansion of the agricultural frontier. This process of concentration applies to more than the land. In many regions, the concentration of water resources and good soils in the hands of a small minority pushes the rural population toward steep hillsides or the tropical lowland moist forests, which accelerates the advance of the agricultural frontier.

Table 3.2 Food Consumption by Country for Latin America and the Caribbean

Country	Per Capita Average Calories Available (as % of need) (1988-90)	Annual Percent of Change in Calorie Intake (1970-90)	Annual Percent of Change in Cereals Consumption (1970-90)	Annual Percent of Change in Roots and Tubers Consumption (1970-90)	Annual Percent of Change in Meat Consumption (1970-90)	Annual Percent of Change in Milk Consumption (1970-90)	Grain Fed to Livestock as % of Total Grain Consumption 1970	1990
Belize	114	0.6	-0.7	3.6	1.3	1.2	x	x
Costa Rica	121	0.6	0.2	-1.1	1.5	1.3	16	24
Cuba	135	0.9	0	0.4	0.4	-0.7	0	4
Dominican Rep.	102	0.7	2.7	-2.7	4.5	-0.4	x	x
El Salvador	102	1.3	0.9	1.4	2.2	1.1	25	28
Guatemala	103	0.4	0.2	3.9	-1.7	-2.7	13	25
Haiti	89	-0.1	-0.3	0	0.3	-2	0	9
Honduras	98	0.2	0	-3.2	0.4	-1.3	16	35
Jamaica	114	0	-0.3	1	2.5	-1.4	x	x
Mexico	131	0.7	0.5	0.5	3.8	1.4	18	31
Nicaragua	99	-0.3	0.2	2.8	-3.1	-2.5	19	0
Panama	98	0	-0.5	-0.5	1.5	-0.5	13	30
Argentina	131	-0.4	-0.3	-1	-0.7	0.4	46	42
Bolivia	84	0	0.3	-1.7	2.6	-0.6	22	35
Brazil	114	0.5	0.5	-2.2	1.6	1.6	44	55
Chile	102	-0.2	-0.3	0.7	0.6	0.3	29	33
Colombia	106	1	0.9	1.1	2	-0.1	13	20
Ecuador	105	0.6	1.7	-3	1.2	-0.5	8	22
Guyana	108	0.3	0.4	-1.6	1.1	0.4	x	x
Paraguay	116	-0.1	-0.1	-0.6	-0.8	1	x	x
Peru	87	-0.9	-0.4	-2.8	0.2	-2	16	28
Suriname	106	0.5	0.3	5	2.3	2.8	x	x
Uruguay	101	-0.6	-0.1	-0.5	-2	1.9	37	12
Venezuela	99	0	0.1	-2	1.2	-0.7	16	35

Sources: FAO, 1992; UNDP, 1992; WRI, 1992
Note: x = not available

Box 3.1 Indicators of Drug Production in Latin America and the Caribbean

Major Drug Production, Cultivated Surface, and Employment

Country	Production (T)			Surface (ha)				Employment
	Coca 1990	Marihuana 1990	Opium 1990	Coca 1980	Coca 1990	Marihuana 1990	Opium 1990	1988
Belize	x	60	x	x	x	400	x	x
Jamaica	x	825	x	x	x	2,250	x	x
Mexico	x	19,715	62	x	x	41,800	10,100	x
Bolivia	64,400	x	x	22,800	58,400	x	x	350,000
Colombia	32,100	1,500	x	4,000	41,000	2,000	16,250	50,000
Ecuador	120	x	x	x	150	x	x	x
Peru	138,400	x	x	70,000	121,300	x	x	300,000

Sources: Eastman, 1993; UNEP, AECI, & MOPU, 1990; Tanswell, 1985; Walstar, 1990

Coca Prices in Colombia (dollars/Kg)

Product	1985	1990	Variation (%)
Coca Leaf	4	2.1	-47,5
Coca Paste	1,400	750	-47,5
Cocaine in Colombia	9,000	6,000	-33
Cocaine in U S A	40,000	30,000	-25

Sources: Gallopín et al., 1991; UNEP, AECI, & MOPU, 1990; Kendall, 1985

Value per Hectare for the Principal Crops (1985-88 actual and potential prices in dollars)

Crop	Price
Coca	3,500 to 4,250
Cacao	2,600
Tea	2,600
Coffee	500 to 800
Banana	600
Rice	380
Corn	300
Meat	60

Sources: Gallopín et al., 1991; Boucher, 1991

Patterns of Peasant Land-Use in Cochabamba, Bolivia (%)

Crop	1971	1985
Banana	51.9	13.8
Rice	12.3	10.9
Yucca	9.2	4.4
Oranges	4.3	3.2
Coca	22.3	67.9

Source: Dávila, 1989

Peasant systems represent half of the rural population (20 percent of the total), occupy 20 percent of the productive area, and account for 50 to 60 percent of all agricultural products consumed in Central America and the Andean countries (UNEP, AECI, & MOPU, 1991; Molina, 1989). Yet, this sector has benefitted the least from regional development and as mentioned, increasingly finds itself pushed onto lands with less agricultural potential, such as hillsides.

Peasant agriculture on hillsides has more regional importance than recognized, involving 40 to 60 percent of the poor rural population (World Bank, 1990b). In tropical Latin America, this type of agriculture accounts for approximately 30 percent of all production and absorbs 40 percent of the agricultural population. It occupies 17 percent of the total surface area and 29 percent of all agricultural lands. (See Table 3.5.) These regions produce basic products and peasants subsidize the urban food supply by receiving low prices for their products (except in the case of coffee). The deterioration of peasant agriculture on slopes will increase dependency on food imports in most countries in the region, steer migration flows toward urban zones, and increase migration and advance of the agricultural frontier.

In the 1980s, the peasant agricultural crisis coincided with a great boom in drug cultivation that started in the early 1970s. Today, any grower can earn between 1.5 and 15 times more cultivating coca than producing other products. (See Box 3.1.) In 1989, help in eradicating coca plantations was limited to U.S. $350 per hectare of destroyed coca plus U.S. $1,650 for family relocation, while the coca crop itself brought in U.S. $3,500 to 4,250 dollars per hectare. Even though the drug problem is now considered a world calamity, only U.S. $260 million was spent eradicating and reorienting coca production in 1989 in the three Andean countries with the highest production levels (Peru, Bolivia, and Colombia). The region's national agricultural and price policies, coupled with the economic policies of drug-importing countries, compels peasants to use excellent agricultural lands (valle de Huallaga in Peru), lands that would otherwise provide basic food (el Chapare in Bolivia) and reserves for flora and fauna (Sierra de la Macarena in Colombia), to cultivate coca. Drug cartels in Colombia have shown great flexibility and ability to reorient and relocate drug production. Poppy cultivation for heroin production grew from a few hectares in 1990 to between 20,000 to 25,000 hectares in 1992 (Takatlian, 1993).

Table 3.3 Inputs in Agriculture by Country for Latin America and the Caribbean

Country	Cropland in 1989			Percent of Cropland Irrigated		Average Annual Fertilizer Use (Kg/ha)		Average Annual Pesticide Use (Kg of act. ingr./ha)	
	Total (10^6 ha)	Per Capita	Rural per Capita	1977-79	1987-98	1977-79	1987-89	1975-77	1982-84
Belize	0.05	0.3	x	2	4	36	71	x	x
Costa Rica	0.5	0.18	0.34	10	22	143	191	6.1	6.1
Cuba	3.3	0.31	1.2	22	26	133	192	2.5	3
Dominican Rep.	1.4	0.2	0.52	11	16	41	50	1.5	2.2
El Salvador	0.7	0.14	0.26	9	16	133	121	1.9	3.9
Guatemala	1.8	0.2	0.38	3	4	53	69	2.8	2.8
Haiti	0.9	0.14	0.19	8	8	4	3	0.2	x
Honduras	1.8	0.35	0.63	4	5	13	20	0.6	0.5
Jamaica	0.3	0.1	x	12	13	55	105	3.2	5.3
Mexico	24.7	0.28	0.96	20	21	44	73	0.8	1.1
Nicaragua	1.3	0.33	0.83	6	7	31	55	2.4	1.6
Panama	0.6	0.24	0.51	5	5	44	62	2.8	4.3
Argentina	35.7	1.1	7.8	4	5	3	5	0.2	0.4
Bolivia	3.4	0.47	0.97	4	5	1	2	0.2	0.2
Brazil	78.6	0.52	2	2	3	42	46	0.9	0.6
Chile	4.5	0.34	2.1	28	28	27	73	0.4	0.3
Colombia	5.4	0.16	0.6	7	9	55	90	3.8	2.8
Ecuador	2.6	0.25	0.53	19	21	30	30	2.1	1.2
Guyana	0.5	0.62	x	25	26	22	29	1.8	1.3
Paraguay	2.2	0.52	0.88	2	3	2	6	2.3	1.8
Peru	3.7	0.17	0.55	31	33	35	54	0.7	0.8
Suriname	0.7	0.16	x	56	85	49	74	2.4	3
Uruguay	1.3	0.42	3	5	8	54	48	0.9	1
Venezuela	3.9	0.2	0.94	6	7	51	162	1.9	2.2
Latin America & the Caribbean	179.8	0.41	1.4	x	x	x	x	x	x

Source: WRI, 1992
Note: x = not available

Box 3.2 Sources and Consumption of Food in the Andean Countries

Percent of Source of Food in the Peruvian Andes (Nuñoa)

Source	1962	1985
Local Cereals	20.8	4.7
Tubers	73.5	41.2
Meat	5.7	5.3
Processed Grain	0	34
Others	0	14.8
Average Daily Calories	3,122	1,292

Source: Leonard & Thomas, 1988

Hours Worked to Purchase 1,000 Calories in Bolivia

Product	1975	1984
Sugar	0.16	0.51
Maize	0.17	0.64
Wheatflour	0.21	0.52
Beans	0.22	3.47
Potatoes	0.76	2.35
Oil	0.28	0.51
Milk	1.05	3.95

Source: George, 1988; cited in Goodman & Redclift, 1991

In general, cultivated species, the progress of commercial agriculture, and the population's diet are interrelated. For instance, in rural zones replacing a native species with an introduced species can force a change in consumption habits and a crisis in peasant agriculture. Ultimately, a decrease in crop varieties can translate into dependency on industrialized products and a reduction in daily calorie income. (See Box 3.2.)

If we consider agricultural productivity indexes for the various life-zones, the only areas showing food problems for their potential population in 2030 are the tropical lower mountain moist forests, the Paramo, the Puna, the tropical and subtropical deserts and semideserts, and the steppes. (See Table 3.7.) All the remaining life-zones have agricultural lands that could feed their potential populations in 2030.

Table 3.4 Agriculture Land Concentration by Country for Latin America and the Caribbean

Country	Gini Coefficient		
	1960	1970	1980
Belize	x	x	x
Costa Rica	x	0.83	x
Cuba	x	x	x
Dominican Rep.	x	0.79	x
El Salvador	0.84	0.81	x
Guatemala	x	0.85	x
Haiti	x	0.5	x
Honduras	x	0.78	x
Jamaica	0.8	0.82	x
Mexico	x	x	x
Nicaragua	x	x	x
Panama	x	0.78	0.84
Argentina	x	x	x
Bolivia	x	x	x
Brazil	0.85	0.84	0.86
Chile	x	x	x
Colombia	0.87	0.86	x
Ecuador	x	x	x
Guyana	x	x	x
Paraguay	x	x	0.94
Peru	0.95	x	x
Suriname	x	x	x
Uruguay	0.83	0.82	0.84
Venezuela	0.94	0.92	x

Source: FAO, 1988
Note: x = not available

The potential for agricultural expansion is great enough at the regional level to meet probable demand for new lands. In only three life-zones does the present amount of agricultural land exceed the optimal potential one: the tropical and subtropical deserts and semideserts, the subtropical forests, and the temperate moist forests. (See Table 3.7.) However, these indicators show a different situation at the country level. In Central America and the Caribbean, the lands needed to feed projected populations using low inputs in agriculture wouldn't be available in 2030 except in Panama. (See Table 3.6.) In South America, available agricultural lands will be able to support estimated populations in 2030, even with low inputs, except in Chile, Colombia, Ecuador, and Peru. The situation in Central America and the Caribbean improves a little if an intermediate level of inputs is used: only Cuba, the Dominican Republic, Guatemala, Haiti, Jamaica, and El Salvador will fall short of farmland and food. In South America, only Chile and Peru will be unable to feed their populations if an intermediate level of inputs is available. (See Table 3.6.) The high use of agricultural inputs would solve the food problem in most countries in the region, though the intensive use of fertilizers, pesticides and herbicides entails economic, health-related, and environmental problems of its own.

The model used to calculate these indexes (FAO, FNUAP, & IIASA, 1983) excludes some alternatives that could solve local food problems. For instance, the migratory agricultural systems used by Amazonian aborigines could support 6.5 people per hectare—triple the number of people fed per hectare in the low-input model already mentioned.

The potential for expanding agriculture is evidently low in Central America and the Caribbean and greater in South America. Latin America and the Caribbean has 193 million hectares of potential agricultural lands in addition to the 179 million hectares currently in use and would need to cultivate 19 percent of their area (100 percent of the potential agricultural lands) to feed their population in the year 2030 if only a low level of inputs is available. With an intermediate level of inputs, 7 percent of the area would have to be cultivated (38 percent of all potential agricultural lands). If a high level of inputs is used, 4 percent of new land would have to be cultivated (22 percent of all potential agricultural lands). Right now, 9 percent of total land (49 percent of the potential agricultural lands) is used for agriculture (Gómez & Gallopín, 1989a).

Table 3.5 Agriculture and Constraints in the Hillsides for Tropical Latin America and the Caribbean

	Hillsides		Agriculture Population		No Soils Constraints		Potential Cropland
Country	Percent of Total Land	Percent of Total Cropland	Percent of Country	Percent of Total Rural Population	Surface (10^6 ha)	Percent of Hillside	Percent
Costa Rica	73	42	20	30	1.8	48	49
Dominican Rep.	57	26	15	30	0.14	5	8
Guatemala	82	44	40	65	3.2	36	30
Haiti	79	54	50	65	0.31	14	21
Honduras	83	21	12	20	2.9	32	26
Jamaica	80	51	15	30	0.5	55	49
Mexico	45	22	15	45	x	x	x
Panama	79	13	15	30	2.1	36	36
Salvador	93	65	30	50	1.4	74	77
Bolivia	43	26	x	x	18.4	42	17
Colombia	43	43	15	50	6.6	14	11
Ecuador	64	37	25	40	5.6	31	27
Peru	52	29	25	50	10.1	16	10
Venezuela	55	32	x	x	10.1	20	13
Tropical Latin America & the Caribbean	17	29	x	x	63.2	25	x

Sources: FAO, 1988; Posner et al., 1981; Winograd, 1989
Notes: x = not available; all data for 1980-1990

Table 3.6 Agricultural Productivity Indicators by Country for Latin America and the Caribbean

Country & Surface (10^6 ha)	Agricultural Land Needed to Feed Population in 2030 (10^6 ha)			Potential Agricultural Land		Land Expansion Potential	Potential Population Supporting Capacity Ratio
	Low Input Use	Int. Input Use	High Input Use	Total (10^6 ha)	Per Capita in 2030		
Belize (2.3)	0.1	0.04	x	0.5	1.7	high	12
Costa Rica (5.1)	<2.4>	0.7	x	1.6	0.3	medium	2.3
Cuba (11.1)	<30.8>	<3.8>	x	3.1	0.3	low	0.8
Domincan Rep. (4.8)	<6.3>	<1.6>	x	1.1	0.1	low	0.6
El Salvador (2)	<4>	<1>	x	0.4	0.03	low	0.4
Guatemala (10.8)	<11.4>	<3.1>	x	2.3	0.1	low	0.7
Haiti (2.7)	<6.8>	<1.9>	x	0.5	0.04	low	0.25
Honduras (11.2)	<8.2>	1.8	x	2.6	0.2	low	1.4
Jamaica (1)	<1.9>	<0.48>	x	0.3	0.08	low	0.6
Mexico (190.9)	7.5	22	x	26	0.2	low	1.2
Nicaragua (11.8)	<4.6>	1.4	x	3	0.3	low	2
Panama (7.6)	1.7	0.5	x	1.9	0.5	medium	4
Argentina (273.7)	22.6	<8.2>	4	52	1.1	low	6.4
Bolivia (108.4)	9.1	2.6	1.3	30	1.6	high	11.5
Brazil (845.6)	117	33.2	16.6	177	0.7	medium	5.3
Chile (74.9)	<28.3>	8.2	4.9	5	0.25	low	0.6
Colombia (103.9)	25.8	6.8	2.4	27	0.5	high	4
Ecuador (27.7)	<12.7>	2.7	2	7	0.3	medium	2.6
Guyana (19.7)	0.6	0.15	0.09	5.6	3.5	high	37
Paraguay (39.7)	4.2	1.3	0.7	12	1.3	high	9
Peru (128)	13.9	3.9	1.8	27	0.66	high	3.8
Suriname (15.6)	0.2	0.06	0.04	3.5	5.8	high	55
Uruguay (17.5)	1.3	0.5	0.3	5	1.3	medium	10
Venezuela (88.2)	19	6.1	2.7	21	0.55	medium	3.4
Latin America & the Caribbean (2,041.7)	391	108.2	x	415.4	0.55	medium	x

Sources: FAO, 1982; FAO, 1988; FAO, FNUAP, & IIASA, 1984; Gómez & Gallopín, 1989
Notes: x = not available; <> indicates that land needed is larger than available land

Table 3.7 Agricultural Productivity Indicators by Life-Zones for Latin America and the Caribbean

Life-Zones & Surface (10^6 ha)	Agricultural Land Needed to Feed Population in 2030 (10^6 ha)			Potential Agricultural Land		Land Expansion Potential	Potential Population Supporting Capacity Ratio
	Low Input use	Int. Input use	High Input use	Total (10^6 ha)	Per Capita in 2030		
TmF(665)	27.1	7.2	3.8	100	1.84	high	13.8
TlmmF (46.7)	<139>	34.7	18.9	12	0.07	low	0.35
TdF (188.7)	17.8	5.1	2.4	47	1.4	low	9.1
TvdF (140.1)	44.6	12.7	6.4	7	0.16	low	0.55
TSlTdF) (106.6)	2.9	0.85	0.4	10.5	1.8	medium	12.3
Paramo (4.3)	<770>	<30.8>	<17.1>	0.8	0.05	medium	0.03
Puna (87.9)	<78>	<21.7>	13	13	0.8	medium	0.35
T-STmF (78.4)	59.1	14.8	9.8	19.5	0.4	medium	1.6
D-M (18.6)	4.5	1.3	0.7	2.8	0.27	medium	2
T-STDsDs (116.2)	<412>	126	73.7	6	0.07	low	0.05
STmF (147.4)	35.5	10.6	4.7	57	0.66	low	5.5
STdF (145.9)	43	14.3	7.3	43	0.6	medium	3
STS (103.8)	24	8.2	3.7	42	0.75	low	5.1
STtS (10.3)	16	5.2	3	2.6	0.18	low	0.5
STDs (75)	31	10.3	4.4	3.8	1.2	medium	0.37
TemmF (33.9)	5.1	1.2	0.7	2	0.5	low	1.6
S (49.2)	<500>	5.5	0.1	3	6	high	0.5
TemS (23.7)	0	0	0	0	0	low	0
Latin America & the Caribbean (2,041.7)	2,209.6	310.5	170.1	372	0.51	medium	x

Sources: FAO, 1982; FAO, 1988; FAO, FNUAP, & IIASA, 1984; Gómez & Gallòpin, 1989; Winograd, 1989
Notes: x = not available; <> indicates that land needed is larger than available land

TECHNICAL NOTES:

Table 3.1 Production data are from WRI (1992, Table 18.1) and FAO (AGROSTAT, 1992). Cereal production includes cereals for feed and seed. Cereals comprise all cereals harvested for dry grain, excluding crops cut for hay or harvested green. Roots and tubers cover all root crops grown principally for human consumption. Yields are calculated from production and area data. The agricultural production index portrays the disposable output (after deduction of feed and seed) of a country's agricultural sector relative to the base period 1979-81.

Table 3.2 Data of calorie intake and food consumption are from FAO (1992). Data on calories available as percent of need come from WRI (1992, Table 16.3) and FAO (1992). The minimum daily calorie requirement is the energy intake necessary to meet the energy needs of an average healthy person. The calorie supply as a percent of requirements includes calories from all food sources. Food consumption (cereals, roots and tubers, meat and milk) is equivalent to per capita consumption in kilograms per year. The percentage of grain fed to livestock is calculated from data on grain and feed by USDA from WRI (1992, Table 18.3).

Table 3.3 Agricultural land data are from WRI (1992, Table 18.2). Input data are from WRI (1992, Table 18.2) and FAO (1992). Cropland refers to land under temporary and permanent crops, temporary meadows, market and kitchen gardens, and temporarily fallow land. Land data for 1989 were used to calculate the per capita cropland of the rural population for 1990. (See Table 1.1.)

Table 3.4 Agriculture land concentration data come from FAO (1988, Annex II, Rural Poverty, Table 3.7). Gini Coefficient is a measure indicating how much actual distribution diverges from an ideal equal distribution: The closer to one, the more divergence. The Mexican data were not used because of over-estimation due to the inclusion of the "ejidos". This information does not include data for some countries which experienced land reform processes such as Peru, Chile, and Ecuador.

Table 3.5 Data on area and agricultural hillsides were elaborated with information from Posner et al. (1981). Hillsides are equivalent to the TlmmF, T-STmF, Paramo, and part of the Puna life-zones. Soil limitations (constraints) are defined by topographic, bioclimatic, and edafic characteristics and used to obtain broad potential land-uses (i.e., Protection, Forests and Pastures, Annual Crops, Permanent Crops). The absence of soil limitations refers to land without physical and chemical constraints that will affect agronomic management and agricultural productivity. In the case of hillsides, the absence of soil constraints doesn't take into consideration certain chemical constraints (i.e., problems of nutriments) (Posner et al., 1981). Percentages were based on the total country area. Population and soil limitation data are from Posner et al. (1981) and FAO (1988). Potential agricultural lands are from FAO (1988) and Winograd (1989b).

Table 3.6 and 3.7 Agricultural productivity indicators are from FAO and IIASA (FAO, 1982 & 1988; FAO, FNUAP, & IIASA, 1984). These data were adapted by Gómez and Gallopín (1989a) for the countries, great ecosystems, and life-zones of the region. The production potentials at different input levels are measured in caloric and protein equivalents. This procedure allows the addition of different crops and the estimation of potential population density. The model assumes that on each studied unit a certain number of crops may be cultivated. Crops are chosen for maximum calorie production. But limitations on the level of inputs adopted also have to be considered. The potential population density is calculated by dividing yields, in Kcal/ha, by daily calorie needs. Daily calorie needs per person are assumed at 2,700 Kcal. Post-harvest losses represent 10 percent of agricultural production. Agricultural lands necessary for feeding the potential population are calculated by pulling the calorie needs of the potential population in relation to potential yields. Three input levels are considered in the model:

- *Low level: local and current crops without use of fertilizers, pesticides or weed control, fallow rotation without long-term soil conservation, intensive labor force, and low capital coefficient. Subsistence production with precarious or fragmentary land occupancy.*
- *Intermediate level: local and current crops, limited use of fertilizers, pesticides and weed control, limited fallow rotation and use of some long-term soil conservation techniques, use of manual tools and animal labor, intensive human labor including paid family work, intermediate capital coefficient, and accessible credits. Subsistence production with commercialization of surplus and, in some cases, concentrated land occupancy.*
- *High level: a combination of optimum crops with cultivars of high production, correct application of fertilizers, weed and pest control, minimum fallow periods and adequate soil conservation measures, mechanization, low utilization of labor force, and high capital coefficient. Commercial production.*

Agricultural land potential has been calculated based on Gómez and Gallopín (1989a) by considering that 3/4 of the potentially agricultural lands are effectively useful for agriculture. The land expansion potential is based on lands that can be potentially cultivated (reserves) as the percentage of the total lands (used and reserves) according to the definition of FAO, FNUAP, & IIASA (1984). Between 80 and 100 percent represents a high potential; between 60 and 80 percent intermediate potential, and between 40 and 60 percent low potential. The support-capacity ratio of the potential population is calculated on the basis of potential population fed at an intermediate input level divided by the population projected for the year considered (2030), assuming that the total of potentially cultivated lands is used.

Box 3.1 Data of drug production indicators are estimates provided by the police and custom officials. They should be used with caution, but they show the problem's general dimensions.

Box 3.2 Data on sources and food consumption in Andean countries illustrate local cases describing the general situation of marginal rural and urban areas.

4. ENERGY

Energy production and use in Latin America and the Caribbean affect land-use, human health, and environmental stability. (See Atmosphere and Climate.) Thus, the potential of various traditional energy resources, such as hydroelectricity, and of renewable energies (biomass, solar, geothermic, and wind energies) can be important indicators of development potential.

Latin America and the Caribbean contain 19.5 percent of the world's hydroelectric potential, and 21 percent of all energy consumed in the region is hydroelectric (WRI, 1992). On the other hand, half the region's capacity to generate hydroelectricity is yet to be developed. (See Tables 4.1 and 4.2.) Although hydroelectricity is the cleanest way to produce energy, dam construction has produced significant environmental impacts that must be taken into account in terms of resource planning and use. At present, sedimentation in many dams is accelerating, decreasing their useful life. Moreover, in dam construction, often important forest areas are flooded and native populations displaced, while pests' populations can increase and water quality can decrease once the structures are built. The kilowatts generated per flooded area in the region's principal dams illustrate poor planning. (See Box 4.1.)

Box 4.1 Hydropower Generated per Hectare Inundated for Selected Dams in Latin America and the Caribbean

Dam	Country	Kilowatts/hectare
Paulo Alfonso	Brazil	2,490
Pehuenche	Chile	1,250
Guavio	Colombia	1,067
Rio Grande II	Colombia	295
Alicura	Argentina	154
Itaipu	Bra-Par	93
Aguamilpa	Mexico	80
Urra I	Colombia	55
Piedra del Aguila	Argentina	48
Jupia	Brazil	42
Sao Simao	Brazil	41
Tucurui	Brazil	30
Paredao	Brazil	30
Ilha Solteira	Brazil	27
Salto Grande	Argentina	24
Guri	Venezuela	18
Urra II	Colombia	16
El Chocon	Argentina	15
Furnas	Brazil	8
Curua-Una	Brazil	5
Tres Marias	Brazil	4
Samuel	Brazil	3
Sobradinho	Brazil	2
Balbina	Brazil	1
Brokopondo	Suriname	0
Latin America & the Caribbean	----	22

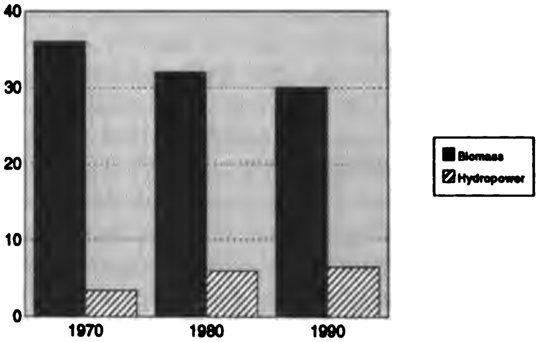
Sources: Goodland & Ledec, 1989; Suárez, 1993

As for other forms of renewable energy, fuelwood reserves amount to 1,266 million barrels oil equivalent (boe), solar energy to 10 million boe, and wind energy to 7 million boe (Dessurs, 1989). Use of traditional energy sources (fuelwood, charcoal, and husks) is significant throughout the region, and in the Caribbean, accounts for 80 percent of the domestic energy consumption in rural areas. (See Table 4.1 and Figure 4.1.)

Although at the regional level energy potential is virtually unlimited, large segments of the population lack an adequate energy supply. Fuelwood used in rural regions, in some cities, and by industries illustrates the situation. In 1989, wood production reached 0.66 cubic meters per capita (2 cubic meters per capita, if only the rural population is considered). The region has sufficient forests to meet the demand if forestry management is adequate. (See Table 4.1.) But some 80 million people currently depend directly on fuelwood, overexploiting the resource and producing an acute scarcity in many areas. Forty years from now, at least 50 million people are expected to inhabit the arid and densely populated zones, precipitating an acute fuelwood deficit (Lugo, 1987).

Although deforestation from wood consumption is less than that driven by land-use changes, it nonetheless accounts for approximately 10 to 12 percent of all regional deforestation from 1980 through 1985 (Lanly, 1984). In some zones and countries, fuelwood shortages

Figure 4.1 Percent of Energy Requirements from Land-Use Based Resources in Latin America and the Caribbean (1970-1990)
(fuelwood and charcoal, bagasse production, and hydropower)
(percent of total requirements)



Source: WRI, 1992

Table 4.1 Bioenergy Production by Country for Latin America and the Caribbean

Country	Roundwood Production for Fuels and Charcoal per Capita (m3)	Bioenergy Potential (10^6 T)			Traditional Fuels as % of Total Requirements	
		Firewood	Husks	Residues		
	1989	1990	1990	1990	1979	1989
Belize	0.05	x	x	x	54	55
Costa Rica	0.97	0.9	0.7	31.4	34	33
Cuba	0.28	1	33.5	146.2	30	27
Dominican Rep.	0.15	0.1	3.8	68.6	31	23
El Salvador	0.98	0	0.9	47.3	49	46
Guatemala	0.84	4.9	1.5	518.4	51	57
Haiti	0.96	x	x	x	80	82
Honduras	1	2.2	1	41	56	62
Jamaica	0.01	x	x	x	6	8
Mexico	0.17	47.5	14.4	933	6	5
Nicaragua	0.83	3.8	1.3	35	52	49
Panama	0.78	4.1	0.4	25	31	26
Argentina	0.21	37.5	4.8	427.3	6	5
Bolivia	0.18	25.5	0.8	63.2	19	16
Brazil	1.24	158.2	146.9	1,773.1	36	30
Colombia	0.5	23.9	5.6	348.7	18	17
Chile	0.5	15	0	174.6	13	12
Ecuador	0.64	6.1	1.5	96	29	24
Guyana	0.02	x	x	x	28	33
Paraguay	1.32	9.7	0.6	37.3	66	59
Peru	0.33	24.2	2.8	245.3	19	20
Suriname	x	x	x	x	1	2
Uruguay	0.78	2.3	0.1	53	20	24
Venezuela	0.04	10.5	1.7	238.7	1	1

Sources: Gallo Mendoza et al., 1992; UNDP, 1991; WRI, 1992
Note: x = not available

are serious, and only dynamic reforestation and energy policies, along with the use of alternative energy (i.e., in the Peruvian or Bolivian "Puna" and the region's arid zones) will solve the problem.

Besides fuelwood and hydroelectricity, sugar cane and agricultural, agroindustrial, and forestry wastes are significant energy resources. (See Table 4.1.) At present, only Brazil produces bioethanol at a large scale. There, 12.7 billion liters of ethanol replaced 200,000 barrels of oil in 1990-91, and, between 1975 and 1985, the ProAlcol program allowed Brazil to save 9 billion dollars in hard currency by substituting this fuel for petroleum (Hall & House, 1992). At the same time, CO_2 emissions, which could be avoided, make up to 18 percent of all fossil fuel emissions in Brazil (Hall & House, 1992). Fuelwood, sugar cane husks, and agricultural, agroindustrial, and forestry wastes met a large part of rural agroindustrial needs in 1990. (See Table 4.1.) Indeed, biomass energy systems, though underutilized at present, represent a significant energy potential for the region. Switching to these energy-production systems could help lower the global CO_2 emissions, and satisfy the new emissions standards at relatively low cost since biomass fuels do not contribute to the increase of CO_2 if they are produced and consumed sustainably. To allow these resources to regenerate continually, production systems should be modernized to supply various types of energy (Hall & House, 1992). The key issues are loss of prime food-producing farmland and soil depletion. (For instance, if agricultural wastes and dung normally used to preserve soil fertility are used for bioenergy production instead, soil fertility can decline with negative impacts on agricultural yields. This also can creat the need to use a larger amount of agrochemicals.)

Table 4.2 Hydroelectric Resources by Country for Latin America and the Caribbean

Country	Exploitable Hydropower Potential (gigawatt-hours/year)	Installed Hydropower Capacity (gigawatts) 1989	Total Hydropower Generation	
			(gigawatt-hours) 1989	Percent of Capacity 1989
Belize	x	x	x	x
Costa Rica	37,000	1	3,328	52
Cuba	x	0	82	19
Dominican Rep.	2,517	0	950	66
El Salvador	3,319	0	1,452	41
Guatemala	43,370	0	2,089	55
Haiti	430	0	320	52
Honduras	240,000	0	880	77
Jamaica	335	0	110	63
Mexico	159,624	8	22,950	34
Nicaragua	17,277	0	268	30
Panama	16,233	1	2,181	45
Argentina	390,000	7	15,150	26
Bolivia	90,000	0	1,270	42
Brazil	1,194,900	45	214,238	55
Chile	132,433	2	9,603	48
Colombia	418,200	6	29,875	54
Ecuador	115,000	1	4,918	62
Guyana	63,100	0	5	29
Paraguay	78,000	5	2,784	6
Peru	412,000	2	10,518	53
Suriname	12,840	0	910	55
Uruguay	4,880	1	3,902	37
Venezuela	250,000	7	34,200	56

Source: WRI, 1992
Note: x = not available

TECHNICAL NOTES:

***Table 4.1** Fuelwood and charcoal production data are from WRI (1992, Table 19.2) and UNDP (1991, Table 22 of Human Development Indicators). Bioenergetic potential are from Gallo Mendoza et al. (1992, Annex 1, Tables 19 and 22). Bioenergetic potential refers to the current potential of biomass energy (fuelwood, husks, and residues) that is not used to generate energy, but does exist. Residues include agroindustrial, agricultural, forestry, and urban wastes. Traditional fuel resources data come from WRI (1992, Table 21.2).*

***Table 4.2** Data are from WRI (1992, Table 22.2). Hydroelectric potential is equivalent to the hydroelectricity that can be exploited with the current available techniques. Installed hydroelectric capacity is the total sum of dams in operation at present. Generated hydroelectricity refers to current production.*

***Box 4.1** Data for Argentina, Latin America, and the Caribbean are from Suárez (1993). Data for other countries are from Goodland and Ledec (1989).*

III. The State of the Environment

The state of the environment reflects the development models applied. Indicators of a region's natural endowment, environmental problems and changes, and the condition of natural resources over time will help analysts (a) assess the importance of natural resources in the development process; (b) see the limitations and potentialities of the local or regional resource base; (c) evaluate the environmental consequences of the ultimately misguided development that frequently passes for progress; and (d) spot trends that may impede or promote sustainable development.

Forests and rangelands play a particularly important role in the development of Latin America and the Caribbean, providing vital ecological services as well as economic resources. Charting the evolution of forest gains and losses at country and life-zone levels thus sheds light on how to design sustainable resource-management policies. Key to this exercise are indicators that show supply and demand, as well as the stock of the resource. (See Projections in Land-Uses.) In the region's tropical countries, the conversion of forests to pasture lands is also an important trend—one best described in terms of statistics on deforestation, pasture land area, pasture productivity, cattle population, and biological carrying capacity. (See Food and Agriculture.)

Latin America and the Caribbean are characterized by their high species and ecosystems diversity, as well as by the great variety of uses local populations have found for these resources. Since, the region's fauna and flora are economically, ecologically, and socially important, biological diversity has become a great concern at the local, regional and global levels. Accordingly, indicators are needed to show the state of the biological diversity and the policies adopted to protect it at country and life-zone levels. Key here is identifying the most threatened habitats and species to set conservation priorities. The current and potential uses of all ecological and biological diversity must be assessed in the design of policies for their protection and sustainable use at local and regional levels.

Freshwater resources are essential to human life and economic development. Coastal resources from which industrial products and food may be extracted are also a determinant of development potential in many countries of the region. In both cases, the state of the resources and the pressures exerted on them must be understood to determine the problems that limit the sustainable use of resources. Especially important is thorough knowledge of the area of the main coastal ecosystems, the size and distribution of the population inhabiting them, the conservation programs in force, and the damages produced by human activities. Also key to successful management policies are knowledge of the value of resources at local levels and the uses to which they are put.

In recent years, the process of economic development has generated important gaseous emissions that change the atmosphere's composition, thus increasing the greenhouse effect, which has important consequences on climate, sea level, ecosystems distribution and composition, and agriculture. Evaluating the environmental impacts of emissions means taking account of the origin, composition, and heating potential of different gases at country and life-zone levels. These emissions must also be related to economic and population growth by comparing emissions per capita and per unit of GNP. Establishing the level of current and accumulated emissions will also help policy-makers elaborate control policies at local, national, and global levels; and, knowledge of emission/absorption potentials with regard to different land-uses can help them find ways to decrease or mitigate the emissions' negative effects. (See Ecosystems and Land-Use and Projections in Land-Uses.)

1. ECOSYSTEMS AND LAND-USE

The functioning of ecosystems depends on the transformation of solar energy into plant biomass through photosynthesis. Both net primary productivity and the annual production are good general indicators of ecological endowment and carbon storage. Adding data on agricultural potential facilitates the evaluation of alternative resource-uses, as well as the management of natural resources and land-use (Gómez & Gallopín, 1989b).

Data on the region's climate and soils show that the tropical and subtropical moist forests, covering 64 percent of the natural regional area, are responsible for 81 percent of the net primary production. Tropical and subtropical dry forests, covering 25 percent of the area, represent 14 percent of the net primary production. Arid zones, which cover 7 percent of the natural surface area, represent only 1 percent of net primary production. (See Table 1.1.) In spite of these important differences, the agricultural potential (potential yield value) of the tropical and subtropical humid zones closely resemble that of the tropical and subtropical dry areas. (See Table 3.7 in Food and Agriculture.) This suggests that one of the alternatives to the advance of the agricultural frontier may be the intensification of the use of agricultural lands in drier zones while the tropical moist forests may be de-

Table 1.1 Natural Productivity Indicators by Life-Zone for Latin America and the Caribbean

Life-Zone	Historic Natural Net Primary Production (10^6 T/ha/y)	Current Net Primary Production (1990) (10^6 T/ha/y)
Tropical Moist Forest (TmF)	7,714	7,150
Tropical Lower Montane Moist Forest (TlmmF)	411	86
Tropical Dry Forest (TdF)	1,076	390
Tropical Very Dry Forest (TvdF)	688	360
Tropical Savannas (Tropical Dry Forest) (TS-TdF)	554	260
Paramo	9	1.5
Puna	176	30
Tropical and Subtropical Montane Forest (T-STmF)	416	170
Delta and Mangrove (D-M)	273	20
Tropical and Subtropical Desert and Desert Shrub (T-STD&Ds)	116	47
Subtropical Moist Forest (SmF)	1,459	350
Subtropical Dry Forest (SdF)	832	330
Subtropical Savanna (STS)	509	60
Subtropical Thom Steppe (STts)	3.9	1
Subtropical Desert Bush (STDs)	75	39.5
Temperate Moist Forest (TemmF)	200	110
Steppe (E)	98	8
Temperate Savanna (TemS)	24	18.7

Sources: Gómez & Gallopín, 1989; Winograd, 1989

veloped on the basis of agroforestry systems that maintain the forests' basic ecological characteristics.

In most countries of Latin America and the Caribbean, natural resources are still the foundation of the economy. So far neglected, the most pressing environmental issue, in terms of both problems and opportunities, is land-use within the regional ecosystems. The three basic choices are (a) bringing more potentially usable lands into cultivation; (b) intensifying land- use; and (c) rehabilitating and restoring abandoned lands (secondary forests, fallow, terraces, etc.) (Gallopín et al., 1991a; Lugo, 1988a).

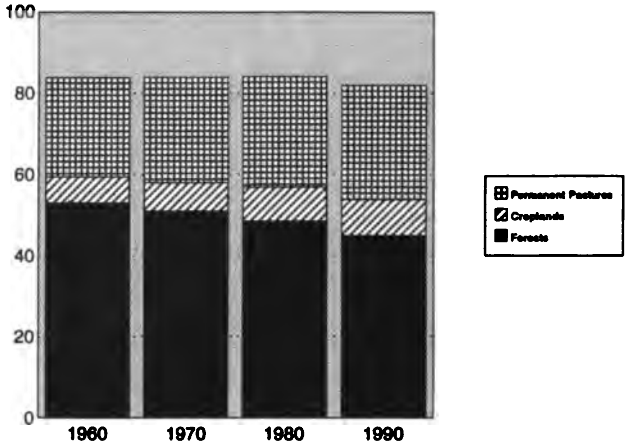
Current land-use problems—among them, erosion, desertification, the loss of soil fertility, pasture degradation, salinization, flooding, and the under-utilization of the best lands—lead to deforestation and the conversion of natural systems or to the loss of extensive areas that are difficult to rehabilitate. (Gallopín et al., 1991a; UNEP, AECI, & MOPU, 1990). In most countries, increases in agricultural and livestock production have been based on land expansion (by means of colonization programs and the advance of the agricultural frontier), instead of productivity increases achieved by increasing the intensity of use and of utilizing resources in a more integrated way.

During the 1980s, 58 million hectares of the region's natural forests areas were depleted. But though pasture lands increased by 21.4 million hectares, agricultural lands by 11.4 million hectares, and plantations by 4.6 million hectares, 10 million hectares were transformed for temporary or speculative uses, including the production of illegal crops. (See Tables 1.2 and 1.3; Figure 1.1.)

Other trends and statistics also underscore the importance of land-use and production in the region. For instance, the livestock industry in Central America occupies 28 percent of the total subregion and 67 percent of all agricultural land, but contributes with only 11 percent of the income from agricultural exports. In contrast, coffee, which occupies 12 percent of the agricultural area and 4 percent of the total agroproductive area, contributed U.S. $1,500 to $3,100 per square kilometer of productive land, compared to U.S. $18 to $48 per square kilometer for livestock production (Leonard, 1987). Similarly, in Brazil (in the northern region of the Legal Amazonia), the livestock industry creates only 0.006 jobs per hectare and produces only 1.2 million tons of meat annually but was responsible for 60 percent of deforestation from 1978 through 1988 and generated only 9 percent of the zone's economic value. (See Boxes 1.1 and 1.2.) For perspective here, immigrant peasants (or colonists) without access to sustainable technologies and techniques generated 0.3 jobs per hectare and were responsible for 40 percent of the deforestation in the same period. At the regional level, the livestock industry generates one job per 80-200 hectares of pasture land, whereas peasant agriculture provides one job per 1 to 2.5 hectares of agricultural land (UNEP, AECI, & MOPU, 1990). Notably, livestock production is mainly responsible for the conversion of natural ecosystems in tropical zones.

In open and closed tropical forests, the livestock production leads to the deforestation of more than 2.4 million has/year while migratory agriculture is responsible for 1.9 million has/year of forest loss (Winograd, 1991a). [In migratory agriculture, after a short cultivation period (2-4 years), large segments of the deforested area is transformed into pastures that are abandoned after seven to ten years (Hecht, 1989; Eden, 1990)]. Permanent agriculture, especially for export crops, is responsible mainly for the deforestation of 1.1 million hectares per year in these forests. Other activities (forest exploitation, mining, construction, etc.) cause an equivalent amount of deforestation annually (Winograd, 1991a).

Figure 1.1 Percent of Forests and Productive Lands in Latin America and the Caribbean (1960–1990)
(percent of land area)



Source: FAO, 1992

Box 1.1 Patterns of Land-Use in the Northern Region of Brazil

Activity	Surface (10^3 ha) 1988	Percent of Region 1988	Employment 1988	Employees per hectare	Annual Production 1988	Economic Value (dollars)	Mean Deforestation (10^3 ha) 1978-88	Net Annual Emissions CO2 Eq. per capita (T of C)
Livestock Raisers	17,000	(4.8)	100,000	0.006	1.2 million T of meat	325 million	907	2,010
Loggers	x	x	1,000,000	x	24.6 million m3 of logs	900 million	x	0
Small Farmers	7,500	(2.1)	2,000,000	0.3	32.7 million T of all crops	x	606	64
Garimpeiros	13,500	(3.8)	690,000	0.05	112 T of gold	1.7 billion	x	0
Extractivists	12,200	(3.4)	200,000	0.02	x	60 million	0	0
Large Scale Miners	1,500	(0.4)	x	x	x	1 billion	x	0
Hydro-Developers	531	(0.15)	x	x	7 megawatts of electricity	x	x	x
TOTAL	52,781	(14.8)	3,990,000	0.075	x	3.53 billion	1,512	82

Sources: Browder, 1987; Fearnside, 1990; World Bank, 1990
Note: x = not available

Box 1.2 Land-Use Indicators for the Northern Region of Brazil

Production System	Forest Type	Clearing	Clearing Size (ha)	Number of Species in Field	Production (T/ha)	Value (dollars/ha)	Years of Use	Nourished People (pop/ha/y)	Net Annual Emissions CO2 Equivalent (T of C)	Eq. People Using Fossil Fuel Annually in the City
Kayapo	Dry Forest	Slash & Burn	1	10-42	12.5	x	2-4	6.5	13	18
Isla das Oncas	Moist Forest	Harvest	1	20	1.5	300	x	x	0	0
Colonist	Moist Forest	Slash & Burn	2-5	5-10	4.35	x	2-3	3	126-315	176-442
Livestock	Moist Forest	Slash & Burn	2,000-20,000	1-5	0.07	60	5-10	0.5	42,000 to 420,000	58,800-588,000

Sources: Anderson, 1990; Browder, 1989; Fearnside, 1990; Hecht, 1988

Table 1.2 Patterns of Land-Use by Country for Latin America and the Caribbean

Country & Surface (10^6 ha)	Natural & Altered (10^6 ha)		Percent of Change	Urban (10^6 ha)		Percent of Change	Plantations (10^6 ha)		Percent of Change	Pastures (10^6 ha)		Percent of Change	Agriculture (10^6 ha)		Percent of Change	Wastelands (10^6 ha)		Percent of Change
	1980	1989		1980	1989		1980	1989		1980	1989		1980	1989		1980	1989	
Belize (2.3)	2.2	2.1	-0.5	0.01	0.01	0	x	x	x	x	x	x	0.05	0.05	0.8	x	x	x
Costa Rica (5.1)	2.4	1.3	-4.5	0.08	0.1	2.5	x	0.03	x	2	2.3	1.5	0.6	0.5	-1.2	x	x	x
Cuba (11)	4.9	4.1	-1.9	0.3	0.37	2.3	x	0.2	x	2.6	3	1.5	3.2	3.3	0.3	x	x	x
Dominican Rep. (4.8)	1.1	1.1	0	0.2	0.26	2.5	x	x	x	2.1	2	-0.5	1.4	1.4	0	x	x	x
El Salvador (2.1)	0.6	0.6	0	0.2	0.2	0	x	x	x	0.6	0.6	0	0.7	0.7	0	x	x	x
Guatemala (10.8)	7.6	7.4	-0.3	0.2	0.23	1.5	x	0.01	x	1.3	1.4	0.8	1.7	1.8	1.2	x	x	x
Haiti (2.8)	1.2	1.2	0	0.2	0.21	0.5	x	x	x	0.5	0.5	0	0.9	0.9	0	x	x	x
Honduras (11.2)	6	6.7	1.2	0.09	0.12	2.5	x	x	x	3.4	2.6	-2.4	1.7	1.8	0.6	x	x	x
Jamaica (1.1)	0.56	0.51	-0.9	0.08	0.09	2.9	x	x	x	0.2	0.2	0	0.26	0.3	0.4	x	x	x
Mexico (190.9)	76.9	73.7	-0.4	2.6	3.2	2.8	x	0.2	x	74.5	74.5	0	24.5	24.7	0.1	12.4	14.6	1.8
Nicaragua (11.9)	5.7	5.2	-0.9	0.1	0.1	0	x	x	x	4.9	5.3	0.8	1.2	1.3	0.8	x	x	x
Panama (7.6)	5.8	5.4	-0.7	0.07	0.08	1.4	x	x	x	1.2	1.5	2.5	0.5	0.6	2	x	x	x
Argentina (273.7)	86.4	85.4	-0.1	1.1	1.15	1.5	0.7	1.1	5.7	143.2	142.4	-0.06	35.2	35.7	0.1	7.15	8	1.2
Bolivia (108.4)	77.7	77.9	0	0.2	0.26	2.5	0.03	0.03	0	27	26.7	-0.1	3.4	3.4	0.3	0.06	0.1	6.7
Brazil (845.7)	598.2	577.7	-0.3	4.5	5.5	2.2	3.8	6.7	7.6	161	169	0.5	71.1	78.6	1	7.05	8.16	1.6
Chile (74.9)	52.7	50.6	-0.4	0.45	0.5	2.5	0.8	1.5	8.8	11.9	13.4	1.3	5.3	4.5	-1.7	3.75	4.45	1.9
Colombia (103.9)	86.2	65.9	-1.6	1	1.1	2.2	0.09	0.17	8.9	30	40.2	3.4	5.6	5.4	-0.5	1	1.1	1
Ecuador (27.7)	20.7	19.5	-0.6	0.4	0.45	1.2	0.04	0.07	7.5	4	5	2.5	2.5	2.6	0.8	0.07	0.09	2.9
Guyana (19.7)	18	18	0	0.03	0.03	0	x	x	x	1.2	1.2	0	0.5	0.5	0	x	x	x
Paraguay (39.7)	22.3	17	-2.4	0.12	0.15	2.5	x	x	x	15.6	20.4	3.1	1.7	2.2	3	x	x	x
Peru (128)	90	89	-0.1	0.7	0.8	1.4	0.08	0.15	8.8	27.1	27.1	0	3.5	3.7	0.6	6.56	7.3	1.1
Suriname (15.6)	15.5	15.4	0	0	0	0	x	x	x	0.02	0.02	0	0.06	0.06	4	x	x	x
Uruguay (17.5)	2.5	2.6	0.4	0.1	0.1	0	x	x	x	13.6	13.5	-0.07	1.4	1.3	-0.7	x	x	x
Venezuela (88.2)	65.6	64.8	-0.1	0.6	0.7	1.7	0.12	0.22	8.3	17.2	17.6	0.3	3.7	3.9	0.5	0.96	1	4
Latin America & the Caribbean (2,016.8)	1240.6	1193.4	-0.4	13.2	16	2.1	5.8	10.4	7.9	545.1	570.4	0.46	170.5	179.1	0.5	39.3	45.2	1.5

Sources: Winograd, 1989; WRI, 1990 & 1992

Note: x = not available

A scarcely studied problem of great importance in the region is land alteration. Fallow, secondary forests, marginal lands, abandoned terraces, etc., covered 22 percent of the regional territory in 1980. The potential of these lands is enormous. (See Boxes 4.1 and 4.2 in Projections in Land-Uses.) In the Peruvian sierra (hillsides) more than one million hectares of terraces are appropriate for high-yielding, erosion-proof agriculture, though only 20 percent of these lands are now in use and the rest, highly deteriorated, has been abandoned. Tropical secondary forests cover 30 percent of the tropical forest area. Through adaptive forest management, these wood resources could be doubled by the year 2000 (Wadsworth, 1987). Instead of exploiting this potential productively, current forestry and agricultural policies promote the advance of the agricultural frontier, the subutilization of the better lands, and the selective felling of natural forests.

Apart from deforestation, the accelerated degradation of pasturelands, tropical soil erosion and fertility loss, and the subutilization of lands and natural resources are further land-use problems in the region. These include desertification brought on by overgrazing, salinization, and the alkalinization of irrigated soils in arid and semiarid zones. In the arid zones, inhabited by 16 percent of the regional population in 1980 and covering 22 percent of the total area, some 12.6 million hectares were irrigated and 280.5 million hectares were in permanent pastures. Of this land, 33 percent of the irrigated zones and 72 percent of the pasturelands suffer from desertification. At the local level, the figures are comparable. In Argentina, 38 percent of all irrigated soils suffer from salinization (Gallopín, 1989a) and about 35 percent of Patagonia (800,000 km^2) is becoming desertified (Winograd, 1989b).

Table 1.3 Patterns of Land-Use by Life-Zones for Latin America and the Caribbean

Life-Zones & Surface (10^6 ha)	Natural (10^6 ha)		Percent of Change	Urban (10^6 ha)		Percent of Change	Plantations (10^6 ha)		Percent of Change	Pastures (10^6 ha)		Percent of Change	Agriculture (10^6 ha)		Percent of Change	Altered (10^6 ha)		Percent of Change	Wasteland (10^6 ha)		Percent of Change
	1980	1990		1980	1990		1980	1990		1980	1990		1980	1990		1980	1990		1980	1990	
TmF (695)	568.8	522	-0.85	0.4	0.5	2.7	0.3	1	23.3	23.6	36.4	5.4	7.3	9.6	3.2	74.6	97.6	3	0	0	0
TmmF (46.7)	3	2.2	-2.8	3.6	3.7	0.25	0.25	0.4	7.6	18.5	17.9	-0.3	11.1	12	0.8	10.1	10	0	0.25	0.4	5.6
TdF (140.1)	38.3	33.7	-1.5	1.2	1.5	2.5	1.9	3.3	8.9	64.1	72.8	1.4	20	21.3	0.65	61.5	55.1	-1	0.8	1.2	5
TvdF (140.1)	49.6	47.3	-0.46	0.2	0.3	2.3	0	0	0	46.7	44.6	-0.4	5	4.8	-0.4	30.9	34.5	1.2	7.7	8.5	1
TS(TdF) (106.6)	42.3	30.5	-0.7	0.1	0.2	3	0	0	0	46.5	51.1	0.9	3.5	4	1.4	12.2	11.9	-0.2	0	0	0
Paramo (4.3)	0.8	0.7	-1.2	0.09	0.1	4.4	0	0	0	1.2	1.2	-0.6	0.3	0.3	0	1.8	2	0.8	0.01	0.02	10
Puna (87.9)	16.4	15.1	-0.8	0.5	0.6	2.6	0.01	0.01	5	41	41.1	0.02	3	3.5	1.7	22.4	22.6	0.01	4.5	4.8	0.7
T-STmF (78.4)	12.8	12.4	-0.3	0.5	0.7	3.2	0.3	0.8	10	28.8	27.3	-0.5	8.2	9.2	1.1	27.5	27.2	-0.01	0.3	0.4	3
D-M (18.8)	5.2	4.7	-1	0.2	0.2	2.1	0	0	0	4.2	4.9	1.7	0.8	0.8	0	8.2	7.8	-0.4	0.06	0.1	10
T-STDsDs (116.2)	35.4	33.1	-0.6	2.7	3.4	2.8	0	0	0	36.2	38	-0.2	8	8.6	0.7	14.4	13.6	-0.5	16.5	18.4	1.8
STmF (147.4)	20.8	17	-1.8	1.3	1.8	2.3	1.7	2.0	7	44.7	41.7	-0.7	55	59.3	0.8	24.7	24.3	-0.1	0.3	0.3	0.7
STdF (145.9)	17.9	17	-0.5	0.7	0.9	2.1	0.35	0.6	7.1	50.4	54.5	0.8	16	16.8	0.6	60	56.2	-0.6	0.6	0.75	3.1
STS (103.8)	1.1	1.1	0	1.6	1.8	1.2	0.3	0.4	3.1	59.5	61.5	0.4	28.6	25.6	0	14.4	13.5	-0.2	0.2	0.3	4
STtS (10.3)	0.5	0.4	-2	0.01	0.01	0	0.01	0.01	0	3.3	3.3	0	2.4	2.4	0	3.3	3.1	-0.3	0.4	0.5	2.2
STDs (75)	2.5	2.5	-0.2	0.2	0.2	0	0	0	0	34	33.8	-0.03	0.8	0.8	0.6	36.8	37	0.03	0.5	0.6	1.3
TemmF (33.9)	5.1	4.4	-1.4	0.09	0.1	1.1	0.8	1.6	10	9	9.1	0.1	2.3	2.4	0.4	14.8	14.2	-0.3	1.7	1.9	1.2
S (49.2)	4	3.9	-0.25	0.01	0.01	0	0.01	0.01	0	25	23.9	-0.5	0.2	0.25	2.5	16	16.5	0.43	4	4.4	1
TemS (23.7)	13.2	13.2	0	0	0	0	0	0	0	3.4	3.4	0	0.03	0.04	3	5.6	5.5	-0.2	1.5	1.6	0.7
Latin America & the Caribbean (2,042)	828.7	770.2	-0.7	13.6	16	1.7	5.8	10.4	6	545.1	566.5	0.28	170.5	181.9	0.67	430.3	451.5	0.28	38.3	45.2	1.3

Sources: Gallopin et al., 1991; Gallopin & Winograd, 1990; Winograd, 1990

TECHNICAL NOTES:

Table 1.1 Net primary productivity data are from Gómez and Gallopín (1989b). Actual net primary production was obtained by multiplying the actual (1990) natural and altered area (fallow and secondary forests) for each life-zone by the primary productivity. Natural net primary production was obtained by multiplying the total life-zone area by the net primary productvity.

Table 1.2 Land-use data per country are from WRI (1990b & 1992, Table 17.1). However, since land-use categories for life-zones are more detailed, areas corresponding to urban and wasteland categories were calculated for all countries (Winograd, 1989b, Table 18.1). The areas of natural and altered zones could not be disaggregated, because they were based on various sources. Total land area of the region differ from that of Table 1.3. (See note of Table 1.3 for detailed definitions of natural area, plantations, altered agriculture, and urban land-use.)

Table 1.3 Land-use data per life-zone are from Winograd (1989b, Tables 18.1 and 18.10). The methodology used involved an estimation of cultivated, altered, and natural areas for the year 1980, based on maps available for the region (Morello, 1989, Morello et al., 1989, UNESCO, 1981). The data obtained were then corrected following FAO production yearbooks and assigned to different life-zones with regard to bioclimatic characteristics (Winograd, 1989b, Table 1.1 and 1.2 and Figure 1.1 and 1.2). For example, coffee is produced in two life-zones, TlmmF and STmF. In Central America and the Andean countries 90 percent of this crop is produced in TlmmF, so coffee is assigned to the TlmmF life-zone for these countries. In Brazil and Mexico, however, 90% of coffee is produced in TmF, so coffee is assigned to the Stmf life-zone. In the case of corn, wheat, and beans, life-zones were assigned by production statistics as well as bioclimatic factors. Data for altered and natural areas and plantations were obtained from maps and corrected using country and life-zone data from FAO (1981) and Lanly (1984). Local and national studies were also consulted. Pasture areas were derived from national statistics on livestock populations. These populations were assigned to life-zones with regard to the carrying capacity of each life-zone (i.e., in Argentina 70 percent of the livestock population is assigned to STS, 20 percent to StdF, and 10 percent to S. The corresponding carrying capacities are 0.75, 0.25, and 0.01 Animal Units per hectare). Data were corrected and validated in an iterative process using computer runs of the land-use *model for different base years (1980, 1985, and 1990). The results were then compared to the FAO yearbook. The categories were defined as follows:*

- *Natural: virgin areas (forests, shrub formations, savannas, semideserts, and deserts) and areas with past alteration, but currently similar to the original ecosystems.*
- *Plantations: reforested areas used for industrial and non-industrial forestry.*
- *Agricultural: annual, permanent, non-traditional, and illegal crop areas, including fallow from permanent agriculture.*
- *Altered: denotes a mosaic of patches of land under production coexisting with patches of original and secondary vegetation and areas with slight to moderate soil erosion. Fallow from shifting cultivation and peasant agriculture is included.*
- *Urban: urbanized areas (mainly the cities).*
- *Wastelands: unproductive lands irreversibly transformed in their structure, dynamics, flora, and fauna by extreme soil erosion and desertification.*

Regional totals in Tables 1.2 and 1.3, particularly for the year 1989-90, differ because totals in Table 1.3 are based on data from the land-use models (which used different source maps), whereas Table 1.2 is based on FAO information (WRI, 1992). Table 1.2 presents land area only, whereas Table 1.3 shows the total area (land and water area).

Box 1.1 Data for area, employment, production, and economic value are from the World Bank (1990a) and Browder (1987). Data on deforestation and for the calculation of emissions come from Fearnside (1990a).

Box 1.2 Data for the calculation of emissions are from Fearnside (1990). The data on people using fossil fuels in cities assume that each person emits 0.7 tons of carbon. Emission factors are based on data by Fearnside (1990a). (See Atmosphere and Climate.) In this calculation, the carbon absorbed by changes in land-use is not taken into consideration. For example, a peasant farmer would emit 13 tons of carbon per year (considering a cultivation period of 3 years), although the corresponding fallow period (about a 12-year break) largely absorbs the total and annual emissions.

2. FORESTS AND RANGELANDS

In recent years, tropical deforestation has spawned great interest and important debates. Both stem in part from the magnitude of deforestation and the role that land-use changes play on the increase of greenhouse effect emissions. At current levels, deforestation could destroy part of the region's biodiversity in these zones, as well as soil fertility. On the other hand, the natural resources in forests zones are not being fully utilized.

Despite great interest in the loss of tropical forests, no monitoring program shows the amount and geographical distribution of deforestation. Much of the data on the region is only estimated, and Brazil is the only country with a somewhat credible and a continuous monitoring system

Generally, when deforestation is analyzed in Latin America and the Caribbean, the emphasis is on tropical and subtropical moist forests (closed forests) while tropical and subtropical dry forests (open forests) are ignored. (See Tables 2.1 and 2.2.) During the 1980s, the annual losses of tropical and subtropical closed forests were 5.3 millions hectares (i.e., 0.77 percent per year) while those in open tropical forests totalled 1.6 million hectares (i.e., 0.7 percent per year). (See Table 2.2.) In Brazil, in only one year (1988), forest losses in the Legal Amazonia amounted to 2 million hectares of closed forests (0.52 percent per year) and 1.8 million hectares of open forests (4.8 percent per year). Thus, in 1989, fully 33 percent of the open forests in Legal Amazonia were deforested, compared to 6.4 percent of closed forests (Fearnside, 1990b; Fearnside et al., 1990c). Another striking case is that of the tropical dry forests of Central America, where the natural land covers today make up only 4 percent of the original area.

The loss of regional forests is by no means limited to subtropical and tropical zones. In temperate moist forests in the south of the region, deforestation affects 2.6 percent of the total area. (See Table 2.2.)

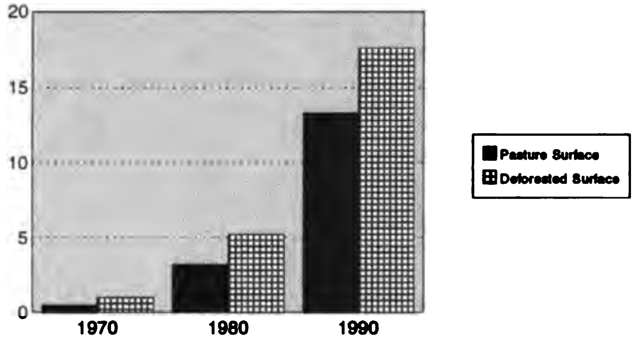
Currently, forestry and conservation policies concentrate almost exclusively on tropical moist forests, with-

Table 2.1 Annual Deforestation and Reforestation by Country in Latin America and the Caribbean (1980-1990)

Country	Extent of Natural Forests		Closed Forests		Open Forests		Ratio	Deforestation Rate	
	Closed (10^3 ha)	Open (10^3 ha)	Deforestation (10^3 ha/year)	Reforestation (10^3 ha/year)	Deforestation (10^3 ha/year)	Reforestation (10^3 ha/year)	Ref./Def.	Closed (%)	Open (%)
Belize	1,354	92	9	x	x	x	x	0.46	x
Costa Rica	1,638	160	42	3	1	x	1:17	2.6	x
El Salvador	141	x	5	x	x	x	x	3.5	x
Guatemala	4,442	100	90	10	x	x	1:9	2.2	x
Honduras	3,797	200	57	x	33	x	x	1.5	1.6
Mexico	46,250	2,100	1,100	28	24	x	1:40	2.3	1.1
Nicaragua	4,496	x	105	1	16	x	1:125	2.3	x
Panama	4,165	x	36	1	x	x	1:36	0.86	x
Caribbean	2,199	x	95	15	10	x	1:3	4.3	x
Central America & the Caribbean	68,482	2,652	1,454	57.7	83.5	x	1:35	2.1	3.1
Argentina	6,680	28,500	60	45	45	5	1:2	0.9	0.16
Bolivia	44,010	22,750	87	2	30	1	1:59	0.2	0.13
Brazil	357,480	157,000	2,263	320	1,226	240	1:6	0.83	0.78
Chile	7,550	x	55	93	x	x	1:0,6	0.72	x
Colombia	46,400	5,300	600	11	75	x	1:60	1.3	1.4
Ecuador	14,250	480	340	6	x	x	1:60	2.4	x
Guyana	18,475	220	2	x	x	x	x	0.01	x
Paraguay	4,070	15,640	20	1	3	x	1:25	0.49	0.02
Peru	69,680	960	270	8	x	x	1:33	0.4	x
Suriname	14,830	170	3	x	x	x	x	0.02	x
Uruguay	490	x	x	x	x	x	x	x	x
Venezuela	31,870	2,000	125	20	120	4	1:10	0.39	6
South America	615,785	233,020	3,825	506	1,499	250	1:7	0.62	0.64
Latin America & the Caribbean	684,267	235,672	5,279	563	1,583	250	1:8.5	0.77	0.67

Sources: Fearnside et al., 1990; FAO, 1991; Lanly, 1984; Repetto et al., 1992; Toledo et al., 1989; Winograd, 1989; WRI, 1990 &1992
Notes: x = not available; Caribbean includes Cuba, Dominican Republic, Haiti, and Jamaica

Figure 2.1 Deforestation in the Northern Region of Brazil (1970–1990)
(Acre, Amapá, Amazonas, Para, Rondonia, and Roraima)
(millions of hectares)



Sources: Fearnside et al. 1990; INPE, 1989; World Bank, 1990

out taking into account zones with high deterioration and forest-loss levels. In these overloaded zones, it is crucial to assess the value, potential, and possible loss of biodiversity.

As for reforestation, the policy challenge is tremendous because for each hectare cultivated, 8.5 natural hectares are deforested. (See Table 2.2.) In zones with closed forests, only 0.56 million hectares per year is reforested—an average reforestation- to-deforestation ratio of 1:10. In open forests, 0.25 million hectares per year are reforested—reforestation to deforestation ratio of 1:6. (See Tables 2.1 and 2.2.) Deforestation is caused mainly by the advance of the agricultural frontier (84 percent of deforestation) and forest exploitation (12.5 percent of deforestation). Construction of hydroelectrical and other infrastructure works account, along with the establishment of large-scale mining industries, for 3.5 percent of deforestation (Lanly, 1984; Winograd, 1989b; Gallopín & Winograd, 1990).

Although Latin America and the Caribbean include more than 46 percent of the world's tropical forests, the region accounts for only 28 percent of round wood production of tropical species, and most of this production is of 15 species (Lugo, 1987). Per capita wood reserves in the region are the world's largest: 243 cubic meters. But scarcely 11 percent of the world's processed wood comes from the region, and the production to reserve ratio is only 0.4. Production exceeds reserves only in a few Central American countries and Paraguay. (See Table 2.3.) Clearly, forest exploitation is mainly selective. Even though the exploited area doubled between 1970 and 1990, harvest intensity remained stable at 8 m^3/ha (i.e., 5 percent of the gross standing volume), compared to 38 m^3/ha in Asia and 12 m^3/ha in Africa (Lanly, 1984; FAO, 1992).

Table 2.2 Annual Deforestation and Reforestation by Life-Zone in Latin America and the Caribbean (1980-1990)

Life-Zones	Extent of Forest (10^3 ha)	South America			Central America and the Caribbean			Latin America and the Caribbean			Deforestation Rate (%)
		Deforestation (10^3 ha/year)	Reforestation (10^3 ha/year)	Ratio Ref./Def.	Deforestation (10^3 ha/year)	Reforestation (10^3 ha/year)	Ratio Ref./Def.	Deforestation (10^3 ha/year)	Reforestation (10^3 ha/year)	Ratio Ref./Def.	
Tropical Moist Forest (TmF)	619,600	3,538	154.5	1:23	191	5.2	1:40	3,729	159.7	1:23	1
Tropical Lower Mountain Moist Forest (TlmmF)	12,200	87	28	1:3	11	0.5	1:22	98	28.5	1:3.4	0.6
Tropical Dry Forest (TdF)	88,600	960	240	1:4	1	x	x	961	240	1:4	0.8
Tropical Very Dry Forest (TvdF)	81,600	240	x	x	0	0	x	240	0	x	0.3
Tropical Savannas (Tropical Dry Forest) (TS - TdF)	51,300	251	4.5	1:56	49	x	x	300	4.5	1:67	0.6
Tropical and Subtropical Mountain Forest (T-STmF)	40,000	65	4	1:17	190	10	1:25	255	14	1:23	0.6
Subtropical Moist Forest (STmF)	41,300	45	221	1:0.2	1,062	42	1:33	1,107	263	1:6	2.7
Subtropical Dry Forest (STdF)	72,200	48	5	1:10	33.5	x	x	81.5	5	1:17	0.1
Temperate Moist Forest (TemmF)	18,600	90	98	1:0.9	0	0	x	90	98	1:0.9	0.5
Latin America and the Caribbean	1,025,800	5,324	755	1:7	1,454	57.7	1:27	6,861.5	812.7	1:8.5	0.7

Sources: Fearnside et al., 1990; Lanly, 1984; Repetto et al., 1992; Toledo et al., 1989; Winograd, 1989; WRI, 1990 & 1992
Notes: x = not available; Extents of forest include natural and altered surface

Table 2.3 Forest Production and Reserves by Country for Latin America and the Caribbean

Country	Roundwood Production per capita (m3) 1989	Timber Reserves		Production/Reserve Ratio (%)
		per ha (m3) 1989	per capita (m3) 1989	
Belize	1	x	x	x
Costa Rica	1.3	x	x	x
Cuba	0.3	x	x	x
Dominican Rep.	0.1	x	x	x
EL Salvador	0.8	x	x	x
Guatemala	0.8	x	x	x
Haiti	0.9	x	x	x
Honduras	1.1	x	x	x
Jamaica	0.08	x	x	x
Mexico	0.25	x	x	x
Nicaragua	1	x	x	x
Panama	0.8	x	x	x
Argentina	0.3	x	x	x
Bolivia	0.2	90	616	0.04
Brazil	1.7	112	425	0.4
Chile	1.3	x	x	x
Colombia	0.6	118	191	0.3
Ecuador	0.9	111	167	0.5
Guyana	0.2	x	x	x
Paraguay	2	18	93	2.4
Peru	0.4	163	577	0.07
Suriname	0.5	192	7,587	0.007
Uruguay	1	x	x	x
Venezuela	0.07	122	226	0.03
Latin America & the Caribbean	0.9	111	243	0.4

Sources: Lanly, 1984; WRI, 1990; WRI, 1992

In closed or open forests being pushed back by the agricultural frontier, livestock production causes 40 percent of deforestation (Winograd, 1991a). Pasturelands increased by 21.4 million hectares in the 1980s. Livestock population rose by 26 million animal units. (See Table 2.4.) In tropical moist forests, pasturelands increased by 12.9 million hectares during the last 10 years, whereas in tropical dry forests they rose by 8.7 million. (See Table 2.5.) In these zones, the carrying capacity went from 2 animal units per hectare the first year to 0.2 animal units per hectare after only 10 years of grazing (Hecht et al., 1988). (See Box 2.1.)

In subtropical and temperate zones, deficient management leads to overgrazing which favors and accelerates desertification and land degradation. Therefore, in regions such as the Argentinian Pampa, losses of plant cover have diminished forage production by 50 percent (Gallopín, 1989a). In the Argentine Patagonia, the intro-

Box 2.1 Export Income per Hectare of Agricultural Land for Some Central American Countries

Product	Guatemala (dollars/ha, 1980)	Honduras (dollars/ha, 1980)	Nicaragua (dollars/ha, 1980)	Costa Rica (dollars/ha, 1980)
Coffee	17.5	15.1	23.5	31.1
Sugar	7.2	x	4.8	7.7
Cotton	15.8	x	8.5	x
Bananas	x.	x	x	60.4
Meat	0.5	0.2	0.2	0.4

Source: Leonard, 1987
Note: x = not available

Table 2.4 Pastures and Livestock Population by Country for Latin America and the Caribbean

Country	Parmanent Pastures (10^6 ha)		Percent of Change	Livestock Population (10^6)		Percent of Change	Carrying Capacity Index (AU/ha)		Percent of Change	Meat Production (Kg/ha)		Percent of Change
	1980	1987-89		1980	1987-89		1980	1987-89		1980	1986-88	
Belize	0.05	0.05	0	0.05	0.05	0	1	1	0	80	140	75
Costa Rica	2	2.3	15	2.1	1.9	-9.5	1	0.82	-18	40	47	17
Cuba	2.6	3	15	6	5.1	-15	2.3	1.7	-26	57	51	-10
Dominican Rep.	2.1	2	0	1.9	2.3	21	1.1	1.1	0	24	32	33
El Salvador	0.6	0.6	0	1.3	1.3	0	2.1	2.1	0	45	37	-18
Guatemala	1.3	1.4	7.7	2	2.3	15	1.8	1.6	-11	43	32	-26
Haiti	0.5	0.5	0	1.4	1.8	29	3.6	3.6	0	50	68	36
Honduras	3.4	2.6	-23	2	2.7	35	0.8	1	25	18	26	44
Jamaica	0.2	0.2	0	0.28	0.4	43	2	2	0	60	55	-8
Mexico	74.5	74.5	0	31.4	35.7	13.7	0.42	0.48	14	10	13	30
Nicaragua	4.9	5.3	6	2.3	1.7	-26	0.34	0.32	-6	12	9	-25
Panama	1.1	1.5	18	1.4	1.4	0	1.3	1	-23	37	37	0
Argentina	143.2	142.4	-0.6	64.2	58.8	-8.4	0.45	0.41	-8.9	20	20	0
Bolivia	27	26.7	0	7.4	8.4	13.5	0.27	0.3	11.1	3	4	33
Brazil	161	169	5.6	123.2	143.3	16.3	0.76	0.85	11.8	13	11	-15
Chile	11.9	13.4	13.4	5.1	5.2	2	0.4	0.38	-5	14	13	-7
Colombia	30	40.2	35	24.7	25.2	2	0.8	0.6	-25	20	16	-20
Ecuador	4	5	24.1	3.6	4.4	23.2	0.09	0.09	0	2	1.9	-5
Guyana	1.2	1.2	0	0.2	0.2	0	20	20	0	200	200	0
Paraguay	15.6	20.4	26.9	5.8	7.7	32.8	0.37	0.39	5.4	6.8	7.5	10.3
Peru	27.1	27.1	0.7	8	7.6	-5	0.29	0.28	-3.4	3	3.5	17
Suriname	0.02	0.02	0	0.09	0.09	0	0.2	0.2	0			
Uruguay	13.6	13.5	-0.7	15.7	16.5	5	1.1	1.2	9	25	21.3	-15
Venezuela	17.2	17.6	2.3	11.1	13.1	18	0.64	0.74	15.5	20	19.3	-3.5
Latin America & the Caribbean	545.1	570.4	4.7	321	347	8	0.55	0.56	1.8	14	13	-7

Sources: FAO, 1992; UNEP, 1991; WRI 1990 & 1992
Note: x = not available

duction of sheep and inappropriate management policies produced changes in pastureland composition and brought on soil erosion, desertification, and overgrazing. As a consequence, 35 percent of this area has been transformed into a desert and the total animal load fell by 20 percent in the last decades. In Andean mountain zones and in tropical moist forests, pasture impoverishment has led to the introduction of exotic species that have invaded important agricultural zones and obstructed the traditional fallow system (Gallopín et al., 1991c).

The accelerated transformation of tropical forests into permanent pastures, as well as the degradation of natural pasture lands in the region's subtropical and temperate zones, constitutes the most important environmental process at the rural level (UNEP, AECI, & MOPU, 1990). Not only is the extent of the land involved tremendous, but effects on ecosystems are practically irreversible. Great investments would be needed to restore and rehabilitate these zones.

TECHNICAL NOTES:

Table 2.1 Forest areas data are from WRI (1992, Table 19.1) with some corrections for countries by Winograd (1991a). Deforestation data for Chile and Argentina are from Winograd (1991a). Deforestation data for Bolivia, Ecuador, Guyana, Paraguay, Peru, Suriname, Venezuela, Belize, El Salvador, Guatemala, Panama, and the Caribbean are from FAO (1991), Lanly (1984), and WRI (1990b & 1992). In Brazil, the average deforestation for the 1980-90 period was calculated according to data from Fearnside et al. (1990c) and INPE (1989). Deforestation data for Colombia are from Lanly (1984), Winograd (1991a) and WRI (1992). Deforestation data for Costa Rica are from Repetto et al. (1992). Deforestation data for Honduras and Nicaragua are from Lanly (1984) and Winograd (1991a). Deforestation data for Mexico are from Toledo et al. (1989). His estimate of 1.1 million hectares of annual deforestation is based on livestock loads and areas. If areas deforested by agriculture are added to this estimate, then Mexico's annual deforestation may reach 1.5 million hectares (Gómez-Pompa et al., 1990). The latter figure was used in Mexico for calculating greenhouse gas emissions for land-use changes. For other countries, figures depicted in Table 2.1 are used to calculate greenhouse gas emmission. (See Atmosphere and Climate.) All reforestation data come from Lanly (1984) and WRI (1992).

At the time of publication of this study, FAO published its report on the state of tropical forests (FAO. 1992. Forest Resources Assessment 1990: Tropical Countries. FAO Forestry Department, Rome). New data from the FAO study may be compared to those in this report. Annual deforestation, according to FAO, for the 1981-1990 period is 7.4 million has/year (1.9 of humid tropical forests; 3.2 of humid deciduous forests; 1.6 of montane forests, and 0.66 of arid zones). Compared to the figure in this study, 6.9 million has/year for 1980-1990, the FAO number is seven percent higher. Data on forested areas in the Latin America and Caribbean region differ. FAO reports 918 million hectares for 1990, 10 percent lower than the 1,025 million hectares in this study for 1980-1990. The FAO figures for reforested areas are 8.6 million hectares in 1990 and 8.1 million hectares for the period 1980-1990.

Table 2.2 The extent of forests per life-zone originates from the land-use models found in Winograd, 1989b, Tables 18.5 and 18.10; and Gallopín and Winograd 1990, Tables 1 and 3. For this reason, area estimates may differ from the ones in Table 2.1. Deforestation and reforestation per life-zone data were elaborated from FAO (1991), Fearnside et al. (1990), Lanly (1984), Winograd (1989b & 1991a), and WRI (1992) and country studies. (See Technical note of Table 2.1.) Country data were used to assign reforestation and deforestation data to life-zones. More specifically, they were assigned with regard to geographic zones and forest types.

Table 2.3 All production and reserve data were elaborated by FAO and cited by Lanly (1984) and WRI (1992).

Table 2.4 Data on pasture area, livestock, meat production, and carrying capacity are from FAO (1992), WRI (1992, Tables 17.1 and 18.3) and UNEP (1991, Tables 3.1 and 3.9). In Tables 2.4 and 2.5 livestock population is given in Animal Units (AU). An Animal Unit is equivalent to one cow, four sheep, or six goats.

Table 2.5 Pasture area, livestock population, and carrying capacity data are from Winograd (1989b), based on estimations for life-zones from data in FAO's production yearbooks. (See Technical Notes Ecosystems and Land-Use, Table 1.3.)

Box 2.1 Data come from Leonard (1987, Table 3-16).

Table 2.5 Pastures and Livestock Population by Life-Zones for Latin America and the Caribbean

Life Zones	Permanent Pastures (10^6 ha)		Percent of Change	Livestock Population (10^6)		Percent of Change	Carrying Capacity Index (AU/ha)		Percent of Change
	1980	1990		1980	1990		1980	1990	
TmF	23.5	36.4	27	21	27.5	31	0.85	0.9	6
TlmmF	18.5	17.9	-3	19	19	0	1	1	0
TdF	64.1	72.8	14	33	44	33	0.5	0.6	20
TvdF	46.7	44.6	-4	12	10	-17	0.25	0.22	-12
TS(TdF)	48.5	51.1	5	25	30	24	0.5	0.57	14
Paramo	1.2	1.2	-6	0.3	0.28	-7	0.2	0.2	0
Puna	41	41.1	0	10.5	11.5	-4.5	0.25	0.28	12
T-STmF	28.8	27.3	-5	29	29	0	1	1	0
D-M	4.2	4.9	1.7	4.2	5	19	1	1	0
T-STDsDs	39.2	38	-2	4	3.1	-22	0.1	0.08	-20
STmF	44.7	41.7	-7	57	58.5	2.6	1.25	1.4	12
STdF	50.4	54.5	8	26	28.5	12	0.5	0.51	2
STS	59	61.5	4	52	53.5	3	0.87	0.86	-1
STtS	3.3	3.3	0	7	7	0	2.1	2.1	0
STDs	34	33.9	0	7	7	0	0.2	0.2	0
TemmF	9	9.1	0	9	9	0	1	1	0
S	25	23.8	-5	5	4	-20	0.2	0.16	-20
TemS	3.4	3.4	0	0.3	0.3	0	0.1	0.1	0
Latin America & the Caribbean	545.1	566.5	3.3	321	347	8.1	0.59	0.62	5

Sources: FAO, 1992; Winograd, 1989

3. BIOLOGICAL DIVERSITY

Biological diversity constitutes one of the main resources for development. In Latin America, biological diversity is not limited to the existence of numerous plant and animal species. The region also contains a great variety of habitats and ecosystems. Some, like the Paramo, the Puna, the Pampa and the Pantanal, as well as the Pacific and Amazon tropical moist forests or the Andean cloud forests, are unique. The potential of plants, animals, habitats, and whole ecosystems must be conserved and studied well if it is to be used sustainably.

Latin America and the Caribbean give shelter to 40 percent of the world's tropical species. About 90,000 of the 250,000 higher plant species flourish in the Latin American and the Caribbean tropical region. Colombia, with 0.77 percent of the world's area, contains 10 percent of the world's animal and plant species. Brazil, with 6.5 percent of the world's area, houses 22 percent of all higher plant species and 25 percent of the world's primates (McNeely et al., 1990). Although plant diversity in Chile is lower than in the region's tropical countries (5,500 higher plants), half of its flora is endemic. Together with Argentina, this country shares, for example, species of trees resistant to acid rain.

In the tropics of Latin America, there may still exist ten thousands of undiscovered plant species, together with 5 to 50 million insect species still unclassified (Gentry, 1986). On the other hand, 36 percent of the main food species and 35 percent of the world's main industrial cultivated species come from Latin America (Kloppenburg and Kleinman, 1987). At current rates, the conversion and deforestation of tropical forests may wipe out 100,000 to 450,000 species in the next 40 years (Lugo, 1988b; Winograd, 1989a). (See Figure 3.1.) Indiscriminate hunting and the trade of living animals also threaten the region's biological diversity. Currently, Latin America and the Caribbean provide (mainly illegally) 14 percent of all living primates, 11 percent of feline furs, 48 percent of living parrots and parakeets, and 36 percent of reptile skins for global trade (WRI, 1992).

This great biodiversity notwithstanding, about 90 percent of all regional agricultural production comes from the use of only 15 cultivated species, and most of these originate from rather homogenous genotypes developed to obtain high yields—a process that invites genetic erosion at the very time that important food crops are being abandoned, especially those on hillsides where the peasant agriculture predominates. In the Andean mountain regions, 10 species of roots and tubers (plus local varieties, including 30 kinds of potato), 3 cereals, 3 legumes, 11 fruits, 2 cultivated nuts, and 225 potential plant species are endangered by homogenous practices in cultivation and land-uses (National Research Council, 1989; Patiño, 1982). Although this number of potential animal and plant extinctions may not be critical, it reveals the increasing pressure on the species and ecosystems that threatens biodiversity, a resource that cannot be revived once lost. (See Tables 3.1 and 3.2.) (In some countries in the region, the situation is critical. More than 5 percent of Mexico's flora is in danger of extinction.)

Box 3.1 Use Index for Local Amazonian Residents

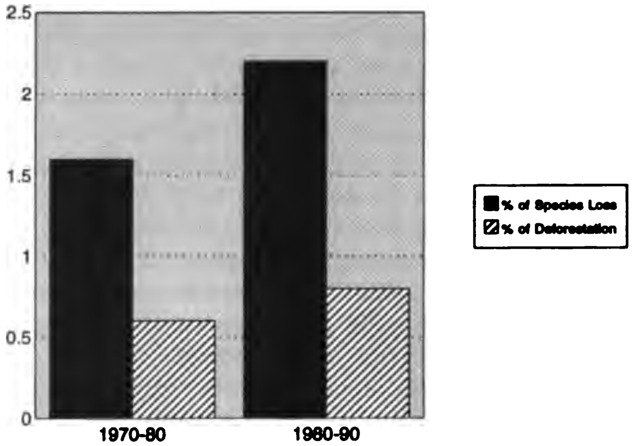
Country	Life-Zone	Forest Type	Amazonian Community	Number of Tree Species Used per Hectare	Number of Tree Species per Hectare	Percent of Tree Species Used for Food	Percent of Tree Species Used	Source
Bolivia	TlmmF	Unmanaged	Chacobo	74	94	40	79	Prance et al., 1987
Brazil	TdF	Managed	Kayapo	118(b)	120(b)	25	98	Anderson & Possey,1989
Brazil	TmF	Managed	Isla das Oncas (a)	25	28	39	89	Anderson,1990
Brazil	TmF	Unmanaged	Isla das Oncas (a)	42	53	11	79	Anderson,1990
Brazil	TmF	Unmanaged	Ka'apor	76	99	42	77	Prance et al., 1987
Brazil	TmF	Managed	Tenbe	73	119	23	61	Prance et al., 1987
Ecuador	TmF	Unmanaged	Shuar	220	242	23	91	Bennet,1992
Peru	TmF	Managed	San Rafael (a)	95(c)	158(c)	23	60	Pinedo-Vasquez et al., 1990
Peru	TmF	Unmanaged	Mishana (a)	72	250	4	26	Peters et al., 1989
Peru	TmF	Unmanaged	Ese-Eja	53	160	33	33	Phillips,1991
Peru	TmF	Unmanaged	Ese-Eja	43	180	24	24	Phillips,1991
Venezuela	TmF	Unmanaged	Panare	34	70	31	49	Prance et al., 1987

Source: Reid et al., 1992 (modified)
Notes: Average number of tree species & tree species used are based on survey of trees over 10 cm at breast height;
(a) = Member of heterogenous population of detribelized Indians and Mestizos (Ribereños)
(b) = Includes shrubs, vines, and tree species under 10 cm in diameter at breast height
(c) = Data is for a parcel of land 7.5 ha

Contrary to public belief, many threatened species and habitats are outside of tropical moist forests. The Species Risk Index for mammals in South America is very high for arid and mountain zones and comparatively low in tropical moist areas. (See Box 3.2.) Without forgetting the tropical moist forests (many of which do suffer high deforestation rates), policy-makers must keep this fact in mind as they formulate conservation policies. (See Box 3.6.)

The whole region still shows a small proportion (4-5 percent of total territory) of areas under protection. That said, Chile and Costa Rica, although possessing scant natural areas, protect a significant proportion of their land. Brazil and Panama too show significant protected and natural areas. In contrast, Guyana—with extensive virgin areas—lacks a protection system. (See Table 3.3.) Some important zones are poorly represented. The least protected areas are steppes, deserts, and subtropical dry forests. The protected areas of tropical moist forests should be increased to conserve habitats and species. (See Table 3.3.) The Species Risk Index for plants in Central America shows a need to expand protected areas and conservation programs for tropical moist and dry forests. (See Box 3.3.)

Figure 3.1 Relationship between Deforestation and Loss of Plant Species in Latin America and the Caribbean
(percent)



Source: FAO, 1992

Like the region's biological wealth itself, the potential for using it is enormous. If 10 percent of the region's 90,000 higher tropical plant species have medicinal uses,

Table 3.1 Threatened Animal Species by Country for Latin America and the Caribbean

Country	Mammals		Birds		Reptiles		Amphibians	
	Number of Species	Percent Threatened	Number of Species	Percent Threatened	Number of Species	Percent Threatened	Number of Species	Percent Threatened
Belize	121	7	504	0.9	107	28	26	0
Costa Rica	203	5	796	0.6	107	7	151	0
Cuba	39	23	286	5	100	10	40	0
Dominican Rep.	x	x	x	x	x	x	x	0
El Salvador	129	5	432	0.7	92	8	38	0
Guatemala	174	5	666	1	204	5	99	0
Haiti	x	x	x	x	x	x	x	0
Honduras	179	5	672	0.7	161	6	57	0
Jamaica	29	7	223	2	38	11	20	0
Mexico	439	7	961	13	717	5	284	1
Nicaragua	177	5	610	0.7	162	6	59	0
Panama	217	6	920	0.7	212	5	155	1
Argentina	255	10	927	2	204	3	124	0.8
Bolivia	267	9	1,177	0.4	180	6	96	0
Brazil	394	11	1,567	2	467	4	487	0.2
Chile	90	11	393	2	82	4	38	0
Colombia	358	7	1,665	2	383	6	375	0
Ecuador	280	8	1,447	1	345	10	350	0
Guyana	198	6	728	0.4	137	10	105	0
Paraguay	157	9	630	1	110	7	69	0
Peru	359	8	1,642	0.6	297	5	235	0
Suriname	200	6	670	0.4	131	9	99	0
Uruguay	77	9	367	0.8	66	14	37	3
Venezuela	305	6	1,295	0.6	246	8	183	0

Source: WRI, 1992
Note: x = not available

10 percent have industrial uses, and 15 percent may be utilized as food, then 31,500 species may be of potential use (Rapoport, 1988). Even more conservative estimates reveal extraordinary potential. At present, 1,000 plant species in the Brazilian Amazon are known to have economic potential. Some 300 Amazonian tree species are already in forestry use (Gottlieb, 1985). (See Box 3.4.) The potential for hunting and breeding of native fauna species is also enormous. At least 24 species (4 camelids, 5 birds, 10 rodents, 2 deer, and 3 iguanas) could be used for these objectives (Masson, 1988; NRC, 1991), and many more species could be raised for meat and leather. Iguana raising, for example, may yield 1.2 T/ha/year of meat. Capybara may have yields similar to those for cattle. Camelids, such as the llama, alpaca, vicuña and guanaco, produce wool that has no competition in the world's markets, and their yields are equivalent to those of sheep (Robinson and Redford, 1991).

Cultural patrimony and diversity are other important resources of the region. As discussed in greater detail below, the knowledge, use, and conservation of biological diversity must be considered in terms of people's relationship to their environment. Native and peasant peoples possess a great knowledge of how to use and manage species, natural resources, and ecosystems—a knowledge that must be conserved, enriched, and respected. In many cases, traditional techniques can solve problems that modern science and technology can't or are just beginning to solve. Indeed, the ancient Mayas organized diversified agricultural systems that could maintain population densities of 100 to 200 inhabitants per square kilometer (based on shifting agriculture) or even 700 to 1,050 inhabitants per km^2 (if intensive agriculture was practiced). For perspective, current densities range from 5 to 15 inhabitants/km^2 in the same zones, and the theoretical limit defined by agricultural science is 40 inhabitants per km^2 for the zones where shifting agriculture is practiced in tropical moist forests (Gómez-Pompa & Kaus, 1990; Brown & Lugo, 1990). Native and peasant systems are usually better adapted to both ecological conditions and economical needs. These systems—based on the temporal and spatial management of genetic diversity and species, the optimal use of space and resources, the conservation of water and soil, and the limited use of inputs—show great potential as sustainable models of land-use and natural resources (Altieri, 1988).

Table 3.2 Rare and Threatened Plant Species by Country for Latin America and the Caribbean

Country	Number of Plant Taxa	Percent Endemic	Rare and Threatened Plant Taxa per 1,000 Existing Taxa	Rare and Threatened Plant Taxa per 10,000 Km2
Belize	2,500-3,000	5	12	29
Costa Rica	10,000-12,000	15	57	266
Cuba	6,000	50	125	396
Dominican Rep.	1,127 (*)	x	x	x
El Salvador	2,500	17	10	19
Guatemala	8,000	15	38	139
Haiti	x	x	x	x
Honduras	5,000	3	10	22
Jamaica	2,746	30	2	8
Mexico	20,000-30,000	14	56	196
Nicaragua	5,000-7,000	1	14	32
Panama	8,000-9,000	13	38-43	176
Argentina	9,000	25-35	17	25
Bolivia	15,000-18,000	x	2	7
Brazil	55,000	x	4	26
Chile	4,750-5,500	50	35	46
Colombia	45,000	33	7	68
Ecuador	16,500-20,000	21	9	40
Guyana	6,000	x	10	25
Paraguay	7,000-8,000	x	2	4
Peru	13,000	x	18	71
Suriname	4,500	x	15	27
Uruguay	x	x	x	4
Venezuela	15,000-25,000	38	6	24

Sources: WCMC, 1992; WRI, 1992

Notes: x = not available; (*) includes Hispaniola Island (Haiti & Domincan Rep.)

Box 3.2 Species Risk Index for Mammal Species in South America

Macrohabitat	Original Natural Area (10^6 Km2)	Percent of Original Area Lost 1960-90	Number of Mammals Species	Number of Mammals Endemic Species	Endemic Species per 100,000 Km2	Species Risk Index
Amazon, Choco, and Pacific Lowland Forests	5.34	12	434	138	51	6
Drylands	10.2	79	509	211	66	52
Western Montane Forests	0.58	80	332	87	56	45
Atlantic Rain Forests	0.19	95	170	19	16	15
Upland Semideciduous Forests	0.72	48	192	5	3	1
Southern Mesophytic Forests	0.78	80	94	14	8	5

Sources: Mares, 1992; Reid et al., 1992; Winograd, 1989

Box 3.3 Species Risk Index for Plant Species in Central America

Country	Original Natural Area (10^3 Km2)	Percent of Original Area Lost (1980-85)	Number of Plants Species (*)	Number of Plants Endemic Species	Endemic Species per 10,000 Km2	Species Risk Index
Belize	22.8	56	2,500-3,000	150	144	64
Costa Rica	51	69	10,000-12,000	1,800	1,051	725
El Salvador	20.7	95	2,500	17	13	13
Guatemala	108.4	63	8,000	1,171	533	336
Honduras	111.9	69	5,000	148	67	48
Nicaragua	118.7	69	7,000	57	25	17
Panama	75.9	48	9,000	1,222	626	300

Sources: Reid et al., 1992; WCMC, 1992; WRI, 1992
Note: (*) Indicates flowering plants

Box 3.4 Most Economically Valuable Fruit Species of Amazonia

Species	Use	Yields (T/ha)	Value (dollars)
Myrciaria dubia	Fruit	11.1	6,660
Grias peruviana	Fruit & Oil	2.3	4,242
Mauritia flexuosa	Fruit	6.1	1,525
Jessenia bataua	Fruit & Oil	3.5	306
Euterpe oleracea	Fruit & Heart Palm	1.5	300
Orbignya phalerata	Fruit, Oil, & Charcoal	1.5	23

Sources: Anderson et al., 1989; Peters et al., 1989

Box 3.5 Valuation of Different Uses of Biodiversity in Latin American Tropical Forests

Activity	Products	Productive Cycle (years)	Net Present Value (NPV) (dollars)
Harvesting (Peru)	Fruits, Latex, & Timber	65	8,890
Agroforestry (Costa Rica)	Coffee, Timber, & Shade	15	5,754
Plantation (Guatemala)	Wood & Fuelwood	15	1,612
Ecotourism (Costa Rica)	Recreation	x	1,250

Sources: Peters et al., 1989; Reiche, 1989; Tobias & Mendelshon, 1991

Table 3.3 Protected Area System by Country and Life-Zone for Latin America and the Caribbean

Country	Number of Sites	Protected Area (10^3 ha)	Percent Protected
Belize	7	118	5
Costa Rica	25	610	12
Cuba	15	867	8
Dominican Rep.	13	550	11
El Salvador	7	22	1
Guatemala	13	99	1
Haiti	2	8	0
Honduras	15	580	5
Jamaica	0	0	0
Mexico	47	5,582	3
Nicaragua	6	43	0
Panama	14	1,311	17
Argentina	69	10,975	4
Bolivia	12	4,837	5
Brazil	160	20,096	2
Chile	69	11,893	16
Colombia	35	5,614	5
Ecuador	13	10,619	38
Guyana	1	11	0
Paraguay	9	1,120	3
Peru	22	5,483	4
Suriname	13	735	5
Uruguay	7	30	0
Venezuela	43	8,618	10
Latin America & the Caribbean	617	89,911	4

Sources: WCMC, 1992; WRI, 1992

Life-Zones	Number of Sites	Protected Area (10^3 ha)	Percent Protected
TmF	95	25,006	4
TlmmF	107	8,742	19
TdF	58	13,246	7
TvdF	47	5,371	4
TS(TdF)	9	2,621	2
Paramo	10	45	1
Puna	22	2,434	3
T-STmF	19	4,145	5
D-M	26	1,894	10
T-STDsDs	14	808	1
STmF	120	3,437	2
STdF	10	1,300	1
STS	22	2,175	2
STtS	8	147	1
STDs	29	1,830	2
TemmF	13	1,911	6
S	10	45	0
TemS	13	1,911	8
Unknown	50	11,433	x
Latin America & the Caribbean	722	97,269	5

Sources: WCMC, 1992; Winograd, 1989; WRI, 1992

Similarly, a colonist in the Brazilian Amazon uses at most five to ten crop species and sustains three inhabitants per year through discontinuous production, the Kayapo Indians in the same region utilize ten to forty-two crop species, with an annual production that may feed a family of six or more. (See Box 3.1 and Box 1.2 of Ecosystems and Land-Use.) At the same time, the use of native species by aborigines and "mestizos" in the Amazon basin shows not only their ability to adapt natural resources and use them, but also the potential productivity of these improved systems. (See Boxes 3.4 and 3.5.)

Box 3.6 U.S. Biodiversity Investments in Latin America and the Caribbean

Country	1989 Funding (10^6 dollars)	Dollars per 1,000 hectares
Costa Rica	6.2	1,217
Cuba	x	0
Dominican Rep.	0.06	14
Guatemala	1.2	114
Haiti	0.68	249
Honduras	0.42	38
Jamaica	1.1	1,054
Mexico	5.5	29
Nicaragua	0.009	1
Panama	0.95	125
Salvador	0.005	2
Other Countries	2.5	x
Central America & the Caribbean	18.9	822
Argentina	0.8	3
Bolivia	0.27	2
Brazil	5.5	6
Chile	0.2	3
Colombia	1.45	14
Ecuador	3.25	118
Guyana	x	0
Paraguay	x	0
Peru	1.9	15
Suriname	0.06	4
Uruguay	0.017	1
Venezuela	0.8	9
South America	19.4	11

Source: Abramovitz, 1991
Note: x = not available

TECHNICAL NOTES:

Tables 3.1 and 3.2 Data on animal and plant species are from WCMC (1992, Table 8.3) and WRI (1992, Tables 20.4 and 20.5).

Table 3.3 Data on protected areas per country are from WRI (1992, Table 20.1) and WCMC (1992, Table 29.6). Data on protected area by life-zone are from WCMC's (1992, Table 29.5) inventory of protected areas per biogeographical province and life-zone. The percentage is in relation to existing natural areas.

Box 3.1 Data on the use of plants in the Amazon Basin were collected from the bibliography mentioned in the Box.

Box 3.2 and 3.3 In order to calculate the Risk Index (Reid et al., 1992) the number of endemic species per unit area is multiplied by the percentage of loss of original area. For calculating the endemic species per area unit, the formula $S_0 = (S_1 A_0 Z)/A^z$ *was used, where* S_0 *is the number of endemic species per area unit,* A_0 *is the standard area (100,000* Km^2 *or 10,000* Km^2*), z is the conversion exponent (0.25 for 100,000* Km^2 *and 0.33 for 10,000* Km^2*),* S_1 *is the number of endemic species, and A is the original area (Reid et al., 1992). Data for Box 3.2 (original natural area and percentage of loss) are from Winograd (1989) and (the total of mammalian endemic species) Mares (1992). Data for Box 3.3 (total and endemic plant species for Central America) are from WCMC (1992, Table 13.1) and (original area and percentage of loss) WRI (1992, Table 19.1).*

Box 3.4 Data refer to more common plant species; however, an important number of other important fruit species with an economic value exist.

Box 3.5 Data for Peru are from Peters et al. (1989); data for Costa Rica (Agroforestry) and Guatemala are from Reiche (1989); and data for Costa Rica (Ecotourism) are from Tobias and Mendelsohn (1991). The NPV is calculated by the annual value of production, minus the costs of production, divided by the real interest rate (Peters et al., 1989).

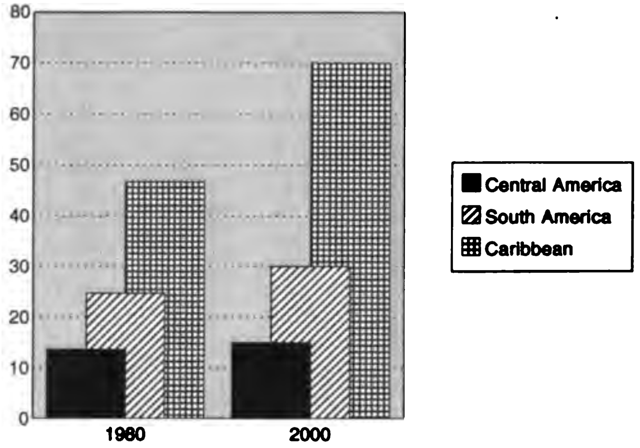
Box 3.6 Data are from Abramovitz (1991). Dollars per 1,000 hectares refer to total country area.

4. FRESHWATER AND COASTAL RESOURCES

For some countries in Latin America and the Caribbean, sea and coastal resources constitute the basis for current and future development. In particular, tourism is one of the greatest income sources in many of the Caribbean countries. (See Appendices 1.1 and 1.2.) But the environmental impact caused by infrastructure works, by urban and industrial pollution (oil and derivatives), and tourism affects beaches, mangroves, coral reefs, and seagrass beds. (See Table 4.1; Figure 4.1.)

More than half of the mangroves in Latin America and the Caribbean are altered by forestry activities, converted to agriculture or aquaculture, or degraded by pollution and infrastructure services (Hamilton & Snedaker, 1984; Saenger et al., 1983; IUCN, 1990). As a result, the catch of the main commercial species—such as shrimp, bass, and shad—is decreasing (Winograd, 1985). Coral reefs are also affected because they receive nutrients and sediments, essential for their survival, from mangroves. These factors are aggravated by such natural phenomena as hurricanes, storms and earthquakes. Although coastal ecosystems have enormous po-

Figure 4.1 Percent of Population in Coastal Areas for Latin America and the Caribbean (1980-2000) *(percent)*



Source: WRI, 1992

Table 4.1 Coastal Resources by Country for Latin America and the Caribbean

Country	Length of Coastline (Km)	Ratio Mangroves/ Coastline	Ratio Seagrass Beds/ Coastline	Protected Areas (Coral, Mangroves, Seagrass, etc.)	Population in Coastal Urban Agglomeration (10^6 people)	
					1980	2000
Belize	386	2	x	x	x	x
Costa Rica	1,290	0	2	7	1	2
Cuba	3,735	1	11	1	7	9
Dominican Rep.	1,285	0	3	3	3	6
El Salvador	307	2	x	x	2	3
Guatemala	400	1	8	x	1	1
Haiti	1,771	0	x	x	1	3
Honduras	820	2	27	x	1	2
Jamaica	1,022	0	0	4	1	2
Mexico	9,330	1	x	9	7	9
Nicaragua	910	1	30	x	1	3
Panama	2,490	2	4	3	1	2
Argentina	4,989	0	x	x	12	17
Brazil	7,491	3	x	4	26	49
Chile	6,435	0	x	x	3	5
Colombia	2,414	2	11	9	3	4
Ecuador	2,237	1	x	2	2	4
Guyana	459	3	x	x	0	0
Peru	2,414	0	x	x	7	14
Suriname	386	3	x	x	0	0
Uruguay	660	0	x	x	2	2
Venezuela	2,800	2	1	3	5	9
Latin America & the Caribbean	54,409	1	3	45	83	145

Sources: Saenger et al., 1983; IUCN, 1990; WCMC, 1992; WRI, 1992
Note: x = not available

Table 4.2 Water Resources by Country for Latin America and the Caribbean

Country	Internal Renewable Water Resources per Capita (1990) (10^3 m3)	Percent of Annual Withdrawals			Percent of Sectoral Withdrawals	
		Total (Km3)	of Water Resources	Per Capita (m3)	Domestic & Industrial	Agriculture
Belize	x	0	0	x	10	90
Costa Rica	32	1	1	779	11	89
Cuba	3	8	23	868	11	89
Domincan Rep.	3	3	15	453	11	89
El Salvador	4	1	5	241	11	89
Guatemala	13	1	1	139	26	74
Haiti	2	0	0	46	32	68
Honduras	20	1	1	508	9	91
Jamaica	3	0	4	157	14	86
Mexico	4	54	15	901	14	86
Nicaragua	45	1	1	370	46	54
Panama	60	1	1	744	23	77
Argentina	22	28	3	1,059	27	73
Bolivia	41	1	0	184	15	85
Brazil	35	35	1	212	60	40
Chile	36	17	4	1,625	11	89
Colombia	34	5	0	179	57	43
Ecuador	29	6	2	561	10	90
Guyana	232	5	2	7,616	1	99
Paraguay	22	0	0	111	22	78
Peru	2	6	15	294	28	72
Suriname	496	0	0	1,181	11	89
Uruguay	19	1	1	241	9	91
Venezuela	43	4	0	387	54	46

Source: WRI, 1992
Note: x = not available

tential for productive activities such as fishing and aquaculture, they are still considered fit mainly for tourist developments. Mangrove areas, whose value resides in the services and goods they can offer (such as protection against tides and erosion or breeding areas for commercial species and fishing sites) have decreased as such economic activities as forestry, land conversion, and pool aquaculture have increased. Yet, the costs of maintaining these services artificially or of replacing the goods and services mangroves provide are high (IUCN, 1990). (See Box 4.1.)

In the case of fishing, the region's current yield is 10.5 million tons per year, compared to an estimated potential of 16 - 24 million tons per year (FAO, 1988). Although regional fishing production could cover the present animal protein deficit in the human population, 75 percent of the fish caught in 1980 was used in fish flour production (Gallopín, et al., 1991c). Just as unsustainably, fishing centers exist for only a few of the many species available, overpressuring some fish species. On the Gulf of Mexico and the Colombian coasts, for example, exploitation is concentrated on 15 of the 165 commercial species. Meanwhile, aquaculture is scarcely developed in the region. In coastal zones, adequate and sustained yields of many marine species could be obtained by using adapted technologies. Oyster breeding in cages or on poles, for example, can yield 180 T/ha/year; shrimp or fish production in well-designed cages or pools can reach 4 T/ha/year (Hamilton & Snedaker, 1984).

In the case of water resources, the region is exceptionally well-endowed. Any water-supply problems are linked more to a lack of adequate infrastructure works than to biological scarcity. All countries still use only a low percentage of the water available to them. (See Table 4.2.)

Box 4.1 Value of Resources in Two Mangrove Forests in Latin America

Value and Employment in the Mangrove Forests in Cienaga Grande (Departament of Atlantico, Colombia)

Activity	Employment	Income in 1980 (dollars/year/person)	Land-Use
Forestry	300	675	Extensive
Fishing	2,600	1,400	Intensive

Source: INDERENA; cited in Winograd, 1985

Value and Employment in the Mangrove Forests in Heroes and Martires de Veracruz (Leon Province, Nicaragua)

Activity	Percent of Families	Income (dollars/month/family)	Principal Person Working
Fuelwood Extraction	29	54	Men & Women
Crab Extraction	6	54	Men
Shrimp Fishing	10	440	Men
Fishing	26	170	Men
Mollusk Extraction	29	36	Women & Children

Source: CATIE, 1991

TECHNICAL NOTES:

***Table 4.1** Coastline length and population data are from WRI (1992, Table 23.1). Area of mangroves and seagrass beds used for calculating ratios are from Saenger et al. (1983) and IUCN (1990). Number of protected areas are from WCMC (1992). Qualitative analysis of impacts are from Saenger et al. (1983), IUCN (1990), and WCMC (1992).*

***Table 4.2** Data on freshwater resources refer to average annual renewable flows. Estimations come from WRI (1992, Table 22.1).*

***Box 4.1** The data are local examples of mangrove use in the region.*

5. ATMOSPHERE AND CLIMATE

Growing concentrations of anthropogenic gases in the atmosphere are significantly changing its composition, intensifying the natural greenhouse effect and decreasing the ozone layer. Global warming is caused by fossil-fuel combustion, industrial emissions, land-use changes, fermentation processes in agriculture and fertilizer use. Emissions of these gases occur in different proportions, and each has its own warming potential. Although the impact and magnitude of these changes is still being debated, models of general atmospheric circulation (GCM) predict increases of the world's mean temperatures of between 1.5 and 4.5° Celsius (WRI, 1990b). This increase—an average—is expected to be higher in high and medium latitudes and lower in the equator. The southern hemisphere would endure lower increases because ocean thermic inertia is comparatively greater there (Salati, 1990).

Table 5.1 Net Emissions of Greenhouse Gases for Land-Use Change by Country in Latin America and the Caribbean

Country	Equivalent CO2 Heating Effect			
	(10^6 T of C) 1980	(T of C) per capita	(10^6 T of C) 1990	(T of C) per capita
Belize	0.1	0.5	0.1	0.5
Costa Rica	3.9	1.7	3.4	1.1
Cuba	0.1	0.01	0.1	0.009
Dominican Rep.	0.31	0.05	0.31	0.04
El Salvador	0.2	0.05	0.3	0.07
Guatemala	5.8	0.85	5.8	0.63
Haiti	0.1	0.02	0.1	0.01
Honduras	5.8	1.6	5.8	1.1
Jamaica	0.1	0.04	0.1	0.04
Mexico	40	0.57	102	1.1
Nicaragua	12	4.3	12	3
Panama	4	2.1	4	1.7
Argentina	0	0	0	0
Bolivia	6.8	1.2	9	1.2
Brazil	182	1.5	264	1.7
Chile	0	0	0	0
Colombia	81	3.1	85	2.6
Ecuador	30	3.7	30	2.8
Guyana	0.2	0.2	0.2	0.2
Paraguay	11	3.4	13	3
Peru	25	1.4	29	1.2
Suriname	0.3	1	0.3	0.75
Uruguay	0	0	0	0
Venezuela	15.5	1	15.5	0.79
Latin America & the Caribbean	424.4	1.2	580	1.3

Sources: Brown & Lugo, 1992; Fearnside, 1990 & 1992; Gómez, 1991; Winograd, 1990; WRI, 1990 & 1992

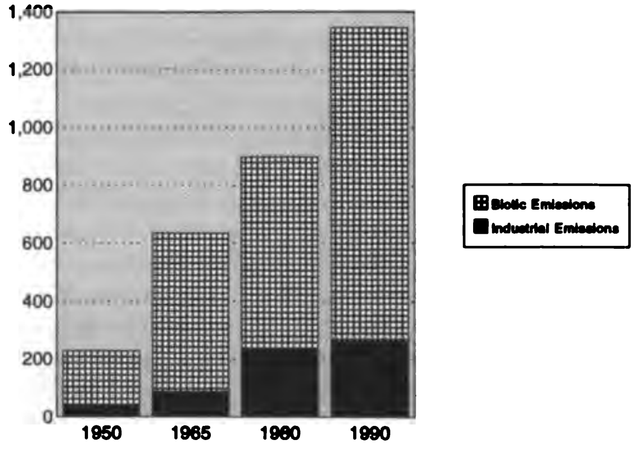
Table 5.2 Net Emissions of Greenhouse Gases for Land-Use Change by Life-Zone in Latin America and the Caribbean

Life-Zones	Equivalent CO2 Heating Effect			
	(10^6 T of C) 1980	(T of C) per capita	(10^6 T of C) 1990	(T of C) per capita
TmF	296.7	15.9	368	14.4
TlmmF	5.5	0.06	6.5	0.06
TdF	22.6	1.3	28	1.4
TvdF	4.5	0.2	5	0.2
TS(TdF)	4.5	1.7	7	1.2
T-STmF	18	1	21	0.9
D-M	0	0	0	0
STmF	71.7	1.7	144	2.8
STdF	1	0.06	1	0.04
TemmF	0	0	0	0
Latin America & the Caribbean	424.4	1.2	580	1.3

Sources: Brown & Lugo, 1992; Fearnside, 1990 & 1992; Gómez, 1991; Winograd, 1990; WRI, 1990 & 1992

Biotic emissions from deforestation and land-use changes are greatest in the Latin American and the Caribbean region because forests are burnt and transformed into barely productive ecosystems. (Elsewhere, wood is often cultivated as a resource.) (See Figure 5.1.) Consequently, gas emissions from land-use changes increased 37 percent between 1980 and 1990, rising from 424 million carbon tons to 580 million tons. (See Table 5.1.) Not-

Figure 5.1 Additions to the Carbon Dioxide Flux in Latin America and the Caribbean (1950–1990)
(millions of metric tons of carbon)



Sources: UNEP, 1991; WRI, 1990

Table 5.3 Net Emissions of Greenhouse Gases by Country for Latin America and the Caribbean

Country	Carbon Dioxide (CO2) (10^6 T of C)						Methane (CH4) (10^6 T of C)	CFCs (10^3 T)	Equivalent CO2 Heating Effect		
	Fossil Fuel & Cement		Land-Use Change		Total				(10^6 T of C)	(T of C)	Per Unit
	1980	1990	1980	1990	1980	1990	1990	1990	1990	Per Capita	of GNP
Belize	x	x	0.1	0.1	0.1	0.1	0	0	0.1	0.5	x
Costa Rica	0.67	0.68	3.5	3.1	4.17	3.8	0.04	0.3	6.1	2	0.8
Cuba	8.3	9.5	0.1	0.1	8.4	9.6	0.06	1	16.8	1.6	1.2
Domincan Rep.	1.7	1.8	0.3	0.3	2	2.1	0.02	0.7	7	0.6	0.8
El Salvador	0.6	0.6	0.2	0.3	0.8	0.9	0	0.5	4.4	0.8	1.2
Guatemala	1.2	1	5.3	5.3	6.5	6.3	0.06	0	6.9	0.8	1.2
Haiti	0.2	0.2	0.1	0.1	0.3	0.3	0.01	0	0.3	0.05	8.5
Honduras	0.5	0.5	5.3	5.3	5.8	5.8	0.06	0.2	7.8	1.5	0.6
Jamaica	2.3	1.4	0.1	0.1	2.4	1.5	0	0.2	2.9	1.2	2.5
Mexico	71	84	36	92	107	176	1.8	5.2	226	2.5	0.7
Nicaragua	0.5	0.6	11	11	11.5	11.6	0.1	0.4	15.6	4	0.2
Panama	0.9	0.8	3.5	3.5	4.4	4.3	0.04	0.2	6.1	2.5	0.7
Argentina	29.3	32.4	0	0	29.3	32.4	0.63	3.1	56.3	1.7	1.2
Bolivia	1.2	1.1	6.2	8	7.4	9.2	0.1	0	10.1	1.3	0.4
Brazil	48.2	55.2	165	240	213.2	295.2	3.1	8.9	386.5	2.5	1
Chile	7.3	7.3	0	0	7.3	7.3	0.06	1.3	16.6	1.3	1.4
Colombia	10.7	14.4	73	77	83.7	91.4	0.8	3	121	3.7	0.3
Ecuador	3.7	4.6	27	27	30.7	31.6	0.2	1	41.3	3.8	0.3
Guyana	0.5	0.3	0.2	0.2	0.7	0.5	0	0	0.5	0.5	0.5
Paraguay	0.4	0.5	10	12.4	10.4	12.9	0.2	0	14.4	3.3	0.3
Peru	6.4	6.1	23	25.3	29.4	31.4	0.2	0	34.1	1.5	0.7
Suriname	0.6	0.4	0.3	0.3	0.9	0.7	0	0	0.7	1.8	1.9
Uruguay	1.6	1.3	0	0	1.6	1.3	0.08	0.3	3.7	1.2	2.2
Venezuela	24.4	28.8	14	14	38.4	42.8	0.35	1.8	57.8	2.9	0.8
Latin America & the Caribbean	222.5	225.6	384.5	525.4	607	779	8	28.1	1.42.5	2.4	x

Sources: Brown & Lugo, 1992; Fearnside, 1990 & 1992; Gómez, 1991; UNEP, 1991; Winograd, 1990; WRI, 1992

withstanding this significant increase, per capita emissions did not rise perceptibly in this period.

Although Brazil is the leading gas generator in the region, with 45.5 percent of the region's total emissions from land-use changes in 1990, Colombia and Ecuador show the highest per capita emission levels, with 2.6 and 2.8 tons of carbon, respectively. (See Table 5.1.) However, national per-capita emissions do not clearly show the origin of the problem. If emissions are analyzed in terms of land-use changes at life-zone levels, then tropical and subtropical moist forests are responsible for 88 percent of the regional biotic emissions. In the case of the tropical moist forests, per capita emissions reach 14.4 tons of carbon, whereas the regional average is of 1.3 tons of carbon per capita. (See Table 5.2.) The activities responsible for these climate-influencing land-use changes range widely by life-zone. Extensive ranching is responsible for 50 percent of all greenhouse gas emissions in the region; shifting agriculture for 32 percent of the regional biotic emissions; and permanent agriculture for 18 percent of these emissions. (See Box 5.1.)

As mentioned earlier, gas emissions are generated in fossil fuel combustion, cement production, and agricultural activities. Carbon Dioxide (CO_2) emissions from land-use changes increased on the average 3.7 percent per year between 1980 and 1990, whereas those originating in fossil fuel consumption and cement production remained stable. (See Table 5.3.)

Latin America and the Caribbean contributed 4.5 percent of the world's carbon emissions in 1990 from energy and cement consumption and 12.1 percent from deforestation. Yet, for every ton of oil equivalent produced, 0.567 tons of carbon are emitted in the region, compared to the world average of 0.725 (Goldemberg, 1989), mainly because the region relies so heavily on hydroelectricity.

As for total greenhouse gas emissions, in equivalent CO_2-heating effect, the region was responsible for 14.8 percent of all emissions in 1990. (See Table 5.3.) Of these emissions, 62 percent is produced from land-use changes, 11.4 percent from fossil fuel consumption and cement production, 23.1 percent from the use of CFCs, and 3.5 percent

Table 5.4 Major Climatic Natural Disasters In Selected Countries for Latin America and the Caribbean

Country	Year	Type of Event	Number of Fatalities	Affected Population (10^3)	Economic Losses (10^6 dollars)
Argentina	1983	Floods	0	5,580	1,000
	1984	Floods	30	12	x
	1985	Floods	14	50	500
	1987	Floods	11	x	x
	1988	Floods	25	4,500	x
Bolivia	1983	Floods	250	50	48
	1983	Drought	0	1,583	417
	1984	Drought	0	1,500	500
	1987	Floods	20	20	x
Brazil	1983	Floods	143	3,330	12
	1983	Drought	0	20	x
	1984	Floods	27	250	1,000
	1985	Floods	100	600	200
	1987	Floods	107	x	x
	1988	Floods	289	59	1,000
	1989	Floods & Landslides	96	x	x
Caribbean Islands (United Kingdom)	1980(*)	Hurricane Allen	18	15	106
	1983(**)	Drought	0	75	x
	1987(***)	Hurricane Emily	x	x	53
	1988(****)	Hurricane Gilbert	45	x	1,000
	1989(*****)	Hurricane Hugo	21	50	180
Chile	1985	Tsunami	x	x	x
	1987	Tsunami	x	x	x
	1987	Floods	109	200	x
Colombia	1987	Floods & Landslides	500	x	x
	1988	Hurricane Joan	26	100	50
Costa Rica	1988	Hurricane Joan	28	120	x
Ecuador	1983	Floods	307	700	232
	1989	Floods	35	30	15
El Salvador	1988	Floods	33	39	x
Guatemala	1987	Floods	84	x	x
Haiti	1986	Floods	69	45	x
	1988	Hurricane Gilbert	54	870	91
Jamaica	1980	Hurricane Allen	8	4	6
	1985	Hurricane Kate	7	x	5
	1986	Floods	54	40	76
	1987	Floods	4	x	31
	1988	Hurricane Gilbert	49	810	1,000
Mexico	1985	Tsunami	x	x	x
	1988	Floods	48	25	x
	1988	Hurricane Gilbert	27	35	4
Nicaragua	1986	Hurricane Joan	120	300	400
Panama	1988	Hurricane Joan	7	7	60
Paraguay	1983	Floods	0	100	82
Peru	1982	Floods	2,500	x	x
	1983	Floods	364	700	989
	1983	Drought	0	620	152
	1987	Floods & Landslides	155	x	x
	1986	Floods & Landslides	38	x	x
Venezuela	1985	Floods	38	15	x
	1987	Floods & Landslides	223	15	x

Sources: Kreimer & Munasinghe & OAS, 1991; UNEP, 1991
Notes: x = not available; (*) Barbados, St. Lucia, & St. Vincent, (**) Antigua & Barbuda, (***) Bermuda, Barbados, St. Lucia, & St. Vincent, (****) St. Lucia, (*****) Dominica, Montserrat, Antigua, St. Kitts & Nevis, & the Virgin Islands (UK)

Box 5.1 Net Emissions in 1980–1990 by Activities in Life-Zones for Latin America and the Caribbean

Life-Zones	Equivalent CO2 Heating Effect	Agriculture (10^6 T of C)	Livestock (10^6 T of C)
TmF	368	184	184
TlmmF	6.5	5.2	1.3
TdF	28	11.2	16.8
TvdF	5	1	4
TS(TdF)	7	1.4	5.6
T-STmF	21	16.8	4.2
D-M	0	0	0
STmF	144	72	72
STdF	1	0.4	0.6
TemmF	0	0	0
Latin America & the Caribbean	580	292	288

Sources: Browder, 1987; Fearnside, 1990; Lanly, 1984

Box 5.2 Current and Cumulative Emissions of Carbon Dioxide for Latin America and the Caribbean

Latin America & the Caribbean	CO2 Emission per Capita
Current from Fossil Fuel (Tons of Carbon) (1987)	0.55
Cumulative from Fossil Fuel (Tons of Carbon) (1800-1987)	0.3
Current from Land-Use Change (Tons of Carbon) (1989)	1.2
Cumulative from Land-Use Change (Tons of Carbon) (1800-1989)	1.5

Sources: Fujii, 1990; Houghton et al., 1991

from the emissions of methane from livestock. Consequently, the average per capita emission of equivalent CO_2-heating effect, was 1.9 tons of carbon in 1990.

Current net emissions of per capita CO_2 from fossil fuel consumption are 0.55 tons of carbon while emissions produced from land-use changes amount to 1.2 tons of carbon per capita. Cumulative CO_2 emissions per capita total 0.3 tons from fossil fuel consumption and 1.5 tons from land-use changes in the 1800-1987 period. (See Box 5.2.) The regional accumulated contribution to the rise in atmospheric CO_2 from fossil fuel consumption was 2.9 percent of the world total in the period 1800-1987. For perspective here, North America contributed 35 percent; Europe (East, West, and Ex-Soviet Union), 46.8 percent; Africa, 1.8 percent; Asia, 9.4 percent; Japan, 3.9 percent; and Oceania, 1.2 percent (Fujii, 1990).

The causes and climatic consequences of the use of land and natural resources should not be analyzed strictly in terms of gas emissions and the greenhouse effect. Although climate change at the regional level (more hurricanes and rainfall, etc.) has not been documented, the social, economic, and environmental effects of some natural events in the region have been magnified by land- and natural resource-use. (See Table 5.4.) Water torrents flooding dry river beds or mud slides would not have claimed any victims or resulted in economic losses if the population had settled in more appropriate areas or if steep slopes had not been deforested. The lack of urban planning and infrastructure services, coupled with the poor use of land, has lead to the unprecedented occupation of spaces where natural climate variations cause natural catastrophes.

TECHNICAL NOTES:

Tables 5.1 and 5.2 Data on greenhouse gas emissions per country and life-zone were calculated for net emissions. The allocation of greenhouse gas emissions by life-zone is based on deforestation data by life-zone. (See Technical Notes for Table 2.1 and 2.2, Forests and Rangelands.) Net emissions by land-use refer to deforestation, in particular. Biomass values are based on the average figures in Brown and Lugo (1992), Fearnside (1990b), and Gómez (1990). A biomass of 298 T/ha was considered for the tropical and subtropical moist forests, 198 T/ha for the mountain tropical and subtropical moist forests, 93 T/ha for the dry tropical and subtropical forests, 70.7 for the very dry tropical forests and tropical savannas. The carbon quantity in the biomass is 50 percent. The quantity of net emissions of greenhouse gases for the tropical and subtropical moist forests are: 88.8 T/ha of CO_2, 4.77 T/ha of CO, and 0.733 T/ha of CH_4; for the tropical and subtropical mountain forests: 59 T/ha of CO_2, 3.17 T/ha of CO, and 0.49 T/ha of CO; for the tropical and subtropical dry forests: 27.7 T/ha of CO_2 and 1.49 T/ha of CO; for very dry tropical forests and tropical savannas: 21.1 T/ha of CO_2 and 1.13 T/ha of CO (Fearnside, 1990). Equivalent carbon dioxide heating effect was calculated in relation to heating potential, with CO_2 as the unit (Lashof and Ahuja, 1990). Thus the heating potential of different gases is $CO_2 = 1$, $CO = 1.4$, and $CH_4 = 3.7$.

Table 5.3 Net CO_2 emissions from fossil fuels and cement production come from WRI (1990 & 1992, Tables 24.1 and 24.2). Net CO_2 and CO emissions from land-use change are based on data in Table 5.1. Estimates of methane are based on data in Table 5.1 and data from WRI (1992, Table 14.2), i.e., animal emissions, wastes, rice agriculture, hard coal mining, and leakages from natural gas pipelines. The CFC estimates are based on data in WRI (1992, Table 24.2). The equivalent heating effect of CFCs was calculated as 7,000, the average of various types.

Table 5.4 Data on Major Climatic Natural Disasters come from OAS (1991, Figure 2) and UNEP (1991, Tables 9.4 and 9.5). The data regarding Hurricane Gilbert's impact in Mexico and Jamaica are from Kreimer and Munasinghe (1991).

Box 5.1 Net emissions from land-use change by activities are based on data in Table 5.2. According to Winograd (1989b & 1991a), a percentage was assigned to these values with regard to the distribution of deforested lands.

Box 5.2 Data on current and cumulative emissions from fossil fuels come from Fujii (1990). Current and cumulative emissions from land-use changes are from Houghton et al. (1991). Cumulative emissions per capita were calculated based on the following formula: $CE_i = \$E_{ti}/\$POP_{ti}$ (Fugii, 1990). T (time period) = 1800-1987 for fossil fuel and 1800-1989 for land-use. CE = cumulative emissions, i = the activity considerated, E_{ti} = annual emissions of CO_2 and POP_{ti} = regional population.

IV. Responses to the Environment

The task of changing development models to achieve sustainable development is a responsibility shared by society and the state. In democratic systems, the most stressful environmental and development-related problems can often be transformed into political issues that demand official responses and actions. But to achieve this goal, societies must be well-informed and organized to participate in decision-making. The state must also have the capacity to act promptly.

Participatory democracies should generate diverse sustainable development institutions to serve as intermediaries between the state and the population. Whether cooperatives, local groups, or non-governmental organization, these organizations must achieve the security and credibility needed to transform denunciations into concrete environmental actions and proposals. With reliable information or indicators in hand, they can better analyze the progress performed or the efforts needed by political institutions and by the civil society more generally.

As for regional and global environmental problems, states must grapple with these through agreements and treaties. Even though individual treaties have limited value, the treaty-making and monitoring system as a whole leads governments toward understanding the importance of international action and toward cooperation in environmental protection. In other words, creating a chain of obligations, precedents, and commitments at the national level is one way to expand and generate new forms of international environmental protection and cooperation.

1. INFORMATION AND PARTICIPATION

A set of techniques and practices related to the management and use of natural resources, sustainability also involves changes in values, institutions, and policies. Getting these changes accepted requires the participation of all social actors at all levels, which in turn requires broadening access to information.

The state of information on environment and sustainable development in Latin America and the Caribbean leaves much to be desired. Most countries in the region nowadays possess sources of information on the state of the environment and on natural resources, largely thanks to growing environmental awareness and The Earth Sum-

Table 1.1 Environmental Information and Participation by Country for Latin America and the Caribbean

Country	Number of Environmental & Natural Resource Profiles & Assesments (1985-1991)	INFOTERRA Member 1991	Number of NGO's in 1990			
			Women & the Environment	Indigenous People	Peasants & Farmers	Support Groups
Belize	2	Yes	x	x	x	x
Costa Rica	3	Yes	13	x	x	6
Dominican Rep.	3	No	2	x	x	1
El Salvador	x	Yes	x	x	x	x
Guatemala	5	Yes	5	x	x	7
Haiti	2	Yes	x	x	x	x
Honduras	3	Yes	15	x	x	4
Jamaica	2	Yes	x	x	x	x
Mexico	3	Yes	10	2	5	69
Nicaragua	2	No	2	x	x	4
Panama	1	Yes	1	x	x	x
Argentina	1	Yes	3	x	x	71
Bolivia	5	Yes	x	3	3	12
Brazil	2	Yes	19	22	1	55
Chile	2	Yes	2	x	2	17
Colombia	2	Yes	3	2	1	25
Ecuador	6	Yes	5	5	1	10
Guyana	2	Yes	x	x	x	x
Paraguay	1	Yes	1	x	x	2
Peru	7	Yes	6	6	1	14
Suriname	0	Yes	x	x	x	2
Uruguay	0	Yes	1	x	x	5
Venezuela	0	Yes	1	2	x	19

Sources: CEPAL, 1990; WRI/CIDE, 1990; Gennino, 1990; Paolisso & Yudelman, 1991; UNDP, 1991

Box 1.1 Public Opinion and Attitudes Toward the Environment in Some Latin American Countries

	Brazil	Chile	Mexico	Uruguay
NATION				
Environmental Problem as Most Important in Nation (%)	2	20	29	3
Most Important Environmental Problem Facing the Nation (%)	Loss of Natural Resources (53)	Air Pollution (33)	Air Pollution (41)	Waste Disposal (22)
Environmental Protection Chosen Over Economic Growth (%)	71	63	72	64
Who is Responsible for Protecting the Environment (%):				
Government	26	36	41	42
Business and Industry	12	22	12	11
Citizens	60	39	43	43
WORLD				
Who is Responsible for Environmental Problems in the World (%)·				
Industrialized Nations	32	37	37	38
Developing Nations	8	9	6	5
Both Equally	56	50	50	49
Contributors to Environmental Problems in the World (%):				
Consumption of Resources by Industrialized Countries	46	43	55	48
Multinational Companies Operating in Developing Countries	45	37	51	50
Overpopulation in Developing Countries	37	37	54	43

Source: Gallup International Institute, 1992

mit in Rio (UNCED, 1992). (See Table 1.1.) However, much of this information is elaborated to complement plans of action and does not describe all environmental problems and opportunities. Moreover, though numerous investigations at different levels on diverse issues related to the environment, natural resources, and management techniques for different ecosystems exist, they have not been systemized in ways that make priorities and needed actions appear. In addition, the available information is too often elaborated at one scale only, making it difficult for decision-makers at all levels to use it. Finally, national environmental statistical compendiums and reports on environmental conditions and trends is all but absent.

Compounding this lack of usable information is a lack of popular participation in environmental decision-making and policy- making at the regional and local levels. The "environmental problematique" is simply not a daily political issue for most of the people and governments of the region. (See Box 1.1.)

In this regard, the rise of non-governmental organizations (NGOs) is surely a positive sign. That the number of NGOs continues to increase is proven by the fact that in Colombia, for example, there were 26 environmental NGOs in 1990, while by March 1994 there were over 400 of these organizations. (See Table 1.1.) Also, NGOs' actions have started to show results at local and regional levels vis-a-vis natural resource management, the appraisal of and respect for native knowledge and cultures, and the implementation of alternative production models. (See Table 1.1.) These organizations have become valid speakers in international discussions of how funds and projects should be managed. They constitute the force that may guide popular participation and produce important changes in development policies and actions. That said, many regional NGOs still function mainly as environmental research institutions and watchdogs. (See Table 1.1.) They desperately need to increase their capacity to formulate concrete sustainable-development proposals and to directly influence action.

TECHNICAL NOTES:

Table 1.1 Data on Non-Governmental Organizations are from CEPAL (1990), Gennino (1990), and Paolisso and Yudelman (1991). Number of environmental studies and profiles are from WRI/CIDE (1990).

Box 1.1 Data are from Dunlap et al. (1992, Tables 1,4,6,10 and 14).

2. INTERNATIONAL TREATIES AND CONVENTIONS

Besides collecting and disseminating information on the environment and natural resources, another significant indicator of the responsiveness to environmental issues is national participation in international treaties and conventions.

Although the region's countries have participated in most such international treaties and agreements, many of the latter have not been ratified. (See Tables 2.1 and 2.2.) Only in recent years have some regional treaties—such as the Treaty of Amazon Cooperation and the Caribbean Convention for Environmental Protection—been signed by many countries. (See Table 2.2.) Frequently, these isolated agreements have limited value and application, though they do help governments comprehend the importance and validity of international action and cooperation to protect the environment. They can also spark cooperation among international institutions, the governments of developed countries, national governments, and NGOs in the design and application of environmental policies.

Yet another international response to development and conservation needs is the debt-for-nature-swap. This new tool, which appeared in response to both environmental problems and the external debt crisis in developing countries, takes different forms in different countries. Even though its application encounters some resistance at the regional level and the results vary according to the country, the outcome has been positive in some countries, such as Costa Rica. Debt-for-nature-swaps should not be regarded as a panacea for reducing the external debt, but in specific cases they can unleash conservation funds. In Costa Rica, funds swapped the external debt for 80 million dollars. (See Box 2.1.)

TECHNICAL NOTES:

Tables 2.1 and 2.2 Data are from WRI (1992, Tables 25.1 and 25.2).

Box 2.1 Data are from WRI (1992, Table 20.6) and WCMC (1992, Table 32.11).

Table 2.1 Participation in Major Global Conventions (Atmosphere, Hazardous Substances, and other Agreements)

	Global Conventions							Regional Agreements	
	Atmosphere			Hazardous Substances					
Country	Nuclear Test Ban (1963)	Ozone Layer (1985)	CFC Control (1987)	Biological Toxins Weapon (1972)	Nuclear Accident Notification (1986)	Nuclear Accident Assistance (1986)	Hazardous Waste Movement (1989)	UNEP Regional Seas	Other Regional Agreements
Belize				CP					
Costa Rica	CP			CP	S	S		C	
Cuba				CP	S	S		C	
Domincan Rep.	CP			CP					
El Salvador	CP			S			S		
Guatemala	CP	CP	CP	CP	CP	CP	S	C	
Haiti	S			S			S		
Honduras	CP			CP				C	
Jamaica	S			CP				C	
Mexico	CP	CP	CP	CP	CP	CP	CP	C	
Nicaragua	CP			CP				C	
Panama	CP	CP	CP	CP	S	S	CP	SEP & C	
Argentina	CP	CP	CP	CP	CP	CP	CP		
Bolivia	CP			CP			S		AMC
Brazil	CP	CP	CP	CP	S	S			AMC
Chile	CP	CP	CP	CP	S	S	S	SEP	
Colombia	CP	CP					S	SEP & C	AMC
Ecusdor	CP	CP	CP	CP			S	SEP	AMC
Guyana				S					AMC
Paraguay	S			CP	S	S			
Peru	CP	CP		CP				SEP	AMC
Suriname									AMC
Uruguay	CP	CP		CP	CP	CP	S		
Venezuela	CP	CP	CP	CP			S	C	AMC

Source: WRI, 1992

Notes: CP = Contracting Party (has ratified or taken equivalent action), S = Signatory, C = Caribbean Convention on Environmental Protection, SEP = South-East Asian Convention on Environmental Protection, AMC = Amazonian Cooperation Treaty; Brackets indicate year convention was created

Table 2.2 Participation in Major Global Conventions (Wildlife, Habitats, and Oceans)

	Wildlife & Habitat						Oceans		
Country	Antartic Treaty (1959)	RAMSAR (Wetlands) (1971)	World Heritage (1972)	CITES (1973)	Migratory Species (1979)	Members of BGCI (number)	Ocean Dumping (1972)	MARPOL (1978)	Law of the Sea (1982)
Belize			CP	CP					CP
Costa Rica			CP	CP		2	CP		S
Cuba	NCP		CP	CP		3	CP		CP
Dominican Rep.			CP	CP		1	CP		S
El Salvador				CP		1			S
Guatemala		CP	CP	CP		1	CP		S
Haiti			CP				CP		S
Honduras			CP	CP		1	CP		S
Jamaica			CP		S	0			CP
Mexico		CP	CP	CP		6	CP	S	CP
Nicaragua			CP	CP		0			S
Panama		CP	CP	CP	CP	0	CP	CP	S
Argentina	CP & MLR		CP	CP		1	CP		S
Bolivia		CP	CP	CP		1	S		S
Brazil	CP & MLR		CP	CP		4	CP	CP	CP
Chile	CP & MLR	CP	CP	CP	CP	4	CP		S
Colombia	NCP		CP	CP		4	S	CP	S
Ecuador	CP	CP	CP	CP		1		CP	
Guyana			CP	CP		1			S
Paraguay			CP	CP		0			CP
Peru	CP & MLR		CP	CP		1		CP	
Suriname	CP	CP		CP	CP	0	CP	CP	S
Uruguay	CP & MLR	CP	CP	CP	CP	0	S	CP	S
Venezuela		CP	CP	CP		2	S		

Source: WRI, 1992

Notes: CP = Contracting Party (has ratified or taken equivalent action), S = Signatory (has signed but not ratified),
MLR = Contracting Party to the Convention on the Conservation of Antarctic Marine Living Resources,
NCP = Nonconsultative Contracting Party to the Antarctic Treaty; Brackets indicate year convention was created

Box 2.1 Debt-for-Nature Swaps in Latin America and the Caribbean

Country	Purchaser/Fundraiser	Date	Face Value of Debt (10^6 dollars)	Cost (10^6 dollars)	Conservation Funds Generated (10^6 dollars)	Purpose
Bolivia	CL	08/87	0.65	0.1	0.25	To Establish Beni Biosphere Reserve and three conservation areas totaling 1.5 million has.
Costa Rica	FPN	02/88	5.4	0.92	4	To expand, manage, & protect three national parks: Guanacaste, Monteverde, & Corcovado
	Netherlands	07/88	33	5	9.9	To finance forestry development activities & protect & manage natural resource programs
	TNC	01/89	5.6	0.78	1.68	To help meet management costs and land purchases at four parks; to fund five other projects involved in conservation
	Sweden	04/89	24.5	3.5	17.1	To complete the management and restoration of Guanacaste National Park
	Sweden, WWF, & TNC	03/90	10.7	1.95	9.6	To support La Amistad Regional Conservation Unit; to fund education, protection, ecotourism, & management programs; to fund the National Biodiversity Institute
	RA, MCL, & TNC	01/91	0.6	0.36	0.54	To purchase lands for Monteverde Cloud Forest Reserve
Dominican Rep.	PRCT & TNC	03/90	0.58	0.12	0.58	To support protection and reforestation
Ecuador	WWF, TNC, & MBG	12/87 04/89	10	1.4	10	To support management, conservation, protection, and inventorying in six Andean & Amazonian parks
Guatemala	TNC	10/91	0.1	0.075	0.09	To support Sierra de las Minas Biosphere Reserve
Jamaica	TNC, USAID, & PRCT	10/91	0.6	0.3	0.44	To fund and protect Montego Marine Park and mountain forests
Mexico	CI	02/91 08/91	4	0.18	0.5	To fund ecosystem conservation data centers & campaigns dealing with education & communication

Source: WRI, 1992
Notes: CI = Conservation International, TNC = The Nature Conservancy, WWF = World Wildlife Fund,
RA = Rainforest Alliance, MCL = Monteverde Conservation League, PRCT = Puerto Rican Conservation Trust,
MBG = Missouri Botanical Garden, FPN = National Parks Foundation of Costa Rica

V. Progress Toward Sustainability

Anticipating the unsustainable aspects of development, as well as opportunities for and obstacles to the sustainable management of land and natural resources, is essential to the elaboration and application of sustainable development policies at the national and life-zone level in Latin America and the Caribbean.

In particular, it is necessary to question the ecological and technological feasibility of sustainable development at the regional level should profound political, social, and economic changes be implemented. For this purpose, the most important information is that on productive potential, on the amount of land needed to satisfy the population's basic needs, and on the region's production goals. Using alternative scenarios to anticipate the environmental situation and the state of natural resources in the region is also essential in orienting development. Finally, information on the costs and benefits of sustainable models is needed so analysts can determine economic possibilities and financial needs.

Analyses based on these types of information will allow policy-makers to elaborate specific responses at the regional level, to strengthen local actions, and to figure out how the region might contribute to the solution of global problems while satisfying its own basic needs. To help achieve this goal, indicators should show, the local and regional results of applying various management approaches and selecting various land-uses.

1. PROJECTIONS IN LAND-USE

Considering the present situation of Latin America and the Caribbean and the possible consequences of maintaining current development strategies, the need to consider development alternatives is clear. To be sustainable, responses, actions, and policies must be formulated with the long term in mind. For ecological and political reasons, it is necessary to allow 40 to 50 years to transform the development patterns now predominating at regional, subregional, and local levels. On the other hand, responses and actions leading to sustainable development must be based on a realistic assessment of socio-economic, technological, and ecological potentialities and limitations.

This report draws on a study based on simulation models containing alternative scenarios (reference and sustainable) with regard to land-use changes for 18 life-zones in Latin America and the Caribbean for the next 50 years (Winograd, 1989b; Gallopín & Winograd, 1990; Gallopín et al., 1991a). Using this information, some indicators were constructed to forecast consequences of various development alternatives for the region.

As this report shows, no important ecological restrictions at the regional level make it impossible to satisfy sustainably the population's basic needs. Food production, forestry and fishing resources, ecosystem conservation, and a surplus of products for export all seem possible. However, some local and regional restrictions do come into play: (a) the fragility of some ecosystems; (b) lack of knowledge of appropriate management technologies; (c) the deterioration, degradation, and overload of some overworked ecosystems; (d) high rates of occupation and demographic growth in certain zones; (e) natural restrictions, such as the fertility limitations of tropical red soils or the presence of large arid and semiarid areas.

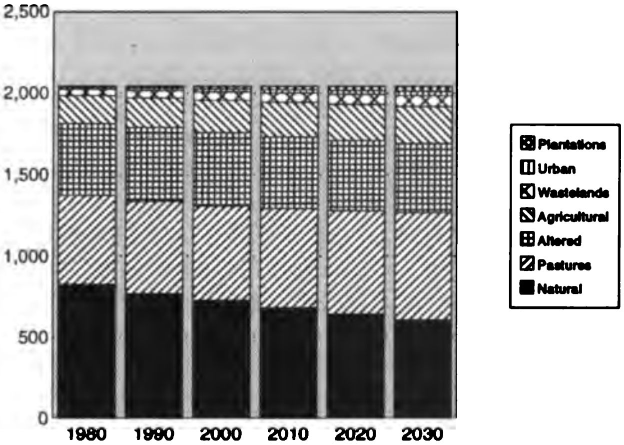
The sustainable scenario is based on the following three processes (Gallopín & Winograd, 1992):

1. *Productive rehabilitation and restoration of altered and deteriorated ecosystems covering 22 percent of the regional area.* This process represents the most realistic strategy for managing many temperate, subtropical, and tropical ecosystems.
2. *Priority to productive rural integrated systems (agroforestry, extractive activities, aquaculture, etc.).* Priority to productive rural integrated systems (agroforestry, extractivist activities, aquaculture, etc.). These must be favored in all the appropriate zones to maximize the potential of many ecosystems in the region.
3. *Technological hybridization and pluralism.* These will promote new forms of organization and participation and foster the integration of traditional and modern technologies, leading to technological adaption to local scenarios, and to increased sustainability.

An analysis of the two scenarios shows that the greatest regional problem is land-use. (See Figure 1.1.) The potential of lands for agriculture exceeds their current use, while the current use of land for ranching exceeds their potential. (See Table 1.1.) The Index of Land-Use seems to indicate that land-use cannot be expanded (lands used at present equal the potential ones), mainly because of the excessive use of land for ranching. This activity occupies more than 100 million hectares (or the equivalent to 60 percent of current cultivated lands).

If the results of the model run for different life-zones are analyzed in detail, we see that applying the sustainable model in the region would permit deforestation to

Figure 1.1 Projections of Land-Use in Latin America and the Caribbean (1980–2030)
(millions of hectares)



Source: Winograd, 1989

fall by more than 80 percent, especially in tropical and subtropical moist and dry forests. (See Tables 1.2, 1.3, 1.4 and 1.5.) In addition, if the area under reforestation doubled annually in the next 40 years, the reforestation-to-deforestation ratio would increase from 1:7 in 1980 to 2:1 in 2030. This fact will not imply, however, that the areas dedicated to production should diminish. Agricultural lands that amounted to 8 percent in 1980 would have to occupy 13 percent of the total regional area. The per capita availability of agricultural lands would fall from 0.44 in 1980 to 0.35 in 2030—still enough to feed the potential population and produce a surplus for export if an intermediate level of agricultural inputs were used. (See Tables 3.6 and 3.7 in Food and Agriculture.) The ranching area would decrease from 32 percent in 1980 to 23 percent in 2030, due to technical improvements and an increase in livestock carrying capacity (from 0.6 current animal units/ha to 1.5 animal units/ha).

In terms of climate change, the region contributes mainly through the advance of the agricultural frontier and land-use changes. Total emissions will drop significantly from the equivalent of 424 million tons of CO_2-heating effect in 1980 to 78 millions tons in 2030. These emissions will be reabsorbed by the various land-uses on which the sustainable model for the region is based.

Although the models show that the region could evolve toward sustainability supported by sufficient natural resources and that new technologies are not mandatory for this model, economic factors must also be taken into account. In a world increasingly dominated by pragmatic and competitive models of development, it is especially important to look at economic viability and the sustainable model's implementation costs and benefits.

Table 1.6 illustrates the investments needed to obtain regional sustainable development in land-use. These costs do not include investments and the costs of industrial development, infrastructure, technical assistance, and scientific and technological development. Only the direct costs of land conversion, rehabilitation, restoration, reforestation, and conservation in Latin America and the Caribbean are included. The calculations for land-use changes in the sustainable scenario indicate

Table 1.1 Potential Land-Use by Life-Zone for Latin America and the Caribbean

Life-Zone	Potential Agricultural Land (10^6 ha)	Potential Pasture Land (10^6 ha)	Potential Productive Land per Capita 2030	Agricultural Land Needed in 2030		Land-Use Index (Potential/Actual)
				Surface (10^6 ha)	Input Level	
Tropical Moist Forest (TmF)	100 (15)	47 (7)	2.7	50	L - I	3.2
Tropical Lower Montane Moist Forest (TlmmF)	12 (25)	12 (25)	0.14	10	H	0.8
Tropical Dry Forest (TdF)	47 (25)	63 (33)	3 2	39	L - I	1.2
Tropical Very Dry Forest (TvdF)	7 (5)	52 (37)	1 3	7	I	1.2
Tropical Savanna (Tropical Dry Forest) (TS-TdF)	10.5 (10)	57 (53)	11.6	8	L - I	1.2
Paramo and Puna	13.8 (15)	28 (30)	1.6	5	I	0.8
Tropical and Subtropical Montane Forest (T-STmF)	19.5 (25)	17 (22)	1.7	18	I	1
Deltas and Mangroves (D-M)	2.8 (15)	0.5 (3)	0.3	2	H	0.6
Tropical and Subtropical Deserts and Desert Shrub (T-STD&Ds)	6 (5)	15 (13)	0.14	5	H	0.4
Subtropical Moist Forest (STmF)	57 (40)	32 (22)	1	38	I	0.9
Subtropical Dry Forest (STdF)	43 (30)	46 (32)	2.5	34.5	I	1.2
Subtropical Savannes (STS)	43 (40)	25 (24)	1.2	42	I	0.8
Subtropical Thorn Steppe (STtS)	2.6 (25)	0.5 (5)	0 2	1.5	H	5.4
Subtropical Desert Bush (STDs)	3.8 (5)	33 (44)	11.9	2.5	I	1.1
Temperate Moist Forest (TemmF)	2 (5)	5 (15)	1 9	2	I	0.6
Steppe and Temperate Savannas (S and TemS)	3 (4)	28 (38)	62	1.5	I	1.3
Latin America & the Caribbean	372 (18)	462 (23)	0.49	266	I	1.1

Sources: Gómez & Gallopín, 1989; Winograd, 1989
Notes: Brackets indicate percent of life-zone surface
L = Low, I = Intermediate, & H = High

Table 1.2 Land-Use Indicators for the Tropical and Subtropical Moist Forests for Latin America and the Caribbean

Tropical and Subtropical Moist Forests (812.4 million hectares)	1980	2030	
		Reference Scenario	Sustainable Scenario
Forested Area (million hectares)	579.6	433.4	510
Annual Deforestation (million hectares)	3.6	2.7	0.75
Deforestation Rate (%/year)	0.63	0.63	0.15
Annual Reforestation (million hectares)	0.26	0.42	0.5
Reforestation/Deforestation Ratio	1:14	1:6.5	1:1.5
Cropland Area (million hectares)	62.3	86.5	111.8
Pasture Area (million hectares)	68.3	106.8	56.8
Altered Area (million hectares)	99.3	169	108.8
Reforested Area (million hectares)	2	17	21.4
Cropland per Capita	1	0.74	0.96
Forested per Capita	9.6	3.7	4.4
Net Addition to the CO2 Flux for Land-Use Change (millions of T of Carbon)	334.4	240	67
Net Greenhouse Gas Emission for Land-Use Change (millions of T CO2 eq. Carbon)	368.4	265	73.5
Greenhouse Gas Emission for Land-Use Change per Capita (T of CO2 eq. Carbon)	6.1	1.9	0.5

Sources: Fearnside, 1990; Gallopín et al., 1991; Winograd, 1989; Winograd & Pérez, 1992

Table 1.3 Land-Use Indicators for the Tropical and Subtropical Montane Moist Forests for Latin America and the Caribbean

Tropical and Subtropical Mountain Moist Forests (125.1 million hectares)	1980	2030	
		Reference Scenario	Sustainable Scenario
Forested Area (million hectares)	15.8	4.5	16.5
Annual Deforestation (million hectares)	0.42	0.17	0
Deforestation Rate (%/year)	2.65	3.8	0
Annual Reforestation (million hectares)	0.07	0.07	0.25
Reforestation/Deforestation Ratio	1:6	1:2.5	x
Cropland Area (million hectares)	19.3	31.9	20.6
Pasture Area (million hectares)	47.3	55	31.6
Altered Area (million hectares)	37.6	23.5	37.8
Reforested Area (million hectares)	0.55	3	13
Cropland per Capita	0.18	0.13	0.1
Forested per Capita	0.15	0.018	0.07
Net Additions to the CO2 Flux for Land-Use Change (millions of T of Carbon)	21	10	0
Net Greenhouse Gas Emissions for Land-Use Change (millions of T of CO2 eq. Carbon)	23.5	11	0
Greenhouse Gas Emission for Land-Use per Capita (T of CO2 eq. Carbon)	0.22	0.05	0

Sources: Fearnside, 1990; Gallopín et al., 1991; Winograd, 1989; Winograd & Pérez, 1992

Table 1.4 Land-Use Indicators for the Tropical and Subtropical Dry Forests for Latin America and the Caribbean

Tropical and Subtropical Dry Forests (474.4 million hectares)	1980	2030	
		Reference Scenario	Sustainable Scenario
Forested Area (million hectares)	106.8	67.8	99.9
Annual Deforestation (million hectares)	1.3	0.7	0.14
Deforestation Rate (%/year)	1.2	1	0.14
Annual Reforestation (million hectares)	0.2	0.21	0.46
Reforestation/Deforestation Ratio	1:6.3	1:3.3	3.4:1
Cropland Area (million hectares)	41	57.6	68.6
Pasture Area (million hectares)	161.2	218.3	139.6
Altered Area (million hectares)	152.4	100	128.5
Reforested Area (million hectares)	2.1	11	25.4
Cropland per Capita	0.78	0.46	0.55
Forested per Capita	2	0.5	0.8
Net Additions to the CO2 Flux for Land-Use Change (millions of T of Carbon)	25.1	18	3.6
Net Greenhouse Gas Emissions for Land-Use Change (millions of T of CO2 eq. Carbon)	28.1	19.4	4
Greenhouse Gas Emission for Land-Use Change per Capita (T of CO2 eq. Carbon)	0.53	0.13	0.03

Sources: Fearnside, 1990; Gallopín et al., 1991; Winograd, 1989; Winograd & Pérez, 1992

Table 1.5 Land-Use Indicators for Latin America and the Caribbean

Latin America and the Caribbean (2,041.7 million hectares)	1980	2030	
		Reference Scenario	Sustainable Scenario
Forested Area (million hectares)	754.8	540.1	671.1
Annual Deforestation (million hectares)	5.6	3.8	0.93
Deforestation Rate (%/year)	0.74	0.7	0.14
Annual Reforestation (million hectares)	0.81	1	1.6
Reforestation/Deforestation Ratio	1:7	1:4	1,7:1
Cropland Area (million hectares)	170.5	228.5	266.1
Pasture Area (million hectares)	545.1	659.6	478
Altered Area (million hectares)	439.3	421.5	411.4
Reforested Area (millions of hectares)	5.8	36.3	81.9
Cropland per Capita	0.48	0.3	0.35
Forested per Capita	2.1	0.72	0.9
Net Addition to the CO2 Flux for Land-Use Change (millions of T of Carbon)	384.5	270.5	71.1
Net Greenhouse Gas Emission for Land-Use Change (millions of T CO2 eq. Carbon)	424.4	298.2	78
Greenhouse Gas Emission for Land-Use Change per Capita (T of CO2 eq. Carbon)	1.2	0.4	0.1

Sources: Fearnside, 1990; Gallopin et al., 1991; Winograd, 1989; Winograd & Pérez, 1992

Table 1.6 Cost Estimation for Sustainable Development of Land-Use in Latin America and the Caribbean

Land-Use Changes	Surface (10^6 ha)	Action Level	Costs (dollars/ha)	Mean Annual Investment (10^6 dollars)
Natural to Agriculture	45	Reconversion (100%)	400 to 500	405 (10.2 %)
Natural to Agriculture (irrigation)	8	Reconversion (75%) Rehabilitation (25%)	6,000 to 7,650 1,500 to 3,000	802 (20.7%) 90 (2.3%)
Agriculture (hillsides) to Agriculture (hillsides)	20	Conservation (100%)	350 to 550	180 (4.5%)
Natural to other Uses (agroforestry, forestry, etc.)	33	Reconversion (100%)	300 to 400	231 (5.8%)
Rangelands to other Uses (agroforestry, agriculture, etc.)	18	Restoration (100%)	500 to 750	225 (5.7%)
Altered to Agriculture (irrigated and unirrigated)	39	Rehabilitation (80%) Restoration (20%)	250 to 750 750 to 1,000	310 (7.8%) 140 (3.5%)
Altered to Altered (agroforestry and harvesting)	75	Reconversion (67%) Rehabilitation (33%)	25 to 50 250 to 450	38 (1%) 175 (4.4%)
Other Uses to Forestry	71	Reforestation (100%)	200 to 800	710 (17.9%)
Wasteland to other Uses	2	Rehabilitation (50%) Restoration (50%)	1,500 to 2,000	70 (1.7%)
Other Uses to Natural	50	Restoration (50%) Rehabilitation (50%)	160 to 250	205 (5.3%)
Natural to Natural	185	Conservation (100%)	15 to 45	111 (2.8%)
Watershed Management and Conservation	25.5	Conservation and Reforestation	500	255 (6.4%)
Total in Latin America & the Caribbean	571.5			3,965 (100%)

Sources: Gallopín & Winograd, 1991; Winograd, 1989

that an investment of about 200 billion dollars will be needed during the next 50 years (equivalent to an average annual investment of 3.9 billion dollars). (See Table 1.6.) These estimates should be checked against those of other studies. According to FAO (1988), the investment funds needed for an agricultural expansion based on 10 percent increases of agricultural lands and harvested areas in Latin America for the 1983-2000 period would be of U.S. $1.7 to $2.7 billion dollars per year. On the other hand, studies of the Worldwatch Institute (1988 & 1989) show that Latin America and the Caribbean should invest from 4.25 to 4.6 billion dollars annually in soil conservation and reforestation—valid if the area to be reforested in the region amounts to 10-15 percent of the world's total and that 15 percent of the world's agricultural lands are in the region.

However, the analysis of the sustainability scenario above requires additional analysis to determine land origin, destination, and management. Productive activities in the sustainable scenario are based greatly on ecosystem restoration and rehabilitation. Indeed, the increase in agricultural lands occurs principally because previously degraded natural ecosystems (48 percent) and pastures and other altered lands (52 percent) are restored and rehabilitated. At the same time, about 20 million hectares of hillsides will benefit from soil conservation, agroforestry system recuperation, and terrace restoration and reforestation. (See Box 1.1.) About

Box 1.1 Land Rehabilitation in the Sierra Region of Peru

Land-Use	Surface (10^3 ha)	Used Land (%)	Degraded Land (%)	Rehabilitation Costs (dollars/ha)	Construction Costs (dollars/ha)	Agricultural Yields (T/ha)
Terraced Land	1,000	25	55	250 to 750 of terrace rehabilitated	0	40 potatoes 1.8 broad beans
Irrigated Land	1,221	67	33	1,500 of land affected by salinity	6,000 to 7,650 of land irrigated	15 potatoes 0.9 broad beans

Sources: Masson, 1987; OAS, 1987

Box 1.2 Rehabilitation in the Secondary Forests of Tropical Latin America and the Caribbean

Life-Zones	Altered Surface (10^6 ha) 1990	Total Wood Volume (10^6 m3)	Potential Annual Extraction (*) (10^6 m3)	Extraction Ratio (%)	Potential Wood Needs in All Regions in 2025 (10^6 m3)
Tropical Very Dry Forests (TvdF)	34.5	974	7.7	0.8	x
Tropical Dry Forests (TdF)	55.2	6,875	93.6	1.35	x
Tropical Lower Montane Moist Forests (TlmmF)	10	1,215	21.2	1.75	x
Tropical Moist Forests (TmF)	97.7	44,795	1,487.3	3.35	x
Total Dry and Moist Forests	197.2	53,859	1,619.8	3	1,545

Sources: Brown & Lugo, 1990; Winograd, 1989
Note: (*) indicates that 50% of secondary forests are exploited with extraction of only annual volume

Box 1.3 Potential Carbon Sequestration by Reforestation and Agroforestry Land-Use in Latin America and the Caribbean

Land-Use	Potential Surface (10^6 ha)	Carbon Absorption (T/ha/year)	Annual Carbon Sequestration (10^6 T of C)
Reforestation with Good Tropical Plantations	18	10.1	181.8
Reforestation with Mean of Latin America Plantations	53	7	371
Reforestation in Marginal Lands	6	3.2	19.2
Agroforestry with Tropical and Temperate Plantations	33	3.5	115.5

Sources: Trexler et al., 1989; Winograd & Pérez, 1992

33 million hectares of natural ecosystems will be converted to agroforestry and the extraction of products for the international market. At the same time, 75 million hectares of altered and secondary forests would be managed to produce wood and other forest products. (See Box 1.2.) (Plantations alone could cover 71 million hectares.) Restoration and rehabilitation activities will not only decrease wasteland areas but will also allow the incorporation of 50 million hectares into the system of protected areas. About 25 million hectares of upper watersheds will be maintained under conservation and management programs. Finally, 185 million hectares will be in protected areas for wildlife and biodiversity. In total, 13 percent of the territory will be protected by some system of conservation and protection.

These land-uses would help sequester part of the carbon emitted into the atmosphere by human activities and would mitigate the problem of the global climate change. A quick calculation shows that 110 million of hectares reforested and used for agroforestry purpose could absorb at least 687.5 million tons of carbon—i.e., 20 percent of the world net emissions for 1987. (See Box 1.3.)

Even though this analysis shows that sustainable development is ecologically, technologically, and economically feasible for Latin America and the Caribbean with regard to land-use, future analyses should prove the feasibility of the investments needed to solve such serious regional socio-economic problems as rural and urban poverty, lack of services in urban areas, and lack of infrastructure. Also, alternative technologies for energy-use need to be developed. In spite of the present economic restrictions, it is possible to adopt strategies favoring more sustainable development in the region. Latin America and the Caribbean have comparative advantages with respect to their natural resources, ecological characteristics, and production capacity.

Every development strategy should be based on these comparative advantages so that national and regional production is diversified and restrictions on development are minimized. Clearly, the constraining factors are more social and economic options than technological and managerial (Gallopín & Winograd, 1990; USAID & WRI, 1993). To become a reality, this sustainable strategy will have to be economically and ecologically feasible, socially and culturally accepted, and politically anticipated.

TECHNICAL NOTES:

Table 1.1 Data on the potential of agricultural lands are from Gómez and Gallopín (1989a, Table 3.7). Potential pastureland data are from Winograd (1989b), Tables 18.2 and 18.9). The potential of productive lands includes ranching and croplands. Data on agricultural lands needed in 2030 come from Winograd (1989b, Tables 18.2 and 18.9). These data are based on soil capacity, potential agricultural productivity, needs for food production, and surplus for export, based on the sustainable scenario model for Latin America and the Caribbean (Project on Ecological Prospective for Latin America, UNU & IDRC, Gallopín et al., 1989). The level of agricultural inputs is based on potential agricultural yields according to different input levels and the necessary production to feed the potential population and to obtain a surplus for export.

Tables 1.2, 1.3, 1.4, and 1.5 Data were provided by land-use simulation models, according to two alternative scenarios (reference and sustainable) elaborated by Winograd (1989b) and Gallopín et al. (1991a). These models were corrected and rerun for this study. Greenhouse gas additions were calculated according to results from the models with emission factors from Fearnside (1990a) applied in the same way as in Table 5.1 and 5.3 (Atmosphere and Climate). The models of land-use change exist for 18 regrouped life-zones to simplify the presentation.

Table 1.6 Data on costs for a sustainable development in regional land-use are based on information in Gallopín & Winograd (1991b), modified by new calculations performed for this work. Changes in land-use refer to changes in area from one category to another, and were provided by the simulation models for a sustainable scenario (Winograd, 1989b; Gallopín et al., 1991a). Costs of changes in land-use (in dollars per hectare) are based on information in the literature for the region. Average annual investments were obtained by multiplying area by cost per hectare with a 50-year scenario.

Box 1.1 Data on terraces in the Peruvian Sierra are from Masson (1987). Data on irrigation are from OAS (1987).

Box 1.2 Data on altered areas come from Winograd (1989b). Wood volumes and annual volumetric increment of secondary forests come from Brown & Lugo (1990) and Lanly (1984). The extraction ratio is the potential of annual extraction to the total wood volume. Wood need values in the region were obtained by considering an annual consumption of 2 m^3 per capita.

Box 1.3 Data on forestry and agroforestry are from Winograd (1989b) and Gallopín and Winograd (1991b). Data of carbon absorption come from Trexler et al. (1989, Appendix 3) and Winograd and Perez (1992, Tables 3 and 4).

VI. Appendices

1. ENVIRONMENTAL INDICATORS FOR THE CARICOM COUNTRIES AND THE CARIBBEAN ISLANDS

The Caribbean islands have environmental and development characteristics different from the other countries of the region. Besides their ethnic and cultural origin (European, African, Aborigine and Mestizo), the Caribbean Islands have comparatively small total areas and scarce natural resources, high population densities, intense migratory activity, economic dependence on a single export, or service, or activity, (whether bananas, tourism or oil refining). Moreover, the economic activities that these countries do depend on tend to have strong negative impacts on the environment, periodical life-threatening and expensive natural disasters are part of life in these subregions, and the prospect of a sea-level rise as a consequence of global climate change would hit these nations particularly hard (Rodriguez, 1992).

Population density in the CARICOM countries, similar to that in Southeast Asian countries, is 70 times higher than that of Latin America, and 70 percent of the population inhabits coastal zones. (See Appendix 1.1.) Degradation rates and pressures on the natural resources are thus high in the most productive areas where most of the economic activity is concentrated (mangroves, corals and seagrass beds). (See Appendix 1.2). Besides absorbing solid wastes and sewage waters, coastal zones are being transformed by tourism developments and oil pollution. Although tourism is a signifi-

Appendix 1.1 Economic and Human Development Indicators for CARICOM Countries and Caribbean Overseas Territories

Country	Density (people per Km2) 1980-90	Gross Domestic Product per Capita (dollars) 1990	Tourist Arrivals (10^3) 1985	Life Expectancy at Birth (years) 1990	Adult Literacy (%) 1985	Human Development Index 1990
CARICOM (*)						
Antigua and Barbuda	193	4,600	140	74	90	0.832
Bahamas	24	11,420	1,370	69	x	0.920
Barbados	593	6,540	359	75	99	0.945
Dominica	105	2,210	21	75	80	0.800
Grenada	338	2,190	x	70	x	0.751
St. Kitts and Nevis	136	3,330	47	70	80	0.719
St. Lucia	394	1,900	95	72	83	0.699
St. Vincent and Grenadines	177	1,720	x	70	x	0.636
Trinidad and Tobago	242	3,160	191	72	96	0.876
OVERSEAS TERRITORIES						
Anguilla (UK)	73	x	x	x	x	x
Aruba (N)	311	x	206	x	x	x
Cayman Islands (UK)	85	x	x	x	x	x
French Guiana (F)	1	x	x	x	x	x
Guadeloupe (F)	190	x	145	74	x	x
Martinique (F)	300	x	193	76	x	x
Montserrat (UK)	127	x	x	x	x	x
Netherlands Antilles (N)	236	x	570	77	x	x
Puerto Rico (USA)	405	x	1,500	76	x	x
Turks and Caicos Islands (UK)	21	x	x	x	x	x
Virgin Islands (UK)	92	x	168	x	x	x
Virgin Islands (USA)	310	x	411	72	x	x

Sources: UNDP, 1991; USAID & WRI, 1993; World Bank, 1992
Notes: x = not available, (*) CARICOM also includes Belice, Jamaica, and Suriname;
F = France, N = The Netherlands, UK = United Kingdom, USA = United States of America

Appendix 1.2 Coastal Resources and Biological Diversity Indicators for CARICOM Countries and Caribbean Overseas Territories

Country	Length of Marine Coastline (Km)	Ratio Mangroves/ Coastline	Number of Protected Areas in Coastal Areas	Number of Plant Species	Percent Endemic	Percent of Threatened Species	Number of High Vertebrate Species	Percent Endemic	Percent of Threatened Species
CARICOM (*)									
Antigua and Barbuda	153	0.1	x	766	0.7	0	18	22	11
Bahamas	3,542	0.7	10	1,172	9.4	2	129	18	7
Barbados	97	0	1	542	0.8	0	x	x	x
Dominica	148	x	1	1,127	0.8	6	86	6	3
Grenada	121	x	11	919	0.4	0.4	79	2.5	3
St. Kitts and Nivis	x	x	x	533	x	0	59	2	2
St. Lucia	x	x	5	909	1.1	0.3	78	11.5	6
St. Vincent and Grenadines	x	x	2	1,000	x	x	138	4	2
Trinidad and Tobago	362	0.2	6	2,132	9.3	0.2	x	x	x
OVERSEAS TERRITORIES									
Anguilla (UK)	x	x	x	321	0.3	x	6	x	x
Aruba (N)	x	x	2	460	5.4	0	x	x	x
Cayman Islands (UK)	x	x	11	518	3.4	x	x	x	x
French Guiana (F)	x	x	x	5,000	x	1	x	x	x
Guadeloupe (F)	x	x	2	1,670	1.6	1	x	x	x
Martinique (F)	x	x	2	(@)	(@)	x	x	x	x
Monserrat (UK)	x	x	x	554	0.3	0.2	x	x	x
Netherlands Antilles (N)	x	x	5	x	x	0	x	x	x
Puerto Rico (USA)	x	x	13	2,128	9.4	4	175	26	17
Turks and Caicos Islands	x	x	5	x	x	x	x	x	x
Virgin Islands (UK)	x	x	10	x	x	x	x	x	x
Virgin Islands (USA)	x	x	4	x	x	x	x	x	x

Sources: FAO, 1992; USAID & WRI, 1993; WCMC, 1992
Notes: x = not available; (*) CARICOM also includes Belice, Jamaica, and Suriname;
(@) = Plant species for Guadeloupe and Martinique; Plant species = flowering plants;
High vertebrates = mammiferous animals, birds, reptiles, and amphibians;

cant income source, it exerts additional demographic pressure on the island's resources. In 1985, 5.5 million tourists—the equivalent of 80 percent of the stable population—spent time in the islands.

In spite of these indications of environmental degradation, the vital indicators, in some countries, are higher than the regional average in Latin America. Literacy rates are high. So is life expectancy, and the subregion's Human Development Index is among the highest of the world. (See Appendix 1.1.)

But most Caribbean agricultural economies are buffeted by external market fluctuations and are vulnerable to hurricanes. Most islands harvest bananas and sugar cane, which has significant environmental and economic impacts since these crops are regularly grown on steeply sloped forest lands with high erosion rates and the pesticides that are frequently applied damage the broader ecosystems of which croplands are a part (PNUMA, AECI, & MOPU, 1991).

On the other hand, Caribbean islands have since the arrival of the conquistadors experienced great continual changes in how their lands, forests, fauna and flora are used. These changes have produced massive extinctions, and led to the invasion of domestic plants and animals at the expense of endemic species. (See Appendix 1.2 and 1.3.)

Appendix 1.3 Land-Use and Agricultural Indicators for CARICOM Countries and Caribbean Overseas Territories

Country	Cropland			Permanent Pastures				Forests		
	Total (10^3 ha) 1980	Total (10^3 ha) 1990	Per Capita 1990	Total (10^3 ha) 1980	Cattle/ha 1980	Total (10^3 ha) 1990	Cattle/ha 1990	Total (10^3 ha) 1980	Total (10^3 ha) 1990	Deforestation Rate (%/year) 1980-90
CARICOM (*)										
Antigua and Barbuda	8	8	0.09	3	5	4	4	6	5	1.6
Bahamas	9	10	0.04	2	2	2	2.5	324	324	x
Barbados	33	33	0.1	4	6	4	5.2	x	x	x
Dominica	17	17	0.2	2	3.5	2	4.5	31	31	x
Grenada	14	13	0.1	3	2	1	4	3	3	x
St. Kitts and Nevis	14	14	0.3	1	5	1	5	6	6	x
St. Lucia	17	18	0.1	3	3.3	3	4	8	8	x
St. Vincent and Grenadines	10	11	0.06	2	4	2	3.5	14	14	x
Trinidad and Tobago	116	120	0.1	11	7	11	5.5	230	221	0.4
OVERSEAS TERRITORIES										
Anguilla (UK)	x	x	x	x	x	x	x	x	x	x
Aruba (N)	2	2	0.03	x	x	x	x	x	x	x
Caiman Islands (UK)	x	x	x	x	x	x	x	x	x	x
French Guiana (F)	4	8	0.09	4	1.5	10	1.9	7,300	7,300	x
Guadeloupe (F)	38	29	0.09	22	4	27	2.4	70	69	0.1
Martinique (F)	20	20	0.07	19	3	20	1.8	40	38	0.5
Montserrat (UK)	1	2	0.1	1	9	1	10	4	4	x
Netherlands Antilles (N)	8	8	0.04	x	x	x	1	x	x	x
Puerto Rico (USA)	x	x	x	x	x	x	x	x	x	x
Turks and Caicos Islands (UK)	x	x	x	x	x	x	x	x	x	x
Virgin Islands (UK)	3	4	0.3	5	0.6	5	0.4	1	1	x
Virgin Islands (USA)	7	7	0.06	9	0.9	9	0.9	2	2	x

Sources: FAO, 1992; USAID & WRI, 1993; WCMC, 1992
Notes: x = not available; (*) CARICOM also includes Belice, Jamaica, and Suriname;
N = The Netherlands, F = France, UK = United Kingdom, USA = United States of America

TECHNICAL NOTES:

Appendix 1.1 Economic data are from the World Bank (1992, Box A.1 of World Development Indicators), USAID & WRI (1993, Table 1 and 2), and UNDP (1991, Table 1 of Human Development Index). Tourist Arrivals are from UNDP (1991, Table 7.9).

Appendix 1.2 Coastal resource data are from USAID & WRI (1993, Tables 18 and 19). Biological diversity data are from WCMC (1992).

Appendix 1.3 Agriculture data are from FAO (1992). Forest data are from FAO (1992) and USAID & WRI (1993, Table 13).

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