United States Agency for International Development
Dominican Republic

PDC-5517-I-00-0105-00
Delivery Order No. 9

Intensive Survey of Rural and Urban Activities Impacting Water and Coastal Resources

Submitted by:
Tropical Research and Development, Inc.

January, 1991

ACKNOWLEDGEMENTS

This study builds on the efforts of the U.S. Office of Housing and Urban Affairs/Washington DC to develop and test risk-assessment methodologies applicable to the developing world and to assess risks to ecological resources in the Dominican Republic. This was the second study of this nature to be conducted; the first study addressed the health risk of urban activities in Bangkok, Thailand.

Tropical Research and Development, Inc. (TR&D) assembled and managed the team that conducted the study. Innumerable people and organizations facilitated the work of the team. Particularly recognized is the excellent administrative and technical support of TR&D and the assistance of Larry Laird and Odalis Perez, as well as the friendly support staff at the Mission. Technical support from Gene Wilken and Bruce Bayle is recognized and appreciated, as is the invaluable administrative and secretarial support of Jeanette Casals and Saskya Carrasco.

The provision of vehicles, guides and a helicopter by the Instituto Nacional de Recursos Hidraulicos (INDRHI) made reconnaissance of the many potential sites both possible and fruitful. A detailed evaluation of the coast could not have occurred without the "flyover". Many other Dominicans and organizations frequently went out of their way to provide the team with their ideas and their time, as well as documents, information and other resources. Special thanks is extended to Hector Lopez, Domingo Marte, Sixto Inchaustegui, José Serulle, Carlos José Bonilla, Jose Martínez, Venecia Alvarez, Roberto Castillo and all others who contributed so graciously. The dedication of those named and unnamed Dominican professionals in the face of severe resource constraints is inspirational.

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AECI	Spanish Agency for International Cooperation (Agencia Española de Cooperacion Internacional)
ADF	Agricultural Development Foundation
A.I.D.	Agency for International Development, Washington DC
BARC	Betsville Aerated Rapid Composting system
BID	Inter-American Development Bank (Banco Interamericano de Desarrollo-see IDB)
CAASD	Corporation of Aqueducts and Sewerage of Santo Domingo (Corporación de Acueducto y Alcantarillado de Santo Domingo)
CDE	Dominican Electrice Corporation (Corporación Dominicana de Electricidad)
CDSS	Country Development Strategy Statement
CEA	Governmental Sugar Council (Consejo Estatal del Azúcar)
CEDOIS	Dominican Center for Organizations of Social Concern (Centro Dominicano de Organizaciones de Interés social)
CEUR	Center of Urban and Regional Studies (Centro de Estudios Urbanos y Regionales)
CIBIMA/USAID	Marine Biology Research Center of the Autonomous University of Santo Domingo (Centro de Investigaciones de Biologia Marina de La Universidad Autonoma de Santo Domingo)
CONATEF	National Technical Forestry Commission (Comisión Nacional Técnica Forestal)
CORAASAN	Corporation of Aqueducts and Sewerage of Santiago (Corporación del Acueductos y Alcantarillado de Santiago)
DA	Development Assistance
DED	German Social-Technical Cooperation Service
DGF	General Forestry Directorate (Dirección General Forestal)
DNP	National Parks Directorate (Dirección Nacional de Parques)
DR	Dominican Republic
DRP/SEA	Department of Fishery Resources of the SEA (Departamento de Recursos Pesqueros de la SEA)
DVS/SEA	Wildlife Department of the SEA (Departamento de Vida Silvestre de la SEA)

EAI	Enterprise for the Americas Initiative
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
FDD	Dominican Foundation for Development (Fundación Dominicana de Desarrollo)
FEDOMASEC	Dominican Federation of Ecological Associations (Federación Dominicana de Asociaciones Ecológistas)
FIRENA	National Forestry Investment Project (Fondo de Inversiones en Recursos Naturales)
FRUDOCA	Dominican Fruits (Frutas Dominicanas)
FTZ	Free Trade Zones
FUDECO	Foundation for Community Development (Fundación Para el Desarrollo Comunitario)
FY	Fiscal Year
GDP	Gross Domestic Product
GODR	Government of the Dominican Republic
GTZ	German Society of Technical Cooperation
IBRD	International Bank for Reconstruction and Development
IDB	Inter-American Development Bank
IMF	International Monetary Fund
INAPA	National Institute of Potable Water and Sewerage (Instituto Nacional de Aguas Potables y Alcantarillados)
INDESUR	Institute for the Southwest Development (Instituto para el Desarrollo Del Suroeste)
INDOTEC	Dominican Institute of Industrial Technology (Instituto Dominicano de Tecnologia Industrial)
INDRHI	National Institute of Hydraulic Resources (Instituto Nacional de Recursos Hidraulicos)
INSTRAW	International Research and Training Institute for the Advancement of Women (United Nations)
IPM	Integrated Pest Management
JACC	Joint Agricultural Consultative Committee (Junta Agroempresarial de Consultoria y Coinversion)
JICA	Japan International Cooperation Agency
MGD	Dominican Navy (Marina de Guerra Dominicana)
NGO	Nongovernmental Organization
OAS	Organization of American States
ONAPLAN	National Office of Planning

	(Oficina Nacional de Planificación)
PAHO	Pan American Health Organization
PLANIACAS	National Plan of Study, Use and Control of Underground Water (Plan Nacional de Investigación, Aprovechamiento y Control de Aguas Subterráneas)
PROGRESSIO	Foundation for Human Improvement (Fundacion Para el Mejoramiento Humano)
PRONATURA	Fund for Nature (Fondo Pro Naturaleza)
PVO	Private Voluntary Organization
RD$	Dominican Republic Peso
SEA	Secretary of State of Agriculture (Secretaria de Estado de Agricultura)
SESEPAS	Secretary of State of Public Health and Social Assistance (Secretaria de Estado de Salud Pública y Asistencia Social)
SGTNRM	Sustained Growth Through Natural Resource Management
STP	Technical Secretariat of the Presidency (Secretariado Técnico de la Presidencia)
SURENA	Subsecretary of Natural Resources (Subsecretaria de Estado de Recursos Naturales)
TA	Technical Assistance
TDZ	Tourism Development Zone
TFAP	Tropical Forest Action Plan
TFR	Total Fertility Rate
TNC	The Nature Conservancy
UASD	Autonomous University of Santo Domingo (Universidad Autónoma de Santo Domingo)
UN	United Nations
UNDP	United Nations Development Programme
UNPHU	Pedro Henriquez Ureña National University (Universidad Nacional Pedro Henriquez Ureña)
US	United States of America
US$	United States Dollar
USAID	United States Agency for International Development/International locations
USAID/DR	United States Agency for International Development/Dominican Republic
WHO	World Health Organization

EXECUTIVE SUMMARY

The purpose of this report is to provide USAID/Dominican Republic and the Government of the Dominican Republic (GODR) with the information needed to make decisions concerning the allocation of its resources in the natural-resource management sector. This survey had three principal tasks:

- to evaluate rural, urban, and coastal activities impacting water and coastal resources nationally,
- to identify and evaluate potential sites for pilot projects, thereby giving focus and substance to the overall evaluation,
- and to develop an Action Plan which the Mission can use to develop the Sustainable Growth through Natural Resource Management Project.

This executive summary will focus on findings which support the principal recommendations to the Mission.

RURAL ACTIVITIES

Principal findings

The main cause of environmental deterioration and degradation of water and other natural resources in the Dominican Republic is deforestation of areas only suited for forest production, conservation of biological diversity, non-consumptive recreation, and water conservation. Extensive areas of land in the Dominican Republic have a slope of 25 percent or greater. For this reason, studies of land-use capability have determined that about 56 percent of national territory should be in forests (McCaffrey, 1989). Forest coverage is estimated at 20 percent of total land area, down from 80 percent in 1900 (CONATEF, 1991) Although commercial loggers are thought to be the chief cause of past forest conversion, regeneration of forests (particularly on steep slopes) is prevented by continual inappropriate use of the land by subsistence farmers, who lack alternative means of support.

Key factors responsible for forest conversion -- although not studied in detail -- are thought to be slash-and-burn agriculture and charcoal production. Loss of tropical forest in the Dominican Republic is now estimated at a rate of 20,000 ha per-year; the area affected by firewood and charcoal extraction is degenerating at a rate of 60,000 ha per-

year. (CONATEF, 1986). If these rates of deforestation continue, natural forests will be substantially depleted in 10-to-25 years.

The key impacts of deforestation on hydrological cycles and resources are (Likens et al., 1969; MacKinnon, 1983; and MacKinnon, et al.):

1. a decrease in infiltration and recharge of aquifers,
2. an increase in the volume and velocity of superficial runoff,
3. a decrease in uniformity of stream flow (very low or no flow during dry periods and more frequent flooding during rains and storms).

These changes also lead to increased instability of slopes, laminar erosion and sedimentation of streams and rivers. These impacts have cascading and synergistic impacts on ecological and economical environments, including increased sedimentation rates for dams and irrigation infrastructure and destruction of coral reefs and sea- grass lands.

Principal Recommendation

1) Select a pilot watershed as a demonstration site for activities leading to environmental restoration and sustainable development. The evaluation team recommended the sub-watershed upstream of the Sabana Yegua Reservoir. The other reservoir considered high priority by the team was the Rio Nizao. The selected watershed should be studied as part of the project feasibility and design cycle in order to more clearly define both the physical and institutional environment, as well as the nature and objectives of the intended project. The team further recommends that the project design use the FIRENA model and that the institutional structure for implementation use as a model the organization in San José de Ocoa. A better legal framework for project implementation should be promoted.

URBAN ACTIVITIES

Principal Findings

The urban population in the Dominican Republic has almost quadrupled since 1955, growing at a rate much faster than the provision of adequate services and infrastructure. Most of the growth and urban problems are focused in the capital city of Santo Domingo. The development of Free Trade Zones (FTZ) and tourism has been spectacular. Santo

Domingo comprises around 25 percent of the total population of the country (Gonzales, et al. 1991).

Water pollution in the Ozama and Isabela rivers from urban sources is most significant in the capital. Although some 40 percent of the city's land area is reportedly connected to a sewerage system, the system serves only a minority of the population. Treatment plants and pumping stations work only intermittently. At most, two percent of Santo Domingo's waste water is treated. Exacerbating this problem is discharge of largely untreated, industrial waste into either the drainage-and-sewage system of CASSD or directly into the Ozama and Isabela rivers or into the ocean (Gonzalez et al., 1991).

Although sewage and industrial pollution represent a significant problem, a greater health risk to more people may stem from uncollected solid waste and night soil, sometimes disposed of in illegal, unsanitary dumps. In 1990, Santo Domingo's population produced an estimated 1,230 metric tons of solid waste per-day -- close to one-half-million tons per year (estimated by source). Most of the city's waste is never collected. It is taken by rain into low-lying areas, where toxic, sewage-contaminated liquids seep into groundwater and, when daily cuts of electricity cause a loss of pressure, into the drinking-water system. Disease vectors and rodents also proliferate in these humid and nutrient- laden environments (80 percent of the wastes are thought to be organic). Transportation and landfill are the two principal bottlenecks in the solid-waste-disposal system.

Water contaminated in this manner is probably the main vector by which diseases such as cholera, typhoid, paratyphoid, gastroenteritis, giardiasis, amoebic dysentery and hepatitis are spread. The most cost-effective solutions and the solutions most likely to be maintained are the simple, non conventional ones -- pit latrines, composting toilets, composting of organic waste and garbage collection by small, private enterprises or PVOs with push carts to collection points.

Principal Recommendation:

Assist in the creation of private-enterprise collection of garbage from areas not served. Also, provide technical assistance and training for implementation of a composting system that renders organic waste and night soil safe for recycling in the soil.

COASTAL ACTIVITIES

Principal findings

Activities having the greatest impact upon the coastal zones are upland deforestation, development of irrigation schemes and urbanization. The most damaging activity is deforestation.

Deforestation alters the volume and timing of freshwater inflows to marine systems, greatly diminishing the flow in dry seasons and increasing the likelihood of floods during precipitation events. The more uniform flow rates to which most marine and aquatic systems are adapted maintain certain salinity levels and a steady location for the saltwater-freshwater interface and also provide continual flushing of salts in mangrove and other coastal-wetland system. Alterations in flow rates can destroy marine communities. Diversion of water for agricultural irrigation -- the largest user of water -- can aggravate this problem. Increased erosion and flooding, caused by deforestation, can cover with sediments marine communities that depend upon clear water, thereby destroying the community. Sea-grass beds and coral reefs are two such communities threatened in this manner.

The team's December flyover revealed essentially no flow in the Ocoa, Nizao, and Yaque del Norte rivers. This lack was most likely due to a combination of poor rainfall and the diversion of water for irrigation. Lowered freshwater flushing of mangrove soils was likely responsible for die-off of about 20-30 hectares noted at the mouth of the Yaque del Norte River. Coral formation and growth have been cut short where turbidity has increased near discharging rivers, particularly along the south and southwest coast and along the north coast at Rio Yeguada, near Miches, Rio San Juan and Rio Yasica. At several locations along the east and north coast, where the larger watersheds discharge -- Bahia de Yuna, Rio La Yeguada at Miches, Bahia de la Jina, Rio Yabon near Sabana de la Mar, Rio Yuna and Rio Nigua -- turbidity problems affect sea grasses.

Increasing and potentially unsustainable demand for coastal resources, particularly fishery resources, is the second most important issue in the coastal zone. Tourism development in particular increases demand for fishery resources, potable water, land and even obscure resources, such as palm fronds and coral reef curios. In an island community of 7.5 million people, a tourist-population increase of even approximately 1.5 million people per-year (1990 estimate) represents a significant impact. Each tourist consumes nearly five times the resources of a local citizen (Brown, 1991). Between 1970 and 1990, numbers of hotel beds increased from 1,305 to 20,000. Growth in tourism has slowed, but has not stopped. The potential for over-exploitation of coastal resources is great.

Hartshorn et al. (1981) estimated the total, sustainable yield of marine fisheries at about 10,500 metric-tons-per-year. Data provided by the Dominican Republic Department of Fisheries shows the total 1988 catch to be about 19,000 metric tons, and sources believe the actual catch to be higher. Lack of trend data on catch-per-unit-effort and per-species prevent further commentary.

The third critical issue in the coastal zone is "multi-use" conflicts stemming from coastal zone development. For example, in the area of the Bahia de Ocoa and Bahia las Calderas, myriad types of resource development and use are changing the ecological character of these small bays and affecting the artisanal fisheries there. These activities include development of (vacation) second-homes, a large salt operation, irrigation and agriculture, as well as timber cutting for charcoal in the dry forests, increased fishing pressure from an estimated 100 boats, off-loading of LP gas at a reception terminal and the potential development by the government of a shipyard. The conch fishery is thought to be nearly depleted.

The Samana Bay is the most important sanctuary for humpback whales in the North Atlantic. It also has one of the most important marine nurseries (shrimp, oysters and fish) in the Caribbean and the largest extension of mangroves in the Dominican Republic. Nevertheless, tourism development is growing. Development of irrigated agriculture along the Yuna and the use of agro-chemicals is thought to have had negative impacts on the fishery. The mangroves are being cut for charcoal, and interest in conducting oil exploration and drilling in the Bay has begun.

Principle Recommendations:

1) Given that one of the most important aspects of good coastal-zone management is watershed management, the implementation of an exemplary watershed management project is critical. (See first recommendation)
2) Study the potential over-fishing problem and institutional hindrances to better fishery management. In particular, support a basic, fishery-research program and a program to monitor catch by species and area.
3) Select a site(s) (from Monte Cristi, Samana Bay and Bahia de Ocoa) to conduct a pilot coastal-zone management project. Before project implementation, a more thorough and holistic study should be done of the site(s) selected. A systems study and/or a GIS approach (giving spatial data that can be overlaid to highlight conflicts) is recommended.

ACTION PLAN

This action plan will elaborate upon the four principal recommendations and actions considered most important by the project team. It will then summarize the remaining actions and recommendations generated by the team's survey.

RECOMMENDATION\ACTION #1\RURAL

Step 1: Select a pilot watershed as a demonstration site for activities that should lead to environmental restoration and sustainable development. The area recommended by the team is the sub-watershed, upstream of the Sabana Yegua reservoir.

The other watershed considered a high priority by the team was the Nizao river. Because three economically and financially important dams are located on this river (already existing or under construction), this watershed is beginning to receive international attention. The three sub-basins contributing to the Sabana reservoir, however, receives no international assistance, nor are they included in any future plans.

Step 2: The selected watershed should be studied as part of a project pre-feasibility or feasibility development effort. This study should more clearly define the geographical boundaries of the site(s), the bio-physical, socioeconomic and institutional environment and the nature and objectives of the project (which could be a component of the SGTNRM project). Basic studies already carried out on the sub-basins of Las Cuevas and Corade or Del Medio through the terminated MARENA project could provide the base from which analyses could be initiated.

Project feasibility and development studies should include regular meetings with project beneficiaries to include their opinions in the project design. These meetings should be conducted by some private sector PVO\NGO, such as PRONATURA or the San Jose de Ocoa organization.

Step 3: As regards project design, the project team recommends that the institutional structure for project implementation be modeled after that used by the organization in San Jose de Ocoa. If the Sabana Yegua reservoir is selected, the disbanded Junta Padre de las Cuevas could be resurrected though the organization would require further institutional development assistance and would need to be coordinated with on-going GTZ efforts. If a sub-watershed in the Nizao River is chosen, the Mission should explore the feasibility of giving the San Jose de Ocoa organization responsibility for implementation.

An integral part of project design for SGTNRM should be the FIRENA project model, in which usufruct rights to irrigation and flatter, better agricultural lands are given to local populations, who are practicing slash-and-burn agriculture and charcoal production in the unstable slopes of the watershed. The project design ensures that every member of the community has a stake in maintaining the watershed. This design best assures access to water, upon which access to land is dependent.

The project design should include a technical assistance (TA) and an environmental-education component. TA could be provided through project funds or could draw upon existing USAID IPM and On-Farm Water Management projects. TA should be used to encourage the use of indigenous species for reforestation and to protect or restore riparian vegetation. TA could also introduce community-based problem-analysis and problem-solving methodologies designed to target illiterate audiences.

Step 4: USAID would be able to use leverage engendered by this project (through such mechanisms as conditionality or covenants) to promote a legal and policy environment which would favor this project and sustainable development activities in general. Policy dialogue would center upon three primary areas: 1) comprehensive legislation requiring integrated management of watersheds with attendant budget allocations to assure effective implementation (a thorough economic cost\benefit analysis would be beneficial); 2) legislation to support regional, community organizations, which would require a devolution of revenue-generating abilities; and 3) legislation modifying near-total restriction on the use of forest resources. This process has started, but needs to be encouraged. CONATEF, which has taken the lead in the effort to revise forestry legislation, could be contacted to conduct further studies in this area for the Mission.

RECOMMENDATION\ACTION #2: URBAN

STEP 1: As part of the project-design process, the Mission should conduct a more thorough investigation of the nature, magnitude and impacts of the garbage and human-waste disposal problem in the slums of Santo Domingo. This study should attempt to define the boundaries of a potential urban project (or component of SGTNRM), based upon a description of the physical, socioeconomic and institutional environments found within the barrios, as well as to define the purpose and objectives of the project. In addition, project beneficiaries should be included in the project-design process in order to increase the possibility of project success.

STEP 2: The Mission should seek to encourage the establishment of private-sector, garbage-removal industry. Enterprises within this sector would use push-carts or another appropriate conveyance to collect garbage and night soil in those areas of the city which

are inaccessible to garbage trucks and not currently served. The entrepreneurs would take refuse to collection points, where municipal trucks have access.

Since garbage and human-waste disposal is also a problem in the Dominican Republic, the feasibility of composting the waste should be explored. If composting is found to be feasible, the project would contain an extensive TA component responsible for training CAYUDAMIENTO personnel in the management of large-scale composting programs.

Since an estimated 80 percent of the country's solid waste is organic matter, the Beltsville Aerated Rapid Composting system (BARC), which converts waste into night soil, is recommended as an easy, inexpensive (in terms of initial outlay and recurrent costs), effective and odorless choice (Shuval et al., 1981).

Two essential questions need to be answered by the feasibility study. The first is technical; what is the actual composition of Santo Domingo's garbage? The second would address the fundamental question of funding -- how to provide start-up funds (grants) to establish a private-sector, garbage-collection industry without creating dependence upon project funds for continuing operation. Strategies to be considered include payment from the city to entrepreneurs, collection of rents for services and off-setting costs through the sale of recycled goods or compost.

RECOMMENDATION\ACTION 3: Coastal

Since the most important aspect of good coastal-zone management -- good watershed management -- has been addressed above, the following two recommendations will address the second and third most important environmental threats necessitating action: increased and potentially unsustainable demand for coastal resources (particularly fisheries) and "multi-use" conflict in the development of the coastal zone.

Step 1: As part of the project-design cycle, conduct a thorough investigation of the nature, magnitude and impacts of the potential over-fishing problem. Attention should be given to institutional arrangements which hinder sustainable fisheries management. And the need to improve monitoring and enforcement of regulations deserves special attention. Once again, project beneficiaries should be included in the project-design process.

In response to a serious paucity of reliable data, the project should stress the need to collect data necessary for better planning, management and enforcement. The development of a basic, fishery-research program and a program to monitor catch by species and area is essential. CIBIMA would be the most appropriate agency to

implement to efforts outlined above. GTZ is already conducting a similar project, so new efforts should be coordinated. The utility of funding the establishment of a marine research station in support of this effort should be investigated. The Department of Fisheries may be the appropriate agency to administer\coordinate a monitoring program.

RECOMMENDATION/ACTION 4:

Step 1: To assist in the final selection of a site(s) for a pilot coastal zone management project, support a preliminary study, consisting of a more thorough compilation and analysis of existing data and on-ground research. The team recommends the following sites for further investigation:

a. Monte Cristi and the Northwest coastline, particularly around Buen Hombre, from Punta Buen to Bahia de Icaquitos (where the last vestiges of relatively intact beach and dune systems are thought to remain);
b. Samana Bay, particularly at Rio Una, where the largest single stand of mangrove (7,783 ha) stands; and
c. the Bahia de Ocoa, under greater pressure from multiple uses, is the most likely location for a marine lab and may represent a good opportunity for planned intervention.

The team recommends that the study use as a starting point, the same criteria used in this study, but go into greater depth with each point -- hydrological characteristics, biological characteristics, socioeconomic importance, status, activities, role of change, impacts, costs of trends and productivity.

Step 2: As part of project preparation, or as a separate study or a project component, a more thorough and holistic study should be conducted of the site(s) selected. The team recommends either a systems approach or a study using GIS, such as the GIS system developed by James Dobbins and Associates, Inc. (coastal zone planners) or a combination of approaches. In either case, the study should develop an understanding of the bio-physical environment, the human activities and their interactions (including their spatial locations) sufficient to indicate appropriate coastal-zone management and to guide development of general coastal policy. The need for institutional collaboration for coastal zone management should be examined as well.

Step 3: Using the information developed in the above study, implement a pilot coastal-zone management project(s) at the selected site(s). Another component of the project would be study of the need to strengthen laws, policies and the role of government agencies and NGOs.

ADDITIONAL RECOMMENDATIONS

Recommendation 1: Sponsor a PVO/NGO to develop a national data bank of pollution levels, problems and impacts.

Recommendation 2: Fund a pilot project(s) for the construction of wetlands to capture of stormwater runoff and waste water (could include sewage waste) recycling.

Recommendation 3: In conjunction with INDRHI, support development of a model, water-use plan for either the Rio Yuna, Yaque del Norte, or the Rio Ocoa (unless the OAS/INDRHI effort to conduct a national inventory and planning exercise is funded).

Recommendation 4: Fund through an organization such as PRONATURA or CIBIMA or perhaps a consortium to conduct a natural-resources inventory of the coastal zone.

Recommendation 5: Follow-up on the recommendations of earlier reports (e.g., Cobb et al. 1991) concerning the development of fuelwood plantations and alternative sources of fuel, such as briquettes made from waste vegetative matter.

1.0 INTRODUCTION

1.1 Background and Context

USAID Dominican Republic recognizes the importance of protection and rational management of environmental resources, particularly water resources, in an island nation such as the Dominican Republic. Deforestation, unsustainable farming on steep slopes, rapid urbanization, untreated industrial discharges, poorly regulated tourism development, heavy pesticide usage, overgrazing, and uncontrolled sewage discharges into aquifers and surface water are among the urban, rural, and coastal activities degrading the quality of water systems in the Dominican Republic. Degradation of these water systems, in turn, sets into motion a series of successive actions and impacts with hydrologic, ecologic-biologic, and socioeconomic implications. The timing and manner in which these problems are addressed, or not addressed, may influence economic growth capacity, quality of life, and social equity in the Dominican Republic for decades to come.

A major strategic objective of the 1992-96 CDSS is to "reduce legislative, regulatory and institutional impediments to rational management of natural resources by public and private sectors to assure long-term sustainability". The CDSS also describes water and watershed management, as well as coastal zones, as among the Mission's four greatest areas of environmental concern.

The Office of Agriculture and Natural Resources is to be combined with the Private Enterprise Office, with basic compatibilities to be sought in the two activities. It is also a time of consolidation of the project portfolio and reduction in available resources. The Enterprise for the Americas Initiative (EAI) could help offset the reduction in resources, however, much difficult work remains to be done before the Dominican Republic can qualify to obtain funds under the debt reduction provisions of the EAI.

With this context in mind, this inclusive study of water resources is intended to assist the USAID Mission in determining its environmental priorities and next steps. It follows on an overview commissioned by A.I.D., Office of Housing and Urban Programs, of urban environmental issues in the Dominican Republic (Cobb, et al., 1991), which also developed a set of recommendations for USAID and the Mission. This study is designed to provide information to facilitate project preparation studies and activities scheduled to begin in the Spring of 1992 for a USAID-funded "Sustained Growth through Natural Resource Management" project.

1.2 Objectives and Tasks of the Study

The purpose of this assessment was to assist the Mission in establishing its environmental priorities; what should be done, who should do it, where, and why. It is also to provide a broad, but sufficiently detailed, picture of national environmental (particularly water resource) problems in the Dominican Republic.

Secondary objectives of the assessment are:

- Provide preliminary information which will facilitate the development of a new project, Sustained Growth through Natural Resources Management, that will institute policy and institutional reforms and implement model environmental management programs for select watersheds and coastal zones.

- Advance the CDSS (Fiscal Years (FY) 1992-1996) goal to initiate a systematic information gathering effort on the causes and consequences of environmental degradation in the Dominican Republic; and the emphasis of the two areas of greatest concern in the Action Plan: management of watersheds and coastal zones.

- Provide information to stimulate and justify action on the part of GODR decision makers, and to provide the basis for environmental education, public awareness campaigns, strategic planning, and the development and coordination of government and private sector policies and programs.

- Develop and test a methodology of ecological risk assessment that may facilitate long-term planning and policy development and that may be applicable in other developing country contexts.

In particular, the study was to conduct the following tasks:

- Provide basic data on the natural resource base, with water resources as the central theme, and data on other resources only as they relate to water resources, e.g. watersheds, and coastal zones.

- Provide basic data on population growth and socioeconomic trends.

- Provide basic data on the nature and magnitude (as available) of rural and urban activities impacting water-related resources, and the nature and magnitude/costs (as feasible) of impacts.

- Assess and prioritize resources at risk and the key threats, and give technical and policy recommendations.

- Assess the state of the data, and identify data and data analysis needs.

- Provide basic data on the national, water-resource related activities of other international aid agencies such as water resource supply or contamination studies, water supply, watershed management, reforestation or park protection in watersheds, coastal zone management, tourism sector, and water pollution control.

- Provide a menu of site options for pilot projects in watershed management and coastal zone management, with basic data on resources and issues, and pros and cons.

- Formulate criteria for the final selection of pilot project sites, prioritize sites according to these criteria, and recommend and justify a minimum of two sites.

- Provide basic data on non-governmental organizations (NGOs) involved in environment, natural resource management, or community development which may be involved in the implementation of pilot projects; preliminary recommendations for the types of potential implementing agencies or the institutional framework.

- Recommend next steps, i.e. provide an action plan.

1.3 Relationship to Mission Goals and Policy Framework

The work of the study, particularly the formulation of recommendations and an action plan, took into consideration the goals of the CDSS work plan. The goals of particular pertinence include the following:

- to strengthen the linkages of Dominican organizations with U.S. groups by funding joint U.S.-Dominican PVO activity,

- to initiate a systematic information gathering effort on the causes and consequences of environmental degradation in the Dominican Republic,

- to authorize the Sustained Growth Through Natural Resource Management Project,

- and to assist PVO efforts to persuade the GODR to change current forestry policies and to overhaul and strengthen forestry legislation.

The recommendations are also consistent with the strategic goals and action plan objectives outlined in the Mission Action Plan for 1991-1992 (Cobb, 1991).

The Mission believes that the presence of the following policies or factors are key to achieving these goals and objectives:

- the participation of private organizations in the management and control of national parks, coastal zones, watersheds and similar resources of concern,
- local autonomy and democratic decision making, and
- a macro-economic environment that enables the creation and growth of economically viable activities, particularly private investment and exports, which are simultaneously consistent with the sustained and rational use of natural resources.

2.0 LEGISLATIVE AND INSTITUTIONAL STRUCTURE AFFECTING WATER AND COASTAL RESOURCES

2.1 Analysis of Institutional Framework

As a general rule, the legal framework needs consolidation, updating, and strengthening. This particularly includes the legal framework concerning forestry and forest protection. The recent initiative, Law 290 of 1985 is attempting to consolidate forestry laws and correct problems constraining private initiative (CONATEF, 1991). It is too early in the process of the attempted revision of forestry laws to make meaningful observations, although care should be taken to ensure that the new law will achieve the objectives intended, and that it will not favor only private interests with the financial resources to take advantage of new economic incentives (McCaffrey, personal communication). The new forestry law, or a separate law, may also address the many issues of watershed protection and management in a more comprehensive fashion. No large water development project should be without a watershed component.

A comprehensive law concerning water resources should be developed; the legislation drafted as part of the GTZ/INDRHI water project may be a good beginning. Similarly, laws (standards and policies) concerning water pollution need consolidation and strengthening. In the final analysis, however, even when good laws exist, institutions do not have the resources to enforce them.

In general, public sector institutions suffer from the following constraints: 1) lack of continuity (and occasionally lack of technical competence) of agency leadership due to the system of placing political appointees in leadership positions, 2) large and underutilized staffs with a large proportion of agency budgets going for salaries, 3) a critical lack of resources and funds to actually implement activities and projects, 4) when funds are available, an emphasis is put on capital outlays to the detriment of maintenance of existing structures or programs, 5) a shortage of trained and technically competent personnel within the agency, 6) critically low (non-competitive) salaries for trained technicians, 6) unclear or overlapping functions with other agencies, 7) lack of mechanisms for coordination both within and among agencies, and 8) a sense that planning is futile as decision making is highly centralized (compilation of personal communication from agency interviews and Lopez et al. 1991).

Although initiatives that have emphasized local autonomy, private enterprise, and use of the private sector have generally been more efficient and successful, the public sector should not be ignored. Certain roles can only be filled by a strong public sector, such as the setting and enforcement of policy. The public sector should be strengthened, but

also restricted to those functions which cannot be fulfilled by private concerns. The structural adjustment agreement with the IMF (concerning reductions in the public sector, and the raising of salaries to be competitive with the private sector) should be implemented.

As pollution control, particularly in the Santo Domingo area, is of great interest now, observations of the current system and standards include the following: 1) standards do not take into account natural quality variability of various river systems, or variable end uses; 2) standards do not attempt to make compatible effluent and water quality standards; 3) state owned industries may be responsible for the majority of pollution in certain areas, and clean-up of only private concerns does not solve the water quality problem; 4) six months may be an unreasonable time period to require companies to evaluate the best alternatives to pollution control, order, import (if necessary) and install equipment, 5) in certain cases, the installation of end-of-pipe pollution control equipment may not be the best approach to pollution control (e.g., changes in process design, plant management, or resource recovery may be more appropriate in certain cases), 6) involvement of government agency personnel entrusted with enforcement of pollution standards in the installation of pollution control equipment may represent a conflict of interest, and 7) the current legal division of responsibilities for pollution control is not clear.

2.2 Legislation Protecting and Managing Water Resources

2.2.1 Legislation Regulating Water Use and Management

The first modern Dominican legislation regulating potable water supplies was the Public Health Code, **Law No. 4471 of 1956,** which gave the Secretary of State of Public Health (SESPAS) control over potable water supplies. This law also gave SESPAS responsibility for determining the potability of water supplies using international standards, and declared that water sources for population centers should be secured with protection zones. This law established that any public or private work (construction, repair, or modification) that had any relation to water supply or waste disposal had to have prior approval of SESPAS, which had to prepare a report for each special case (Castillo, n.d.).

The second law concerning water sources was **Law No. 5994 of 1962** which created the National Institute of Potable Water and Sewerage (INAPA). This law gave INAPA primary responsibility for the formulation of plans for water supply systems and for the disposal of liquid wastes in both rural and urban areas. It also gave INAPA responsibility for the execution of water supply and waste disposal plans and programs, and the right to establish tariffs to finance potable water supply and sewerage works. This law established that water supply for human consumption had the highest priority over other

water uses. **Law No. 8955 of 1963** elaborated upon **Law No. 5994** with specific rules and gave INAPA responsibility to promote the reforestation of watersheds to protect potable water sources (Castillo, n.d.).

Law No. 6 of 1965 created the National Institute of Water Resources (INDRHI) which was charged to organize, direct, and regulate the exploitation of water supplies in cooperation with the Corporation of Industrial Promotion, the Dominican Electrical Corporation, and INAPA (Castillo, n.d.).

Law No. 487 of 1968 declared that exploitation of groundwater for domestic uses had priority over exploitation of this source for industrial or agricultural (irrigation) use (Castillo, n.d.).

Law No. 498 of 1973 created the Corporation of Water Supply and Sewerage of Santo Domingo (CAASD), restricting thereby the jurisdiction of INAPA. Through this law, responsibility for planning and implementing water supply and waste disposal programs for the city of Santo Domingo and areas of influence passed from INAPA to CAASD. It also stated that any water supply or liquid waste disposal installations constructed either privately or by the government in Santo Domingo would become the property of CAASD. **Law No. 582 of 1977** created a similar corporation with similar functions for the city of Santiago, Corporation for Water Supply and Sewerage for Santiago (CORASAN) (Castillo, n.d.).

2.2.2 Legislation Regulating Water Pollution

The public health code mentioned previously, **Law No. 4471 of 1956,** prohibits the direct or indirect disposal of waste waters that might injure the health of humans or animals into rivers, lakes, or other water courses that serve or may serve as a source of potable water supply for domestic, agricultural, industrial, or recreational use unless the national sanitary authority SESPAS expressly authorizes it, or previous treatment has rendered them innocuous. If infractions are discovered upon inspections, the sanitary authority can order the correction of the problem; and if it is not corrected in a reasonable time, can commission the construction or repair of works to be charged to the proprietor (Castillo, n.d.).

Law No. 5914 of 1962, or the fishery law, prohibits the arbitrary alteration of waters courses with industrial residues, or the dumping in waters of materials or substances noxious to fish populations, thereby obligating the owners of industrial installations to install the devices necessary to annul dangers to fishery resources. This law also prohibits the abandonment of fishery products or wastes in beaches, riverbanks, and in

special use zones established by the Secretary of State of Agriculture (SEA). This law gives responsibility for fishery resources to the Department of Fishery Resources in the Secretary of Agriculture (DRP/SEA) (Castillo, n.d.).

Law No. 5852 of 1962, concerning the ownership of terrestrial waters and the distribution of public waters, directs INDRHI to investigate whenever it is suspected that an industrial establishment is releasing into waters substances noxious to health, vegetation, or fish populations; and if the risk is found to be real, to suspend work until the owners adopt remedial measures. If the owner has not adopted remedial measures within six months, the law states that the industry should be ordered closed. In cases where the industry has been granted water use concessions, this concession shall be considered expired without the right of indemnization at which time the water acquires properties noxious to health, vegetation, or fish populations. The expenses of the investigation shall be paid by the person who lodged the complaint in the case where the results prove the complaint unfounded, and by the owner of the establishment, in the contrary case (Castillo, n.d.).

The Dominican Republic has passed a law, **Law No. 218 of 1984,** indirectly protecting water supplies by prohibiting the importation of substances that are able to contaminate or degrade the environment and endanger the health of inhabitants, such as human excrement, animal wastes and their derivatives, and pharmacological products and pesticides that have been prohibited or discontinued in their country of origin (Castillo, n.d.).

Decree No. 226 of 1990 created the National Commission of Ecological Sanitation, whose fundamental purpose is the control of contamination of rivers from industrial effluents.

2.3 Legislation Regulating Related Resource Use

2.3.1 Forestry Legislation

There are currently four basic laws and one decree governing forestry new in the Dominican Republic. **Law No. 5856 of 1962** created the General Directorate of Forests (DGF), defined its role in national forest management, and regulated all forestry activities, including conservation, utilization, management, and transportation. **Law 211** was passed in **1967** to check the deforestation of the country's pine forests, which closed all operating sawmills, prohibited further harvesting of trees, and taxed imported wood, all of which eliminated incentives to plant trees (Reynoso, et al., 1988).

An attempt was made to correct this situation with the passage in **1982 of Law No. 705** which established the National Technical Forestry Commission (CONATEF). They were charged to develop national forest policies and promote development of the forestry sector through providing an opportunity for renewed forest harvesting with the acceptance (by CONATEF) of forest management plans. **Law 290 of 1985** (amended in 1988) attempted to further establish incentives for the forestry sector through granting various types of tax exemptions. **Decree No. 25 (1987)** required CONATEF to restrict charcoal production to demarcated and designated commercial firewood and charcoal zones. The net effect of these laws has been to effectively render all cutting of trees illegal, except in areas with accepted forest management plans and in designated charcoal areas with strict permitting (Reynoso, et al., 1988).

A new effort is underway, spear-headed by CONATEF, to compile and revise the forestry legislation in order to correct some of the weaknesses of the current framework. A basic outline of the new framework has been developed and is beginning to undergo public exposure and discussion (CONATEF, 1991).

2.3.2 National Park Legislation

Law No. 67 of 1974 created the Directorate of National Parks (DNP), an autonomous institution responsible for developing, managing, regulating and protecting a system of parks and reserves to preserve and perpetuate the country's natural and human heritage. The law requires that these areas possess national importance because of their scientific, cultural, scenic, historical, prehistoric, archeological and/or indigenous value, or have a great potential to furnish open-air recreational opportunities to a large number of visitors (Reynoso, et al., 1988).

2.3.3 Legislation for Coastal Areas and Marine Resources

Law No. 3342 of 1952 first defined the country's territorial waters, establishing a territorial limit of three nautical miles from the coast. The Navy (MGD) has the power to control any water and coastal activity up to 500 meters from the maximum high tide according to **Law 3003** (Reynoso, et al., 1988).

Law No. 5914 of 1962 first attempted to regulate fishing, assigning responsibility to the Department of Fishery Resources (DRP/SEA). **Decree No. 303 of 1987** specifically protects mangrove areas, but considers them forests and empowers their management to the DGF and the Wildlife Division of the SEA. Several other decrees and resolutions regulate fishing seasons and establish control over other activities that effect coastlines and fisheries such as export licenses and grant permits to construct structures in coastal

zones. Construction permits are to require environmental impact assessments for all coastal development projects, however compliance with this requirement is frequently nominal or circumvented altogether (Reynoso, et al., 1988).

2.4 Government Institutions Responsible for the Protection and Management of Water Resources

2.4.1 Agencies Responsible for Water Resources

a. **The Secretary of State of Public Health and Social Assistance (SESPAS)** is charged with the application of the Public Health Code (**Law No. 4471**), and as such is legally responsible for setting drinking water standards and monitoring compliance with these standards. SESPAS plays an important role in water supply and sewage disposal programs in fringe urban areas and small rural communities, and presides over the Administrative Counsel of INAPA (República Dominicana, 1991).

b. **The National Institute of Potable Water and Sewerage (INAPA)** is an autonomous institution of the state principally responsible for water supply and sewerage as per **Law No. 5994**. Their fundamental role is the study, design, planning, coordination, construction, supervision, administration, commercialization, operation, and maintenance of water supply, treatment, and sewage and stormwater disposal services in urban and rural areas. Except for Santo Domingo, Santiago and surrounding areas of influence, the entire country is under INAPA's jurisdiction (República Dominicana, 1991).

c. **The Corporation of Aqueducts and Sewerage of Santo Domingo (CAASD)** is an autonomous state organization created by **Law No. 498 in 1973**, analogous to INAPA and with the same functions, i.e. the construction, administration, operation, and maintenance of water supply and sewerage systems. The jurisdiction of CAASD, however, is solely the city of Santo Domingo and various populations in its area of influence (República Dominicana, 1991).

d. **The Corporation of Aqueducts and Sewerage of Santiago (CORAASAN)** is an autonomous state organization created by **Law No. 582 of 1977**, analogous to INAPA and with the same functions, i.e. the construction, administration, operation, and maintenance of water supply and sewerage systems. The jurisdiction of CORAASAN is solely the city of Santiago, the second largest city in the country (República Dominicana, 1991).

e. **The National Institute of Water Resources (INDRHI)** was charged by **Law No. 6 of 1965** to organize, direct, and regulate the exploitation of water supplies in cooperation with the Corporation of Industrial Promotion, the Dominican Electrical Corporation, and INAPA. Through its eight departments, Planning, Finance-Administration, Hydrology, Pipe-line Projects, On-going Projects, Small Dams, Supervision, and Irrigation Districts, INDRHI is responsible for the development and conservation of water resources. This includes the study, projection and construction of all major hydraulic, storage and energetic works, watershed conservation, and assessment and management of water resources, including rivers, lakes, springs, and lagoons (República Dominicana, 1991).

f. **The Dominican Electric Corporation (CDE)** is in charge of the production, transportation, and distribution of electric energy, and the development with INDRHI of hydroelectric sources. Its relative autonomy and financial independence give it comparative advantages to other agencies in the Dominican public sector (República Dominicana, 1991).

g. The **Navy** has a part in the maintenance of many of the wind mills (pumping well water) installed in the country (República Dominicana, 1991).

2.4.2 Agencies Responsible for Pollution Control

SESPAS has a responsibility for the overall quality of water as it affects public health. **INAPA, CAASD, and CORAASAN** share in this responsibility as far as the provision of potable drinking water and the disposal of sewage waste and storm water run-off is concerned. As industrial wastes can affect drinking water supplies and are sometimes discharged into sewerage systems (where they exist), these organizations also have a concern in pollution from this sector (Castillo, n.d.).

Various laws and decrees through the years have apparently given responsibility for the regulation of pollution from the industrial sector to various government bodies created by them. The first was **Law 4471 (1956)** which created **SESPAS** and gave them the legal authority to inspect the dumping of noxious wastes and order the problem corrected. **Law 5852 of 1962** gives **INDRHI** the legal authority to inspect industrial installations and order corrections and/or shut-downs if activities are degrading water resources. **Law 5914 also of 1962** prohibits industries from dumping substances harmful to fish populations, and gives the **Department of Fishery Resources (DRP/SEA)** responsibility for these fishery resources (Castillo, n.d.).

As the problem of industrial pollution had reached acute stages in some areas in spite of past legislation, a recent decree, **No. 226 of 1990**, created a new **National Commission of Ecological Sanitation**, which was charged with the establishment of pollution standards and their enforcement. This Commission has followed the directions outlined in past legislation i.e., the analysis of pollution on a case by case basis, the ordering of the installation of pollution control equipment if warranted, and the occasional shut-down of industrial operations if the company had not complied within the six-month compliance period. The Commission has concentrated on private rather than state owned industries, with some Commission members establishing companies for the installation of pollution control equipment (**Decree No. 226**).

2.4.3 Agencies Responsible for Forest and Park Resources

a. **General Directorate of Forests (DGF)** was created by Law No. 5856 (1962) initially under the SEA, but was transferred to the Dominican Air Force six years later by **Law 206**. The functions of the DGF include (1) inventory, demarcation, management and surveillance of forest resources, particularly public forest lands; (2) forest research; (3) sale of forest products and reforestation; (4) organization of the national registry of forest property; and (5) national forest planning (Reynoso et al., 1988).

Since the creation of CONATEF (below), the DGF shares with them the power of approval for the felling, extraction, and transportation of all forest products. The DGF shares primary responsibility for soil conservation and reforestation programs with the SEA's Subsecretary of Natural Resources (SURENA). To date, SEA has undertaken most activities in reforestation and protection of watersheds above major hydroelectric and water supply dams. Shortage of funds has been a problem in satisfactory completion and follow-through of these activities as large dam projects in the Dominican Republic have rarely included components and funding for reforestation and conservation of watersheds above these dams (Reynoso et al., 1988).

b. **National Technical Forestry Commission (CONATEF)** was created by **Law 705 (1982)** to develop and implement national forestry policies and advise the President. **Regulation No. 658 (1986)** expanded its functions to include oversight functions of forestry development and preservation, including (1) review of all private forest management plans and projects and (2) annual review of public institution work plans to assure compliance with national forestry policies. With the creation of CONATEF, policy making and executive functions were split, with the DGF retaining executive functions (Reynoso et al., 1988).

c. **National Parks Directorate (DNP)** was established in 1974 under the office of the Administrative Secretary of the President to manage the country's National Parks. As with most public agencies, the lion's share of the budget goes for salaries, with little remaining for the actual protection, management, and improvement of national parks and scientific reserves (Reynoso, et al., 1988).

2.4.4 Agencies Responsible for Marine and Coastal Resources

a. **Department of Fishery Resources (DRP/SEA)** was legally created in 1962 by **Law 5914**, although it existed as a section of the Secretary of Agriculture since the 1950s. It initially managed an aquaculture station built by FAO and later began a program to introduce exotic fishes. Today, the main functions of the DRP/SEA are (1) the collection of fish-catch statistics, (2) the granting of permits for aquaculture and freshwater fishing, as well as the import and export of fish products and the policing of these activities (together with the MGD and INDRHI), (3) the provision of aquaculture extension services, and (4) the provision of technical information on fisheries. The Department is composed of five units: the Aquaculture Division, the Fisheries Division, the Division of Interior Waters, the Technical Information Division, and the Statistics Unit (Reynoso et al., 1988 and personal communication - see Appendix 6).

b. The **Dominican Navy (MGD)** dominates the management of ocean fisheries because of its policing powers, and its established network of boats and command posts. It was also the main actor in recent containment and clean up activities associated with the shipwreck of boats with large oil supplies. It has also been a key participant in the development of the National Contingency Plan for Oil Spills, a major concern for the Dominican Republic due to its location next to major shipping lanes (Reynoso et al., 1988, and Garcia, personal communication).

c. The **Center for Research in Marine Biology** of the Autonomous University of Santo Domingo **(CIBIMA/UASD)** has been carrying out marine and coastal zone research in the entire country for the last 25 years, and publishes studies in a folio of reprints for each year. It also carries out activities in teaching and extension. Studies have included inventories of marine flora and fauna, biology of aquatic fauna, the ecology of aquatic ecosystems, fishery potentials, aquaculture, water quality, and hydrological, geological, paleontological, and oceanographic studies. Extension has included consultations, collaboration with the public sector, and the development of courses, seminars, and conferences in the ecology and management of marine resources, aquaculture and interior fisheries, and pesticide pollution (Reynoso et al., 1988 and I.Bennelly and V. Alvarez, personal communication).

2.5 Non-Government Agencies (Directly or Indirectly) Involved in Efforts to Conserve Water Resources

The non-governmental agencies involved in efforts to conserve water or coastal resources can be divided into two basic camps: (1) those with a community development or socioeconomic orientation involved in water issues indirectly through water development (provision of potable water supply or irrigation) or forestry activities (reforestation, forestry development, watershed protection, substitution of agroforestry for slash-and-burn) and (2) those with a biological conservation orientation involved in water or coastal issues through promotion of ecologically sound development and park protection (most biological parks are in coastal zones or upper watersheds). To the knowledge of these authors, no non-governmental organization in the Dominican Republic works exclusively in water policy, conservation or pollution issues. Those organizations considered most pertinent to this study are described on the following pages (McCaffrey, 1989 and C. Bonilla and P. Quinn, personal communication).

2.5.1 Community/Forestry Development NGOs

- **Asociación para el Desarrollo de San José de Ocoa, Inc.** is an autonomous organization established in 1968 with a Board of Directors composed of both private and public sector representatives, and funded from both international, private and government (Technical Secretariat of the Presidency) sources. Its specialty is the organization of rural inhabitants for community projects through the development or strengthening of local committees composed of local community leaders. The objective is to achieve local autonomy and self-sufficiency, and it is considered reached when involvement of the Asociación in community development is no longer required. Of the 17 communities with which the Asociación has been involved, 4 have now built their own aqueducts. Activities have been concentrated in the upper watersheds of the Nizao and Ocoa rivers, and include small scale irrigation development, watershed protection, reforestation; production of timber and fruit trees, housing, education and health activities, and construction of feeder roads. Their basic premise is that the farmer can work wonders when given alternatives and constructive channels for their energy.

- **Floresta, Inc.** was established in 1984 with a private sector Board of Directors and an Executive Director. Activities emphasize assistance for the development of agroforestry (as an alternative to slash-and-burn) to communities and small farmers willing to participate in the program. The agroforestry system developed includes the use of trees for poles, citrus fruit trees, and spices. Assistance also includes product preparation (e.g., drying of spices), marketing (to international buyers), and legal assistance to obtain land security. Funding includes donations from the Dominican Republic government

(Technical Secretariat of the Presidency), from Floresta, Inc. USA (with whom they maintain close ties), and from USAID/DR (monies for a revolving fund for loans for agroforestry development). Activities have concentrated in rural areas of Villa Altagracia (McCaffrey, 1989 and Garcia, personal communication).

- **Plan Sierra, Inc.** was established in 1979 with a Board of Directors composed of public and private sector representatives, and whose President is President of the Dominican Republic. Activities include integrated rural development, technical forest management, seedling and wood production, agroforestry promotion and research in the 2,000-square-kilometer area of the Municipio de San José de las Matas on the north side of the Central Mountain Range covering the Yaque del Norte and Bao river watersheds. Their budget is large (approximately RD$6 million). They do receive revenues from the sale of forest and agricultural products, but operations are subsidized with large international donations and fixed monthly appropriations from the GODR (McCaffrey, 1989 and personal communication).

- **Progressio (Fundación para el Mejoramiento Humano)** was legally incorporated in 1983 with a private sector Board of Directors and an Executive Secretary. Early activities concentrated on the production and distribution of free tree seedlings to small hillside farmers. (It distributed about 4 million seedlings between 1984 and 1988.) They are now trying to concentrate on more comprehensive watershed planning and management, including land use, soil conservation, and agroforestry concerns with the promotion of reforestation with trees for multiple uses. In this regard, they are now preparing a management plan for the upper and mid watersheds of the Rio Camu. The most important contribution of PROGRESSIO has probably been in public education and the heightening of awareness of the deforestation problem. The foundation receives donations from various private and international sources (McCaffrey, 1989 and F. Dominguez, personal communication).

2.5.2 Environmental NGOs

- **Federación Dominicana de Asociaciones Ecologistas (FEDOMASEC)** was incorporated in early 1989 and is composed of nearly 40 ecological associations and conservation groups from all over the country. The Federation has four primary goals: (1) to promote the conservation, preservation, study, and sustainable development of natural resources primarily through environmental education and the publicizing of environmental transgressions, (2) to bring together groups dedicated to the study and preservation of natural resources, (3) to promote the formation, training, and growth of new groups, and (4) to collaborate and support governmental agencies and programs related to the sustainable management of natural resources and the creation of a national

conservation strategy. The majority of the members of FEDOMASEC are volunteers, and many participate in various environmental protection campaigns including reforestation, construction of more efficient stoves, soil conservation, and the clean-up of rivers or beaches. The World Wildlife Fund is assists in the funding and execution of several environmental education programs in local communities (Lopez et al., 1991 and H. Lopez, personal communication).

- **Fondo Pro Naturaleza (PRONATURA)** is a non-profit organization established in early 1990 whose main objective is the conservation and sustainable development of the renewable natural resources and biological diversity of the country. Although individual persons may join, PRONATURA is not so much an association of individuals, but rather an "umbrella" organization of private and public associations working in the field of natural resources. Founding members include FEDOMASEC, Floresta, Progressio, Plan Sierra, Asociación para el Desarrollo de San Jose de Ocoa, Mujeres en Desarrollo, Direccion Nacional de Parques, Universidad Nacional Pedro Henriquez Ureña, and the Instituto Superior de Agricultura. PRONATURA works chiefly through the provision of institutional and financial support for projects or activities of its members. It also works largely through committees comprised of individuals and institutions that are not necessarily members of PRONATURA. One of its chief accomplishments has been the establishment of a Subprogram of Debt for Nature within the Central Bank with an initial quota of $80 million. PRONATURA is now trying to develop a project to inventory coastal zones (PRONATURA literature and D. Marte, personal communication).

- **Foundation for Science and Art, Inc.** is active in the promotion of natural resource conservation through the development of national seminars, the publication of seminar proceedings and contributions, and research and publication of various pamphlets, books, and a magazine dedicated to environmental, among other, matters (Seulle and Boin, personal communication).

2.6 Activities by International Organizations

Except in the sense of the development of water resources for irrigation, energy, or potable water supplies, the conservation or protection of water resources has not historically been a primary emphasis of international organizations. The most important international activities to date with some relation to water and coastal zones include:

1) Inventory of the country's natural resources by the OAS in 1967.
2) Inventory of the country's forest by the FAO in 1970. (Most later studies still depend on the data collected in these inventories.)
3) Environmental profile of the Dominican Republic by A.I.D. in 1980.

4) A Natural Resources Management Project by A.I.D./GODR in 1983/84 which updated the country's aerial photo base, developed resource inventories of seven watersheds and two forest zones, drafted a National Forestry Management Plan, and implemented watershed management in Ocoa and Nizao watersheds.
5) Plan Nacional de Investigación, Aprovechamiento y Control de Aguas Subterráneas by IDB in 1983.
6) Biological diversity assessment by A.I.D. in 1988 promoting park protection in upper watersheds and coastal zones.
7) On Farm Water Management Project, research to conserve water and increase efficient water use.
8) Tropical Forestry Action Plan by FAO in 1991.

International interest has grown in recent years in watershed management, and pollution monitoring and control (both industrial and domestic wastes). Ongoing or projected international activities involving water supplies, watersheds, and/or coastal zones, or impacting the same, include:

- An analysis of contamination in the Rio Ozama by the French in 1991. This diagnostic contains a proposal for a major, capital-intensive project to solve sewage disposal problems in Santo Domingo.
- The French are planning a project to develop an International Convention Center on the San-Souci beach of Santo Domingo, and tourist developments at Casa de Campo, Marina Puerto Chiquito (Sosua) and Marina de Barahona.
- A feasibility study for an irrigation project (RD$109 million) in the Constanza Valley was just completed by the Japanese in 1990.
- A feasibility study for groundwater development in the western region of the Dominican Republic is underway by the Japanese.
- A feasibility study is underway by the IDB to restore, manage, and protect the Rio Bao watershed.
- The IDB is developing a project ($50 million), Agricultural Development of the San Juan Valley, to include watershed protection for the Sabaneta dam.
- The IDB is disbursing a loan to the Central Bank for sub-loans to developers for tourism development. This was preceded by an extensive study to develop a national plan for tourism development; there is no mechanism for environmental review of sub-loans.
- The GTZ has had a water resources project with INDRHI since 1986, which has concentrated on institution strengthening and the development of a data base and measurement stations for data collection on rainfall and groundwater flow rates of rivers.

- The GTZ has been integrally involved in rural development in San José de Ocoa with the Development Association there; assisting with institution strengthening and the development of the FIRENA program.
- The GTZ has a project in fisheries development that also includes a scientific research component; they propose to conduct an inventory of fisheries on the south coast.
- GTZ has conducted preliminary studies as part of a proposal to conduct water quality monitoring for the four largest rivers, the Ozama, the Yaque del Sur and Yaque del Norte, and the Yuna.
- The Spanish have been working with the Directorate of National Parks, and are studying, preparing/updating and beginning to implement management plans for Los Haitises and the National Park of the East; and are planning a study of Monte Cristi.
- The Spanish have recently initiated a study of the Rio Nigua watershed, hydrology, and the activities which have an impact there upon.
- The Spanish are planning a study of biological contamination of four river systems (Isabela, Ozama, Yaque del Norte, and the Yuna).
- The OAS has been studying with INDRHI the hydrology of the Artibonito watershed and the preliminary feasibility of various water development projects.
- The OAS has just prepared a proposal together with INDRHI to conduct a comprehensive study of water resources and prepare a national management plan.

Further detail can be found in Appendix 3.

3.0 INVENTORY OF RESOURCES

3.1 Climate

The climate of the Dominican Republic is primarily determined by its location in a tropical area with trade winds, and by orographic effects. The variations over the year in temperature, sunshine hours, and relative humidity are small compared to the variations in individual days.

The temperature is tropical and predominantly maritime, so seasonal variations of temperature are small. Although reduced by the nearness of the ocean, the diurnal temperature range exceeds the annual temperature range. The seasonal variations in humidity are small with moisture remaining high all year due to strong ocean influences on the climate of the West Indies.

The rate of rainfall for the country is 1,400 mm/year, varying between 2,000 mm/year on the Atlantic coast, due to the orographic effect caused by the trade winds over the Central mountain range, and 800 mm/year in the northwestern and southwestern regions (leeward of the range). This translates into an average runoff volume of 19,074 million cubic meters/year, of which 1,500 million cubic meters is absorbed to recharge groundwater.

Although the West Indies are practically always under the influence of maritime air masses, the local and partly seasonal variations of precipitation are surprisingly high. As far as rainfall totals are concerned, most can easily be attributed to orographic effects.

The rainy season generally extends from May to November, and dry season from December to April. The Dominican Republic lies within the hurricane belt with tropical storms constituting a major weather hazard. Extreme precipitation events are caused by hurricanes (tropical cyclones) and intensive thunderstorms. For that reason, the island is affected by hurricanes.

The trade winds in combination with sea breezes are the predominant winds. The trade winds and breezes are usually light to moderate in speed. Wind speeds of storm strength are usually associated with cold fronts or tropical storms.

3.2 Water Resources

According to PLANIACAS 1983, the ground-water potential of the Dominican Republic has been estimated at 1,500 million m^3 annually which recharges the three most important aquifers of the Dominican Republic. Most of that groundwater runs throughout the tertiary limestone. Groundwater quality is good except in some coastal areas where saline intrusion has taken place. There are also groundwater salinity problems in the Neyba Valley due to low-lying land. Other areas such as the Northwestern region (Valverde Mao, Santiago Rodriguez, Laguna Salada) present some problem in the water quality for use in irrigation.

There are more than 5,000 wells in the country. It is estimated that more than 250 million cubic meters of groundwater is currently extracted annually, or 25 percent of capacity. Approximately 50 percent of the wells have a discharge of less than 80 liters per minute and 30 percent have depths of less than 25 meters; the deepest wells hardly exceed 200 meters.

Taking into account the remaining groundwater availability, more than 75 percent of the total capacity, the groundwater resources may play an increasing role in meeting water needs, particularly for irrigation. Groundwater resources currently contribute greatly to meet important demands in the domestic and industrial sectors.

This low rate of use has historically been due to the abundance of surface waters, lack of electricity, and the high cost of making some supplies potable because of the hardness levels. The cost of removing dissolved salts (mainly calcium and magnesium salts) is too high compared to regular treatment of surface or ground water in order to achieve an acceptable hardness level (less than 150 ppm).

The Dominican Government has targeted the south region for water development interventions. The region includes the Neyba Valley with a volume of water available from 210 to 250 million m^3 per year and the zone of Barahona-Sierra Bahoruco with an estimated 165 to 210 million m^3 per year available. The government is also targeting the Planicie Costera Oriental in which available groundwater is estimated at around 350 million m^3 per year.

PLANIACAS has estimated that the Dominican Republic can access available water (surface water and groundwater) in order to cover the water demand by the year 2000. The estimated demand will approach 4,900 million m^3.

Table 1. Water Demand Versus Estimated Hydrological Potential for the Dominican Republic (in millions of m^3)

Regions	Water Demand		Estimated Water surface	Hydrologic Potential Groundwater
	1980	2000		
Yaque del Norte	870	1,608	3,440	45
San Juan	157	276	1,360	50
Yaque del Sur	381	576	1,060	565
Azua	182	408	125	75
Yuma-Camu	570	1,146	2,470	225
Ozama-Nizao	332	851	3,240	550
TOTAL	2,492	4,865	11,695	1,510

3.2.1 **Rivers**

The Central cordillera is the highest mountain range in the Antilles, and from it originates four of the more important rivers of the Dominican Republic; the Yaque del Norte, the Yuna, the Yaque del Sur and the Artibonito.

The Yaque del Norte has a length of 296 kilometers and drains a watershed of 7044 Km^2, about 15 percent of the country. The average annual flow is about 64 m^3/sec. This river system contains the largest irrigation network in the country and has great hydroelectric potential, only part of which is being used at this moment. One of the main problems with this river system is the high sediment load eroded from seriously deteriorated, steep watersheds.

The Yuna river with a length of 209 km, is the second largest in the Dominican Republic. It has a watershed of 5498 km^2 and discharges into Samana Bay. The average annual flow at the Villa Riva is about 91 m^3/sec. It experiences cyclic floods every two or three years. It carries very high silt loads that obstruct the existing irrigation systems.

The Yaque del Sur river with a length of 183 km begins on the highest part of the southern flank of the Central cordilleran. It drains a watershed of 4972 km^2. It discharges into the Neyba Bay close to Barahona. The river runs primarily through an arid and semiarid region with precipitation of less than 1,200 mm/year.

On the western flank of the Central Cordilleran also runs the Artibonito river which is the boundary with Haiti. This river is the longest of the Hispaniola Island at 321 km. Its watershed is the biggest, with 9,013 km^2.

3.2.2 **Description of Dominican Watersheds**

Based on the hydrographic division of the country (OAS, 1967), illustrated and described in the "Perfil Ambiental de la República Dominicana" (Hartshorn et al., 1981), 14 hydrographic regions can be identified:

1. Región del Río Yaque del Norte
2. Región de los Ríos Masacre y Chacuey (Dajabón)
3. Región del Río Artibonito (Occidente)
4. Región del Lago Enriquillo
5. Región de Pedernales (Extremo Suroeste)
6. Región del Río Yaque del Sur
7. Región de los ríos Ocoa y Nizao (Sur)
8. Región de la Costa Norte (Puerto Plata)
9. Región del Río Yuna
10. Región de los Ríos Haina y Ozama (Distrito Nacional)
11. Región de la Península de Samaná
12. Región de la Costa Noreste (Bahía de Samaná)
13. Región de San Pedro de Macorís y La Romana
14. Región de Altagracia (Extremo Oriental)

In general, the most important watersheds based on production potential, integrated development, and population density, originate in the Central mountain range. Soil loss within the hydrographic system has been calculated for the principal watersheds. The following data were adapted from Hartshorn et al., (1981).

Table 2. Sub-Watersheds and Soil Erosion

Watershed	Area (km^2)	% of the Country Area	Erosion (tons/ha/yr)
Las Cuevas	569	1.1	275
Taveras	737	1.5	275
Bao	933	1.9	346
Nizao	992	2.0	125
Ocoa	563	1.1	507
Maguaca	172	0.4	294
Guayubin	734	1.5	111
Chacuey	386	0.8	95

The data for these watersheds indicate that accelerated erosion is depositing millions of tons of sediment into the country's river systems. The data show soil loss ranging from 95 tons/ha/yr in the Chacuey watershed to a maximum in the Ocoa watershed of 507 tons/ha/yr. Deforestation and indiscriminate hillside farming using primitive techniques has led to erosion in the watersheds of the Dominican Republic. Basic factors leading to such destructive soil utilization are increased population pressure, low education levels in rural areas, acute food and shelter needs, and the lack of an appropriate technology to maximize soil productivity. (see Appendix 4, Other Issues of Relevance to the Study.)

3.2.3 **Continental Fishing**

Statistics show artisanal fishing in continental waters to have increased in recent years, mostly because of the construction of dams and of the promotion of fishery activities among farmers. Exotic species such as tilapia, carp, and lobinas have been stocked in many lakes and lagoons; many artisan fishermen depend on these resources for their own sustenance, as well as for the local market.

3.3 Soils

The Dominican Republic has a great variability of soils. The best soils of the country can be found on Cibao (north region) and San Juan (southwest region). According to the Ramirez (1985) most of the soils in Dominican Republic are inceptisols (58 percent). Aridisols are the second most common with 11.6 percent. These soils can be found mainly in the south part of the Dominican Republic (Azua, Neyba, Barahona), and also on the northwest (Monte Cristi, Santiago Rodriguez, Mao). Within these two regions are found some saline soils. Entisols soils are mainly located in mountain areas and also in river basins constituting ten percent of the soils. Saline soils are not easily irrigated without problems of salinization unless they are heavily flushed, which can in-turn raise water tables, increase salinity of surface waters, or increase risks of erosion. The well developed soils, such as ultisols and some oxisols cover close to nine percent of the Dominican Republic. Vertisols and molisols represent four and three percent respectively. Histosol soils are less than one percent of the surface area.

3.4 Forests

Forest land comprises most of the country. According to an inventory compiled by DIRENA using 1983-1984 aerial photographs, approximately 13,800 km^2 of the national territory was covered in forests, 6.1 percent Coniferae (2,950 km^2), 6.01 percent Latifoliate species (2,893 km^2), and 16.7 percent dry forest (8,055 km^2). Additionally, 2.5 percent (1,202 km^2) were lands that should be used only for water production, wildlife, and conservation.

Despite efforts by the government to halt the cutting of trees and reduce the energy dependence on firewood and charcoal, deforestation continues unabated with resulting destruction of vital watersheds. The FAO Tropical Forestry Action estimated that the annual rate of deforestation in the Dominican Republic was 80 square kilometers. FAO studies estimated declines of 30 percent in the primeval forest and 70 percent in the pine and mixed pine broad leaved forest cover. Estimated decline in humid and subhumid broad-leaved forests are 86 percent and 69 percent.

3.5 Agricultural Lands

According to the OAS study (1967) using the Land Capability Classification, 12.6 percent (6,009 km^2) of the land is suitable for cultivation. Most of the prime land for agricultural use is found in the Cibao Valley and is devoted to sugarcane production. Marginal crop lands (Class IV) comprise 7.7 per cent of the country (3,639 km^2).

3.5.1 Farming Frontier Advance

Although there is no precise data on the recent rate of the advancement of the agricultural frontier in the Dominican Republic, available statistics indicate a decrease in forest cover from 69 percent in 1940 to 26 percent in 1967. Thus, changes in land use over the past 27 years has produced a decrease in forest cover by a total of two million hectares, or 76,000 hectares per year (Hartshorn, et al., 1981). Since deforestation rates are higher than reforestation rates, it is safe to infer that a high percentage of the deforested land is being devoted to agricultural production.

3.5.2 Shifting Agriculture

Shifting agriculture is intimately related to the advancement of the farming frontier. There are no statistics on its actual size, but it is considered to be the initial stage of the conversion of forest areas to subsistence agriculture, then to pasture, with great negative impact on availability of natural resources which can negatively impact the ability of rural populations to support themselves.

3.6 Rangelands

Almost one quarter of the country has the potential for pasture. A total of 11,682 km^2 have been classified as sustainable for rangelands. From this total, 5,611 km^2 are lands with erosion hazards, and for this reason its usage is limited. Permanent plantation usage is the best case scenario.

Cattle production is practiced to varying degrees of intensity in fenced ranches throughout the country. In the north an southwest, particularly in dry forests, goats and cows graze freely on public and private lands, frequently overgrazing and causing forest degradation.

3.6.1 Rangeland and Pasture/Cattle Production Zones

Six areas with important livestock activity were recognized:

Eastern Flatlands

This area is concentrated around Monte Plata, Bayaguana, Hato Mayor, El Seibo, San Pedro de Macorís, La Romana and Higuey. Most of this area is classified as Subtropical Moist Forest, with an annual precipitation of 1200-1400 mm per year. Dominant soils are inceptisoles and entisoles with low to gentle slopes.

Northeastern Coastal Zone

This zone includes coastal flatlands, hills, and areas with steep slopes along the northeastern coast from Laguna Nisibón to Sabana de la Mar. Most of the area is classified as Subtropical Wet Forest with an average precipitation of 1,600-2,200 mm per year. The soils of the flat coastal areas belong to the ASDS 02C (MARENA, 1987) characterized by gentle slopes, deep, and moderately drained. Many of these areas were wetlands or mangroves that have been converted to improved pastures. Soils from hills and steeper areas are usually Utisols. They are commonly used as native pastures, and some of them have trees and shrubs in different successional stages.

Northern Coastal Zone

This zone is similar to the Northeastern Coast, and extends from Nagua to El Papayo. Important activity occurs in Gaspar Hernandez, Maria Trinidad Sanchez and Rio San Juan. The area is similar to the Northeastern Coast because it includes coastal areas with gentle slopes, hills and broken areas. However, the zone is a little dryer, mostly a Subtropical Moist Forest, with a small wetter area around Nagua.

Central Cibao Zone

This is a diverse zone located in areas around Santiago, San Francisco de Macorí, La Vega, Moca, and Cotuí. Even though diverse, the area is generally characterized by low to gentle slopes, good soils, and good precipitation.

Northwest Line

This zone is located in the northwestern part of the country in areas near Monte Cristi, Dajabon, Santiago Rodriguez and Mao. It is a dryer area where natural vegetation is mostly Subtropical Dry Forest with average precipitation of 700-1,000mm. Small areas of Subtropical Moist Forest with average annual precipitation of 1,000-1,200mm are also included in this zone. Soils in this area are Entisols, Inceptisols, and Aridisols. The area used includes flat areas as well as hills and steeper slopes. It is important to mention that because this area is dryer it is a more fragile ecosystem that can be degraded quicker.

Southern and Southwestern Zone

This zone includes the areas of San Cristobal, Baní, Azua, and San Juan.

3.7 Parks and Protected Areas

The Government, through the Direccion Nacional de Parques (DNP), has created a network of six Scientific Reserves, 12 National Parks, two Wildlife Sanctuaries and one scenic highway which form the system of protected areas. They represent approximately 13.6 percent of total land mass. According to the Biological Diversity Assessment, the devastation of natural habitats for agriculture, livestock and charcoal production is the major factor causing the elimination of the flora and fauna.

There are no rivers or lakes especially protected in the country; nevertheless, Enriquillo stands out among the lakes due to its unique hydrological and geological characteristics, and the fact that it has at its center the National Park of Isla Cabritos. Surface water resources within the national parks and scientific reserves receive protection, though activities in the buffer zones, and sometimes in the parks themselves, may have a negative impact.

3.8 Endangered Species

According to the latest inventory, La Diversidad Biologica en la Republica Dominicana, (1990), 89 species and subspecies of fishes, reptiles, birds and mammals are considered threatened. 15 species are endangered, 37 vulnerable, 13 rare and 24 are still undefined. Thirty nine threatened species need special attention: two fishes, 13 reptiles, 21 birds and three mammals. In the Dominican Republic 14 threatened species do not live within protected areas: 13 reptiles and one bird (Burhinus bistriatus).

4.0 INVENTORY OF COASTAL RESOURCES

4.1 Mangroves

4.1.1 General Characteristics

Mangroves are salt-tolerant, woody, seed-bearing plants that range in size from small shrubs to tall trees depending on site conditions and availability of nutrients. Most commonly, they thrive along sheltered, intertidal coastlines on saline sediments that are often acidic and anaerobic. There are three common mangrove species: (1) red mangroves; characterized by prop root formations that resemble "long spider-like legs", (2) black mangroves; characterized by pneumatophores (pencil-like upright roots that protrude from the soil surface) and, (3) white mangroves. Zonation in mangroves, probably the result of soil salinities, often follows the pattern where red mangroves are most seaward, black mangroves are intermediate between the open water and uplands, and white mangroves are along the upland edge of the mangrove community.

There are three major factors that limit the distribution of mangroves in the Dominican Republic: (1) salt water, (2) tidal fluctuation, and (3) substrate and wave energy. While salt water is not a requirement, in fact mangroves grow quite well in freshwater, it reduces competition from other vascular plants. Freshwater from terrestrial runoff is an important input to prevent soil salinities from reaching hypersaline conditions that excludes even mangroves.

Tidal fluctuation plays an indirect role in increasing mangrove productivity and distribution by carrying nutrients, dispersing propagules, and maintaining lower salinities in areas of high evapotranspiration rates. Mangroves grow best in environments where wave energy is low. High wave energy prevents establishment of propagules and can erode away sediments and destroy mangrove root systems.

The importance of the mangrove community is three fold: (1) food chain support, (2) shore line stabilization, and (3) water quality enhancement. Leaf litter and detritus produced by mangroves is exported during tidal cycles, and in conjunction with large rainfall events, to the nearshore marine environment. Microbial breakdown enriches the detrital particles becoming a nutritious food resource for a variety of marine organisms. Where storm surge tides are common, mangroves provide a stabilizing influence to shorelines and in river deltas. The mangrove-dominated banks are less likely to erode than river banks having no vegetation. Mangroves extract nutrients from circulating waters and their anoxic soils have the ability to sequester some toxins and metals. As a result,

they have an important function in the maintenance of water quality in the nearshore marine environment.

4.1.2 **Distribution**

Figure A1 in Appendix 1 shows the distribution of mangrove communities in the Dominican Republic. The location and land area of mangrove communities were taken from 1:50,000 topographic maps of the coastline. The northern coast has the largest area of mangrove totaling more than 18,000 hectares. The largest concentrations are found at Monte Cristi (1,550 hectares) and Bahia de Samana (three stands of 7,783 ha, 1,326 ha, and 1,208 ha plus numerous smaller stands). By far, the largest and most robust single stand is the 7,783 hectare stand at the mouth of the Rio Yuna, where trees appear to be greater than 15 meters tall. The mangroves at the mouth of the Rio Yaque del Norte appear to offer more landscape heterogeneity and thus more and varied habitat potential.

The east and southeast shore have a total of 1,308 hectares of mangrove, 1,173 of which are within the Parque Nacional del Este. Most of the south coast has wave energies that are not conducive to mangrove communities, thus where they exist they are in protected estuarine areas and along the river banks upstream from their confluence with the Caribbean. There are a total of 647 hectares of mangrove on the south coast. The Praque Nacional Jaragua has a total of 2,471 hectares of mangrove in two stands, one just north of Laguna Oviedo and on the western shore surrounding several lagoons.

4.2 **Beaches and Dunes**

4.2.1 **Characteristics**

Beaches and dunes are not stable entities, being constantly subjected to forces that either erode them or add to them/deposit materials. Beaches and their landward dunes are dynamic and ever changing deposits of unconsolidated sediments that vary in size and character from rock fragments to fine grained sands. Beach forms vary depending on the slope of the nearshore coastal shelf, the composition of beach material, and the forces of tides and waves. In general beaches are in a dynamic equilibrium between erosional and depositional forces and any actions that change the balance of these forces can cause erosion and beach loss.

While not particularly biologically productive, beaches and their associated dunes support a large number of plant and animal species. Terrestrial sources of organic matter, and that deposited from open waters, often support a diverse array of filter feeding

consumers, which in turn are the basis for numerous coastal birds. Diatoms and phytoplankton are the main source of primary production within the waters, and where dunes are stable, they are colonized by numerous plant species that are adapted to the shifting nature of the environment.

4.2.2 Distribution

Figure A2 in Appendix 1 shows the location of most important beaches. By far the greatest concentrations of beaches are along the northern coast. Several good beaches are located along the northeastern shore. Beaches of the south coast are relatively scarce. There are several beaches of importance along the southwest coast south of Barahona: La Cienaga, San Rafael, Paraiso, Caleton and Enriquillo; although the wave energy of this coastline makes these beaches less attractive for tourism development.

4.3 Other Coastal Wetlands

4.3.1 Characteristics

Landward of the mangrove forests and beach and dune systems, where there is no slope or a slightly depressional landscape, drainage is poor, and there is sufficient rainfall, freshwater marshes often prevail. Dominated by sedges, shrubs and herbaceous plants, they are often very productive ecosystems providing important habitat for a variety of indigenous and migrating birds as well as herptofauna, reptiles and mammals.

Generally marsh wetlands are wet year round, but may dry out occasionally during the dryer times of the year. Hydrology, especially the period and depth of inundation is extremely important, dictating species composition. Marshes that remain wet year-round have the greatest populations of fish and invertebrates that form the basis for wading bird populations.

4.3.2 Distribution

Figure A3 in Appendix 1 shows the main areas of marsh wetlands in the coastal zone. The largest concentrations are (1) along the north coast stretching from Cabo Engaño at the eastern tip of the country to Sabana de la Mar, (2) the extensive wetland complex of the Rio Yuna flood plain has been converted to rice and cattle production, (3) at Bahia Escocesa between Cayo Jackson and the city of Nagua that are now in rice and cattle production, and (4) in the vicinity of Sabaneta de Yasica, also given over to agriculture.

4.4 Coral Reefs

4.4.1 General Characteristics

Coral reefs are considered one of the most diverse ecological communities and most important marine resources of the Caribbean. They grow along coastlines where waters are clear, clean and free of suspended sediments, excessive freshwater runoff and pollutants. Corals are particularly sensitive to pollution from either toxic origins (metals and chemical contaminants) or excessive nutrients.

Coral reefs are the basis for most of the coastal fisheries of the Dominican Republic. In addition, they often provide breakwaters which protect bays and estuaries and limit coastal erosion. The reefs and the beaches they protect are a substantial portion of the natural resource base upon which the Dominican Republic's growing tourist industry depends.

4.4.2 Distribution

Figure A4 in Appendix 1 shows the distribution of coral reefs along the coast of the Dominican Republic. The map of the distribution of reefs is based on 1:50000 quadrangle maps and a single flyover of the coast. No attempt was made to assess the general health of the reef communities.

Coral reefs can be found scattered along nearly the entire coastline of the Dominican Republic. In some areas where wave action and substrate limit coral production, the reefs resemble marine terraces or flats (sometimes referred to as coral escarpments) of lower diversity than the deep water reefs and those along more protected shorelines. Wherever turbidity is high, corals are less likely to flourish.

The north coast stretching from the tip of the Samana peninsula to Monte Cristi has the largest concentrations of coral reefs. The single largest concentration and most "pristine" reefs that were encountered during the flyover are located in the stretch of northwest coast from Punta Buren to Bahia de Icaquitos. In this area there were significant concentrations of fringing reefs, patch reefs, and near shore reef escarpments that appeared to be in excellent condition. There were other areas of good reef development, although of patchy distribution in the following areas: (1) near Cayo Jackson, Las Terrenas, and La Barbacoa on the north coast of the Samana Peninsula, (2) at la Ermita between Rio San Juan and Gaspar Hernandez, (3) the area around and west of Puerto Plata.

4.5 Seagrass Beds

4.5.1 General Characteristics

Seagrass beds are extremely productive near shore environments that provide a large quantity of food for grazers such as fish, green turtles, shrimp and crabs, and are nursery grounds for many commercial fish including snapper and grunt, and several invertebrates including conch and lobster. While the grasses themselves are productive, they also provide a substrate upon which rich communities of algae grow, increasing the nutritive value and grazing opportunities for many organisms.

Seagrasses are associated with coral reef communities because, like the corals, seagrasses require clear, shallow water; but unlike the corals they require a soft substrate. Rarely are seagrasses associated with coasts dominated by mangroves because the organic stained waters discharging from mangroves on the falling tide lowers water transparency. Seagrasses are sensitive to toxins, elevated temperatures from thermal discharges, and over enrichment that increase phytoplankton production and thus lowers light transmittance through the overlying water. Areas near large river discharges where turbidity is high, and where fresh water inflows may lower salinity of near coastal waters, are not conducive for seagrasses.

4.5.2 Distribution

Sea grasses are found throughout the marine waters of the Dominican Republic. In some areas they are extremely dense and cover as much as 80-90 percent of the available substrate. In others, they are very patchy and cover only 10-20 percent of the bottom. Percent cover in seagrass areas is related to exogenous impacts, like terrestrial sediment inputs, storm events, prevailing currents, and wave action. Figure A5 in Appendix 1 displays the distribution of seagrass beds in the Dominican Republic.

Seagrasses along the southwest coast of Parque Nacional del Este and in the straights between the main land and the island of Sanoa were estimated to cover about 30 percent of available substrate.

In the more protected areas of the east coast south of Cabo Engano, there were relatively dense growths of seagrasses, as well as along the northeast coast stretching from Cabo Engano to the scientific reserve at Laguna del Limon. There is potential seagrass habitat along the southern shore of Samana Bay, but water clarity on the day of the over flight was not sufficient to verify their presence.

Very dense growths of seagrass beds are intermingled with the fringing and patch reefs along the entire northern coast stretching from Cabrera to Monte Cristi.

There is evidence of extensive areas of sea grass beds in the southwest around Isla Beata (because it is reported as an important conch fishing grounds), although this was not confirmed during the flyover or site visit.

4.6 Marine Fisheries

4.6.1 General Characteristics

The marine fishery of the Dominican Republic is at an artisanal level. Current data on the size and composition of the fishing fleet were not available. Earlier estimates (INDOTEC, 1980) put the size of the fleet at about 1,400 boats dominated by (90 percent of the fleet) "cayucos" and "yolas" half of which were motorized. Estimates based on site visits to Bahia Ocoa, and the southeast coast, as well as the flyover of the entire coast, suggest that the fishery is still overwhelmingly dominated by the yolas type boats which measure from four-six meters in length.

Table A1 in Appendix 1 gives the tonnage of the fish catch by coastal province. The largest percentage of catch was shared by Puerto Plata (25.5 percent); where the majority of landed fish come from the offshore fishery at Banco Navidad and Banco Plata, Distrito Nacional (15.2 percent), Maria Trinidad Sanchez (10.4 percent), and La Altagracia (9.9 percent).

4.6.2 Distribution

Figure A6 in Appendix 1 shows the main near shore fisheries as determined by a map provided by PROMOSA and earlier work by Hartshorn et al. (1981). The off shore fishing areas (Banco Navidad and Banco Plata) are not included in the map, yet are extremely important.

4.7 Endangered and Threatened Species

4.7.1 General Characteristics

As in most cases throughout the world, the most important reason for declines in listed species populations (with the possible exception of sea turtles and the West Indian manatee) has been loss of habitat. Of the 14 listed endangered, coastal species (four of which are sea turtles), eight are birds. The critical habitats for the listed birds are primarily

coastal lagoons and wetlands, two habitats that have been under considerable pressure; and as noted above, coastal wetlands other than mangroves have suffered almost complete conversion to agricultural uses.

4.7.2 Distribution

Figure A7 in Appendix 1 shows possible distribution of endangered species as best as they can be determined using major concentrations of required habitat types as the key factor, and secondarily the earlier work of Hartshorn et al. (1981).

4.8 Parks and Protected Areas

4.8.1 General Characteristics

Some of the most important coastal resources in the Dominican Republic have been declared national parks and as such enjoy some measure of protection. The major factor influencing their protection is, unfortunately, not the result of a strong presence of park personnel, but their remote locations. A general description of each follows.

Parque Nacional del Este - The park is 434 km^2 of lowland broadleaf forest, mangrove swamps, beaches, and sea grassbeds. It contains a bio luminescent bay (Las Calderas), and the island of Saona. The lagoons on Saona are said to be habitat for the endangered flamingo. In addition, the white-crowned pigeon is said to nest there and the park is visited by manatee and provides nesting habitat for sea turtles.

Saona Island has a settlement (Mano Juan) of approximately 300 people who use the marine and nearby terrestrial resources. Increasingly tourists are using western beaches and making day trips to Mano Juan.

Parque Nacional Los Haitises - The 328 km^2 park located on Samana Bay contains outstanding landscape of carst topography, mangrove swamps. The vegetation is low-land broadleaf forest and mangrove. There are frigate bird and pelican nesting areas off-shore. There is invasion by agriculture in the southeastern and southwestern quadrants of the park, funded by GODR Agricultural Bank loans to youtia producers.

Parque Nacional Jaragua - A 1,400 km^2 park created in 1983 to protect the coastal and marine environment of the southwest. It contains 12 vegetation types including dry forests and mangrove swamps, several lagoons and Isla Beata. The park is an area of high biological diversity and endemism containing 400 plant species, 130 bird species, and 54 reptile species. It contains important turtle nesting beaches and conch beds.

Pressure along the northern border of the park from Oviedo is reported to be quite high, with conflicts over wood cutting, trapping of crabs, and collection of turtle eggs.

Parque Nacional Monte Cristi - A 550 km^2 marine park, created in 1987 to protect the marine resources of the northwest coast. The park contains three principle ecological community types, mangrove swamps, marine grass beds, and coral reefs. Encroachment on the park and its resources is in the form of salt production in areas immediately adjacent to the mangroves, marina development, fishing, and some wood cutting in the mangrove extremes.

Redonda and Limón Lagoons Reserve were designated scientific reserves in 1984, and are located along the country's northeastern coast near Miches. These two lagoons cover 10,100 hectares and possess high primary biological productivity. The contribute many nutrients to the neighboring marine ecosystem which helps maintain the region's productive fishery. IAD recently settled the lands around the reserve and encouraged farmers to cultivate rice. This settlement may cause future impact on the reserve plant and animal communities.

4.8.2 **Distribution**

Figure A8 in Appendix 1 shows the distribution of parks and scientific reserves in the coastal zone.

5.0 POPULATION AND SOCIOECONOMIC TRENDS

5.1 Population Growth Trends

Population growth has been rapid over the last 40 years, and will continue to be rapid because of the presence of very large numbers of children in Dominican society. Thirty-eight percent of the population is under 15 years of age, which is close to the region's high (40 percent in Haiti), which is much higher than in the English-speaking Caribbean. Crude fertility rates will remain high resulting in unavoidably strong population growth for several decades to come. The total population currently stands at seven million and is estimated to reach nine million by the end of this decade and at least 11 million a generation later (see Appendix 7 - Demographic Data).

There are definite signs, however, that the peak of the population explosion is now past and that the country is moving into the second half of the demographic transition. Annual natural growth rates have been declining from 2.7 percent during 1965-80 to 2.2 percent during 1980-89; for the 1990s they are projected to fall to 1.8 percent, in line with today's rates for upper middle-income countries listed in cross-national data banks. The single most important indicator that today's population increase is coming under control is the total fertility rate (TFR) - the average number of children women are expected to have over their lifetime. The Dominican TFR decline has been more spectacular than almost anywhere else in the hemisphere, from 6.9 to 3.6 in one generation (1965 to 1989). But further declines will be much more difficult to achieve and it is hard to understand how the World Bank can predict that a net reproduction rate of 1.0 will be reached by 2010.

Population density has risen gradually from 17.9 inh./km^2 in 1920 to 118.5 at the time of the last census (1981). At present it can be estimated at 145 inh./km^2. This figure compares favorably with values of 260 in Trinidad, 218 in Jamaica and 228 in neighboring Haiti. Population pressure on the Dominican side of the island is mounting, but at this point is neither catastrophic nor irreversible partly due to emigration to the U.S. (50 percent of Plan Sierra population in 20 years, 1965-1985).

Unlike in the case of Puerto Rico, Dominican migration to the U.S. does not (yet) appear to have a very large impact upon population parameters in the Dominican Republic. The authoritative evaluation of sources and claims concerning Dominican migration to the U.S. (Larson and Sullivan, 1987) proves convincingly that most reported estimates are vastly exaggerated by factors between 2.5 and 6. Even if all the Dominican-origin persons in the U.S. in 1981 (150,000) had been reported to the Dominican Republic, the Dominican population density for that year would only have been driven up from 118 to 121 inh./km^2.

5.2 Spatial Trends

As the majority of Dominicans now live in cities, the level of urbanization has risen by close to ten percent every decade for the last three decades. In 1960 the level of urbanization was 30 percent, and has risen to 60 percent today. At the same time, Santo Domingo has steadily increased its share of the urban population, from 40 percent to 53 percent. If present trends hold, the capital city will grow from its present 2 million to 3.2 million inhabitants by the year 2000. This will serve to further increase the dominance of the capital over all other cities; urban primacy is already high, although not unusually so for small island nations. What is particular in the Dominican Republic is that the hypertrophy of the capital has not strangled growth of secondary and regional centers. Several secondary and regional centers continue to show both demographic and economic vitality (the team verified this service center character of growing cities in the cases of two provincial centers of agricultural areas, Santiago de los Caballeros and Oviedo, and two service centers for duty free zones, La Romana and Barahona) be it as service centers for an agricultural region (Santiago de los Caballeros, Oviedo) or for duty free zones (La Romana, Barahona).

Internal migration plays a significant role in the growth of Third World cities but this role is declining rather rapidly in the Dominican Republic (as it is throughout the Caribbean). Twenty years ago (1960-70) migration accounted directly for 43 percent of the increase in the urbanization level, a figure which is now down to 26 percent (1980-90) and can be expected to fall further. Indirectly, however, the effect of migration will still be strongly felt for a long time since rural-urban migration is strongly selective of the young and females. A significant part of the rural fertility potential is thus transferred to cities where children born later to migrant women will then be counted as urban natives. Statistics on urban birth rates hide this indirect contribution of migration and its relative size has so far not been measured in the Dominican Republic.

Overall, there is no true rural exodus in the Dominican Republic. Population is increasing in most rural areas and the rural population decline is apparent in some provinces in the 1981 census. This is almost certainly due to changes in survey methodology and classification. Small towns and villages are now being classified as "urban" although no rural-urban migration has taken place. Despite a shrinking economic base in some regions, there has not been anything resembling a generalized flight from the land. It is true, however, that a large part of the natural population increase of rural areas is being transferred to towns and cities - about 86 percent of the increase by official estimates. Since this process involves large numbers of individuals - about 66,000 per year at present - it is easy to mistake it for a demographic expression of rural collapse ("exodus") when in fact it is a sign of rural population stability.

Net migration is negative almost throughout the country and the directional bias towards the capital city dominates all other migration. But there are four exceptions to this trend in the 1981 data: (1) Santiago, the second largest province, is holding its own with only a negligible net loss. (2) La Romana and San Pedro de Macoris are gaining population from the surrounding provinces. (3) San Cristobal and Monte Plata are stable. Finally, (4) Pedernales has been gaining but this gain involved few individuals and has probably come to an end with the closing of the Alcoa bauxite mine.

The following conclusions can be drawn at this point:

- The capital city (Distrito Nacional) is becoming increasingly dominant without suppressive development in other regions. It not only allows growth to happen in other regions but appears to stimulate it in the adjacent provinces of San Cristobal, Monte Plata and San Pedro de Macoris.

- Unlike most countries in the region, the Dominican Republic has at least four growth poles outside the capital city. It is possible that the strong development of mass tourism in the eighties has added yet another growth pole on the Northern coast.

- Both overall population increase and migration to the capital continue to be strong, adding scale and urgency to problems generally associated with the demographic transition.

5.3 General Socioeconomic Conditions

The Dominican per capita GNP has grown by an average of 2.5 percent between 1965 and 1989, a very respectable rate by international standards. Recently, however, the performance has worsened, falling from the 7.0 percent of the 1970's to negative rates in 1984 and again in 1989 (minus 5 percent). As prices collapsed for the main exports (sugar, gold and coffee), the GODR reacted by initiating massive public works, increased foreign debt, and measures causing inflation. The peso declined from 3 to 13 per $US between 1986 and 1991.

Torn between external adjustment policy pressures, electoral promises, international recession, urban unrest, and declining rural living standards, the government failed to implement a coherent long-term strategy for sustainable growth. This has led to conditions where its powers to redress the situation are now seriously limited. For the purpose of this study the following effects of recent policies are significant:

- By letting the prices for imported energy rise in an unprecedented fashion (gasoline: 322 percent; diesel fuel: 544 percent since 1986), the quantity of oil imports has been brought under control. Annual increases in energy consumption were 11.5 percent in the 1970s as compared to 2.4 percent in the 1980s. Over the last few years, oil imports have been reduced by 20 percent. But this "victory" comes at a high cost in that demand for charcoal has risen and all hopes of substituting propane in most urban households has vanished. Since charcoal is still cheap, individual short-term interests are winning the battle against deforestation and soil erosion.

- The combination of massive public sector works and high inflation have redirected resources from health and education towards a capital-intensive construction sector. Health levels are not very good by hemispheric standards and probably worsening of late, and malnutrition according to some reports, affects nearly half of the Dominican Republic's children. Education levels are also being affected negatively. Public spending on education has declined from 2.4 percent of Gross Domestic Product (GDP) in 1970 to 1.9 percent in 1982 and 1.4 percent in 1989 (World Bank, 1991). While the private sector has increased its share in schooling at all levels, there can be little doubt that long-term investment in human resource development is suffering from misplaced public spending priorities.

- There are many indications that recent policies have accentuated and accelerated a process of rural economic stratification which has been observed throughout the region. The removal of some subsidies, the increase in indirect taxation and the re-allocation of government priorities toward free zones, tourism and public construction work have all had the effect of worsening the situation of the small peasantry. One effect has been the inability of the rural sector to absorb most of its natural population increase. Another effect has been the increased polarization between small and large landholdings. Between 1971 and 1981, the average smallholding (below 80 tar.) size declined by 31 percent while the average large holding (above 8,000 tar.) size increased by 18 percent (Sanchez Roa, 1989).

While rural adaptation to scarcity causes more soil erosion, urban adaptation results principally in lower levels of social development. Despite a relatively high level of urbanization compared to the region, the Dominican Republic has on average low values for caloric intake (2,357) and life expectancy (67); many professional observers think that the poorest third of the population is no better off today than it was ten years ago. The soil erosion impact of poverty is quantitatively less significant in urban than in rural areas, but it is not negligible. Deep gullies and ravines and eroding walkways and foundations are common sights in the poverty belts of Santo Domingo and other cities.

Public investment strategies, rapid urbanization, the constant burden of external debt, and high energy prices make it unlikely that the rural sector could recover significantly in the foreseeable future. There shall thus be more rural poverty and more migration into the poverty belt of Santo Domingo. For the increasing number of families living under these conditions, there are few options. Basically, risk avoidance and short-term survival assume the highest priority, while long-term investment in human resources, agricultural modernization, and the preservation of the land resource can receive attention only once basic survival needs have been satisfied. The collective long-term interest is thus being ignored. It is not clear that the State is up to the task of preserving it.

5.4 Trends in Demand for Water and Water-Related Resources

Water demand for irrigation and industrial uses is discussed in other sections of this report. As far as drinking water is concerned, the following population-driven estimates can be given:

Table 3. Estimation of Demand for Water as a Function of Population Increase, 1980 to 2000

	1980	1990	2000
POPULATION (in millions)			
Rural	2.42	2.63	2.76
Distrito Nacional	1.54	2.41	3.64
Other Urban	1.58	2.13	3.12
Total	5.54	7.17	9.52
DRINKING WATER (in million M^3/Year)			
Rural	26.50	28.80	60.53
Distrito Nacional	191.11	299.08	464.59
Other Urban	115.34	155.49	284.79
Total	332.95	483.37	809.91

Information to Table 3. (con't)

Notes:

- Population figures and projections are Mission estimates based on annual growth rates 1990-2000 of 0.5 percent (Rural population increase, the difference between natural increase and migration), 2.88 percent (Total) and 4.2 percent (Distrito Nacional).

- Water demand is based upon estimates in Tahal (1983) expressed in liters:

Rural	30	40	60
Distrito Nacional	340	340	345
Other Urban	200	200	250

The above estimates and projections are based on linear extrapolations of current needs. While they appear to be weighted for changing socioeconomic stratification (Tahal, 1983) they do not distinguish between need satisfied and need unmet. Most of the population of the Distrito Nacional use only a fraction of the UNDP-inspired standard of 340 l/day and that most of the rural population make do with much less than the assumed 30 l/day.

Access to safe drinking water is severely restricted. Although all of the 133 urban communities have central drinking water systems, most of the urban population has no direct access to piped water. Most of the 8,615 rural communities are not connected to water mains (World Bank, 1991). Where there is direct or indirect access to piped water, there are frequent interruptions of supply and most of the water is seriously contaminated. Even such a significant user as the Free Trade Zone of Barahona receives piped water for only 90 minutes per day. The installation of powerful suction pumps by some private, institutional and industrial users increases social inequalities and a popular sense of injustice. Incidents of water riots comparable to the food riots of past years have been reported as recently as December, 1991.

The inadequacy of drinking water supply is due in some large measure to leakage. A frequently advanced estimate is that only 60 percent of water pumped is actually distributed to end users. While many of the pipe leaks are due to inadequate maintenance, outright sabotage and water theft are not uncommon, especially in the poorer barrios of Santo Domingo.

As the capital city approaches a population of three million, two thirds of which live in slums and barrios of high density, water related resource problems are becoming increasingly serious. Piping infrastructure for drinking water, and drainage, the storm

drainage system and waste removal services demand attendance if major epidemics of water-carried diseases are to be avoided. Demand for water and water-related resources can thus be expected to rise at a much faster pace than the simple linear progression of the urban population would suggest.

Even with the expansion of Valdesia to a three dam system (nearing completion) and the project increase of water transported from there to Santo Domingo via the aqueduct (from the present $3m^3/s$ to $6m^3/s$) the supply of potable water will still be insufficient, even grossly inadequate by UNDP standards.

6.0 SUMMARY OF RURAL ACTIVITIES AND PROBLEMS AFFECTING WATER AND RELATED RESOURCES

6.1 Forestry Activities

6.1.1. General Description of Forestry Problem

Deforestation is recognized as the number one cause of multiple problems affecting natural resources, especially water and soils, in the Dominican Republic. Its causes include accelerated exploitation beyond sustainable yields of natural forests for wood, firewood, and charcoal, without compensatory reforestation. Another key factor is the clearing of forests for agriculture, cattle, and slash-and-burn, often on lands ill-suited for agriculture and pasture.

According to FAO statistics, in 1900, 80 percent of the national territory was covered with forests, in 1940 forest coverage was 69 percent, and by 1967 the percentage had dropped to 26 percent. Forest coverage is currently estimated to be at 20 percent. As land classifications have determined forests to be the optimal use of approximately 55 percent of national territory, it can be presumed that 35 percent of the land is being misused and undergoing erosion and desertification, with consequent negative impacts on the water and soil resources.

In the 1960s coniferous and broadleaf forests were disappearing at such an alarming rate due to industrial exploitation, that by 1968 it was declared illegal to cut in these forests. The dry forest, considered as one of the most fragile ecosystems, has also suffered. Species composition has permanently shifted, with a loss of many of the principal, and more valuable, species for timber, firewood, and charcoal (CONATEF, 1991).

It has been difficult to control all cutting, as firewood and charcoal still constitute the principal fuel in 70 percent of Dominican homes. Most persons do not have the incomes to purchase alternative fuels, even if they were available. In fact, cutting for firewood or charcoal is now considered the principal cause of deforestation in rural areas. Christiansen (1987) estimates annual requirements of about 4,090,000 M^3, distributed as follows: 175,000 M^3 in industrial firewood; 1,305,000 M^3 in domestic firewood; and 2,610,000 M^3 for charcoal production. Approximately 30 percent of the country's total energy requirements are met by sources of vegetative origin.

There are no reliable records of forest use for commercial and domestic purposes, since commercial use is illegal. The lack of data does not allow an accurate evaluation of the sector and its contribution to the country's economy, or to rates of deforestation.

According to Christiansen (1987), the requirements for serrated wood in 1987 was 250,000 M^3, almost completely imported from the United States, Chile, and Brazil. Existing standing timber of 800,000 M^3 (on the existing 6,000 commercial hectares), plus an additional 52,000 new hectares, would be required to substitute wood imports with the country's forests under forest management (Pinus occidentalis and Pinus caribaea).

CONATEF (FAO\UNDP, 1987) estimates the loss of tropical forest at 20,000 ha per year, and the area affected annually by firewood and charcoal extraction at 60,000 ha. If this use and destruction rate continues, it is expected that natural forests will be depleted in 10 to 25 years.

6.1.2. Impacts and Costs of Forestry Problems

Deforestation produces some of the most extensive and cascading negative environmental impacts affecting physiography and soils, hydrological cycles and resources, climate and air quality, and biological resources (fish, wildlife, and conservation areas). The following is a listing of negative impacts by sector.

6.1.2.1 Impacts on Physiography and Soils

- Instability of slopes, beds, and banks of rivers, lakes, and coastal areas.
- Laminar erosion, in furrows and ditches.
- Loss of nutrients and organic matter.
- Decline or alteration of micro-flora or micro-fauna.
- Decline in cation exchange capacity.
- Soil compacting.
- Laterization.

These primary impacts on soils in turn have a multitude of secondary environmental impacts. If the land is put into inappropriate use, a large proportion, or even total loss, of the productive potential of that land can ensue. This decreases the availability of productive land, and can generate rural unemployment, cause intensification of use on remaining land (furthering increasing erosion or contamination), and raise production costs on remaining lands. Deforestation of lands with a high forestry potential may also carry an opportunity cost compared to that which could be derived from sustainable forestry practices.

The increased erosion caused by deforestation and improper land use increases turbidity and sediment loads in rivers and streams which leads to a more rapid sedimentation rate of dams, irrigation works, navigable waterways, and ports, increasing maintenance costs

and shortening useful life. Large increases in turbidity, or too heavy of a sediment load, can increase eutrophication, destabilize river banks, and alter or destroy riverine and coastal ecosystems. Increased sediment loads also increases the scouring and destructive power of water, and can lead to damage of other infrastructure, such as roads. The situation is so critical in Haiti at the moment that sediments are overloading storm drainage structures and covering roads (blocking traffic for hours) after storms.

6.1.2.2 Impacts on Hydrological Cycles and Resources

- Decrease in infiltration and the charge of underground water sources (aquifers).
- Increase of superficial runoff, i.e. the proportion of rainfall running overground directly into low-lying areas, rivers, or streams, rather than being absorbed by soils.
- Increase in the velocity of runoff and the magnitude of peak flows.
- Decrease of the uniformity of stream flow, or increase in the seasonality and magnitude of oscillations of stream flow volumes and rates.
- Increased flooding.
- Increase in the swamping and standing of water after rainfalls.

As water is one of the most basic substances to life, the impacts of deforestation on hydrological cycles is probably one of the most serious. Secondary impacts include possible alteration or destruction of riverine or coastal ecosystems. As most aquatic animals and plants are adapted to certain conditions of water flow, turbidity, salinity, and seasonal volume, all are affected by changes in the hydrological cycle. It can be expected that deforestation would have far reaching effects on aquatic communities. Destruction or degradation of aquatic habitat would in turn impact artesinal and commercial freshwater and coastal fisheries.

Increased oscillations in the seasonality of flow rates also affects human consumption and those economic activities that depend on a more reliable water source. This would include irrigation, hydroelectric generation, industrial and domestic consumption. The complete or seasonal drying up of streams and the decrease of aquifer recharge may necessitate the construction of dams or other water storage facilities, and water conveyance facilities, sometimes at great economic cost.

Increased flooding can inflict heavy economic losses and tolls in human death and suffering. Floods destroy homes, irrigation infrastructure, agricultural crops, roads, and many other fruits of human activity. Floods also have a greater power to carry heavy sediment loads, and therefore can rapidly bury coastal ecosystems or fill reservoirs behind dams (e.g., the Valdesia Dam in 1979, due to hurricane David and tropical storm Frederick). The Dominican Republic is already prone to floods from tropical storms and hurricanes, which can be formidable forces of destruction as well.

6.1.2.3 Impacts on Climate and Air Quality

- Increase in temperatures near to the land.
- Local and regional desiccation of climate.
- Release of dust, smoke, and CO_2 from the burning of vegetative matter.
- Decreased consumption of CO_2 from decreased photosynthesis.

The foremost negative effect has to do with undesired changes in local and regional micro-climates, and the possible changes in global climate (earth warming) brought on by increases in CO_2. Changes in local and regional micro-climates can affect community structure of local ecosystems and farming.

6.1.2.4 Impacts on Biological Conservation, Wildlife and Fishing

Possible impacts could include the following:

- Elimination of threatened or endangered species, leading to possible extinction.
- Damage or elimination of nests and lodging trees.
- Elimination of feeding or breeding areas.
- Damage or destruction of aquatic spawning or nursery areas, as well as sea-bed organisms (benthos).
- Displacement of wildlife by noise and human presence, resulting in crowding and increased competition to wildlife populations in forests not yet exploited.
- Elimination of rare and endemic species.
- Increases in noxious animals, plagues, or disease vectors.
- Damage to existing conservation areas: parks, reserves, protected areas directly, or indirectly by affecting the buffer zone of these areas.
- Invasion of protected areas with vague legal status or poorly marked limits.
- Damage or destruction of areas with conservation value, and perhaps under study for protection, but not yet protected.

6.2. Crop Production

6.2.1 Soil Erosion and Depletion

The agricultural sector of the national economy has lost some of its relative importance over the last several decades, but that loss has not diminished the pressures on the soil, water, and forest resources. There appears to be an increasing deterioration of the upper watersheds, especially in terms of very high rates of soil erosion. Additionally, irrigated areas are suffering diminished soil productivity from water-logging of soils, increasing salinity, and loss of soil structure (USAID, 1990).

A large percentage of the country's beans (approximately 80 percent) and tubers are grown on mountainous lands. The greatest long-term negative impact of agricultural production on these steep lands is the loss of soil (and subsequently soil productivity) through water erosion. A reduction in soil productivity would adversely affect food price stability and the nutritional intake of rural farmers.

In upper watersheds, uncontrolled/unauthorized colonization of public lands has taken place over the years. The resulting land uses are subsistence agriculture, wood harvesting for domestic needs (fuel wood and construction wood), and uncontrolled grazing. This situation results in negative effects on water flow and quality. Governmental regulations are in place to regulate rural colonization and land uses, but enforcement is lacking. The task of increasing food production to feed a growing population and modifying/regulating crops grown on steep marginal lands is difficult. One of the main objectives of the Government is to increase food production to feed a growing population and to reduce the level of expensive food imports. An increase of agricultural productivity and an increase in the acreage under cultivation will both be necessary over the long-term.

Traditional slope farming practices do not include protection of soils against strong and prolonged rainfalls which is common in most of the mountainous areas and most densely inhabited of the country. The eroded soils of these slopes are taken downward by the waters and deposited in water currents to be taken further to the artificial basins and coastal estuaries. Here they generate a negative impact on the useful life of hydraulic works and marine environments.

In recent years beef cattle production activities have decreased in the norther coastal zone. The area is currently experiencing accelerated tourist development which has stiffened competition for labor and other resources. However, in the area near Puerto Plata, dairy farms have been increasing because of improved marketing opportunities.

The Northwest Line is not as important as other livestock zones. Livestock activity in this zone is carried out by small and medium producers who manage dual purpose production systems and semi-intensive dairy farms (usually in cooperation). By-products from crops are used to improve the diet of dairy cows. CODAL-NESTLE has approximately 14 milk reception centers to buy an estimated production of 80,000 l/day.

The most intensively managed and productive cattle farms are in the southern and southwest zones. Production is oriented towards dairy products in very specialized units. Particularly high technological levels have been reached in the areas of Baní and San Cristobal. In these units, cows are confined and industrial by-products, crop residues and

fed stuff are provided to guarantee a balanced diet. The cows with the highest genetic potential are also raised on these farms.

6.2.2. **Overuse of Pesticides**

6.2.2.1 General Description

The country's recent reduced per capita GNP growth rate (from seven percent growth in the 1970s to 2.5 percent in the 1980s with two years of negative growth) is in large part due to the collapse of the world price of primary products such as sugar and coffee. The GODR has responded by encouraging crop diversification (since the late 1970s) including high-value fresh vegetable crops for the U.S. and other developed country markets (USAID, 1990).

New crops demanded new technology that was not readily available in the country. Of particular importance was increased pesticides use. In addition to new pests, the use of larger quantities of pesticides was required to be able to market unblemished produce as demanded by consumers. Regulations on the levels of pesticide residues are very strict in OECD countries. In 1985, some of the growers seeking new market and product alternatives organized themselves in the Junta Agroempresarial de Consultoría y Coinversión (JACC). Its' mission was to facilitate access to new markets as well as introduce the technology required for the successful export of the new fresh vegetables products. Although JACC operates in other areas such as aquaculture, forestry, and livestock enterprises the agricultural component is by far its largest.

Initially Dominican growers did not pay enough attention to the level of residues that accumulated in the crops. The utilization of the products was at first encouraged by their price. When the Dominican Peso started to lose value in relation to the US Dollar, imports of pesticides was based at the official rate of 1:1. This situation continued until 1982 when the government decided that pesticides import costs should be based on the parallel exchange rate that was then approximately 1.6 Dominican Pesos per US Dollar. In others words, there was then a subsidy on the price of pesticides in the order of 60 percent. Furthermore, there were no import duties on pesticides. The low price of pesticides encouraged their utilization in spite of the local efforts to work with the safer integrated pest management (IPM) approach.

An area where the problem of pesticide abuse has been particularly intense is the Constanza Valley (Gómez, 1991). This is a relatively high valley where dominant crops include several kinds of fresh vegetables, potatoes, garlic, and flowers. Other areas affected by the applications of high pesticides rates include Azua, and San Juan. The Azua area also produces fresh vegetables such as tomatoes and melons.

Currently there are efforts under way to rationalize the use of pesticides in the areas that produce fresh vegetables products. The most important one is the IPM program that is being supported by USAID/Dominican Republic. This is a joint effort of the JACC, the Plant Protection Department of the Ministry of Agriculture, and the Foundation for Agricultural Development. This project started in 1990, and is already doing applied research and extension at a national level. The program has a total of 11 agronomists and entomologists who operate through a national office in Santo Domingo and three regional offices in Azua, and La Vega y Santiago. In addition to the IPM program, JACC is currently working on the development and establishment of a modern laboratory that is going to provide a pre-certification service for export oriented products.

6.2.2.2. Impacts and Costs

Pesticides can pose a health hazard to all forms of life. Excessive and careless application of these agents can result in serious losses and costs. In the Dominican Republic this problem has already cost the country potential earning because vegetable crops failed to meet pesticide residue standards of OECD countries.

In addition to the presence of pesticides residues, a new thripid pest (**Thrips palmi Karni**), was partially responsible for the stopping of Dominican products in the US market (Alvarez, personal communication[1]). The same source indicated that 1,496 shipments were rejected in 1989. This figure represented 80 percent of the annual production with an estimated loss of $16 to $20 million US dollars.

Agricultural biocides: insecticides, herbicides, and fungicides, applied to irrigated crops may also reach water supplies. Biocides may be washed from the plant, leached from soils, or reach supplies directly through aerial spraying, accidental spills, or the washing of equipment.

Biocides vary in their potential impacts on the environmental and human health. Biocides that break down quickly generally present less of a problem than those which persist for years or even decades. Persistent biocides which enter the aquatic environment are known to concentrate in living tissue as it moves up the food chain from smaller to larger organisms. Soil fauna necessary for healthy soils can be permanently altered or destroyed through persistent use of biocides (Webb, 1991).

[1] Porfiro Alvarez is the head of the IPM project that has been implemented jointly by JACC, Plant Protection from the Ministry of Agriculture, and the Agricultural Development Foundation (ADF). The project is being executed with USAID/DR PL-480 funds.

6.2.3 Irrigation/Salinization

6.2.3.1 General Description

According to INDRHI (1987) an area of 250,000 ha is under irrigation, mostly in the regions of Yaque del Norte (39 percent), Yuna (16 percent) and Yaque del Sur (13 percent). The irrigated surfaces presently benefit 58,000 producers who own farms of four hectares on average and utilize 45 per cent of the area potentially irrigable, estimated to be around 552,000 ha. The volume of water consumed in agricultural activities is estimated to be around 2,500 Hm^3, for an average endowment of 10,000 M^3/ha/year.

Approximately 250,000 hectares is devoted to fruit and vegetable production. A major agricultural crop for local consumption that requires irrigation is rice. Major issues and concerns with rice production are poor water management and the salinization of semi-arid zones. An additional 300,000 hectares could be brought under agricultural production through irrigation. A constraint on irrigated lands, and potential irrigated lands, is deforestation in mountainous areas and the attendant sedimentation of irrigation works.

Most of the irrigation projects are a sub-product of the hydroelectric developments and do not make efficient use of the constructed infrastructure and in the maintenance of the system. In addition, the irrigators lack organization and training in irrigation management. Furthermore, user fees are insufficient to cover operation, maintenance, and conservation costs of the irrigation districts. Only 25 percent of irrigation waters are estimated to be consumed by crops; the rest filters, evaporates and/or drains directly into drainage systems (Webb).

6.2.3.2 Impacts and Costs

Depending in the soils, the crop, and management and type of irrigation, up to 60 percent or more of the water applied to crops may reenter water supply through artificial drainage or percolation to the groundwater. Of course, the quality of the unconsumed water is significantly altered.

Sufficient water applied to the soil is able to leach the salts formed there out of the root zones into the surface drainage or groundwater. Flood irrigation, in particular, can add soluble salts, or decrease the salinity of water supplies if local conditions are appropriate (low rainfall, salty soils or parent material).

High slat or mineral content of water can negatively affect downstream riverine ecology as many species are only tolerant of a certain range of osmotic pressure. High mineral content can also negatively affect water quality for downstream domestic, industrial, or

particularly further agricultural use. The mineral content of irrigation drainage water ranges from two to ten times greater than incoming irrigation water. Each successive use for irrigation can further concentrate salts until the water is useless for further irrigation and cannot support life (Webb, 1991).

6.3 Livestock Production

6.3.1 Description

Livestock production is one the most important agricultural activities in the Dominican Republic. It utilizes almost 50 percent of the total area dedicated to agriculture, approximately 1,200,000 ha. In this area there are some 2,000,000 head of cattle, of which 700,000 are reproductive cows. A survey conducted by PRODELESTE (Proyecto de Desarrollo Lechero del Este of PNUD/FAO) in 1990 indicated that 76 percent of the producers are dedicated to dual purpose (beef and diary), 26 percent produce only beef cattle, and 4 percent have specialized dairy farms. The whole activity produces approximately 300,000,000 liters of milk and 30,000,000 pounds of beef. In addition, it provides protein (meat and milk) to the population and raw materials for both dairy industry (milk processing) and tanneries producing leather used in the production of other goods.

Productivity and intensity of the livestock activity in the Dominican Republic is comparable to that of other cattle producing countries with similar resources. Currently, 40 percent of the area is under improved pastures, the rest are areas of native pastures with trees and shrubs in different stages of plant succession. Average stocking rate is 1.2 animal units (AU)/ha. Average meat production is approximately 170-200 kg/ha/year (RD$ 2100-2300 ha/year).

Semi-intensive dairy farms is the dominant production system in the central Cibao zone. There are also abundant byproducts from crop production (e.g., green pigeon pens, sugar cane) and industries (e.g., malt for breweries) that are commonly used for supplemental feeding. The zone also contains several milk reception centers (centros de acopio) of the CODAL-NESTLE milk processing plant located in Santiago which facilitates marketing of milk. In the Eastern flatlands, the most important production system is dual purpose, but specialized beef cattle is also important.

6.3.2 Activities Impacting Water and Natural Resources

6.3.2.1 Overgrazing

Livestock producers and technicians working in extension programs have a good idea of the recommended stocking rates for the area they are working on. However, due to normal weather variability - mainly precipitation - annual and seasonal variations in forage production and availability are common. During dry years, adjustments in stock rates are necessary to avoid overgrazing and consequent deterioration of pastures. Part of the problem that leads to site deterioration is that even though the ranchers might recognize they are in a dry year they do not have a system to really evaluate how much impact the drought is going to have. Furthermore, there are few alternatives and the pressure continues on a site that has less than enough forage supply. The result is overgrazing.

Over grazing reduces both the foliar and basal cover and eventually alters the hydrologic condition of the soil. Less cover exposes more bare ground to trampling, which in turn increases soil bulk density and reduces infiltration. The final result is then an increased potential erosivity of soils due to overgrazing. Overgrazing was observed in the North Eastern and the North coasts as well as in the North West line. According to technicians from PRODELESTE there have been two consecutive dry years. Erosion and later sediment transport from overgrazed areas are partially responsible for the color observed in the waters of these areas.

6.3.2.2 Establishment of Improved Pastures

Establishment of new pastures is similar to establishing new crops. Planting and fertilizer application follows intensive plowing of the soil (most sites are plowed three times). Erosion is enhanced by the fact that this activity takes place during the rainy season. Environmental impact is larger when the sites have significant slope and major precipitation events occur.

Impact on coastal resources and estuarine species reaches a peak where part of the mangrove areas have been converted to forage production. In those cases loss of the mangrove also means loss of its environmental services, the buffering effect on the coastline and production of organic matter.

6.3.2.3 Fencing

Fence building and maintenance exert an important pressure on forest resources in livestock producing areas. Fencing requires a post every 3.4 yards and a "mother post" every 20 to 25 yards. Lack of incentives and guarantee of resource accessibility prevent post production for fence building and maintenance from becoming an activity more in balance with the local potential for forest to produce them.

6.3.3 Status of Rangeland Resources

Eastern Flatlands

There are few problems of resource degradation from livestock production in the Eastern Flatlands. However, in Monte Plata and Bayaguana the situation is different. Specialized, semi-intensive dairy farms are common in these two areas. They are located in the Subtropical Wet Forest life zone, with annual precipitation of 1600-2000 mm per year. Soils are poor, mostly shallow to very shallow ultisols with steep slopes which makes them highly erodible. During a trip to this area severe degradation of soil resources was observed. Top soil was practically nonexistent in some areas, and severe gully erosion was observed.

Northeastern Coastal Zone

The current livestock management system in the northeastern coastal zone is not compatible with the utilization of natural resources under a holistic approach. The combination of heavy rainfall and shallow soils with livestock production in steep slopes of this zone is likely to produce severe soil erosion. The problem is aggravated by the conversion of wetlands and mangroves in the coast line to improved pastures. Water of the rivers discharging in this area were dark-brown during the visit to this zone, indicating it was transporting considerable amounts of sediments. The impact of those sediments in the ocean was evident in the increased turbidity and color of the ocean water near this coast.

Northern Coastal Zone

In the Northern Coastal zone, areas with steep slopes and shallow soils of slow permeability are being used. This activity needs to be carefully evaluated because it has potential to produce undesirable impacts on coastal resources and tourism.

The Government owns and operates two marble quarries in the Samana Peninsula and a magnetite ore reserve in Manzanillo Bay. The Government is conducting oil exploration drilling in the south insular platform and northern offshore banks.

Sand, gravel and sandstone are extracted from many Dominican rivers. This activity is mostly concentrated at the mouth of the Nigua river basin with apparent disregard for habitat and coastal degradation. Other areas damaged by sand extraction are Playa Estero, Juan Esteban, and Cuello y Cuello. Dune sand extraction occurs in Las Dunas of Caldera Bani. Despite acknowledgement of the problem and the establishment of a coordinating group, dune destruction has continued although with less intensity. Marine salt extraction through evaporation occurs in the Monte Cristi area near Lagunas de Marigo, Salina and Piedra and near Las Salinas in the Bahia Las Calderas.

6.5. Hydroelectrical Energy Production

6.5.1. General Description of Problem

The high cost of oil has caused the government to explore the possibility of substituting hydroelectrical power to generate electricity. The Dominican Republic produces neither oil, gas, nor coal, and its hydroelectrical potential is limited. Only 28.9 percent of energy requirements are satisfied with vegetable fuels (firewood, sugar-cane bagasse, charcoal); 64.9 percent with oil by-products; 2.2 percent with coal; and 4.0 percent with hydropower.

Eighty-nine percent of the electric energy supply comes from the Corporación Dominicana de Electricidad (CDE) and Falconbridge Dominicana (private mining enterprise), and 11 percent from Consejo Estatal del Azúcar (CEA). This energy is basically thermic with 22 percent generated in coal plants, 64 percent with liquid fuels and 18 percent in hydroelectric plants. However, the energy supplied is not enough to cover current requirements. This results in permanent daily rationing with sudden cuts of electricity to industry, business, and homes. Most use emergency generators with a consequent increase in the hydrocarbon requirements.

The electric energy requirements of the country are estimated at around 900 to 1,000 mw and the production is around 500 to 550 MW in average, with a maximum of 700 to 750 MW in optimal situations. This creates a deficit of about 400 mw, which cannot be easily overcome (Santos Cayado, personal communication).

It can be estimated, from studies of the projected and constructed dams for the generation of hydroelectric energy, that at present there is a current hydroelectric capacity of 216 MW. Fourteen new projects are being studied to increase the installed capacity to 480 MW/year.

6.5.2 **Impacts and Costs**

Dams can have impacts upon physical and hydrological conditions, land use patterns, as well as local flora and fauna. Dams reduce river flow downstream which can impact navigation , cultivation, drinking water supplies as well as the physical configuration of the coastline or river deltas. Dams trap sediment and silt which reduces deposition downstream which affects adjoining land. Eutrophication is an un-intended consequence of dam building which can increase weed growth and BD loads. The reservoir creates a large body of water which changes local temperatures, increases evaporation, and effects the entire water cycle for the river valley.

The dam itself and the reservoir cover a large area of land. People who lived and farmed that land will be relocated onto areas not previously used. This could exacerbate soil erosion, overgrazing, and deforestation. This can also lead to species loss of flora.

6.5.3 **Importance of Watersheds**

The deforestation of watersheds has had a severe impact on water resources which has largely taken four forms: a dryer, hotter micro-climate and more erratic rainfall patterns, greater disparity in seasonal river flows, increased sedimentation of river beds and infrastructure works, and increased flooding.

Clear cutting of a forest immediately causes the micro-climate to become dryer (due to loss of evapotranspiration from the plants) and hotter (due to the change in the albedo of the earth's surface). With less evapotranspiration and hotter temperatures, the mountainsides are no longer a place of intensive cloud formation and bursting (as the clouds lift the temperatures drop). The result is that the rains seem to be condensed into one short period instead of evenly throughout the season. All contributing causes have not been determined.

Deforestation of watersheds compound more erratic rainfall patterns to produce greater disparity in seasonal river flows. Forested watersheds have a much greater water retention capacity than non-forested ones. Forested watersheds will break the fall of rain and allow it to slowly absorb into the soils around the root zones for ground water. This water slowly feeds the rivers and streams, moderating the effects of erratic or seasonal rainfall.

Another result of lack of tree cover and increased velocity of surface run off is the increased capacity of the water to carry sediments, not only a greater volume but also larger sizes. As such, the maintenance costs and life span of downstream development projects such as dams and irrigation systems are adversely affected.

Increased sedimentation can also cause river beds to rise in many valley bottoms. The combination of increased volumes of water and reduced capacity of the river bed to contain water leads to increased flooding.

A recent study of all watersheds was carried out by the TFAP (FAO\UNDP, 1987) and ranked in their order of importance for intervention based on indicators such as level of forest coverage, population density, hydroelectric energy production, irrigation, and the areas of possible reforestation. The study concluded that the regions of Yaque del Norte, Yaque del Sur and Ocoa-Nizao were in greatest need of comprehensive watershed management.

The Inter-American Development Bank has funded a feasibility study for the "Plan de Manejo de la Subcuenca del Río Bao" (Management Plan for the Sub-Watershed of Río Bao), which is part of the Yaque del Norte river system. The hydroelectric dam of Tavera-Bao is the oldest in the country and has one of the biggest sedimentation problems. This Plan will be finished in July, 1992, and will become the first comprehensive management plan of a sub-watershed in the Dominican Republic.

A similar water management plan will soon be required for the Nizao River due to three competing demands for the river's water. An aqueduct whose source is the Valdesia Dam is currently supplying three m^3 per second of drinking water to Santo Domingo and is planned to supply six m^3 per second. The dam also supplies the Bani area irrigation system (18,750 hectares). The Jiguey dam and the Aquacata dam are currently being constructed in the Nizao river's higher watershed and will complement the Valdesia dam's hydroelectrical generation capacity. As a result, overall water volume demands, as well as conflicting demands (water storage for year-round irrigation versus constant water flow for hydroelectric needs and potable water for the capital city) will make management of the Nizao water resources both essential and difficult (Overseas Development Administration).

7.0 SUMMARY OF URBAN ACTIVITIES AND PROBLEMS AFFECTING WATER AND WATER-RELATED RESOURCES

7.1 Urban Growth and Activity

Urbanization in the Dominican Republic has progressed at a rate much faster than the provision of services and infrastructure in all but a few locations. While successive governments since 1965 have invested large sums in the construction of streets, water systems, and public housing, there are more urban residents today who do not benefit from such investments than ever before. Even the consumption of energy has not kept up with urban growth. While per capita consumption almost tripled since 1965 (World Bank, 1991), the urban population more than quadrupled. As public sector services are falling behind, the private sector has expanded greatly in some areas. For example, most education at all levels in Santo Domingo is now provided by private institutions. Most water-related services, however, are in the hands of state and parastatal agencies, with the exception of the retail sale of bottled drinking water.

Two types of urban development, Free Trade Zones (FTZs) and tourism, have both prompted and absorbed much of the urban investment since 1965. In 1988, the 25 Free Trade Zones directly provided five percent of the employment of the economically active population, and seven percent of foreign exchange (Dauhajre et al., 1989). The FTZs provide modern, formal sector employment to a predominantly female labor force. Because the cost of operating a factory of comparable size and type in the Dominican Republic FTZ is the lowest anywhere among the 23 countries covered by the Caribbean Basin Initiative (Dauhajre et al., 1989), growth continued to rapidly expand (by 22 percent), even during 1990 when most of the economy was declining. Critical analysis by social scientists has highlighted negative aspects of FTZ employment (Corten, 1985; Duarte, 1986; 1980), however, given the alternatives, both the government and the population consider employment in FTZs highly desirable.

FTZ workers live in households which differ significantly from national averages in size, education levels and consumption patterns. Taking an average household size of 4.9, their incomes help to support no fewer than 500,000 urban residents, most of them outside of Santo Domingo. Since most of the workers are migrants (Duarte, 1986) it can be assumed that FTZs are the principal reason for the continued vitality of urban centers outside the capital city. Urban problems of water supply, drainage and pollution are thus decentralized and demand action in two dozen distinct locations and local political structures. While the industrial activities of FTZs appear to have few water-related problems, their role in urban demographic growth most certainly does increase the magnitude of such problems in existing cities.

The recent expansion of tourism has been as spectacular as that of the FTZs. Foreign visitors have increased from 63,000 in 1970 to 1.6 Million in 1990. Installed capacity has grown from 1,305 to over 20,000 hotel beds in the same period, and tourism receipts have risen from US$ 16 Million to US$ 750 Million constituting 30.4 percent of foreign earnings in 1989. Water-related problems of tourist developments are not limited to the large quantities of water used by the hotels during periods of high occupancy, but include those of expanding settlements of employees and their families in previously pristine areas. Some of these settlements are dense, informal, and polluted, while others benefit from publicly subsidized housing developments (e.g., in the Puerto Plata - Sosua region).

As in the case of other urban growth the principle long-term water-related impact of tourism may well be indirect (Table A4). Expanding urban populations with attendant increased demand and investment has exacerbated the urban bias of most Third World policies and economies. Urban bias increases rural poverty which in turn is linked to the destruction of the hillsides. Large increases in the number of hotel beds which are currently projected, planned, or are being built come at a heavy environmental cost ultimately undermining the profitability and sustainability of tourism.

7.2 Sewage Management

Public sewage evacuation and treatment systems exist in only a few municipalities and have never been analyzed in detail. They will increasingly become an issue because of the frequent overlap of tourist and other uses of some areas. For example, the location of both FTZs and major tourism investments in urban places such as La Romana, Santo Domingo, Puerto Plata and Barahona. Because of the magnitude and scale of the problems in the capital city, and the paucity of documentation on other areas, this report will be limited to the Santo Domingo area.

Data concerning sewage are collected in the Urban Environment Strategy Paper (Cobb, 1991) and the Rio Ozama Diagnostic Study (SOGREAH, 1991) and will be summarized here. Although some 40 percent of the city's land area is reportedly connected to a sewerage system of a total length of 615 km, this system serves only a minority of the population. In addition, most piping is inadequate (eight inch diameter) and the four treatment plants and five pumping stations work only intermittently. At most, two percent of the urban population's waste water is treated. Garbage and industrial waste are indiscriminately dumped into this system and further reduce its effectiveness. Most of the piped sewage remains untreated and reaches the ocean directly or through the Ozama and Isabela rivers.

Most other sewage is either discharged directly into the rivers and the sea or is left to become part of the open-air sewage and storm runoff typical of the poorer barrios. An

unknown proportion is taken care of by private septic systems or injected into the aquifer by industries and at least one governmental agency. Depth of the aquifer, the availability of drilling equipment, and the cost and availability of alternatives are factors which limit this practice.

The cost of building, operating, and maintaining a complete and adequate sewage system for the city is beyond any realistic plan. Such a system would utilize enormous quantities of water for the operation of a waterborne collection system, incur high construction costs in poor soil conditions and street design in densely populated areas, and would have to maintain considerable annual expenditures on administration and maintenance in a political structure which does not lend itself easily to these tasks (see Figure A11, Appendix 1 for map of sewage disposal in Santo Domingo).

Compared to an ideal system the current way of discharging sewage is cheap in municipal-budgetary terms but negatively impacts public health. Water contamination by sewage is the main mechanism for the spread of diseases such as cholera, typhoid, paratyphoid, gastroenteritis, giardiasis, amoebic dysentery and hepatitis. Should an epidemic of any one of these diseases occur it would be uncontrollable for a considerable amount of time because of the long time lags required to effect major changes in a sewage disposal system.

Contaminated water also has a high social cost, particularly on women. The hardship of seeking and carrying potable water, sometimes from long distances, usually falls on women or older children. The time and opportunity costs to the family (in terms of lost income) of caring for sick children usually falls disproportionately to women as well. The costs of buying bottled water or of filtering water is a chronic factor now adding to the operating costs of businesses and families, and is a disproportionate burden to the poorer segments of society.

Given the economic and political outlook of the country the only practical solution which addresses both health and environmental concerns may be to provide those two thirds of Santo-Domingo's population which live in the barrios along the Ozama river with non-conventional alternatives to the existing system. Such alternatives (i.e., pit latrines, composting toilets) can provide significant health benefits at a small fraction of the cost of conventional systems (Cobb et al., 1991). While considerable investments would be needed even in the non-conventional approach they would be small compared to the benefits to the national economy of improving the morbidity and mortality levels of that population. Data existing in health statistics and household expenditure surveys (but not available to this team) could corroborate the following estimates. If the cost was $100 for each of 300,000 households (for a package of (1) individual or community toilet, (2) access to drinking water, and (3) participation in solid waste removal, the savings on

treatment of sick children alone could pay for the whole investment within ten years. However, taking into account savings in work days of the adult population, a three year estimate would not be a particularly optimistic guess, given the enormous opportunity cost of high morbidity and low life expectancy. It is clear that such cost/benefit guesswork cannot take the place of a much more detailed study of the issue, but it should not be dismissed summarily. At least two PVO's listed by our team have achieved and documented dramatic decreases in morbidity and mortality rates with investments along the line suggested above.

The only proposal for solving the sewage situation in Santo Domingo (SOGREAH, 1991) is conventional. It proposes a collector ring and two treatment plants on the plateau rather than along the river and sea shore, a ring closed on the Western side by a five kilometer tunnel. The investment and maintenance costs will be very high but can no doubt be added to the national debt. But the permanent need for large quantities of water and electricity will be such that the system will not function very long. This will be another instance of permanently mortgaging governmental budgets with no benefit in return. In addition, this approach ignores the sewage needs of the barrios located below the collector, i.e. of the majority of the population.

7.3 Solid Waste Disposal

The solid waste issue will only be addressed here as far as the City of Santo Domingo is concerned. Since USAID has just conducted an excellent report on the matter (Cobb, 1991).

Santo Domingo's population in 1990 produced an estimated 1,230 tons of solid waste per day or close to one half million tons per year (estimates vary by up to 80 percent according to source). The main producers are households (65 percent), public markets (10), commerce (6 percent) and parks and gardens (6 percent). Higher-income areas produce more waste per household but are numerically less frequent and reside in low-density areas; hence the apparent link between poor barrios and garbage. On average, the waste contains 80 percent organic matter and 12 percent paper.

Most solid waste is never collected. Although 46 percent of the municipal budget ($DR 40 Million) and substantial foreign donor allocations (e.g., 35 new trucks in December, 1991) are committed to garbage collection, something in excess of 40 percent of daily garbage production is left to rot in the streets, on empty lots, along the river banks and on improvised sites, and an undetermined proportion is dumped into the two rivers and the sea.

While the present situation contains some savings for the municipal budget it also includes considerable costs in terms of devaluation of real estate and tourism potential, pollution of seashore and rivers, and increased health risks. But these costs do not accrue directly to the municipality. The solid waste problem is thus a classic illustration of what makes a Third World governmental institution so inefficient. Taking better care of the collection and disposal of solid waste would only increase the costs and general burden of the municipality (AYUNTAMIENTO) while all the benefits (in economic activity, real estate value, tourism receipts and health levels) would go elsewhere.

Transportation and landfill are the two principal bottlenecks of the present solid waste disposal system. An inadequate number of compaction trucks are in existence at the moment - the Strategy Paper contains contradictory numbers between 44 and 108 - less than 75 percent of which are operational on any given day. In addition, there are some 60 dump trucks and other pieces of equipment. Private enterprises (e.g., EMLURB with 17 trucks) have a superior record of keeping equipment rolling and delivering garbage to destination.

Initial collection is a problem separate from garbage transportation since much of the population lives in areas inaccessible to compaction trucks. Some initiatives by PVOs and private enterprise have been successful in organizing garbage delivery to collection points. The economic feasibility of buying household garbage by micro-entrepreneurs (tricicleros) has been demonstrated in the La Zurza project (IDI-SODIZUR). Short of redesigning and rebuilding most of the barrios, this appears to be the most promising route towards a solution of the solid waste problem in those areas. The EMLURB experience shows the superior cost/benefit ratio of the private sector.

Guaricano, San Isidro and up to very recently Cancino are the active landfills of the city, located at six kilometers, 22 kilometers, and eight kilometers, respectively, from the center. Cancino and San Isidro have problems of access while all three of them have problems of drainage. Several more sites have been opened, and closed again soon after opening, due to public complaints.

Health risks associated with the current solid waste situation are considerable. Generalized seepage of toxic and contaminated liquids into the ground water, the aquifer, and the under-pressurized drinking water system currently exist. Disease vectors, as well as rodents, proliferate throughout the city because waste removal is so deficient: waste accumulates and provides for humid and nutrition-laden living from collecting refuse such as bottles and cardboard from landfills and from garbage piles throughout the city. Many of the minor and all of the major landfills provide food for pigs for market whose meat fitness for human consumption in open to question. Large numbers of families (150 at one site) make a living from collecting refuse such as bottles and cardboard from landfills.

Due to the unsanitary conditions of the landfills they are exposed to serious health risks. Many actually live either on, or close to the major landfills. Any radical change in the disposal of garbage would deprive them of a living and the collectivity of their recycling services.

The landfill at Guaricano will have to be closed by 1992 and it is unlikely that anything more than temporary solutions will be found for the landfill problem. However, the most urgent problem at this time is the initial collection, not the permanent disposal of garbage, as collection affects a greater amount of families. Private enterprise and PVOs can solve the collection problem, but their contribution is dependent upon a public commitment to having an agency remove garbage from collection points. A minimal form of private-public partnership will be indispensable.

Since such a large proportion of garbage here is organic matter, disposal problems may be eased through some form of sanitary composting. If public health risks can be minimized using some form of composting technique that destroys bacterial contamination, and if strong interests of private fertilizer producers do not interfere, this compost can be distributed free or sold (to offset costs) as a soil enhancer. One of the most promising systems for rendering organic waste, dry matter/night soil, or sewage, safe for recycling in the soil is the Beltsville Aerated Rapid Composting system (BARC). This system is appropriate for developing countries in that it is simple to build and operate (limited, simple, and inexpensive mechanical equipment), is highly effective in destroying pathogenic bacteria, viruses, and helminths, is an anaerobic process that does not produce any of the foul smelling gases associated with anaerobic decomposition of organic matter, and is fairly inexpensive to operate (Shuval et al., 1981).

7.4 Industrial Pollution

Data on industrial pollution are seriously deficient, however, some indications suggest this issue requires more attention. Action in this field will require social and political skills since any radical and direct approach is unlikely to bear fruit (e.g., it appears that temporary plant closings have led to an exchange of the minister responsible, rather than changes in pollution practices). The following is a partial list of issues and offenders.

7.4.1 Solid Waste and Surface Soil Pollution.

It appears that this is not at this time a very major issue. The team observed PCB oils leaking from transformers in government-run workshops, hundreds of drums containing (properly labeled) toxic and acid liquids rusting away and contaminating the soil in the Barahona FTZ, the rusting remains of rolling stock and other equipment in lots near active or formerly active industries, and cows grazing among the tons of improperly handled

plastic materials of an industrial polluter. Every industry appears to lack proper disposal practices. However, this is probably not the area needing the most urgent attention since it does not yet appear to affect large human or animal populations.

7.4.2 Liquid Waste Emissions.

The most apparent instance of improper handling of liquid wastes is the effluent of the Fabrica Dominicana de Cementos into the Isabela river; the discoloration of the river is obvious. However, the effluent from the Industrias de Asbestos Cementos may in fact be more dangerous because of the apparent absence of any safety equipment and the great long-term danger posed by asbestos fibers washing up on the shore where thousands of people live and children play. In terms of quantity, the Cerveceria Nacional Dominicana and the Industria Nacional del Papel Bonao were the largest industrial users of water at the time of the 1981 A.I.D. Dominican Republic Country Environmental Profile, but this means little in terms of defining their pollution impact.

Other examples of water pollution outside of Santo Domingo are the following:

Location	Industry	Body of water affected
Santiago	FTZ	Yaque del Norte
Barahona	CEA Sugar Mill	Sea
San Pedro de Macoris	Sugar Mills (2)	Higuame
La Romana	Largest Sugar Mill	Rio Dulce
La Vega	Meat Processing	Camú
Puerto Plata	Rum Factory	San Marcos
Haina	Thermo-electric	Haina
Haina	Cardboard	Haina
Haina	Car Batteries	Haina
Villa Altagracia	Paper Factory	
Haina		

The most serious industrial water pollution problems are clearly concentrated in the capital city and have now become urgent in residential areas. A coherent, comprehensive land-use plan separating industrial and residential land uses does not exist, however, partial plans have been enforced (e.g., the Banque Industrial Norte was indeed meant to protect residential areas from industrial encroachment and pollution). The city, without the benefit of a land-use plan, has grown causing the several dozen industries located in that area to be surrounded by residential neighbors. This is what made the recent explosion of the Zurza canal a tragedy when it might otherwise have remained a curious incident of industrial pollution.

The FTZs which have more than doubled since the time of the 1981 study possibly posing significant problems as some include textile dying processes. Most, however, produce little liquid industrial waste.

Mines such as Falconbridge (Bonao), Rosario Dominicana (Cotui) and ALCOA (now closed in Pedernales but leaving a very large open pit) produce liquid waste and storm runoff waters rich in heavy metals. Their effect on biodiversity in rivers and coastal waters is probably significant but has not been measured.

Air pollution. The smoke stacks of Metaldom, Falconbridge and the industrial, institutional and commercial power plants emit sulfur and other emissions which must influence morbidity levels in nearby, especially urban areas. The only recent systematic study of such pollution is the one done on the impact of the Falconbridge mine (Instituto superior de agricultura, 1991) which popular opinion had accused of causing everything from birth defects to spreading plant diseases and causing harvests to fail. High levels of Nickel, Chromium and other metals were indeed found in the soil, water, vegetation and animal skins close to the mine and these levels diminish with distance from the mine. While the study does find significant levels of pollutants downwind from the mine, it nevertheless concludes that they pose no hazard.

From an ecological-historical perspective, most pollution problems are not considered as high a priority as other essentially irreversible environmental problems: loss of topsoil and destruction of upper watersheds, extinction of endangered species, and destruction of rare habitats such as cloud forests or coastal wetlands. Most pollutants, when diffused over wide areas or diluted, do not have demonstrable ecological effects. Even areas of heavy contamination have shown amazing resiliency when the sources of pollution have been removed. Many European rivers have sprung back to life after decades of heavy contamination after pollution control was implemented. The pollutants that may be exceptions are the persistent chlorinated hydrocarbons (e.g., toxaphene, alpha-HCH, PCBs, and the DDT group), long-lived radioactive wastes, and some heavy metals. (Most heavy metals, except mercury and arsenic, do not exist in an organic form and are not bioavailable to most organisms that comprise food webs; therefore, elevated levels in sediments or aquatic environments may not be effected in elevated levels in biota and may pose little or no health or ecosystem risks.)

It appears that there continues to be a need for monitoring and analysis of industrial pollution in the Dominican Republic. One step in the right direction is the brand new laboratory which will analyze water samples and data generated by INDRHI under a German (GTZ) sponsored program. But such monitoring will not in itself bring relief. Other major Caribbean nations at risk appear to be more successful than the Dominican Republic in enforcing pollution standards at this time. For example, Jamaica with its

bauxite processing, Trinidad and Curaçao with their petroleum extraction and refining, Puerto Rico with its thousands of manufacturing establishments and Cuba with its small but old industrial base are now known as "dirty" destinations, a reputation which the Dominican Republic might well acquire if pollution continues unabated. Such a reputation would hurt the tourist trade, one of the highest priority industries for the present and former governments.

7.4.5 **Rapid Storm Water Runoff**

Sewage piping is inadequate to drain storm runoff in the cities of the Dominican Republic. A considerable part of the area covered by any urban settlement is constituted by impervious surfaces - roofs, streets and other paved or compacted spaces - which act as collection systems for water. Runoff in urban spaces is therefore very high - certainly no less than the 80 percent assumed in the Table 4. The quantities of water collected over short periods can be considerable. If we assume, in the absence of better data, homogeneity and equal density of urban areas throughout the Dominican Republic, a one hour storm event of 20 mm rainfall will in 1990 produce the following quantity of runoff:

Table 4: Estimation of 1990 annual and single event runoff of rain water in 10 major cities.

	Population In '000	Area In km^2	Annual rainfall In mm	Annual runoff In m^3	Single 20mm eve runoff In
Santo Domingo	1,938	198.0	1,500	237,600,000	3,168,000
Santiago	399	40.7	1,000	32,558,400	651,168
La Romana	148	15.1	1,100	13,284,480	241,536
San Pedro de M.	115	11.7	1,100	10,322,400	187,680
San Franc. de M.	91	9.3	1,500	11,138,400	148,512
Puerto Plata	65	6.6	1,800	9,547,200	106,080
San Juan de la M.	63	6.4	700	3,598,560	102,816
San Cristobal	56	5.7	1,500	6,854,400	91,392
La Vega	55	5.6	1,300	5,834,400	89,760
Barahona	50	5.1	1,100	4,488,000	81,600
TOTAL	2,980	304.3		335,226,240	4,868,544

The main impact of rapid surface draining of very large quantities of water is physical: street surfaces and foundations are damaged, the steep inclines along urban river beds are collapsing, barrio housing is swept away, pipes, poles, cables and other infrastructure installations are exposed, undermined and damaged. The pollution impact of surface runoff is also considerable. Garbage and waste is carried from higher to deeper locations from where its noxious and toxic elements seep into groundwater. The piles and concentrations of waste, including human wastes, in low-lying locations retain humidity longer and become breeding grounds for numerous disease-carrying organisms. Rain storms appear to wash down the barrios in effect they make them more dangerous habitats.

The damage potential of surface runoff water in tropical urban locations can only be controlled by a combination of measures most of which are prohibitively expensive. Relocating the barrios, redesigning and constructing a street grid or providing drainage canals demand both investments and maintenance budgets which are beyond governmental capacities. Unless properly designed and cared for, the life expectancy of storm drainage systems is extremely short. Because many of the urban problem areas are on sloped terrain sand, rocks and garbage tend to fill and block pipes and canals

rapidly. For example, the costly storm drainage system of Port-au-Prince, Haiti, has been completely rebuilt two times since 1972 and is presently almost beyond repair.

Two control measures have been used successfully in the Dominican Republic to limit runoff water damage. Some towns have strongly curbed streets lined by concrete canals, even across intersections, which controls the physical damage of water to houses and infrastructure installations. Some cities have at times had a functioning garbage collection service, limiting the indirect health impact of rainstorms. Unfortunately both of these measures appear to be beyond the budgetary and political capability of most municipalities in the Dominican Republic at this time. Storm runoff will continue to damage housing and infrastructure to some extent. Its effect can be limited only by (1) re-enforcing the walkways, stairways and foundations in the steeply sloped barrio settlement, (2) getting garbage collected and disposed of rapidly, and (3) properly designing future infrastructure.

8.0 SUMMARY OF ACTIVITIES IMPACTING COASTAL RESOURCES

There are four main activities that occur (or potentially may occur) within the coastal zone directly related to the quality of its marine and terrestrial resources. These include: tourism development, shipping, mariculture and salt pond development, and fishing. In addition, two broad areas of activities, development in rural watersheds and developmer activities in urban watersheds, while not necessarily within the coastal zone, have profound impacts on coastal resources and have been included in the analysis of human impacts. Table A2 in Appendix 1 lists marine related activities, major problem associated with each activity, and their primary and secondary impacts on the terrestrial and marine environments of the coastal zone. These activities and impacts are elaborated below.

8.1 Tourism Development

8.1.1 General Description of the Problem

The rate of increase of tourist arrivals over the period 1980-1990 averaged nearly 15 percent per year (INFRATUR, 1990). It appears that, of the total foreign arrivals, 53 percent arrive in the Santo Domingo area while 32 percent arrive at Puerto Plata. The remaining 15 percent are divided among Santiago, La Romana, Punta Cana, Jimani, Dajabon, and Herrera.

In an island community of 7.5 million, a tourist population increase of nearly 1 million per annum, or about 13 percent of total, represents a significant impact. In addition, each tourist consumes nearly five times the resources that a local citizen consumes (Brown, 1991), making the potential effect of this population increase on the environment equivalent to increasing the present population by 66 percent.

Tourism development has occurred in numerous locations along the entire length of the coastal zone, especially where Tourism Development Zones (TDZ) have been declared in Figure A9 in Appendix 1. Table A3 in Appendix 1 lists the most recent estimates of hotel rooms in the coastal zone, by province. In some areas, especially on the south coast within and radiating east from Santo Domingo (TDZ 1), and on the north coast near Puerto Plata (TDZ 2) and the Samana Peninsula, (TDZ 4A) tourism is relatively well developed. Areas of potential tourism development are located along the northeast and east coast from Sabana de la Mar to Cabo Engano, extending southward to Playa Juanillo (TDZ 3), and on the southwestern coast stretching from Barahona to Oviedo (TDZ 4). Recently the area East of Luperon extending to Punta Rucia has been declared (by Presidential decree) a Tourism Development Zone. In each of the potential locations the main limiting factor is adequate infrastructure.

Tourism development has become an important alternative for needed foreign currency in the Dominican Republic as elsewhere throughout the world in developing countries. In island nations with extensive coastal shorelines and associated beaches, reefs, and marine grassbeds, the potential is significant. Limitations to resort development are both external and internal. The major external limitation is developing a sufficient "market share" to warrant increased resort development, and while all indications are that world tourism is still growing, it represents a limitation not easily overcome. Often in the rush to develop tourist resorts, the very resources which attract tourists are neglected, not protected, and lost. Once gone, reefs, beaches, and coastal habitats are not easily replaced.

In the Dominican Republic, like many developing nations, the major internal limitation is the lack of adequate infrastructure in the form of road networks, airports, public water supplies, and waste treatment technologies. Provision of the needed infrastructure represents a significant investment that must be financed from external sources. The costs of infrastructure development (including the airport, golf course, access roads, and utilities) in the Puerto Plata TDZ were financed by two loans from the World Bank ($21 million in 1974 and $25 million in 1979). The net benefits from tourism development under these circumstances are questionable when both economic and environmental costs are considered (Brown, 1991). As a result of this lack of public infrastructure, many hotels are required to provide their own services at varying degrees of success and efficiency.

8.1.2 **Major Problems and Resulting Impacts**

The general trend is an increase in the pressure on the local environment as tourism development increases. The major problems that result can be grouped into 3 broad areas: (1) release of pollutants, (2) direct conversion of terrestrial and marine habitats, and (3) increased demand for resources.

Release of pollutants: There are several sources of pollutants resulting from tourism development in the coastal zone. The largest is domestic sewage from beach front hotels and ancillary developments. Other sources of pollutants include, stormwater runoff, dumping of solid wastes, and oil and fuel from marinas and boat operation. In some areas, the dumping of solid wastes directly into coastal waters can represent a significant source of potentially hazardous material.

In well mixed surf zones and tidal locations the ultimate consequences of ocean outfalls for domestic sewage are disputed. The enrichment of marine waters that are notoriously low in available nutrients may actually increase productivity, yet net increases in productivity alone may not justify the practice. Since both coral reefs and marine

grassbeds depend on extremely transparent waters, over enrichment for sewage outfalls and the resulting increases in algae production can have serious impact on water transparency and thus these communities (Snedaker and Getter, 1985). Coral reefs are particularly sensitive to toxins that may be released as nonpoint sources of storm water runoff or from marinas (fuel and oil).

Maintenance of good water quality is not only important to marine organisms, it can seriously affect human use of marine resources as well. With the release of sewage and nonpoint source stormwater runoff, water quality can be negatively affected to the point that recreational uses and harvest of marine resources for consumption are impaired. While many beaches have well mixed surf zones, others can easily concentrate human wastes resulting in dangerously high levels where water quality standards for human recreational use are exceeded. While indications are that some marine organisms (bottom fish) do not biomagnify trace metals from sewage outfalls (Mearms, 1981) there is still cause for concern regarding benthic invertebrates, filter feeding mollusks, and some epibenthic invertebrates like crabs, shrimp, and lobster.

Sewage treatment is probably the single most important service (other than potable water supply) necessary to protect the health and safety of people living (or visiting) in the coastal zone, and yet the one most often neglected by public and private development. In the Dominican Republic, most development, whether for tourism or urban expansion, is not serviced by a central sewage treatment system, or small package facilities.

Public waste treatment facilities in the coastal zone are inadequate. Cobb et al. (1991) reported that 40 percent of the population nation wide was served with sewage treatment facilities that are extremely overloaded. This team's interview with CAASD suggested that only 25 percent of Santo Domingo was sewered. The consequences are staggering. Virtually all existing development, and much of the new development, in the coastal zone either injects untreated sewage to groundwater or discharges domestic sewage untreated directly into coastal waters. Both of these practices degrade the quality of the resource base for tourism and threaten the health of the permanent population and visitors alike.

Pollution of near shore waters resulting directly from tourism development is impossible to distinguish from other discharges of point and nonpoint sources in areas around Santo Domingo, although it can be summized that coastal hotels are contributing to an already serious situation.

Direct conversion of terrestrial and marine habitats: With the construction of tourist resorts, marinas, and associated infrastructure, terrestrial communities like beach and dunes, back dune areas, mangroves, and areas of salina are directly converted. Often coral reefs are removed or channels blasted to provide access to open waters. Marine

grassbeds and mangrove swamps are often dredged to provide boat access to marinas. These conversions are direct and irreparable. The connections between terrestrial and marine habitats, the values of fringing mangroves and reefs as buffers against storm waves, not to mention the importance of many of these habitats to indigenous and migrating fauna, make their conversion problematic. Impacts of conversion of any of the coastal communities, because they are tightly coupled, causes loss of habitat value and food chain support throughout the coastal zone. The impacts are manifested in shifts in the community structure of reefs and grassbeds, decreases in the abundance of certain marine organisms, and the eventual loss of fishery potential.

In areas of existing tourism development (Figure A9 in Appendix 1), and radiating outward along the coasts, associated impacts on the marine and terrestrial communities, while not always evident or documented, have been mentioned in numerous interviews with government and private sector individuals. Wherever beach side development of tourist resort facilities was observed on the northern shore, there was complete alteration of beach and dune communities throughout the immediate area of each complex. Associated road networks and nearby commercial developments contributed further to destruction of dune and back dune vegetation. In many areas of the north and northeast coasts, native dune vegetation had been replaced long ago with coconut plantations.

Evidence of destruction of reef communities and marine grass beds is more difficult to document without extensive investigation. The mechanical disturbance of marine grassbeds has become a serious problem in areas where there is heavy boat traffic and may be surmised to be of minor importance in most of the coastal zone, since the number of boats and marinas in areas of seagrass bed communities is relatively small. However there is increasing marina development in the Monte Cristi area with the dredging of channels through the fringing mangrove communities to accommodate pleasure boat traffic (E. Pugibet, personal communication).

Where fringing coral reefs are removed for better beach access, wave action and storm events can quickly erode the beach foreshore and backshore areas. There are reports of serious beach erosion within the last several months at Puerto Plata resulting from destruction of near shore reefs (E. Pugibet, personal communication) and at Boca Chica where bulldozers are being used to push sand onto the beach. The Boca Chica situation is indicative of increasing problems with sand supply and the potential for loss of reefs and seagrass beds. Aerial observation of the Puerto Plata situation revealed beach groin construction immediately upcurrent from the eroded area, thus a possible explanation for erosion may be loss of sand supply in combination with reef destruction.

Increased demand for resources: Wherever concentrations of human populations increase, there is an increased demand for resources from the surrounding environment. Tourism development increases the demand for fishery resources, potable water, land, labor, and even such obscure resources as palm fronds for thatching of beach front palapas. With increased demand comes the potential for over exploitation. Many of the reefs and grass beds throughout the Caribbean region exhibit indications of overfishing of such desirable marine organisms as lobster, conch, and the larger reef fish (Snedaker and Getter, 1985).

The demand for curio items like corals and sea shells can easily out strip the potential of the marine environment to provide them on a sustainable basis in areas of intense tourist development. As these resources are exploited, associated secondary impacts include the complete collapse of reef communities. These communities cannot sustain high levels of harvest of top levels of the food chain without serious shifts in populations of lower food chain organisms. Economic dislocation of artisanal fisherman follows the initial increase in income and numbers of fishermen as over-exploitation eliminates the resource base upon which they depend.

The influence of the increased number of tourists on the demand for local resources is apparent in several examples. The south coast stretching from Santo Domingo to as far east as Parqua Nacional del Este has a growing number of tourist operations transporting tourists to the secluded beaches of the park for day trips. Observations during a single field trip to Parque Nacional del Este estimated the number of tourists using the beaches and near shore waters at over 200 individuals. Unrestrained recreationists have caused declines in the reef communities at Boca Chica (in combination with other activities including dredging, fishing and sewage outfalls (H. Lopez, personal communication).

8.2 Shipping

8.2.1 General Description

There have been several personal reports of increased contamination of south shore coastal areas resulting from ocean dumping of garbage, sewage, and balast tank water by freighters and cruise ships. The magnitude of the problem was impossible to qualify or quantify. Much of the jetsam and flotsam found on the beaches of the southwest coast may be more from unrestrained dumping of garbage and urban runoff both on the island and from islands to the east, and less from passing freighters and cruise ships.

In the Dominican Republic, principle ports are located in the southern cities of Santo Domingo, San Pedro de Macoris, and La Romana. On the north coast Puerto Plata is the main port.

8.2.2 Major Problems

The construction, maintenance, and operation of port facilities can represent a significant impact on the environment. Dredging of habitats for port creation, channel maintenance, and release of toxins and other pollutants are the major problems. Moderately sized accidental oil spills have occurred, and could pose a potential problem. A brief discussion of each follows.

Dredging and jetty construction - In nearshore waters, deep water access to ports for ocean going vessels must be provided and maintained. The process of dredging, whether for newport construction or for maintenance of existing facilities, directly converts marine and terrestrial habitats, increases turbidity, and can be a source of pollutants from accumulations in sediments. The process of dredging converts habitat directly, and disposal of dredge spoil often further damages habitat.

Physical destruction of habitats threatens wildlife, impacts fisheries, and causes loss of sediment trapping capacity and storm surge protection.

Release of toxins, sewage, and garbage - In both nearshore waters and deep water shipping lanes, the release of ballast, sewage, and garbage can pose a threat to marine resources. Ballast often contains toxic substances that if released in open waters probably do not reach concentrations that may be significant. Yet oil residue often forms tar mats that are unsightly and unpleasant to tourists and present an ecological problem on beaches and fringing reefs. Sewage discharges at sea do not present the problems of shore based discharges. Open sea dumping of garbage is problematic because of the prevalence of non-biodegradable plastics that foul beaches and can be ingested by marine mammals, fishes, and birds.

Ballast waste (from foreign ships) is discharged in the shipping lane near the country. Few steps have been taken to control this practice, and its impacts and costs are unknown. It is also unknown what proportion of the heavy litter found on beaches is caused by open ocean dumping. As currents travel from an east to west direction on the south coast, heavy litter problems affect beaches as far west as the San Luis beach of the Jaragua National Park. Litter is reported to be so heavy as to interfere with the spawning of sea turtles on the beach (H. Lopez, personal communication).

Clean up can be a large cost; it is attempted by resort facilities (which have the most to lose) and rarely by municipalities. The only known clean up of the Jaragua beach was done on a volunteer basis (although costs for transportation from Santo Domingo and for food was incurred) by the Federación Dominicana de Asociaciones Ecologistas

(FEDOMASEC). The extinction of an endangered sea turtle would be a cost difficult to calculate economically.

Accidental oil spills - Accidental oil spills can be the most catastrophic impact of shipping, completely destroying nearshore habitats and outright killing fish and shorebirds. The Dominican Republic has already suffered from a couple of these types of accidents. A little over two years ago, a barge carrying crude oil on a routine trip from Santo Domingo to Puerto Plata (for the thermo-electric plant of the CDE) ran aground at La Vacama near the Nisbon lagoon. The barge lost most of its contents of 625,000 gallons of crude, contaminating the shores of Vacama, Las Galetas, Samaná, and Las Terrenas and damaging flora, fauna, fisheries, and tourism. Clean up and attempted containment of the accident was conducted by the Dominican Republic Navy and the Civil Defense. These groups are now preparing a contingency plan tc increase readiness in the case of future accidents (V. Garcia and H. Lopez, personal communications).

Likeliness of further accidents, even more serious ones, is quite high. A large percentage of the oil used in the United States (the world's largest consumer) is refined in the Caribbean. Every day, 23 to 30 supertankers, and approximately 80 smaller ships, transporting more than 3 million barrels of oil cross the Caribbean sea through the shipping lane by Santo Domingo (H. Lopez, personal communcation).

8.3 Mariculture and Salt Production

8.3.1 General Description

Typically the construction of ponds for mariculture and salt production occur in salina areas. Often the salinas are upland, but immediately adjacent to mangroves, but are sometimes found next to bays or lagoons separated from these open water systems by a natural rock of coral dike or sand bar. Sometimes upland fringes of mangroves are converted, and in the more serious cases, ponds are constructed next to estuaries within mangrove forests. Salt evaporators in the Dominican republic appear to be constructed in the salinas areas. In field surveys of the coastal zone, the team did not encounter any mariculture operations.

8.3.2 Major Problems

Occasionally salt evaporators discharge brine solutions to nearby waters raising soil salinities in adjacent mangroves. In addition, large expanses of salt evaporators immediately upland from mangrove communities alter, and in the worse cases, eliminate, overland flow of rain water into the mangrove. The increased soil salinities that result can kill trees.

Access by local fish populations to open waters through tidal creeks can be inhibited, and, in some cases, salt evaporator dikes provide human access to mangroves for wood cutting that otherwise may not have been possible.

Increases in suspended sediment load from saltpond construction are temporary, but erosion of constructed dikes can be a long term source of sediments if not stabilized.

There is a significant area of salt evaporators occupying the areas immediately inland from the mangroves at Monte Cristi. The actual area covered by the evaporators is not known; however, it appeared that nearly 90 percent of the landward edge of the mangroves was given over to salt ponds. A salt operation was also encountered at Bahia Calderas where, on the day of the team's visit, operators were discharging an estimated 1-2 m^3/minute of salty water (65ppt) to the estuary.

8.4 Fishing

8.4.1 General Description

Compared to more temperate fisheries, the fishery of the Dominican Republic is relatively low in productivity. Mostly at an artisanal level, the fishery is dominated by demersal species. The major fishing zones are the shelf areas at Banco Monte Cristi, Bahia de Samana, Cabo Engano, San Pedro de Macoris and Bani-Barahona, and the submerged banks at Banco Navidad and Banco Plata. The latter two areas dominate the Dominican fishery as the source for the largest portion of total annual catch.

Because of low productivity and the lack of effective fishery management, the potential for overfishing the entire marine fishery is significant. In addition, increased local demand at urban centers and in areas of tourism development, can easily deplete local stocks. Some species, such as shrimp, lobster, and conch, which have an international market and tourist inflated local prices, may be seriously depleted if the Dominican Republic has followed the trends of the rest of the Caribbean Islands.

8.4.2 Major Problems

Overfishing causes collapse of the fishery when harvest is greater than population recruitment and growth rates. Once the fishery begins to decline, increased effort to sustain yields results in decreased catch-to-effort ratios. Often prices rise, reflecting the scarcity of supply, which in turn continues to place increased pressure on declining fish stocks. Once collapsed, economic dislocation of fishermen results and increased imports of fish and fish products are necessary.

In 1980, INDOTEC estimated the yield of the insular platform and submerged banks of the Dominican Republic to be between 800 and 2,330 kg/km^2/year, and total potential yield to be 22,312 metric tons. Hartshorn et al. (1981), using a lower suggested yield, estimated a total sustainable yield of 10,454 metric tons. Using the latest published statistics (Oficina Nacional de Estadistica, 1991), the estimated total annual fish catch of marine origin in 1988 was nearly 15,000 metric tons (see Table A1 in Appendix 1). Data provided by the Department of Fisheries shows a higher total annual catch for 1988, almost 19,000 M tons. If the sustainable yield estimate by Hartshorn et. al, is reasonably accurate, the fishery of the Dominican Republic is being over exploited. Unfortunately, data apparently do not exist on any basis except estimates of total volume of catch, thus it is impossible to determine the status of individual fish stocks or catch to effort ratios. Department of Fisheries personnel confirmed that the size of shrimp, lobster and conch were getting smaller, and that fishermen were having to fish longer and farther to maintain their volume (R. Nelasco, personal communication).

8.5 Activities in Rural Watersheds

8.5.1 General Description

The primary activities of concern are agriculture, deforestation, and hydroelectric and irrigation projects. Agricultural activities contribute to sediment transfer and the introduction of pesticides, herbicides, and nutrients to the marine environment. Deforestation contributes to the transfer of sediments and alteration of timing and volumes of freshwater inputs to the coast. The construction and operation of dams alters discharge regimes of major rivers, and thus the timing and volume, of fresh water entering the marine environment.

8.5.2 Major Problems

The major problems in the coastal zone that result from rural watershed activities whether agriculture, forestry, or from dams can be grouped into three areas: (1) inflows of sediments, (2) inflows of toxins and nutrients, and (3) altered fresh water inflows. There is a paucity of reliable data on the levels of contamination and sewage enrichment of fresh water inputs and near shore coastal environments. The evidence of problems and impacts remains anecdotal.

Inflows of sediments - Agricultural practices and deforestation act to increase sediment transfer to the coastal zone, yet hydroelectric dams can trap sediments, and as a result minimize negative coastal zone impacts that may have otherwise occurred. On the other hand, productivity of estuaries and river delta areas depends on an adequate supply of sediments and organic matter from terrestrial sources. There are numerous examples,

world wide, where loss of sediment inputs has caused irreparable damage to coastal fisheries, and even erosion of delta land masses (i.e., the collapse of the herring fishery at the mouth of the Nile River. or the loss of wetlands at the Mississippi River delta).

The impacts of alteration of sediment inputs to marine environments can result from either too much sediment input or too little. Where sediment loads increase, the impacts are sedimentation and increases in turbidity in nearshore areas with subsequent loss of grassbeds and reefs. Where sediment inputs are diminished because of diversion or impoundment behind dams, loss of marine productivity and even erosion of shorelines (resulting from a negative balance between erosional and depositional forces) can result.

Related to sedimentation; it was reported that the western portions of Bahia Ocoa were dominated by sandy substrate, but since the last hurricane, the bottom is now mostly silt and there has been a consequent decrease in grass beds (E. Puqibet, personal communication).

Inflows of toxins and nutrients - Agricultural watersheds and dispersed rural populations without adequate sewage treatment can add significant amounts of agrochemicals and human wastes to river systems via runoff that are in turn carried to the marine environment. Toxins that interfere in biochemical processes, can be biomagnified in food chains to humans, and in rare cases can ultimately result in the collapse of marine fisheries and ecological functions of marine systems receiving them. Increased nutrient inputs can be beneficial, especially if there is a significant harvest of organisms (and thus removal of nutrients) from the receiving marine ecosystem. Yet in many areas, over enrichment results in declines of fragile ecosystems, like corals and seagrass beds, and eventual collapse of marine fisheries and ecological function. In all, with increased inflows of toxins and human sewage, safe water quality standards are violated and waters are rendered unsafe for human uses.

Related to increases in toxins and human sewage; there have been numerous suggestions of possible problems in Bahia Samana, the result of runoff from the extensive areas of rice cultivation.

Altered freshwater inflows - The volume and timing of freshwater inflow to marine systems is critical. Modification of inflows causes rapid fluctuations in salinity and disrupts the saltwater-freshwater interface. With reduced flows, higher salinity water migrates inland and flushing of soil salinity from mangroves is impaired. With increased discharges, marine organisms that are adapted to higher salinity waters, migrate seaward or become extinct. Changes in the periodicity are detrimental to coastal organisms that cannot adapt

to fluctuations in salinity, often pushing ecological communities in the saltwater/freshwater interface toward lower diversity and lower yield systems.

Related to reduced inflows of fresh water; the team's flyover of the coastal zone and interior areas of the country revealed that the Ocoa, Nizao, and Yaque del Norte rivers had no flow; their waters diverted for agricultural irrigation. The Nizao appears to be so dry for extended periods of the year that extensive mining of sand and gravel from the stream bed is taking place in numerous locations down stream from the dam. Die off of about 20-30 hectares of mangroves was noted at the mouth of Rio Yaque del Norte, presumably the result of lowered freshwater flushing of mangrove soils.

8.6 Activities in Urbanized Watersheds

8.6.1 General Description

Whether increasing in size, or remaining relatively stable in spatial extent, urbanized watersheds affect water quality, timing, and quantity. Increased area of impervious surface increases the speed and volume of runoff after storm events. Stormwater runoff carries with it silt and sediments, oil residues, heavy metals, and trash.

Increased urbanization and population density means increased spatial density of wastes. Where urban populations are concentrated in the coastal zone, human and industrial wastes are often discharged in ocean outfalls, often untreated. Further inland, wastes from urban concentrations are usually discharged to a nearby river that carries them downstream to the coastal zone. In the Dominican Republic, a third form of sewage waste management is the injection of untreated sewage directly into the aquifer.
Solid wastes disposal in the coastal zone is problematic. Often solid wastes are dumped in "low" areas (marshes and mangrove swamps) or directly into the ocean at the shoreline. Accumulations of solid wastes in streets, if not removed regularly, are washed with the next rainfall to the nearshore environment.

The demand upon marine resources in areas surrounding urban concentrations usually far exceeds sustainable yields. First, increased population density increases the demand. Second, urban populations with higher income increases demand; and third, urbanization often results in a high concentration of poor who by necessity extract resources from the local environment.

8.6.2 **Major Problems**

Altered freshwater inflows - Alteration of the hydrologic regime through increased impervious surface has two deleterious impacts on near shore waters. First, during storm events, nearly all rainfall runs off the urban area immediately because there is little soil or surface storage. Second, during dryer periods of the year, there is less base flow in rivers and streams with large urban concentrations, since runoff during rain events is so high. The impacts of altered timing and volumes of freshwater inflows are to cause higher concentrations of wastes, and greater fluctuations in the salinity of nearshore waters. These factors seriously impact species composition, lower productivity, and ultimately decrease stability of marine ecosystems. The net result in human terms is the decline of nearshore fisheries.

The volume of freshwater runoff from the ten major urban areas was estimated to be about 335 million m^3/yr using a runoff coefficient of 80 percent. Prior to urban expansion, the freshwater runoff from these same areas was probably half that amount. There are no estimates of the amount of sediment and trash/garbage that is carried annually to the Caribbean via stormwater runoff from urbanized lands.

Inflows of toxins and nutrients - Liquid wastes from industry and human sources are serious threats to the nearshore marine environment if concentrations exceed the capacity of the environment to assimilate them. Factors affecting the assimilation capacity are: type and concentration of the waste, type of community receiving the wastes, and other abiotic factors, like mixing of the near shore waters, rainfall, and soils (in terrestrial communities). The impacts of discharges of human and industrial wastes in the coastal zone are relatively straight forward: they cause water pollution, which in turn causes alteration of marine communities, poses human health risks, contaminates near shore fisheries, and increases eutrophication that contributes to the decline of coral reefs and seagrass beds.

Cobb et al. (1991) estimated that only 40 percent of the urban population in the Dominican Republic is connected to a sewage system, and that existing sewage systems are inadequate. All "treated" sewage is discharged either to rivers (which discharge to near coastal waters) or discharged through ocean outfalls. Untreated sewage is either discharged on site through septic tanks or leach beds, injected to the aquifer (its long term fate unknown), or discharged to rivers or the Caribbean (L. Marion-Landais and J. Infante, personal communication) In other words, effectively, there is little or no sewage treatment in the coastal zone.

Inflows of sediments - Sediment transfer to the marine environment from urbanized areas can be significant. Where sediment loads increase, the impacts are sedimentation and increases in turbidity in nearshore areas with subsequent loss of grass beds and reefs.

Increased resource demand - Increased demand for resources from urbanized areas in the coastal zone is probably the single biggest factor affecting the sustainability of nearshore fisheries in many areas. Ultimately without strict controls on use of resources, whether fisheries, beaches, or wildlands, the quality deteriorates with increased populations and eventually the ecological systems that produce the resources collapse, or undergo regression to a simpler, earlier successional community.

Current demand for coastal resources like firewood and fishery products is difficult to estimate. However as an example of the pressure on the environment to provide resources, an estimate of the demand for charcoal in the Monte Cristi/ Pepillo Salcedo area was developed using an urban population of 15,500 (Oficina Nacional de Estadistica, 1991) annual consumption of .4 m^3/capita (Cobb et al., 1991) and standing stock in mangroves of 25 m^3/ha. The annual rate of potential deforestation of the mangrove community near Monte Cristi is equal to about 25 hectares per year.

Solid waste dumping - Dumping of garbage in the coastal zone is problematic because of improper handling and location of dumps. The practice of using wetlands, direct dumping in coastal waters, landfills located next to river floodplains, and build up of garbage in streets results in release of solid wastes and landfill leachate directly to surface waters. The prevalence of non-biodegradable plastics in garbage can foul beaches and can be ingested by marine mammals, fishes, and birds. Landfill leachate contains many toxic compounds and metals that can represent threats to marine communities and ultimately human health.

8.7 Status of Coastal Resources

8.7.1 Mangroves

8.7.1.1 General Status

For the most part, mangrove communities on the northern shore have not been impacted. There are reports of channelization and cutting for charcoal in the Monte Cristi area, and wood cutting in the extensive forests of the Bahia de Samana. An overflight in a Navy helicopter confirmed channelization for boat access to open water at Monte Cristi, but could not confirm reports of wood cutting. The extent of the channelization is relatively small. Additionally there are reports of potential conflicts with rice cultivation at Bahia de

Samana. There seems to be very little, if any, intrusion into the mangroves from rice cultivation.

The flyover along the entire coastline did reveal that smaller, isolated areas of mangrove are under considerable pressure along the north coast where it was estimated that about 20 percent of the small stands were seriously impacted. This does not represent a large proportion of the entire area of mangroves (probably less than one percent), yet locally the loss of 10-50 hectares can mean local extinctions of numerous species.

It is probably safe to say, that many of the rivers of the south coast were once mangrove lined. However, they have long since been cut and/or filled with the exception of the mangroves along the Rio Higuamo and a 80 hectare forest on the Rio Soco. Several isolated forests near the Rio Soco appear to be completely cut over. The 186 hectare mangrove forest at Puerto Viejo appears to be intact.

Mangroves north of the Laguna Oviedo are reported to be under some pressure from wood cutting, although this report was not confirmed. Mangroves in both the Parque Nacional del Este and Parque Jaragua are relatively removed from population centers (with the exception of the forest at Luguna Oviedo and those near the settlement of San Juan on Isla Saona) and as a result are relatively intact.

Greatest pressures on mangroves occur in areas where development and populations and tourism development proposals are increasing. The extensive forests at Monte Cristi are under considerable pressure from salt production on their upland fringes and reduced discharges of the Rio Yaque del Norte. Those Bahia de Samana near the mouth of the Rio Yuna may be under pressure, although the flyover did not reveal any visible evidence of conversion to rice. The mangroves of the Rio Higuamo, are located just north of San Pedro de Macoris and as a consequence are impacted. The upland fringes of these forests are altered and filled in numerous locations.

In all, while the forests on the north coast are relatively intact, increasing development pressure is evident. Forests of the south coast have been mostly destroyed, and those that remain are under considerable pressure.

8.7.2 **Beaches**

8.7.2.1 General Status

With the exception of the beaches located along the stretch of northern coast from Punta Buren to Bahia de Icaquitos, most of the beaches have been developed in one form or another.

The beaches of the northeast coast have several large tourist resorts. Virtually all the dunes along this stretch of the coast have been altered and planted in palms.

There are several small "pocket" beaches along the eastern windward shore from Cabo Engano to Cabo San Rafael that are still dominated by native dune vegetation. These beaches and the majority of this coastline is inaccessible, except for a dirt road that runs along the coast.

Roughly 50-70 percent of the beaches of the north coast from Nagua to Puerto Plata host some form of tourist development. Here again, the natural dune vegetation has been given over to coconut plantations.

The beaches and dune systems of the northwest coast between Punta Buren and Bahia de Icaquitos are still relatively intact and represent the last vestiges of beach & dune native flora and fauna in the country.

Beach erosion was noted at Puerto Plata and Punta Macao; the former location was reported to have been caused by removal of the fringing coral reefs, while the latter appeared to be due to normal shifting of the point. The erosion at Puerto Plata may be aggravated by the construction of beach groins just to the west of the area of most intense beach loss.

The beach loss at Boca Chica may be the result of jetty construction and the loss of fringing corals. It must be mentioned that the beach nourishment project is only a temporary fix, at best, and may in fact aggravate the situation by further causing declines in fringing reef communities and seagrass beds.

General Status

While estimates from a single flyover of the coastal zone are difficult, it appears that well over 90 percent of the total area of marsh wetlands within the coastal zone have been converted to agricultural production, or otherwise seriously degraded. On the entire

northern coast, only a single marsh of approximately 100 hectares was noted that was somewhat intact, although there was encroachment along its eastern and southern edges). Within this same wetland, located between Punta Macao and Playa del Macao, there was a significant bird rookery.

Other areas of wetlands were noted but for the most part they were seriously degraded either from loss of hydrologic inputs or from cattle grazing. The impacts of agricultural chemicals within the remaining wetlands in close proximity to rice plantations represents a serious threat to remaining indigenous and migrating bird populations..

8.7.3 **Coral Reefs**

8.7.3.1 General Status

Near shore waters along the south and southwest coast, in places especially near concentrations of urban development, and where rivers discharged to the Caribbean, were relatively turbid and are believed to be areas of low coral productivity. The southeast coast along the Parque Nacional de Este and north has significant development of coral substrate, but these were more of the nearshore reef escarpments. In areas along the north coast where rivers discharged into the Atlantic, especially at Rio Yeguada, near Miches, Rio San Juan, and Rio Yasica, turbidity is high (substrates appear to be mud), not at all conducive to coral formation and growth.

Without further evaluation in a more detailed study of reef condition, it is impossible to ascertain the general health of these communities. Professional judgement would suggest that the reefs of the northwest coast are in relatively pristine condition and those around Puerto Plata are probably suffering from over fishing, turbidity increases, and recreational diving.

8.7.4 **Sea Grass Beds**

8.7.4.1 General Status

In general, the sea grass beds on the south coast suffer from turbid river discharges and intense urbanization. For instance, the percent cover at Boca Chica was estimated at less than ten percent during the flyover. The beach nourishment now underway is seriously increasing both turbidity and sedimentation.

Since there is a paucity of data and no quantitative inventory of coastal zone resources, it is difficult to provide trends in resource abundance, especially seagrasses. Observations of the entire coastal zone indicated that grass beds on the southeast coast at Parque Nacional del Este were little impacted and those along the north coast for the most part were in relatively good condition. At several locations along the east and north coast where the larger watersheds discharged (Bahia de Yuma, Rio La Yeguada at Miches, Bahia de la Jina, Rio Yabon near Sabana de la Mar, Rio Yuna, and Rio Nagua), there were obvious turbidity problems that probably have affected seagrasses.

It is unlikely there were extensive seagrass beds at Monte Cristi because of the inputs of organic stained water from mangroves and the discharge of Rio Yaque del Norte. On the day of the flyover, there was no discharge from Rio Yaque del Norte, yet the near shore waters in both Bahia Monte Cristi and Bahia de Manzanillo where extremely turbid, probably the result of bottom sediments and mangrove runoff.

8.7.5 **Fishery Resources**

8.7.5.1 General Status

Total annual fish catch for the Dominican Republic during the period from 1985 through 1988 shows a peak in 1986, a decline in 1987, and a partial recovery in 1988 (Oficina Nacional de Estadistica, 1991). These trends are somewhat disturbing, but without better data collection and reporting, it is impossible to assess the status of fish stocks.

Hartshorn et al. (1981) reporting INDOTEC estimates suggested that the total landings in the five years proceeding their report was near 7,000 metric tons/yr, and that sustainable yields are on the order to 10,000 metric tons/yr. Estimates based on data for 1988 (Oficina Nacional de Estadistica, 1991) are that total fish landings for coastal cities was on the order of 14,000 metric tons and current data provided by Departamento de Recursos Pesqueros for 1990 show total landings of over 19,000 metric tons. Clearly there has been a significant increase in the ten years since the Hartshorn report. Again though, it should be emphasized that there is a paucity of data on individual species, or catch to effort analysis to determine the status of the fishery.

8.7.6 **Endangered Species**

8.7.6.1 General Status

Unknown. Unfortunately there is a paucity of information and population trends for any of the endangered species of the coastal zone.

9.0 CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a prioritized list of conclusions concerning the current state of various aspects of the country's natural resource base, recommendations for Mission interventions, and action steps to be taken. All recommendations and actions have been made in light of the SGTNRM project's purpose which is to:

> assist in developing the knowledge, programs, and institutions which will enable the Dominican Republic to utilize quickly and effectively the resources available through the Enterprise for the Americas Initiative, to undertake large scale efforts to reverse the trends of environmental degradation of watershed and coastal zones, and to promote sustained growth through improved management of the country's natural resources.

In particular, the SGTNRM project is designed to improve performance in three areas:

I Problem Identification and Policy Analysis
II Natural Resource Management
III Long-term Planning

Each of the recommendations below will be parenthetically marked (I,II,or III) according to which of the three objectives it will most promote.

The SGTNRM project calls for intervention in "at least two coastal zones and two watersheds." The recommended sites are listed in the first section of this chapter. The site selection methodology and decision-making criteria are presented in Annex II Description of Methodology and Site Selection for Pilot Projects.

9.1 Conclusions and Recommendations Derived from Rural Issue Analysis

9.1.1 Provide Economic Alternatives to Subsistence Agriculture and Charcoal Production

9.1.1.1 Conclusion

The main cause of environmental deterioration and degradation of water and other natural resources in the Dominican Republic is deforestation of areas only suited for forest production, conservation of biological diversity, recreation, and water conservation. Dense and multi-storied vegetation with deep roots as, in forested areas, acts as a

sponge releasing water slowly, over more uniform time periods. Deforested areas may experience flooding during periods of rain, and little or no water in streams during dry seasons. Social and economic considerations, rather than technical limitations are responsible for the occurrence of such processes.

Current rates of deforestation are primarily caused by the economic activities of low-resource farmers who lack alternative means of subsistence. Projects which promote natural resource management activities must seek to provide low-resource farmers with economic alternatives to subsistence agriculture or charcoal production on unstable slopes and access to financial resources to reduce current deforestation rates. Incentives may include a link of resource/land rights to a continued supply of water resources and protection of the watershed as practiced in the San José de Ocoa model. Another incentive may include an economic option for the utilization of forest resources, based on sustainable rates of extraction.

Results should include improved protection of areas only suited for conservation of water resources and biological diversity.

Recommendation (II)

Promote the creation of a positive incentive structure based on access to resources and alternatives to unsustainable exploitation of steep slopes through replication of the Jan José de Ocoa or similar models at other sites. Access to resources should be tied to protection or sustainable utilization of forest in areas suited for forest production.

Action

Select a pilot watershed as a demonstration site for the activities that should lead to environmental restoration and sustainable development. According to the field visits, literature review, and the criteria established for the study, the areas with the highest priority are the subwatersheds upstream of the Sabana Yegua reservoir and the Río Nizao watershed.

Provide assistance for the development of community groups which will take active roles in the management of their natural resources. Administrative and technical assistance are the best means to accomplish this in a scheme similar to the one followed by the San José de Ocoa development board. The actions recommended here will only succeed if the local population is included in the decision-making process from the outset. Participatory problem-solving and

project design methodologies ensure that project beneficiaries understand and agree with project objectives. In this instance, they will understand the value of maintaining watersheds in their current condition and will work to that end.

Activities should include the movement of low-resource farmers from the more fragile areas within the selected watershed, to areas were they can make a living based on irrigated agriculture, forestry, and/or agroforestry, without causing environmental degradation. The transition can be accomplished through the development of small scale irrigation on more level lands which are generally owned by more prosperous farmers or landowners. The program would ensure that subsistence farmers and landowners share mutual interests. The generally landless, subsistence farmer would gain usufruct rights in perpetuity (inheritable) to the land and water in exchange for small rents and protection of the water source (if the water source dries up, usufruct rights are forfeited). In exchange for relinquishing usufruct rights, the landowner also receives irrigation on lands returned for exclusive use and income from rents.

9.1.2 Improve Pesticide and Irrigation Water Management/Data Base

9.1.2.1 Conclusion

After deforestation, release of poliutants from the overuse of pesticides, salinization of soils (release of salts), and mining operations have the greatest impact on water quality and aquatic habitat in the fresh water environments of the Dominican Republic. However, specific data on concentrations and impacts are not well documented with political action difficult to mobilize.

Pesticide residues from agriculture operations are a non-point pollution source as they enter aquatic ecosystems through the margin of rivers and lakes carried by run-off. The presence of riparian vegetation along the river banks can effectively reduce the access of pesticides and sediments to streams and rivers. The greatest reductions in pesticide risk and contamination, however, come from education in the safe handling, use, and the implementation of IPM practices.

Mismanagement of irrigation areas has caused water-logging and salinization over significant portions of irrigated areas in the Dominican Republic. As much as 58 percent of irrigated acreage in the Dominican Republic may be affected by salinization alone. Salinization affects water quality through increasing the salinity of irrigation runoff or waste water. Increasing salinity can damage freshwater river communities and the availability

of water for further use. As irrigation is the largest user of water, this is a potentially significant factor in water quality in the Dominican Republic.

Mining operations are slightly less of a problem when observed from a national perspective as impacts are usually localized (point sources of pollutants). However, certain local areas and water sources of the Dominican Republic have been greatly impacted by mining operations, varying according to the nature of the minerals being extracted. Mitigation is site specific and usually requires restoration of the natural vegetation after mining operations.

Recommendation (II)

Provide technical assistance required to improve performance of intensive agricultural activities in the selected demonstration watershed, and reduce the impacts of agricultural runoff. These could include better water management, the rational use of pesticides, and the implementation of IPM.

Action

ordinate with the existing project on IPM, the On Farm Water Management, and PRODELESTE to provide needed assistance to the farmers in the selected demonstration watershed. Allocate additional resources to those projects, if required, in case the selected sites are not under the area of influence of such projects.

Where applicable, provide technical assistance for the protection or restoration of riparian vegetation. In areas where the vegetation has been eliminated, include species that can provide additional income such as bamboo.

Recommendation (I)

Develop a national data bank of pollution levels, problems, and impacts to precisely record data collected by different organizations.

Action

Through a competitive approach, sponsor a PVO to develop a data bank on pollution problems in the country.

9.1.3 Support Development of Improved Institutional Framework

9.1.3.1 Conclusion

The existing institutional framework is not ideal for the implementation of the recommendations cited earlier, such as the creation or support of regional development boards to provide technical and other assistance to local communities for greater participation in their own development. Moreover, comprehensive legislation concerning the management of watersheds is lacking, and roles of various government agencies are not clearly defined. The current legislation controlling utilization of forestry resources is clearly counterproductive.

The role of the central government should be redirected to provide guidance and an appropriate framework, leaving the actual implementation to community based organizations and PVOs. Comprehensive legislation specifically geared to promote integrated watershed management should be developed.

Recommendation (I)

The role of the central government should be redirected to provide guidance and the appropriate framework. Actual implementation should be left to community based organizations and PVOs. Comprehensive legislation specifically geared to promote integrated watershed management should be developed.

Support should be provided to strengthen existing regional development boards as well as promote the establishment of new ones. The definition of an appropriate legal framework is an important factor for support, and should include a) a legal basis for integrated watershed management, and b) a legal basis giving regional development organizations a framework for action, a legal identity, and provision for independent financing.

Actions

Promote legislation that will provide the basis for integrated watershed management and the operation of local development boards. CONATEF, which has taken the lead in the current activities to compile and revise forestry legislation, may be the appropriate agency to support or undertake this exercise. The Mission should consider one of three options in its ensuing project design: include a policy dialogue component in the project; include policy compliance as a project convent; predicate disbursement of project funds upon policy compliance.

Provide support for the current process calling for modifications to forestry regulations requiring total restriction in the utilization of forest resources, and offer incentives for sustainable management of forest resources to the local communities and the private sector.

9.2 Conclusions and Recommendations Derived from Demographic, Socioeconomic, and Urban Issue Analysis

Action is recommended on two urban issues. The first, waste and garbage collection, is an urban problem with an urban solution. The second, charcoal consumption, is an urban issue but a rural problem. Urban use of charcoal is a factor contributing to soil erosion in rural areas.

9.2.1 Removal of Solid Waste and Garbage

9.2.1.1 Conclusion

Expanding urban populations, especially in Santo Domingo, are increasingly exposed to health risks associated with inadequate removal of garbage and human waste. Even the small portion of garbage removed by public services is not disposed of properly. Seepage after rainfall carries coliform bacteria and other risk factors into the inadequately pressurized potable water system. All drinking water in Santo Domingo is heavily contaminated making water-borne diseases the principal cause of the Dominican Republic's high levels of morbidity and infant mortality.

Municipal garbage collection suffers from all the ills affecting governmental institutions in the country. An USAID sponsored new project would lack the resource to begin to resolve this problem area. Also, the highest health hazards connected with garbage and human waste are located in the barrios of Santo Domingo, which are mostly unaccessible to garbage trucks. There is much evidence that private individuals and entrepreneurs will respond to financial incentives for collecting garbage and delivering it to collection points where municipal trucks can take over.

Recommendation (II)

Assist in the creation of private enterprises collecting garbage from areas not currently served.

Action

Provide a grant through the Private Sector Office to a non-governmental agency or entrepreneur to plan and implement a pilot project which buys and disposes of garbage.

9.2.2 Reduction of the use of Charcoal

9.2.2.1 Conclusion

Charcoal production can be stopped in an area if the population is given the opportunity to make a better living by alternative means, thus contributing to the reduction of deforestation and soil erosion.

Legislation against the cutting of trees and the production of charcoal has been useless. Recent price increases for petroleum products appear to have driven up both charcoal prices and the demand for charcoal. Virtually all of the urban poor (i.e., two thirds of urban households) and several industries use charcoal as their principal energy source.

Regrowth and surviving forest stands make charcoal production feasible for about two more decades. Electricity and petroleum products are unlikely to become competitive with charcoal before the complete destruction of all forests.

Recommendation (II)

Replicate the San José de Ocoa model at numerous other sites, however, avoid all reforestation and terracing before local community structures can handle such projects in an autonomous way.

Action

Finance the San José de Ocoa organization so it can send community organizers to help reactivate and/or found similar organizations throughout the watershed and adjacent watersheds.

Recommendation (I,III)

Build on A.I.D.'s extensive experience elsewhere by following through on recommendations of earlier reports (e.g., Cobb et al., 1991) concerning fuel wood plantations. Alternative energy sources (e.g., wood and solar energy rather than charcoal for heating) should also be explored.

Governmentally controlled reforestation and wood production schemes should be avoided.

Action

Engage the GODR in policy dialogue concerning the benefits of energy farms and how to legislate and regulate this activity. Provide grants to PVOs to extend existing tree planting programs to include fuel wood. Explore the potential of "debt for energy farms" swaps.

9.3 Conclusions and Recommendations Derived from Coastal Zone Analysis

9.3.1 Better Control of Freshwater Inflows

9.3.1.1 Conclusions

The most important problem in the coastal zone is the alteration of the timing and volume of freshwater inflows to near shore waters due to activities in the rural and urban watersheds. Deforestation is the most important activity affecting the timing and volume of water flow in the rural watersheds of which the most important activity is the expansion of impervious surfaces. Again, water cannot be absorbed by an impervious surface like a city street, and rushes to the nearest low point or stream during times of rain.

The volume and timing of freshwater inflow to marine systems is critical. Modification of inflows, causes rapid fluctuations in salinity and disrupts the saltwater-freshwater interface. With reduced flows, higher salinity water migrates inland from mangroves or estuaries. Marine organisms that are adapted to higher salinity waters migrate seaward or become extinct. Species composition is seriously impacted, productivity lowered, and main ecosystems destabilized. The net result in human terms is the decline of nearshore fisheries.

Alteration of the timing and volume of freshwater inflows also acts in synergy to exacerbate the inflow of sediments and pollutants from activities in rural and urban watersheds (which already by themselves rank higher than all other impacts except for increased resource demand from urban watersheds). Higher volumes of flow during rainy seasons results in higher water velocities and greater erosion and sedimentation. Lower flow volumes during dry seasons leads to a concentration of pollutants. Slash and burn and the implementation of unsustainable agricultural practices on steep slopes is one of the main causes of deforestation and increased erosion.

Recommendation (II,III)

Maintain and enhance freshwater inflows to near shore waters while simultaneously decreasing sediments and contaminants. Implement better watershed and water management, and improve agricultural pest and water management practices. In particular, develop water use plans for all rivers, especially the Jaque del Norte and the Yuna. Replicate the San José de Ocoa model at numerous other sites, and implement integrated pest management.

Actions

1) Fund a pilot project(s) for the construction of wetlands for the capture of storm water run off and waste water recycling. Constructed wetland ecosystems are a low energy, appropriate technology well suited to developing nations for improving the quality of human discharges to the environment, runoff from urbanized lands, and the attenuation of rapid freshwater inflows. The industrial discharge to the Caribbean at Barahona may be a good location for a constructed wetland in lands immediately inland from the beach.

2) In conjunction with INDRHI, support the development of a model water use plan for either the Rio Yuna, Jaque del Norte, or the Rio Ocoa. (If the proposal of the OAS and INDRHI to conduct a national inventory and planning exercise gets funded, this may not be necessary).

9.3.2 Development of Better Fisheries Management

9.3.2.1 Conclusion

The second most critical problem in the coastal zone increased demand for resources from:

A. Tourism development
B. Increased urbanization

Tourism and urban development increases the demand for fishery resources, potable water, land, labor, and even such obscure resources as palm fronds for thatching of beach front palapas. Many of the reefs and grass beds throughout the Caribbean region exhibit indications of over fishing of such desirable species as lobster, conch, and the larger reef fish. The demand for curio items like corals and sea shells can easily out strip the potential of the marine environment to provide them on a sustainable basis in areas of intense tourist development.

Increased demand for resources from urbanized areas in the coastal zone is probably the single biggest factor affecting the sustainability of nearshore fisheries in many areas. The absence of strict controls on use of resources, whether fisheries, beaches, or wildlands, will diminish the quality of resources as populations increase, ultimately leading to the collapse of the ecological system that produces the resource(s).

The potential loss of marine fisheries is a serious threat because of the number of fishermen affected, the importance of fish in the diet, and the impact on tourism. The potential of over fishing is critical, as a whole and especially in local areas and for individual species.

Recommendations (I,III)

The potential for overfishing should be studied and regulations enforced. Better fishery management should be developed.

Action

Develop (fund) a program through the Department of Fisheries, and possibly CIBIMA, to monitor catch by species, area, and by unit effort, to estimate sustainable yield and guide management and enforcement. Coordinate with fishery projects and inventory of GTZ.

9.3.3 Development of Better Data

9.3.3.1 Conclusion

There is a serious paucity of adequate data with which to make accurate assessments of the scale and magnitude of problems, and to guide interventions and public policy, especially in the areas of:

A. natural resource inventories
B. fishery status and use
C. water quality

Recommendation (I,III)

Improve the quality and increase the quantity of data related to the amount and quality of coastal zone resources, their use, and the impacts of human activities.

Actions

(1) Fund a natural resources inventory of the coastal zone through an organization like PRONATURA or CIBIMA, or perhaps a consortium. A detailed inventory of the coastal zone is necessary to document resources and status. Since the World Health Organization has recently taken the initiative to begin a comprehensive water quality monitoring program, water quality data will be available soon. It may be necessary to augment their water quality monitoring stations with some located in areas of high tourist concentrations like Puerto Plata.

(2) Support a continuous research effort in the coastal zone by helping to establish a marine research station headed by CIBIMA. A strong program of research and training in coastal zone communities, issues, and management is urgently needed to train and educate individuals for management and regulatory roles in government and environmental education. CIBIMA already has a leadership role in this area, however, facilities for research and education at a coastal location are needed. There is strong justification (nearness to Santo Domingo, multi use conflicts, productive and diverse bay) for locating such a facility at Bahia Calderas.

9.3.4 Study of One or More Coastal Areas Leading to Pilot Projects in Coastal Zone Management

9.3.4.1 Conclusion

The third most critical problem in the coastal zone is "multi-use" conflicts manifested as cumulative impacts. For example:

A. cumulative impacts of pollution, loss of freshwater inputs, and over fishing on fisheries, or
B. cumulative impacts of loss of fresh water inputs, wood cutting, salt pond construction on mangroves.

Recommendation (III)

Develop a better understanding of the cumulative impacts of human activities in the coastal zone that can guide policy and management. Develop a pilot coastal zone management project using this understanding.

Action

Implement a system study leading to recommendations for public policy and pilot coastal zone management in one or more of the following critical areas:

a. Monte Cristi, Northwest coastline
b. Bahia Ocoa
c. Puerto Plata (added to potential sites)
d. Samana Bay at Rio Yuna

A systems study is a holistic approach of evaluating impacts and interactions between subsystems and various outside forces (see Figure A12 in Appendix 1 for a schematic representation of holistic approach to Monte Crisiti area). It should be designed to look at all aspects of human and natural resources and the interactions between them. Better coastal zone management will balance human activities and nature for improved sustainability (see Figure A10 Appendix 1 for map of recommended sites for pilot project).

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APPENDIX 1
Tables and Figures

List of Tables and Figures in Appendix 1

Table A1. Total Catch and Value by Coastal Province (1988) including only coastal cities.

Province	Catch (metric tons)	Percent	Value 1988 (1000 RD$)
District Nacional	2,272	15.2%	$5,680
Azua	588	3.9%	$1,470
Barahona	628	4.2%	$1,570
El Seibo	725	4.8%	$1,813
Espaillat	13	0.1%	$33
Hato Mayor	233	1.6%	$583
La Altagracia	1,479	9.9%	$3,698
La Romana	598	4.0%	$1,495
Maria Trinadad Sanchez	1,564	10.4%	$3,910
Monte Christi	205	1.4%	$513
Pedernales	973	6.5%	$2,433
Peravia	296	2.0%	$740
Puerto Plata	3,817	25.5%	$9,543
Samana	736	4.9%	$1,840
San Cristobel	366	2.4%	$915
San Pedro de Macoris	501	3.3%	$1,253
TOTAL	14,994	100.0%	$37,485

Notes:

Total catch derived from coastal cities, only, but may contain some freshwater fish. (Republica Dominica en Cifra

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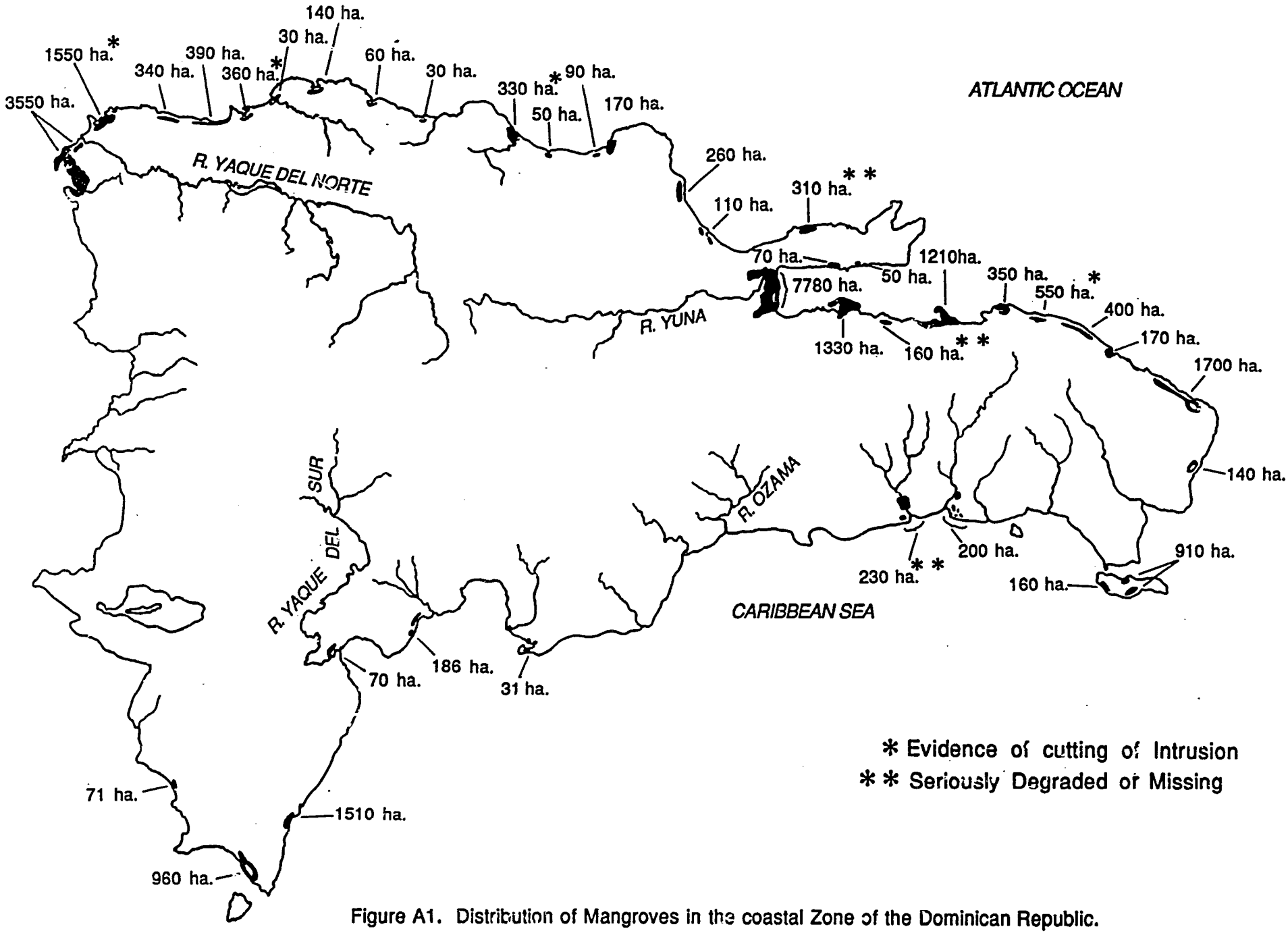

Figure A1. Distribution of Mangroves in the coastal Zone of the Dominican Republic. Distribution and area were derived from 1:50000 quadrangle maps and ground truthed by over flight.

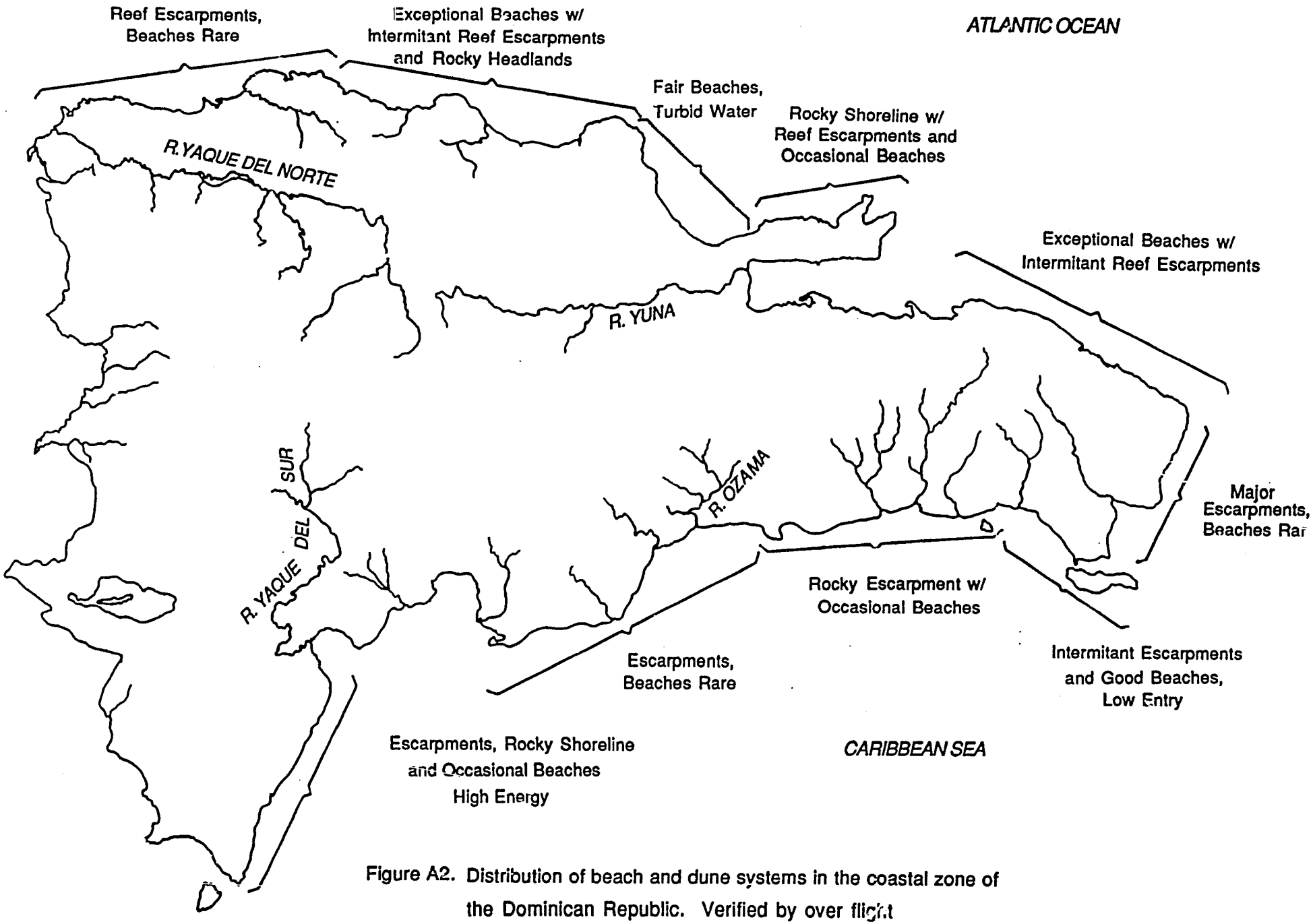

Figure A2. Distribution of beach and dune systems in the coastal zone of the Dominican Republic. Verified by over flight

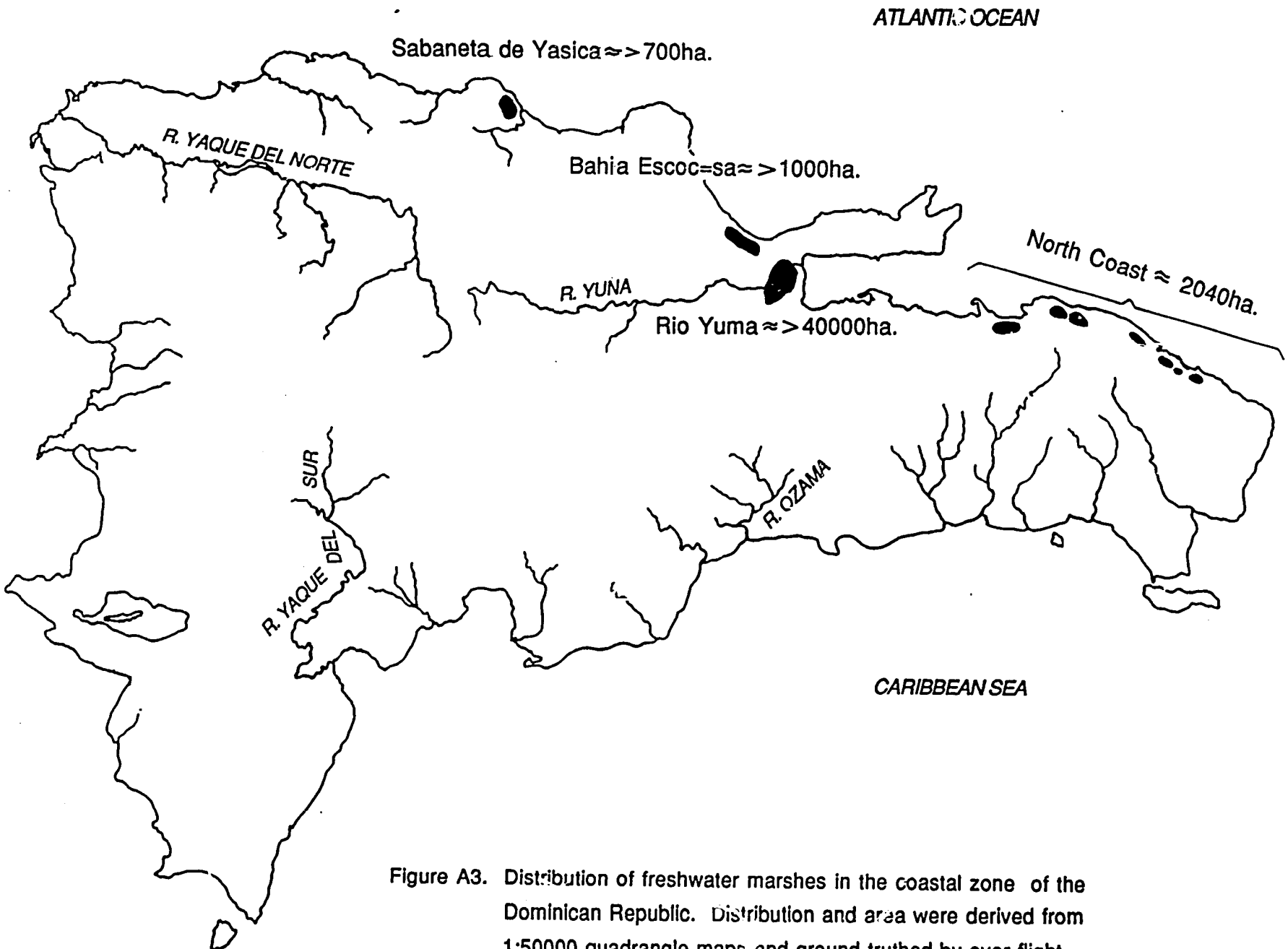

Figure A3. Distribution of freshwater marshes in the coastal zone of the Dominican Republic. Distribution and area were derived from 1:50000 quadrangle maps and ground truthed by over flight.

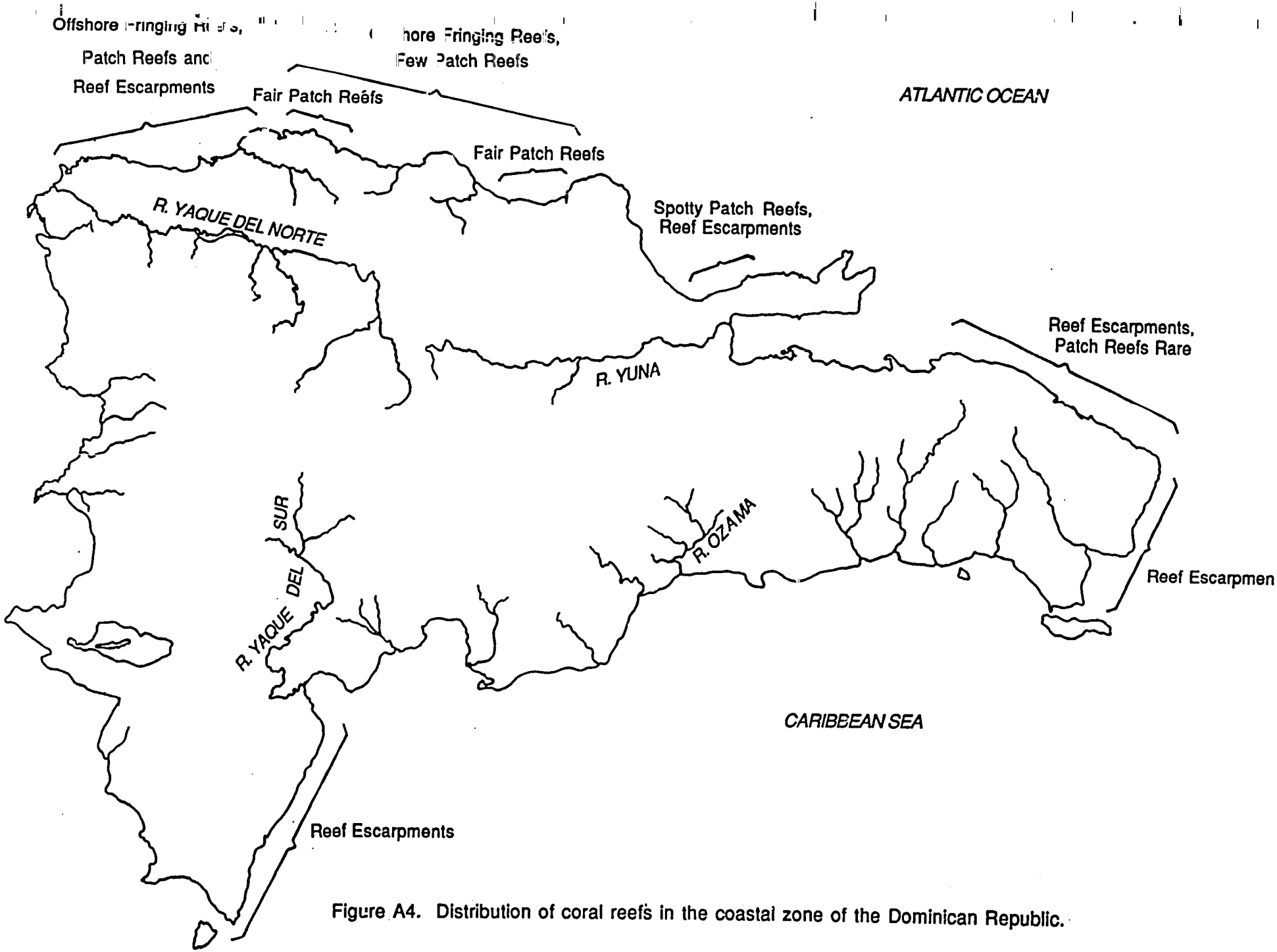

Figure A4. Distribution of coral reefs in the coastal zone of the Dominican Republic.

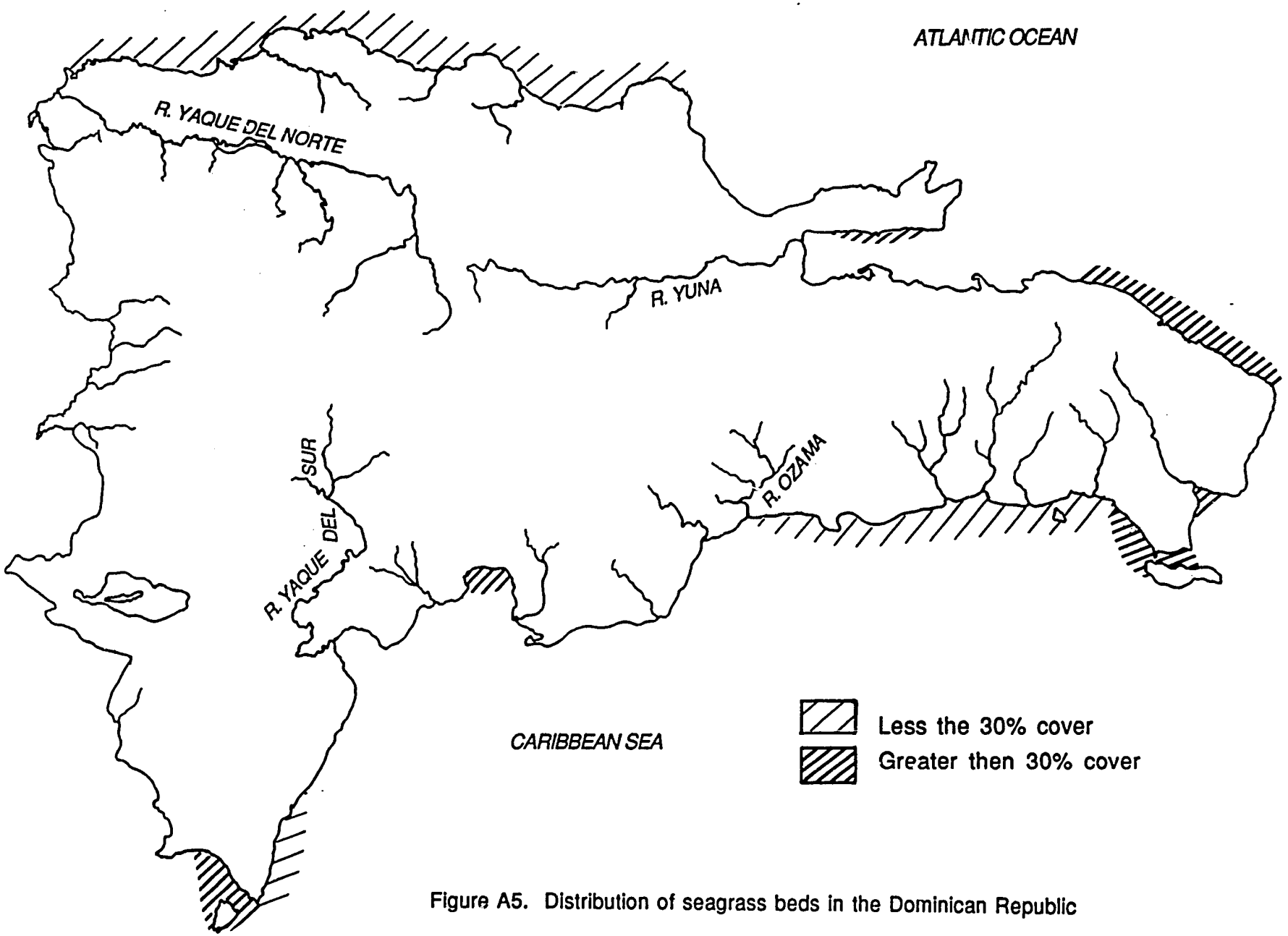

Figure A5. Distribution of seagrass beds in the Dominican Republic

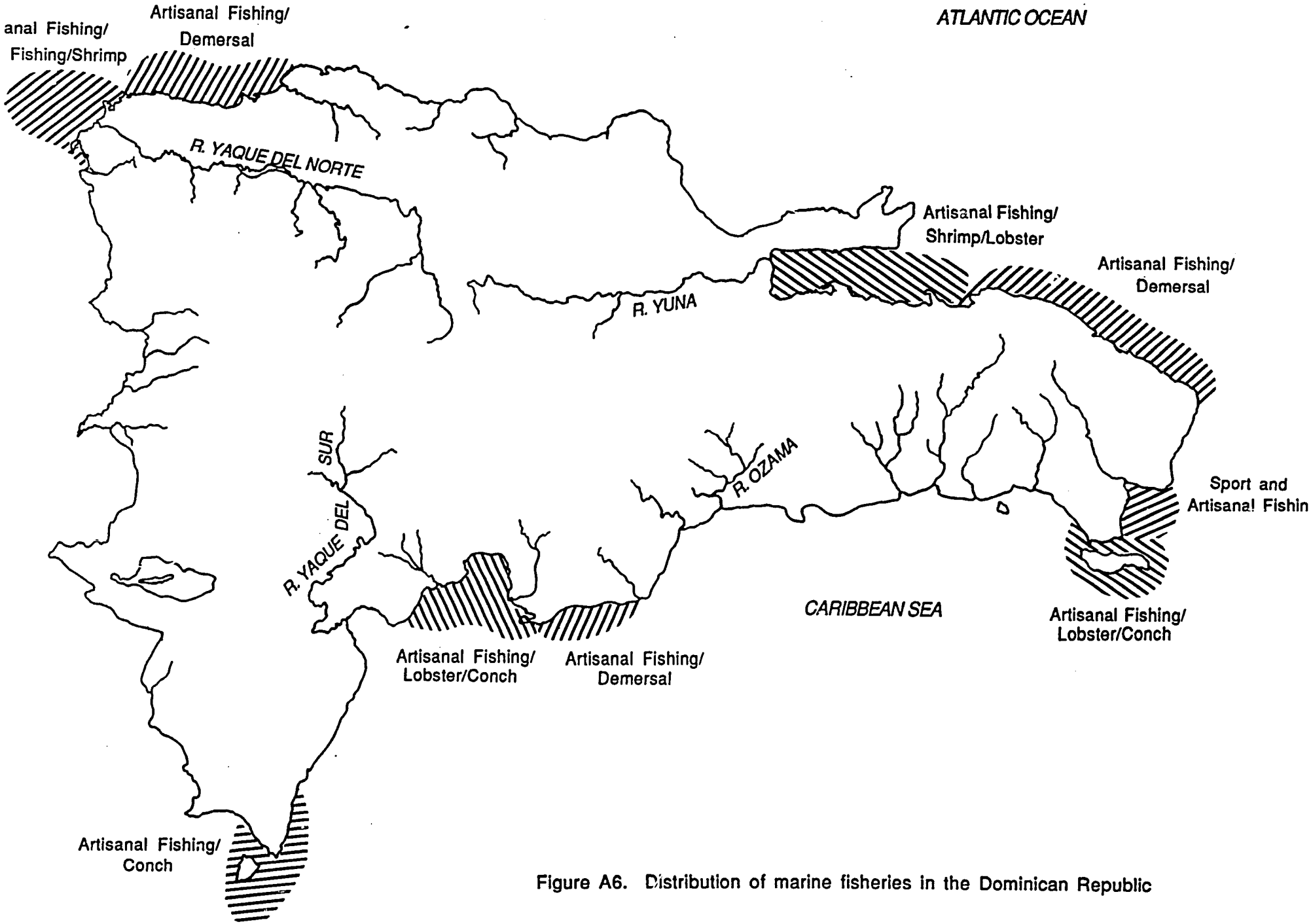

Figure A6. Distribution of marine fisheries in the Dominican Republic

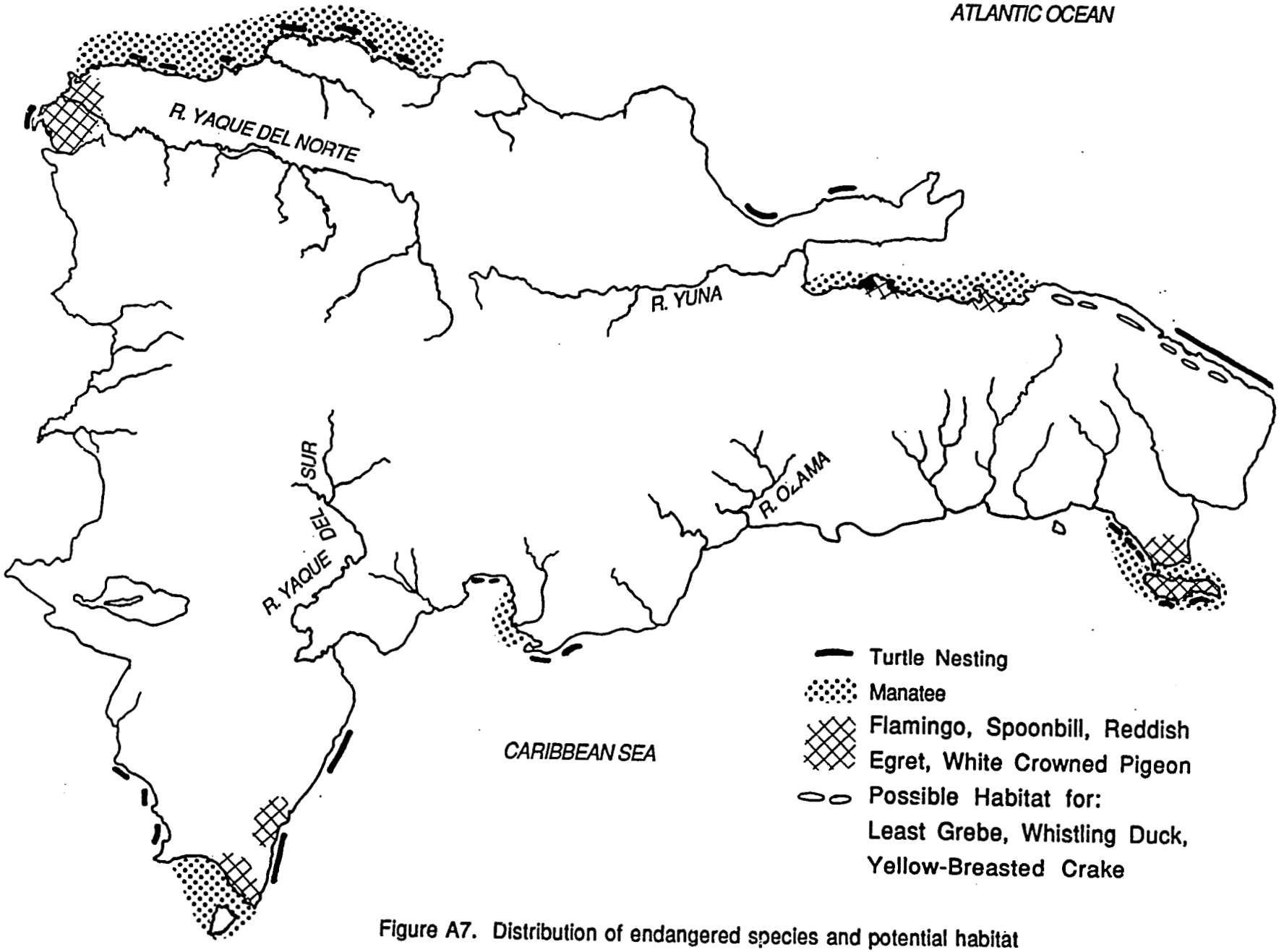

Figure A7. Distribution of endangered species and potential habitat in the coastal zone of the Dominican Republic

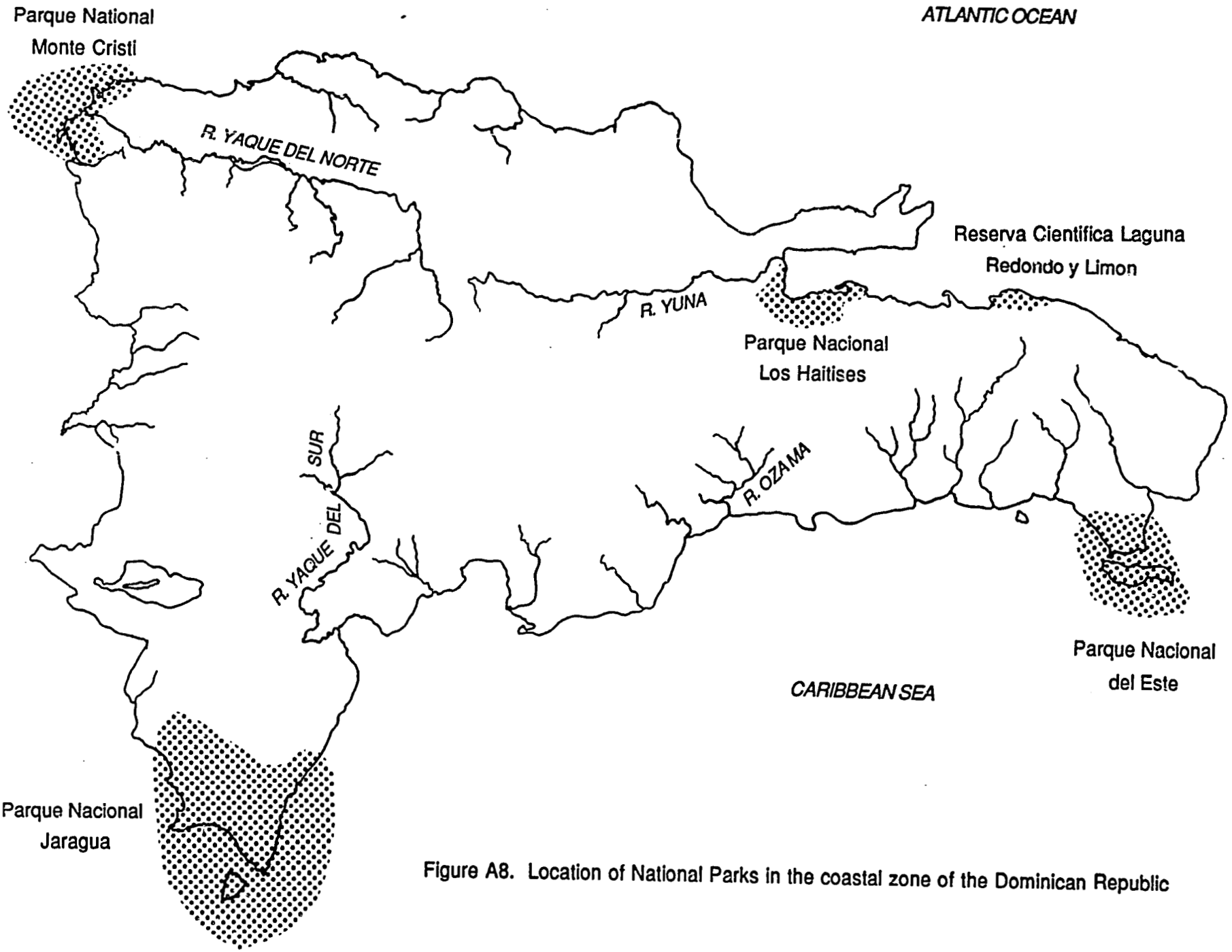

Figure A8. Location of National Parks in the coastal zone of the Dominican Republic

Table A2. Matrix of coastal related activites, problems, and impacts.

Activites	Major Problems	Coastal Impacts	
		Primary	Secondary
I. Tourism Development-			
Hotel & Infrastructure construction and operation	Release of pollutants and toxins	Water pollution	Shifts in comm. structure of marine habitats, violation of safe water quality standards
	Direct conversion of terr. and marine habitat	Loss of habitat and food-chain support	Shifts in community structure, decreases in organism abundance, loss of fishery potential.
	Increased resource demand	Over fishing/other resource depletion	Collapse of reef community, loss of fishery potential, destruction of terrestial habitats.
Marina construction and operation	Direct conversion of terr. and marine habitats	Loss of habitat and food chain support	Destruction of reefs and terr. habitats, loss of fishery potent.
	Release of toxins.	Water pollution	Alteration of marine ecosystems and safe water quality standards
Recreational activities	Increased boating/diving	Physical destruction/ water pollution	Destruction of reefs and grassbeds
II. Shipping			
Channel maintenance/ Jetty construction	Dredging	Physical destruction/Turbidity increases	Destruction of reefs/grassbeds/mangroves and other terr. comm.
Freighter traffic	Release of toxins/ Sewage/garbage	Water pllution	Alteration of marine ecosystems and violationof safe water quality standards

III. Mariculture and Salt Pond Development	Digging/bulkheadin g	Physical destructio/turbidity increase/ Impacts on ecosystems interconnections	Loss of mangrove, salina and marine grassbed ecosystems
IV. Fishing	Overfishing	Loss of fisher/habitat destruction	Collapse of reef community
V. Activities in rural watersheds	Inflows of sediments	Increased turbidity	Loss of marine ecosystems
	Inflows of toxins/nutrients	Water pollution	Alterations of marina ecosystems and violations of safe water quality standards
	Altered freshwater inflows	Increased and/or decreased freshwater inflows	Alteration of estuarine/mangrove ecosystems.
VI. Development of Urban watersheds	Inflows of sediments	Increased turbidity	Loss of marine ecosystems
	Inflows of toxins/nutrients	Water pollution	Alteration of marine ecosystems and violation of safe water quality standards
	Altered freshwater inflows	Increased freshwater inflows	Alteration of estuarine ecosystems
	Increased resource demand	Over fishing/other resource depletion	Collapse of fishery/ reef communities
	Solid waste dumping	Water pollution	Aesthetics/damage to marine organisms

Table A3. Total number of hotél rooms and estimated income by province.

PROVINCE	Coast	Number of Rooms	Estimated Income*
District Nacional	S	3,839	$88,347,867
Azua	S		
Barahona	S	43	$989,570
El Seibo	N	41	$943,543
Espaillat	N		
Hato Mayor	N		
La Altagracia	S	1,956	$45,013,917
La Romana	S	870	$20,021,528
Maria Trinidad Sanchez	N	310	$7,134,108
Monte Christi	N	103	$2,370,365
Pedernales	S		
Peravia	S		
Puerto Plata	N	7,322	$168,503,017
Samana	N	656	$15,096,692
San Cristobel	S	12	$276,159
San Pedro de Macoris	S	1,830	$42,114,248
	TOTAL	16,982	$390,811,012

Notes
Estimated income calculated assuming 65% occupancy rate income = $50US/night and $47US/day miscellaneous expenses.

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Table A4. Ranking of Environmental Impacts in the Coastal Zone

Activity/Problem	Hydrological Importance	Socio-Economic Importance	Ecological Importance	Irreversibility	Trends	Scale	Urgency Gravity	Practicality	Total
Tourism Development									3.375
Release of Pollutants	1	4	2	1	5	2	3	4	2.75
Habitat Conversion	2	3	5	5	4	2	5	2	3.5
Inc. Resource Demand	1	5	5	5	5	3	4	3	3.875
Marina Development									2.875
Release of Pollutants	1	2	1	3	5	2	2	2	2.25
Habitat Conversion	2	3	3	5	5	2	4	4	3.5
Recreation Activities									
Increased Boat/Driving	1	3	4	3	5	3	2	3	3
Shipping									2.375
Channel and Jetty Const.	3	2	3	3	4	2	2	1	2.5
Release of Pollutants	1	2	2	4	4	2	2	1	2.25
Mariculture Development									
Habitat Conversion	2	2	3	5	4	2	2	4	4
Fishing									
Over Fishing	1	5	5	4	4	5	4	4	4
Act. in Rural Watersheds									3.958

Inflow of Sediments	4	3	4	5	5	4	5	3	4.125
Inflow of Pollutants	1	5	4	4	5	4	4	2	3.625
Alt. Freshwater Inflows	5	4	5	3	5	4	4	3	4.125
Dev. Urban Watersheds									3.75
Inflow of Sediments	4	2	4	4	5	3	2	2	3.25
Inflow of Pollutants	1	4	5	4	5	4	5	2	3.75
Alt. Freshwater Inflows	5	4	5	3	5	4	5	2	4.125
Inc. Resource Demand	1	5	5	5	5	5	5	3	4.25
Solid Waste Dumping	1	3	4	2	4	4	5	4	3.375

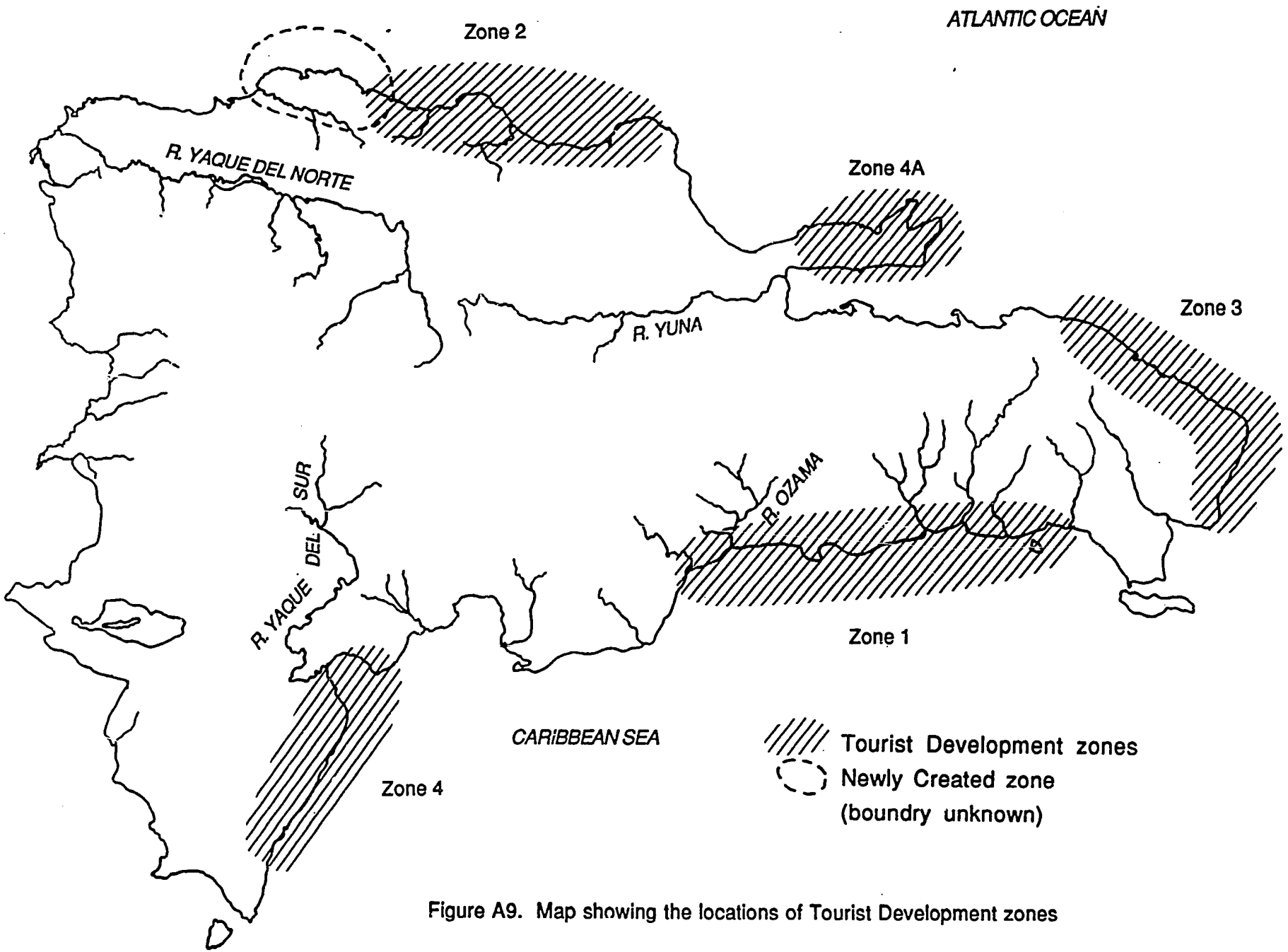

Figure A9. Map showing the locations of Tourist Development zones

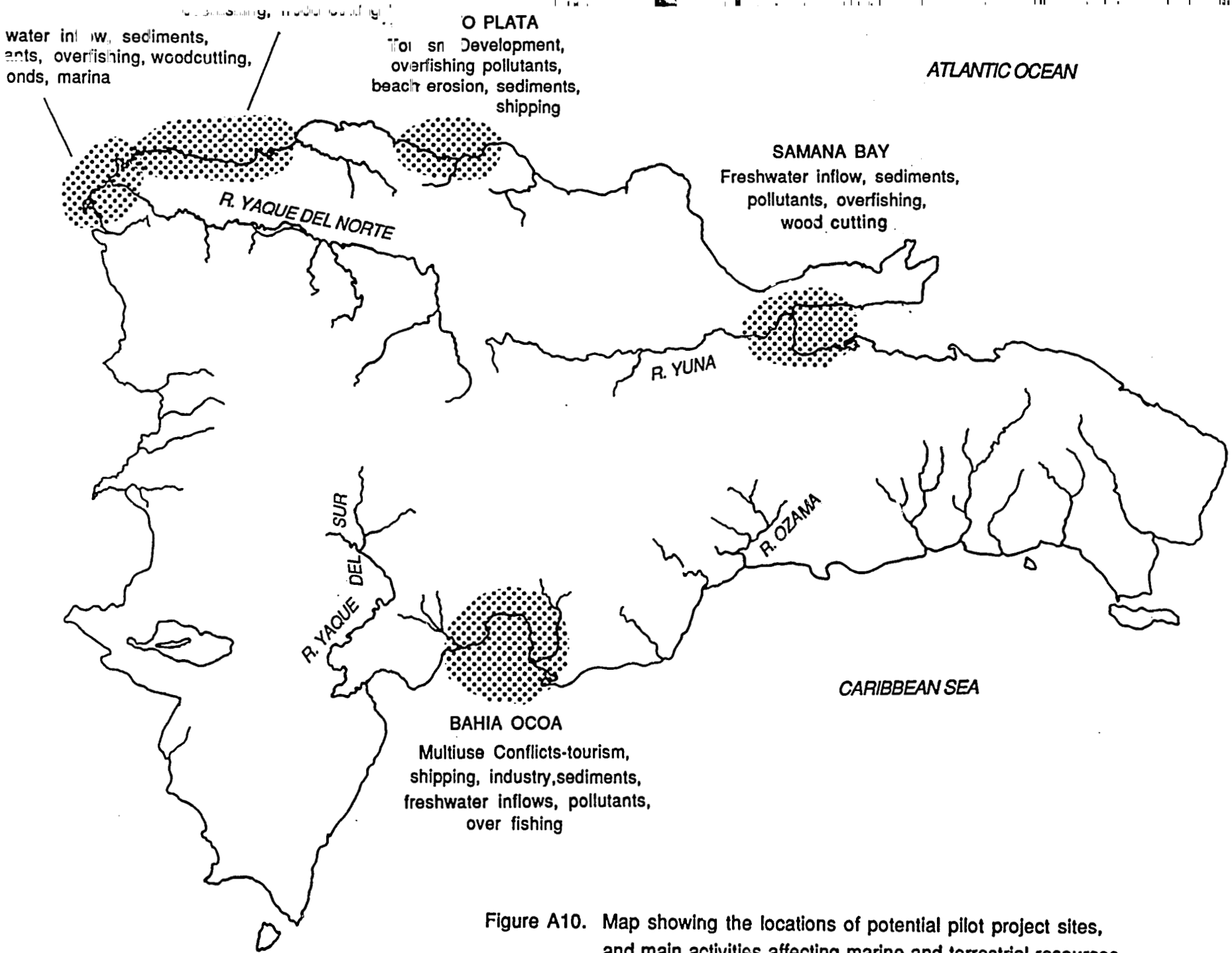

Figure A10. Map showing the locations of potential pilot project sites, and main activities affecting marine and terrestrial resources

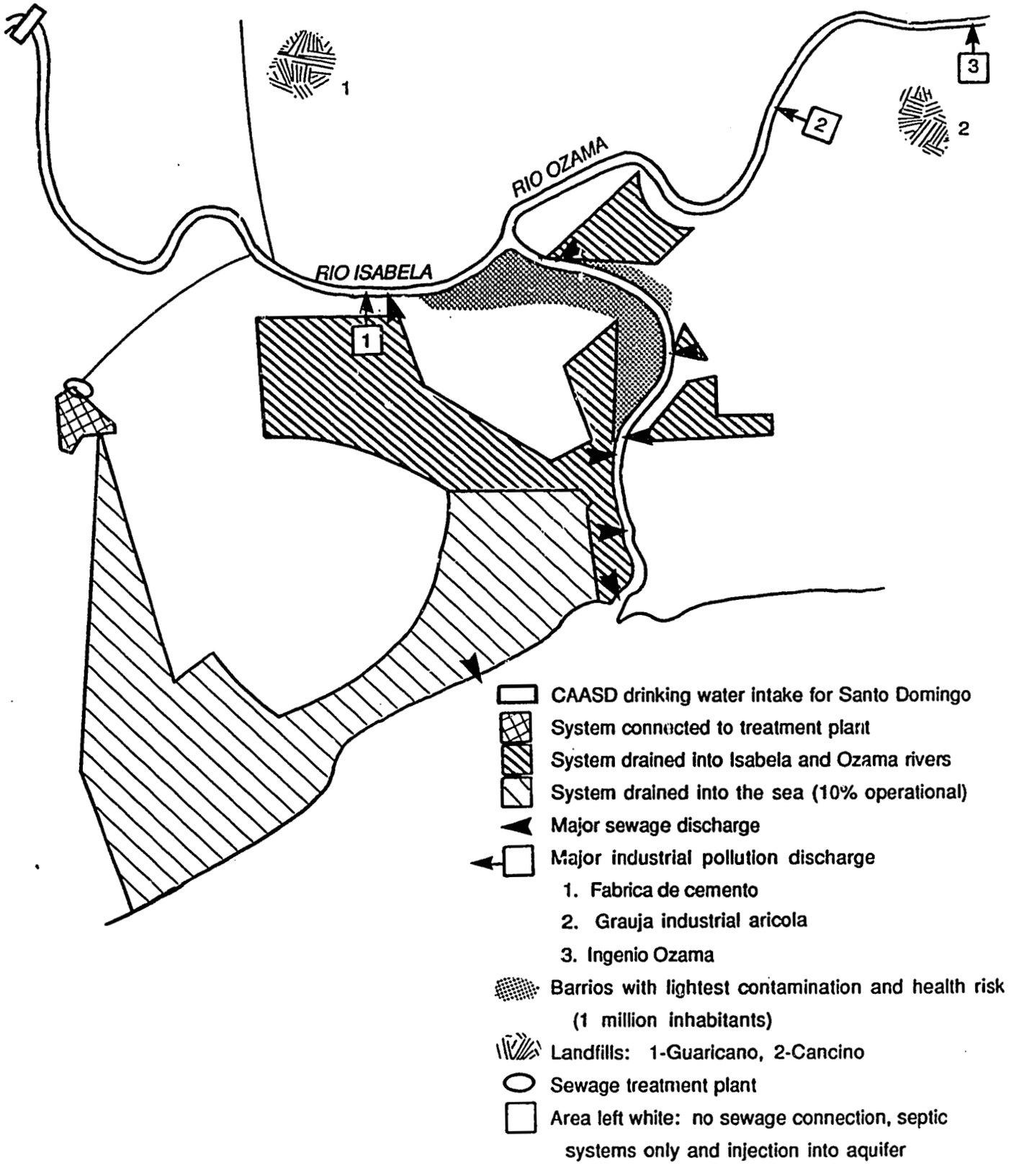

Figure A11. Sewage Disposal in Santo Domingo

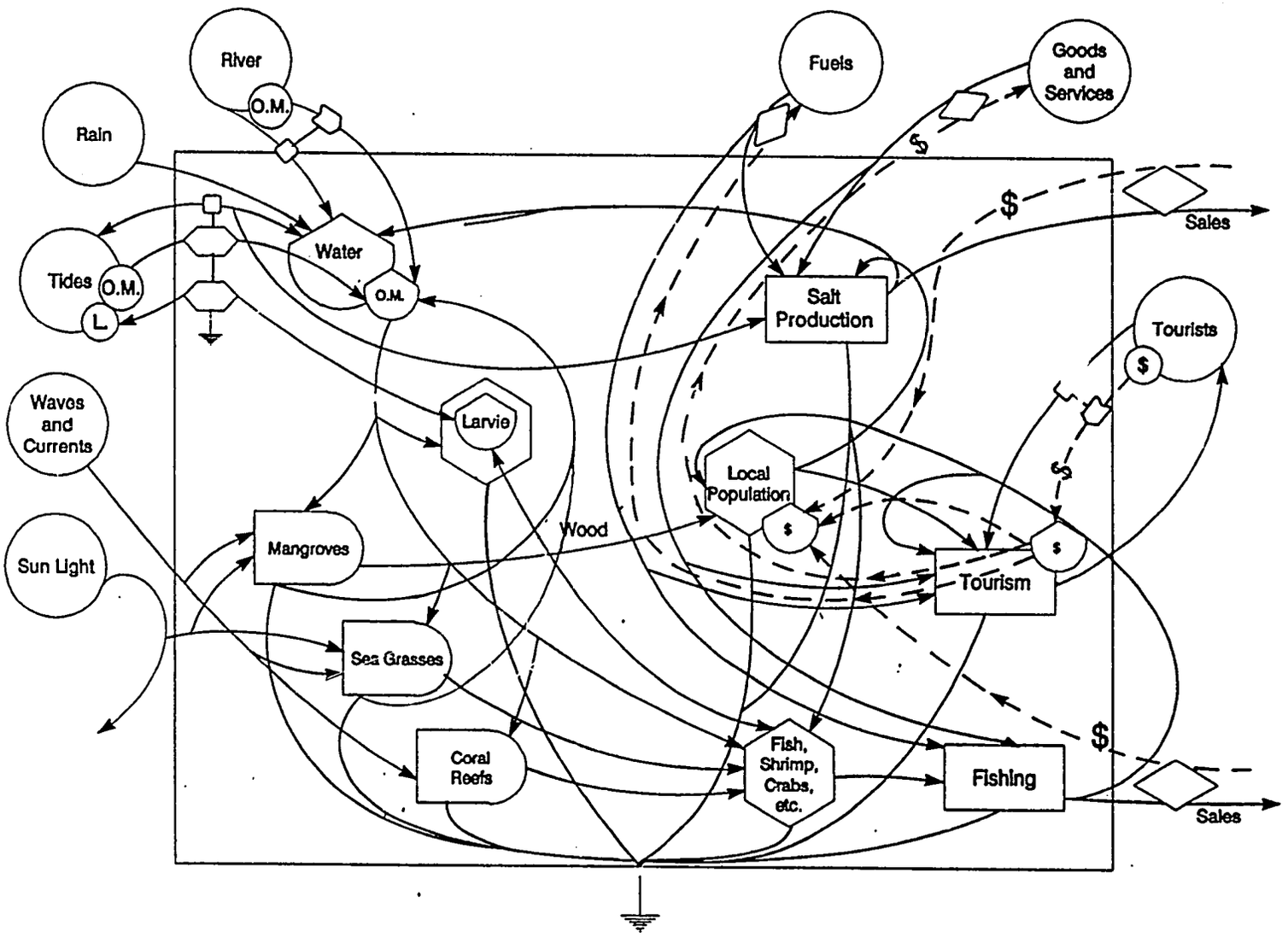

Figure A 12. An aggregated energy systems diagram of Monte Cristi, Dominican Republic showing the main components and pathways of energy and money exchange that should be studied and evaluated. (L.=Larvie, O.M. =Organic Matter)

APPENDIX 2
Rational and Description of Methodology
Ranking of Potential Project Sites

DESCRIPTION OF METHODOLOGY

RATIONALE:

The purpose of this report is to provide USAID/Dominican Republic and the government of the Dominican Republic with the information needed to make decisions concerning the allocation of its resources in the environmental-management sector. This survey had three principal tasks:

- evaluate rural and urban activities effecting water and coastal resources nationally,
- identify and evaluate potential sites for pilot projects -- thereby giving focus and substance to the overall evaluation and
- develop an action plan which the Mission can use to develop the Sustainable Growth through Natural Resource Management project.

As this study was an evaluation to ascertain priorities, it was decided to give a tour of the horizon, with an overview of as many activities and sites as possible, rather than to study one or two activities or sites in depth (any one of which could be the focus of a 12-to-15-month study). As it was, the study was conducted by a four-member team over a three-week period (19 work days) and required the reconnaissance of 20 sites.

The level of effort for the various activities is broken down in the following manner:

- 3 days for orientation and consensus building on the objectives and methodology of the study and other coordinating and administrative meetings,
- 5 days for site visits,
- 5 days for writing-up findings,
- 2 days for travel (to and from country), and
- 4 days for meeting contacts and collecting hard data.

The team leader was in the Dominican Republic for 20 working days before the team arrived to work with the Mission to establish objectives and methodology of the study, identify potential sites for reconnaissance and establish initial contacts.

The task was ambitious for a three-week study, and trade-offs had to be made between comprehensiveness and detail. The methodology used to identify priority activities and sites, therefore, was basically a qualitative one that did not require detailed and quantitative data gathering and analysis. The methodology developed for this study was based on the methodology used by senior consultants Ian Nisbet and Robert Risebrough for the World Bank-funded Environmental Program for the Mediterranean (EPM).

The task of these pollution specialists was similar to that of this team -- to identify and preliminarily evaluate the myriad pollutants (activities) effecting the Mediterranean sea in order to determine the priority problems to be addressed. Their study also ranked marine pollution among other environmental problems encountered in the Mediterranean region. Their short, three-month study and 77-page paper was considered one of the most useful issued from the entire two-year EPM exercise, largely because of the methodology used to determine priority problems. In addition, TR&D recently completely a "tour of the horizon" for USAID/Philippines. Over a six-week period, the 10-person team generated a profile of Philippine urban and industrial environmental management, which the Mission then used to design its Industrial Environmental Management project.

In this study, as well as in the EPM and profile, the team decided not to rely entirely upon economic analysis to determine environmental priorities as the shortcomings of a strict economic framework in environmental decision making are well known (Schramm and Warford, 1989). The key importance of economics as a decision-making tool is not neglected in this study. Its primary importance for Mission and government decision makers is clearly recognized. Economic evaluation was treated as a cross-cutting issue in the interdisciplinary analysis of the impact of each activity. Economics is also an important component of the prioritization methodology and was one of the established evaluation criteria. The team attempted to qualitatively identify the economic costs of the impacts associated with each activity. In some cases, the team also put numbers to these impacts. Further economic analysis is an option of follow-on exercises; and the nature of these analyses is suggested by this study.

The task was to organize data collection and evaluation in such a way as to enable 1) use of the methodology (to establish initial conclusions and priorities) and 2) completion of the task in the time allotted. In order to do this, the team used a scientifically valid technique -- extrapolation from analogous situations to formulate initial conclusions (hypotheses).

Once certain scientific (biological, ecological or sociological) principles are supported by the best available evidence, these same principles can be universally applied. For instance, once it has been shown that mangrove forests require freshwater and saltwater flushing to remain healthy, or that deforestation leads to greater oscillations in the timing and volumes of stream flows and increased sedimentation, it is not thought necessary in each new situation to perform the laborious data collection and analysis that was necessary to establish the principle initially. The report does, however, try to support, wherever possible, claims with reference to the original scientific literature.

The team believes that the considerable information provided in this survey will create a comprehensive picture of rural and urban activities affecting water and coastal resources in the Dominican Republic. The principal conclusions therein will provide the basis upon which the Mission and Dominican policy makers can make decisions concerning environmental-management efforts.

DESCRIPTION OF METHODOLOGY:

I. Methodology for site selection and delineation.

The following are recommended criteria for site selection:

- Perceived hydrological importance
- Perceived socioeconomic importance
- Perceived ecological/biological importance
- Irreversibility of major problems
- Trends in above
- Scale of problems
- Urgency/gravity of major problems
- Practicality

Definitions/descriptions of these criteria follow. A weighing system was developed for each of the criteria (1-low; 2-moderately low; 3- moderate; 4-moderately high; 5-high). In order to select the recommended site, a matrix of sites visited versus the above criteria was constructed and sites prioritized based on an average of totals. See table A2.4. Site descriptions also follow in this appendix.

II. Methodology for prioritization of problems associated with water and coastal areas.

A similar exercise was conducted to determine the priority, natural-resource problem areas. The relative priority of risk from each problem was calculated using the following steps:

1. Identify and describe the general character of the problem, i.e. pollution with sewage wastes.

2. For each problem, analyze and describe the following factors (defined below): hydrologic impact, socioeconomic impact, ecological-biological impact, irreversibility, trends, scale, urgency/gravity.

3. With the use of a weighing system developed for the purposes of this study, assign a numerical weight for each of the above eight factors. (1-low;2-moderately low; 3- moderate;4-moderately high;5-high)

4. Based on an average of all factors, rank the problems in order of risk. See tables A2.1, A2.2 and A2.3, located after definitions.

DEFINITIONS OF WEIGHING FACTORS

Hydrologic Impact: Problems or threats likely to have large negative impacts on the quality or quantity of water resources will be given a higher weight than problems with smaller impacts.

Socioeconomic Impact: Problems or threats likely to substantially and detrimentally effect health, social livelihoods, social customs, aesthetic or other amenities, important cultural or historic artifacts or sites, or women, will be given a higher weight than those with minor sociocultural impact. We place higher weight on problems that are likely to have substantial economic impact than on those with minor economic consequences.

Ecological/biological Impact: Problems or threats likely to substantially hinder ecosystem functioning or key ecological processes, or that substantially interfere with the life cycle (feeding, breeding, nesting, etc.) of any organism of ecological importance will be given a higher weight than those problems with minor ecologic impact. In addition, problems or threats that substantially damage or destroy the genetic or evolutionary fitness of biota scientifically interesting because of its contribution to bio-diversity, its rarity or its life cycle will be given a higher weight than those problems with minor or no biological impact.

Irreversibility: A great weight is assigned to problems for which continuation of current trends would resulted in consequences which are irreversible, at least on reasonable human time scales or at reasonable costs. Examples are the extinction of endangered species or the drainage or destruction of coastal wetlands. Intermediate weight is placed on problems which are theoretically reversible, but only on a long time scale, e.g. destruction of forests or contamination of shallow lagoons with metals or persistent organic compounds. Lower weight is assigned to problems which are more readily reversible, e.g. pollution with degradable organic compounds or discharge of sewage.

Trends: Problems that are likely to continue to increase in severity, such as problems related to population growth and the growth of certain economic activities, i.e. production of sewage and solid wastes, receive a greater weight. A lesser weight is assigned to problems whose severity is likely to decrease.

Scale: A greater weight is assigned to problems which occur on a wide geographical scale than is assigned to local problems. Particularly high weight is assigned to problems that may have global implications or whose effects occur across national boundaries.

Urgency/Gravity: A greater weight is assigned to problems for which there may be irreversible or grave outcomes and for which little time remains to develop remedies. Problems which give us the luxury of a longer time scale to seek solutions are assigned a lesser weight.

Practicality: Greater weight is assigned to problems whose gravity is commiserate with available financial resources for project preparation and project implementation. Problems for which information, services and field work is available are assigned a greater weight. Local interest and support, including private-sector support and international donor agency support was also heavily weighted, as were problems whose remedies would not overlap with on-going projects.

RANKING OF POTENTIAL PROJECT SITES

COASTAL	WATERSHED - Rural	WATERSHED - Urban	WATERSHED - Mixed
Monte Cristi	Sabana Yegua	Ozama/Isabela	Haina
Bahia Ocoa/Calderas	Nizao	Barahona FTZ	
Bahia Samana	Artibonito		
NW Coast @ Buen Hombre	Laguna de Rincon		
Boca Chica	Valle Nuevo		
P.N. de Este	Falconbridge		
P.N. Jaraqua	Dole		
Malecon	Frudoca		

SITES RECOMMENDED

The coastal sites with the highest scores were:

1) Monte Cristi
2) Bahia Ocoa/Calderas
3) Bahia Samana

Further study of one of more of these sites for final selection is recommended.

The rural site with the highest score was the upper watershed of Sabana Yegua and the urban site was Ozama/Isabela.

Further detail about each of these sites, and the basis for the ratings, can be found in the following site descriptions.

Table A2.1 Ranking of Potential Project Sites

Site/Name	Hydrolo-gical importa-nce	Socio-economic importance	Ecological impor-tance	Irrev ersi-bility	Trends	Scale	Urgency /Gravity	Practi-cality	TOTAL
COASTAL									
Monte Cristi	4	5	5	3	5	4	5	4	4.375
Bahia Ocoa/Calderas	4	5	4	3	4	4	4	4	4.130
Bahia Samana	4	5	5	3	5	4	4	3	4.130
NW Coast @ Buen Hombre	1	3	5	5	4	4	5	4	3.875
Boca Chica	1	3	2	5	5	1	4	1	2.75
P.N. del Este	1	2	4	1	2	2	2	3	2.125
P.N. Jaragua	1	2	4	1	2	2	1	3	2.000
Malecon	3	5	3						
WATERSHED - Rural									
Valle Nuevo	5	2	4	4	3	4	4	4	3.750
Nizao	5	5	2	4	5	5	5	4	4.375
Sabana Yegua	5	5	5	4	5	5	5	4	4.750
Laguna de Rincon	2	3	5	5	4	3	5	4	3.875
Artibonito	5	3	4	4	4	5	4	4	4.125
Dole	3	4	1	1	2	2	2	5	2.500
Frudoca	2	3	1	1	2	2	2	5	2.250
Falconbridge	4	5	1	3	2	4	3	2	3.000
WATERSHED - Urban									
Ozama/Isabela	5	5	5	3	5	4	4	4	4.375
Barahona FTZ	2	3	1	1	1	1	1	4	1.750
WATERSHED - Mixed									
Haina	5	5	5	3	4	4	4	4	4.250

Table A2.2 Ranking of Environmental Impacts in the Coastal Zone

Activity/Problem	Hydrological Importance	Socio-Economic Importance	Ecological Importance	Irreversibility	Trends	Scale	Urgency Gravity	Total
Tourism Development								3.375
Release of Pollutants	1	4	2	1	5	2	3	2.5714
Habitat Conversion	2	3	5	5	4	2	5	3.7143
Inc. Resource Demand	1	5	5	5	5	3	4	4.000
Marina Development								2.857
Release of Pollutants	1	2	1	3	5	2	2	2.286
Habitat Conversion	2	3	3	5	5	2	4	3.500
Recreation Activities								
Increased Boat/Driving	1	3	4	3	5	3	2	3.000
Shipping								2.375
Channel and Jetty Const.	3	2	3	3	4	2	2	2.714
Release of Pollutants	1	2	2	4	4	2	2	2.429
Maricult. Development								
Habitat Conversion	2	2	3	5	4	2	2	2.857
Fishing								
Over Fishing	1	5	5	4	4	5	4	4.000
Act. in Rural Watersheds								4.1905
Inflow of Sediments	4	3	4	5	5	4	5	4.2857
Inflow of Pollutants	1	5	4	4	5	4	4	3.8571
Alt. Freshwater Inflows	5	4	5	3	5	4	5	4.4286
Dev. Urban Watersheds								3.75
Inflow of Sediments	4	2	4	4	5	3	2	3.4286
Inflow of Pollutants	1	4	5	4	5	4	5	4.000
Alt. Freshwater Inflows	5	4	5	3	5	4	5	4.428
Inc. Resource Demand	1	5	5	5	5	5	5	4.429
Solid Waste Dumping	1	3	4	3	4	4	5	3.429

Table A2.3 Ranking of Urban Activities/Water Quality Issues

ACTIVITIES/ISSUES	Hydrological Impact	Socioeconomic Impact	Ecological Impact	Irreversibility	Trends	Scale	Urgency Gravity	Total
SOLID WASTE DISPOSAL								4.000
Cont. solids	4	5	3	2	5	5	5	4.1429
Release of pollutants	3	5	2	2	5	5	5	3.8571
STORMWATER RUNOFF								3.8571
Alt. Freshwater Inflows	5	5	5	2	5	4	4	4.2857
Inflow of Pollutants	3	2	4	2	5	4	4	3.4286
SEWAGE DISPOSAL								3.8571
Cont. BOD	5	2	5	2	4	5	4	3.8571
Cont. Coliform	5	4	3	2	4	5	4	3.8571
USE OF GROUNDWATER/INJECTION OF SEWAGE								
Cont. Coliform	4	2	3	4	4	2	2	3.000
INDUSTRY/THERMO-ELECTRIC								2.6429
Release of Pollutants	3	2	4	3	4	3	2	3.000
Inc. Temperatures	3	1	4	1	4	1	2	2.2857

Table A2.4 Ranking of Rural Activities/Water Quality Issues

ACTIVITIES/ISSUES	Hydrological Importance	Socio-Economic Importance	Ecological Importance	Irreversibility	Trends	Scale	Urgency Gravity	TOTAL
CHARCOAL WOOD PRODUCTION/ DEFORESTATION								4.2143
Alt. Freshwater Inflows	5	4	5	3	4	5	4	4.2857
Increased Sedimentation	5	3	4	4	4	5	4	4.1429
CROP PRODUCTION/ IRRIGATION								
Forest Conversion								4.0286
Alt. Freshwater Inflows	5	5	5	5	3	4	5	4.5714
Increased Sedimentation	5	5	5	4	3	4	5	4.4286
Overuse of Pesticide								
Release of Pollutants	5	5	5	3	3	4	5	4.2857
Salinization								
Release of Pollutants	5	5	5	3	2	3	4	3.8571
Water Consumption								
Alt. Freshwater Inflows	5	5	1	1	2	4	3	3.000
LIVESTOCK PRODUCTION								
Overgrazing								
Increased Sedimentation	4	2	3	4	3	3	3	3.1429
MINING/EXCAVATION								3.1429
Increased Sedimentation	4	2	3	4	3	3	3	3.1429
Release of Pollutants	4	4	4	2	2	3	3	3.1429
HYDRO-ELECTRIC ENERGY PRODUCTION								3.6875
Decreased Sedimentation	5	4	3	3	4	4	4	3.3750
Alt. Freshwater Inflows	3	3	5	6	5	5	5	4.000

COASTAL SITE SELECTION FOR PILOT PROJECTS

Coastal Site 1: Monte Cristi

General description: Located on the northwest coast, the area surrounding the settlement of Monte Cristi is dominated by mangrove and salina. Salina areas are under intensive salt production. Evidence indicated some minor timber cutting although no strong indications suggested that this activity was a threat to the mangrove area's continued existence. The mangrove areas are a national park (Parque Nacional Monte Cristi).

Distinguishing hydrological characteristics: Rio Yaque del Norte discharges to this area at Bahai de Monte Cristi. At one time, the river was an important source of organic matter and freshwater. The flow has been much reduced as a result of extensive use of upstream river water for irrigation. The team's flyover found no evidence of discharge from the river, as its flow had been entirely diverted for irrigation purposes 30 kilometers upstream at Guayubin.

Distinguishing biological characteristics: The marine environment is an extremely rich estuarine fishery supported by river discharges of organic matter and the export of detrital matter from the mangroves. Much of the backwater mangroves are scrub, attaining an overall height of only two meters or less. Coastal and tidal-fringing mangroves are more robust, attaining heights of 10 meters. During the flyover, a flock of more than 200 rosette spoonbills were seen feeding in the area.

Sociocultural importance: Two settlements in the area rely extensively on fisheries. In addition, evidence indicated marina development, and ten-to-15 yachts were observed docked at new boat slips.

Economic importance: The area is an extensive, near-shore fishery and could offer the opportunity as the base for an eco-tourism industry.

Management/land tenure: There is no current management although the mangrove areas have been declared a national park. The "upland fringes" of the mangroves include two settlements and extensive areas of salt production. Timber harvesting has been reported in the upland fringes of the mangroves although it was not confirmed during the flyover.

Status/pressures: An area of less than 100 hectares of mangrove at the mouth of the Rio Yaque del Norte was dead, probably the result of the reduced freshwater input of the river. The use of salina areas for salt production could be an important pressure if salty brines are discharged directly to the mangroves. The impacts of salt production needs investigation.

Activities/agencies: The mangrove area is a national park. How much of the area given to salt production is within the national park is unknown.

Rate of change/urgency: Evidence indicates increased development in the area; a channel had just been cut through a portion of the mangroves to provide boat access to open water. Therefore, the rate of change may be increasing, also increasing urgency of the need to address the environmental impact.

Impacts/costs of trends: So far, areas of human impact are along the fringes of the mangrove systems and involve the loss of important driving energies, such as freshwater and organic matter. The loss of the river discharge could have serious implications on the productivity of near-shore areas. Typically, declines in coastal fisheries resulting from decreases in river discharges are not noticed for one or a combination of the following reasons: (1) storages of organics in the benthic communities can carry the system for some time, (2) continued inputs from mangroves during storm events can provide some of the needed organics, and (3) annual, natural variability in marine fisheries often masks early declines. However, depending upon the budget of organic matter and which source is the greatest, the impacts of river diversion are extremely important.

Practicality: The area is relatively compact and offers good potential to develop a project of sustainable multiple use under extreme pressure from both external and internal development. It represents an important coastal marine habitat that is under serious pressure from both internal development (salt production, wood cutting and possibly over-fishing) and external pressure (the declines in river discharge).

Coastal Site 2: Bahia Las Calderas and Bahia De Ocoa

General description: Bahia las Calderas is an extraordinary, sheltered bay 30-40 kilometers southwest of Santo Domingo. It has been suggested as an ideal location for a CIBIMA marine lab. The team's site visit encompassed the entire Bahia de Ocoa since there were several indications that the larger bay was under development pressure and may represent a potential site for coastal- zone-management studies.

The Dominican Republic Navy has a presence at Bahia las Calderas on its eastern shore. There is some evidence of second-and-vacation-home development as well as a large salt operation near the western land terminus (Punta Caballera). On the western shore at Puerto Viejo, there is a large off loading LP gas terminal.

Distinguishing hydrological characteristics: Bahia las Calderas is dominated by local drainage only. The surrounding landscape is dominated by dry thorn forest and receives less than 1000 mm of rainfall per year. The fringes of the bay are dominated by salt flats and to a lessor extent mud flats. The water of the bay had exceptional clarity the day of the team's visit. Bahia de Ocoa receives the outflow of the Rio Ocoa. The river was not flowing the day of our visit. It has been said that when it does flow especially during large storm events it has an extreme sediment load that has already caused serious disruption to the bay and potentially to the fishery. The Rio Jura drains into the bay along its northwestern shore, west of Azua.

Distinguishing biological characteristics: Because of the relatively arid surrounding landscape and the bay's relative protection from the southeastern trades, the waters of both bays are extremely clear. Some small areas of mangrove and button bush was found along the northern shore of Bahia de Ocoa. Extensive areas of coral are reported in the western quadrant of Ocoa. The entire bay has a well developed artisanal fishery.

Sociocultural importance: The eastern shore of Ocoa and Calderas, especially around Palmar de Ocoa and to a lessor extent near Las Salinas, includes relatively well developed areas of second homes (presumably vacationing populations from Santo Domingo). The clear, calm waters and good fishing have attracted considerable investment. Artisanal fishing in the area is an important source of income. We counted more than 70 fishing boats were counted, leading to an estimate of a fleet of about 100 boats. The assurance of regular irrigation, due to the dam at Rio Ocoa, has resulted in a great deal of investment in agricultural infrastructure.

Economic importance: Besides the artisanal fishery and second-home development, discussions with E. Puqibet of the national aquarium indicate there is interest on the part of government in developing a shipyard at one of three locations: Calderas, the northern shore, or at Puerto Viejo on the western shore. Agricultural development near Palmar de Ocoa suggests a relatively well developed agricultural sector. Much wood cutting was in evidence and we were told that much of the charcoal from the area is transported to Santo Domingo. The salt ponds at Las Salinas produce about 48,000 bags of salt per month at an average weight of 70 kilos per bag.

Management/land tenure: Land tenure on most of the lands on the eastern shore appears to be relatively stable. Relatively large agricultural land holdings seem to predominate. On the northern shore, land tenure is more marginal, with numerous settlements of 5-10 dwellings, where the population both fish and farm small plots and raise livestock.

Status/pressures: Timber cutting north of Palmar de Ocoa and along the northern shore, as well as small scale farming and grazing have altered much of the dry forest. Incidental evidence (observations of the very young age of conch landed by one fisherman) at Las Salinas suggests that the conch fishery is nearly depleted.

Activities/agencies: At the present time little is known about planning and management activities in and around the bay.

Rate of change/urgency: It can be expected that pressure on the fishery will increase through the next decade with a growing, second-home tourist presence. Irrigation water from the dam on the Rio Ocoa has spawned considerable investment in agricultural infrastructure around Ocoa, and this trend will likely continue. Timber cutting for charcoal may continue to place considerable pressure of the dry forests of the area.

Impacts/costs of trends: Factors which will increase pressures on the bay are increased second-home development -- due to the bay's proximity to Santo Domingo -- fishing and agricultural development and construction of a shipyard -- should such plans become reality. Since the general coastal currents along the south shore of the island are from east to west, and probably, for at least some portions of the year, the near-shore currents may also be from east to west, the waters of Santo Domingo, laden with pollutants, might potentially effect the bay.

Practicality: The waters and surrounding lands of Bahia de Ocoa and Bahia las Calderas represent a good opportunity for planned intervention in the form of coastal-zone planning, site evaluation, and regulation of development activities and the integration of multiple use of this important resource.

Coastal Site 3: Samaná Bay

General description: Located in the Northeastern Dominican Republic, Semana Bay is the largest bay in the country. It is fed by the Rio Yuna, is one of the largest rivers in the country. The predominant vegetation of the area is degraded, subtropical, humid forest.

Distinguishing hydrological/geological characteristics: The area around the bay, particularly within the Los Haitises National Park, is composed of an extremely permeable karstic substrate of marine origin. The undulating karstic hills in the park may be unique in the world. The area receives the highest rainfall in the country (average 2,500mm/year), as trade winds blowing from the east or northeast first drop their moisture upon hitting the Samaná Bay area, particularly the Cordillera Oriental and Los Haitises. (Speculation suggests that Los Haitises controls the weather for the country.) Rapid percolation of rainfall occurs in the karstic areas, such that rivers are not formed. Especially critical may be the hydro-geology of subterranean water supplies and their relationship to rivers on the south side of the eastern range, including those feeding Santo Domingo.

Distinguishing biological characteristics: The bay is the most important sanctuary for Humpback whales in the North Atlantic. And it has the largest extension of mangroves in the Dominican Republic. Due to the nutrient-rich waters being supplied by the outflow of the Barracote and Yuna Rivers, the bay possesses potentially ideal nursery conditions to sustain large populations of commercially valuable shrimp, oysters, and fish. The bay also is considered one of the most important marine nurseries in the Caribbean; it has been recommended to the National Parks Directorate (DNP) that the park's limits be extended to include the complete estuaries of the Yuna and Barracote rivers and adjoining mangrove areas. Studies have identified 78 endemic and 32 migratory bird species in the Los Haitises National Park, with 13 of these native only to the park zone. Many species of bats live in the karstic caves.

Socioeconomic importance: The bay is home to the most important shrimp fishery in country. Other economic activities include whale research and tourism, with much potential for eco-tourism yet untapped. Miches, close to beaches and the second-largest town in the province, is undergoing development for tourism. There is also on-going exploration and drilling for oil.

Management/land tenure: Land around the bay is a mixture of private and state-owned tracts. One national park, Parque Nacional Los Haitises, and one scientific reserve, Reserva Cientifica Lagunas Redonda Y Limon, border the bay on the southern side.

Status/pressures: Development of irrigated agriculture in Yuna River valley and particularly the poor use of agro-chemicals has had serious debilitating effects on the fisheries. The mangroves are being cut for charcoal. And according to a 1986 report, only 20 percent of the 20,800 ha belonging to Los Haitises National park remained in a natural state; more than 3,000 families were reported to live within the park boundaries, most practicing slash-and-burn agriculture. Only shallow pockets of organic material remain on

top of the karstic substrate, and after slash-and-burn has exhausted the land, cattle ranchers buy the 'rights' of the farmer to graze cattle. The Banco Agricola has given loans to farms to grow malanga or yautia in the park, as the government wishes to stimulate exports.

Activities/agencies: Spanish Agency for International Cooperation (AECI), with the DNP is undertaking a study and preparing a management plan for Los Haitises.

Rate of change/urgency: It was determined in 1988 that Los Haitises Park was in urgent need of protection. Neither the rate of change of other areas surrounding the Bay nor the urgency of planning has been determined.

Coastal Site 4: Northwest Coast at Buen Hombre

General description: This coastal area is north east of Monte Cristi, between Punta Burne and the Bahia de Icaquitos. Extensive off-shore coral reefs provide some protection from waves. Apparently intact are the coastal dune systems, mangroves, salania areas, beaches and reefs. The area is said to be the last remaining area on the coast where the dunes are dominated by native vegetation.

Distinguishing hydrological characteristics: By the gross features of the coastline and sand accumulations associated with escarpments, the dominate near-shore circulation is from east to west.

Distinguishing biological characteristics: This site is an excellent example of the native, coastal-communities grading, from reefs and marine beds, through dunes, with a mangrove slough behind, upland, to dry and moist forests. The area does not have a large human population and thus, remains in a relatively natural state.

Sociocultural importance: The area is the base for a small artisanal fishery. Some evidence suggests salt production at the western end near Monte Cristi.

Economic importance: This zone could become an important eco-tourism area if development were strictly controlled and visitors could be brought in for day trips that also might include the mangrove systems of Monte Cristi.

Management/land tenure: No management now exists. During the team's flyover, two very small concentrations of houses -- at Playa Punta Rucia and at Cacao -- were apparent. Several isolated homesteads were scattered across the area, within the coastal zone. There was no evidence of fishing boats on any of the coastal areas except for approximately 20 homes and about six to eight boats Playa Punta Rucia and about 20 homes and five boats on shore at Cacao.

Status/pressures: The area does not seem to be under much development pressure. In order, however, for it to be preserved, proper planning -- with the goal toward good coastal-zone management and preservation of the resource base -- should be implemented as soon as possible.

Activities/agencies: None that are apparent.

Rate of change/urgency: The rate of change has not been exceptionally fast in the recent past. The announcement, however, that a single, large hotel chain intends to build a resort in the area could indicate coming change.

Impacts/costs of trends: Few human impacts and no environmental losses were noted.

Practicality: This area is extremely important because it represents the last area of coastal beaches, reefs, sea-grass beds, mangrove, and transitional uplands that has not been developed or converted to agricultural production. The area should be preserved for both cultural and ecological reasons. If preserved, the area could form the basis for an eco-tourism industry along the northwest coast.

Coastal Site 5: Boca Chica

General description: Boca Chica is a public-recreation area east of Santo Domingo. It has recently gained notoriety due to "beach nourishment" practices there.

Distinguishing hydrological characteristics: Circulation in Bahia de Andres is poor, due to its location along the coastline. Wind fetch and wave action is directly onshore for much of the year.

Distinguishing biological characteristics: The enclosure has caused poor circulation that, combined with possible enrichment with waste water from hotels and bathers has increased nutrient loads. In addition, the town of Andera, Boca Chica, and Ensanche Belle Vista add significant nutrient load through improper sewage treatment and the common practice of aquifer injection of wastes. During the team's flyover, sea-grass coverage was noted in a very small percentage of the total bay bottom. It is probable that the spatial extent of the grasses was much greater in the past and that they have diminished as the result of diminishing water-clarity.

Sociocultural importance: The beach has high visibility; a number of environmental groups are opposing the beach-nourishment project.

Economic importance: Boca Chica is the main recreational beach for the city of Santo Domingo

Management/land tenure: The Boca Chica Public Recreation Area is entirely owned and managed by the Government of the Dominican Republic.

Status/pressures: Population growth in the Santo Domingo area will increase pressure on the beach.

Activities/Agencies: The Assiacion Pro-Desarrollo de Boca Chica and Ayuntamiento del Distrito Nacional are spending 40 million pesos on the beach-nourishment project.

Rate of change/urgency: Since the rate of degradation is approximately equal to the rate of population increase, urgency is not great. Since the bay has been in slow decline for several years, little need exists to act swiftly to try improve the situation. The apparent degree to which sewage and industrial pollution is causing the decline of sea-grass beds makes effective remediation nearly impossible.

Impacts/costs of trends: With continued human intervention, the bay will continue to decline in environmental quality. The beach-nourishment operation has caused and will continue for some time to cause serious turbidity problems within the bay.

Practicality: Little can be done to solve the bay's problems. Neither over-enrichment nor the efforts to enhance the beach through nourishment for economic reasons can be easily undone. Alternatives that would favor the sea-grass beds and coral reefs would result in the loss of the beach's recreational potential. But continued nutrient enrichment and possible industrial pollution may eventually cause the popularity of the beach to seriously decline.

Coastal Site 6: Parque Nacional del Este and Isla Saona

General description: A national park at southeastern end of the island, it contains 950 hectares of mangrove on the mainland and north coast of Isla Saona. A bioluminescent bay (Bahia Calderas), extensive areas of sea-grass beds (primarily Talassia) and several extraordinary beaches along its western shore all contribute to the area's biological importance.

Distinguishing hydrological characteristics: No rivers flow within the park. The entire area seems to be dominated by local drainage. the Island of Saona has a large area of mangrove and salina (Luguna los Flamencos) immediately to the west of the settlement known as Mano Juan. Another such area can be found east from the settlement (Laguna Canto de la Playa).

Distinguishing biological characteristics: Extensive areas of mangrove line the coasts of Paso de Catuan. Grass beds are located in the protected areas along the southwestern shore of the mainland. The numerous lagoons of the area and especially the Las Calderas (the bioluminescent bay) all distinguish the area biologically.

Sociocultural importance: Because of its relatively remote location, the western coastline of the park is relatively unaffected. The coastal waters are productive and appear to be fished by local fisherman. An old jail on the southern shore of Saona at Mano Juan may be restored by the park service.

Economic importance: The park represents an extensive area of wildlands that could form the basis of a compact, eco-tourism industry, centered around the airport near Cabo Rojo. A resort at Cabo Rojo appears to use the remote stretches of the coast for day trips. Several tourist groups from farther east were observed using beaches for day expeditions.

Management/land tenure: As with most of the national parks, little if any active management exists. The park service has a presence at Mano Juan, where it maintains several buildings and at least two park rangers. Settlements within the park are located on the island of Saona and along the eastern shore at La Granchorra, Las Canas, and El Algibe.

Status/pressures: Timber cutting has been reported in the northern portions of the park, at Mano Juan, and at the settlements along the eastern shore. Increased tourist presence along the western shore is evident at several beaches that have been cleared. Park personnel voice concern that increased boat traffic and the additional use of Las Calderas will negatively effect the grass beds.

Activities/agencies: A work plan for activities sponsored by The Nature Conservency has begun. The work plan will identify resources most at risk and develop a master plan for the park.

Rate of change/urgency: With a growing tourist presence in that portion of the island, pressure on the park is expected to increase through the next decade.

Impacts/costs of trends: Loss of sea-grass beds from increased boat traffic and impacts within Las Calderas comprises the most critical impact. Of secondary importance is timber cutting near several fishing settlements within the park boundaries and from populations immediately to the north of the park. Increased tourism development at Cabo Rojo could increase local populations as well, adding to the pressure for fuel wood.

Practicality: Infrastructure could be improved to provide better access to the interior portions of the park. Funding to increase park personnel would enable better management of park resources and regulation of park use by tourist, day-trip services.

Coastal Site 7: Parque Nacional Jaraqua, Coastal Site, Southwest.

General description: This 140,000-ha park was created in 1983 to protect the coastal and marine environment of the southwest. It contains 12 vegetation types including dry forests and mangrove forests. Immediately to the north, an extensive area of agriculture and the city of Oviedo exert pressure on the northern resources of the park.

Distinguishing hydrological characteristics: The park contains two -- Laguna de Oviedo and Laguna Salada -- of only a handful of freshwater lagoons in the country. No rivers drain into the park, which is dominated by local drainage.

Distinguishing biological characteristics: The park, dominated by dry forests, is located in a region of high bio-diversity and endemism. Preliminary studies have inventoried more than 400 plant species (most regionally endemic), 130 bird species (10 endemic to island), 54 reptile species (36 locally endemic). The park contains the Caribbean's largest colony of birds and one of the most important sea-turtle-egg-producing regions in the Caribbean; fourteen marine turtle species nest along its beach. Isla Beata and Isla Alto Velo are located within the park.

Sociocultural importance: Although the park is located in one of the poorest regions in the country, the large agricultural zone to the immediate north is very productive.

Economic importance: A relatively rich fishing zone, the Laguna de Oviedo supports an important fishery for the city of Oviedo. The southwest coast of the park has high potential as an eco-tourism destination.

Management/land tenure: Although Parque Nacional Jaraqua has been legally declared a national park, the presence of park personnel is limited to an outpost at the northern boundary where Highway 24 enters the park. It has been reported that a citizens group, Grupo Jaragua, organized by Sixto Inchaustegui, is promoting the park and helping to clean beaches and protect nesting turtles. While few residents inhabit the park, the City of Oviedo, to the north, exerts extensive pressure on the park.

Status/pressures: While the park is located one of the best, ecologically conserved areas, some areas near its northern boundary are degraded due to over-grazing, over-fishing and deforestation for charcoal production. Conflicts exist between locals and authorities over the harvest of crabs, sea turtles and their eggs; control is difficult. Beaches are heavily littered with solid waste, washed ashore by currents all the way from Santo Domingo. Garbage has been reported to be so thick that turtles have no place to lay eggs.

Activities/agencies: The park is part of the Parks-in-Peril program, assisted by Grupo Jaragua and sponsored by The Nature Conservancy and World Wildlife Fund (WWF). DRP has a small presence. The Domicana de Associación Ecologistas is conducting an environmental-education campaign in neighboring communities Aguas Negras and Mercía. And Las Mercedes sponsored a day trip, which cleaned up the beach.

Rate of change/urgency: Diminishing resources around the park and continued population growth could continue to place pressure on fringing resources of the park and could compromise the park's current situation.

Impacts/costs of trends: A loss of bio-diversity and endemic/endangered species, as well as damage to a potential eco-tourism industry has already occurred.

Practicality: High potential exists for education within the local communities, especially regarding preservation of coastal resources and wise management of lands. A program of environmental education coupled with field trips to some of the more interesting areas within the park for school children could increase awareness and respect for resources.

Coastal Site 8: El Malecon

General description: This coastal area is located immediately west of the mouth of the Ozama River. The area extends approximately 5 km to the west along the Caribbean sea.

Hydrological importance: Located next to the delta of the Ozama River, this area receives pollutants, floating debris and suspended particles discharged by the river. In addition, it receives all runoff and untreated sewage and industrial waste from the western part of the capital. Two important industries are dumping waste directly into the sea: Cervecería Nacional Presidente and Metaldón (Meales Dominicanos). Runoff from the city is high (i.e, 80 percent of rainfall) and large quantities of solid waste are carried to the sea because of garbage collection problems in the capital. The volume of sewage discharged is unknown.

Ecological/biological importance: As a coastline next to an important river, this area is of great ecological and biological interest. Pollution from the river, untreated sewage and industrial waste pose real threats to both public health and marine life. These pollutants are also transported by sea currents, affecting large areas of the coast and the Caribbean sea.

A 3 cm storm can easily produce some 250 m^3 of runoff/ha. In Santo Domingo, with an area of approximately 20,999 ha, such a storm may produce up to 5 million cubic meters of runoff. This stormwater carries garbage, sediments and pollutants from streets and other areas to rivers and the sea. Debris floats on the water, reducing aesthetic value and discouraging tourism and other recreational uses. Great quantities of sediment, organic matter and other pollutants are suddenly discharged, increasing the turbidity of the water and reducing both the oxygen available for aquatic organisms and the productivity of the coastal zone.

Although some of the costs of such events can be estimated, such as beach-garbage collection, other costs are difficult to determine because they usually require close and sophisticated monitoring. The disposal of sewage into surface waters of rivers and oceans is causing serious deterioration of important natural resources. Water contaminated with sewage is creating sanitation problems that can cause increased costs from medical bills and a loss of earnings due to premature death and absenteeism (Environmental Assessment Source Book). A lack of adequate sewage disposal can create an explosive situation in the event of a cholera epidemic. Such an epidemic would not only cause many deaths among the population, it could also seriously damage the growing tourist industry.

In the Ozama and Isabela rivers, inadequate sewage disposal is contributing to excessive sedimentation. This condition is reducing the rivers' potential use as water ways for transportation and tourism. The Ozama River provides access to the colonial part of the city. But bad odors are effecting development of the river for tourism. Much sewage is going into the ocean, contaminating fish and reducing productivity of coastal areas.

Sociocultural importance: El Malecon is one of the most important and dynamic areas of economic areas in Santo Domingo. It has valuable aesthetic resources and a concentration of the most important hotels, restaurants and other tourist related businesses. Such businesses are an important source of employment and economic activity, bringing badly needed money to the country. Several important government buildings and monuments are located in El Malecon, and it has facilities for agricultural and industrial fairs. Another important characteristic is its location next to the colonial part of the city, providing excellent opportunity for tourist boating activities. A part of this coastal area is occupied by Guibia Beach. This beach was an important area for recreation, but now swimming there is prohibited due to pollution. The area lies within "Parque La Caleta."

Management/land tenure: The area has been developed for tourism. Improvements include sidewalks and terraces. And the infrastructure includes a wall to protect the area from erosion. Hotels, restaurants and other tourism-related businesses are an important source of employment and bring money to the country.

Status/pressures: The government and NGOs express growing concern about the area, due to both its importance for tourism and because of the health risks it poses for the population. While the extent of the pollution is unknown, fish have all but disappeared and swimming is prohibited.

Activities/agencies: Several institutions share responsibility for maintaining this area. Legislation also provides a framework for protection there. Very little, however, is actually being done. This problem is due to a lack of both the resources and an organization cable of effectively coordination activities to determine the extent of the problem, monitor it, and establish mitigating actions. A periodic clean-up by the Federacion de Asociaciones Ecologistas is the only activity to mitigate environmental losses in the area.

Rate of change/urgency: Important resources are at stake. Increasing urban and industrial activity with little regulation or control suggest that action should be taken soon.

Impact/cost of trends: Aesthetic value and tourist potential are diminishing not only in this area, but also from other coastal areas, as well. Other costs include reductions in the fishing industry, due to sewage and industrial pollution on marine populations. Public health is also at risk.

RURAL WATERSHED SITE DESCRIPTIONS IN ORDER OF FINAL RANKING

Watershed Site 1: SABANA YEGUA DAM

General description: The Sabana Yegua Dam was built in 1989 for energy generation, irrigation and flood control. It has an installed capacity of 13.5 MW and an annual production of 69 MWH. Forty three thousand ha of cash crops in the Azua valley are irrigated with turbine water. Three sub-basins contribute to this dam: Las Cuevas river (4.5 M^3/sec.), Grande or Del Medio river (10.6 M^3/sec.), and Yaque del Sur river (high portion). These together cover an approximate area of 160,000 ha.

The sub-basin of the Las Cuevas River has an area of 56,000 ha, 73 percent of which is constituted by mountainous land with steep slopes. Twenty seven percent is lowland with waving slopes. The Grande or Del Medio River sub-basin has an area of 67,560 ha, with 78 percent mountainous land (rainy, very rainy, and low mountainous) and 22 percent lowland (dry and subtropical-rainy). The Yaque del Sur River sub-basin has an approximate area of 30,000 ha. In general, it shows similar features and the same problems as the neighboring sub-basins. However, no basic studies describe the biophysical and socioeconomic characteristics of these river sub-basins.

Hydrological importance: The watershed supplies water to the Sabana Yegua Dam, whose hydraulic infrastructure generates hydroelectric energy and irrigates agricultural production in the Azua valley. The water is also used for human consumption and for agricultural developments, especially in the Constanza and La Culata valleys, located in their highlands.

Biological importance: The watershed contains part of the national parks José del Carmen Ramírez and Armando Bermúdez (spring of the Yaque del Sur River). The parks are in constant need of protection. The Grande or Del Medio River drains the important intra-mountainous agricultural valleys of Constanza and La Culata, where residues from intensive use of agro-chemicals and fertilizers drain into the Sabana Yegua reservoir; this situation needs more investigation and the establishment of measures to mitigate or correct the negative impact in humans and the natural environment.

Socioeconomic importance: The economic importance of energy generation and irrigation is great. Food production for the local market and for exportation in the Azua and Constanza valleys generate employment and significant foreign exchange for the Dominican economy. Furthermore, subsistence farming by most of the watershed's 120,000 inhabitants is in large part responsible for natural-resource deterioration.

Management/land tenure: Land use in the Las Cuevas River sub-basin is distributed as follows: 28.6 percent in farm cropping (beans, pigeon-peas, corn, and coffee); 46.9 percent in pasture; 13.8 percent in forests (mostly coniferae); and 10.3 percent in underbrush.

In the sub-basin of the Grande or Del Medio River, land is dedicated to pasture (46 percent); agricultural cropping (10 percent); high forests, mostly of coniferae (17 percent); dry forests (7 percent); underbrush (5 percent); and a mixture of coniferae and shifting agriculture (15 percent). The most important cash croppings are garlic, beans, potatoes, onions, and vegetables; of less importance are corn, pigeon-pea, yucca, and coffee. Eighty-five percent of farmers are landowners.

Status/pressures: Most of the area is seriously eroded, due in large part to a dense, rural population, a high degree of deforestation, over-grazing and inadequate use of lands suited for forestry to create pasture and grow crops. A high level of poverty, illiteracy, precarious health care, malnutrition and high infant mortality and morbidity rates characterize the population. According to Hartshorn (Perfil Ambiental, 1981), the loss of soil is estimated in about 275 ton/ha/year, equivalent to 1.83 cm/year.

The population of Las Cuevas River sub-basin is of around 40,000 inhabitants, distributed in some 8,000 families, of which 85 percent are rural; the rest (15 percent) inhabit the municipal town of Padre Las Casas and four other settlements: El Naranjito, La Siembra, Monte Bonito, and Guayabal. The majority of the population is dedicated to farming activities and livestock production and, in a minor proportion to trade, charcoal production and firewood collection.

The sub-basin of Rio Grande or Del Medio contains a population of 47,500, distributed in 8,109 homes. The most important cities are Constanza and Bohechío. Most of the population is dedicated to farming activities and trade. Twenty eight percent of the inhabitants are estimated to be immigrants from other regions of the nation.

Activities/agencies: In 1978, National Institute of Hydraulic Resources (INDRHI) began work for the conservation of soils and waters in Las Cuevas river. These efforts were later complemented with the MARENA project (SEA/AID-SURENA). After the MARENA project was finished, actions decreased, and assistance from state agencies practically disappeared. The Peace Corps is continuing technology-transfer.

Rate of change/urgency: A high degree of erosion and poverty inherent to the area create an urgent need for assistance from government and non-government agencies. If intervention does not occur quickly, the volumes of erosion and sedimentation that would collect behind the Sabana Yegua Dam could, in very few years, reduce energy generation. In addition, sedimentation could reduce the dam's ability to regulate water flow. This limitation would threaten food production in the Azua Valley.

Impacts/costs of trends: Deforestation will continue to increase, as will soil erosion and the progressive loss of nutrients. Continued neglect of this site will result in a escalation of sedimentation of water currents and water in the dam reservoir. Energy generation and water volumes for irrigation will decline. Contamination of soils and waters with agro-chemicals and fertilizers will escalate, as will a danger of invasion of national parks. Rural unemployment and poverty, as well as danger of forest fires will also likely increase.

Practicality: Because of the experience in Las Cuevas with the MARENA project, feasibility of establishing a pilot project for the integral management of the sub-basins is high. Proximity to Ocoa would also allow a combining of efforts and shared experiences to avoid failure. A former development committee for Las Cuevas in Padre Las Casas could be re-activated. And the fact that most of the farmers are landowners could be of tremendous help in consolidating actions for resource management. Recent studies already describe the physiological, environmental and socioeconomic characteristics of the Las Cuevas and Río Grande or Del Medio sub-basins. And access is facilitated by well-maintained roads.

Watershed Site 2: NIZAO RIVER

General watershed: With an area of 1,020 km^2, the watershed is located in the south slope of the central mountain range. It occupies territories pertaining to the provinces of Peravia, San Cristóbal and a small area of La Vega. Ninety percent of the watershed relief is slopping and jagged, formed by mountains and slopes, constituted by igneous intrusive rocks in their higher parts and by sedimentary rocks in their middle and lower parts.

Hydrological importance: Of all the watersheds of the country, Nizao stands out for its nacional importance in hydroelectric production and water supply for irrigation. The watershed includes the Valdesia Dam, constructed in 1975 for energy generation and for irrigation. The dam has an installed capacity of 54 MW and a average annual generation of 110 MWH. Its waters irrigate 18,750 ha of agriculture land in the area of Baní.

The Valdesia Dam will soon provide potable water to Santo Domingo by means of conduction and distribution pipelines now being built. In the future, two new basins now under construction in the high portion of the watershed will generate hydroelectric energy. Jigüey will have an installed capacity of 98 MW and annual generation of 202 MWH, and Aguacate will have an installed capacity of 52 MW and annual generation of 208 MWH. Both basins are expected to begin operation in 1992.

Biological importance: From the biological point of view, this watershed is not very important. Nevertheless, 13.6 percent of the area (12,450 ha) are very humid, mountainous forests in the surroundings of Alto Banderas, where Coniferae are dominant. This area could be preserved as a reserve and a protection zone. In the future, the basins of Jigüey and Aguacate and their surroundings could acquire great value because of their scenic value for recreation and eco-tourism. This potential suggests the value of protection, surveillance and restoration, as well as the construction of infrastructures and adequate regulations to guarantee their multiple and sustained development.

Sociocultural importance: The social importance of the watershed lies in its rural population of close to 50,000 inhabitants. The residents live in poverty, with very little attention from government agencies and other governmental institutions and NGOs. The population's use of non-sustainable agricultural practices, the geological fragility of the watershed, the sharp slopes, the erosivity of the soils and the growing destruction of the forest reserves constitute a continuous threat to the stability of this costly hydraulic infrastructure. Its economic value surpasses RD$300 million (US$25 million).

The economic importance of the watershed is food production for local consumption and for exportation, as well as investments by the Dominican people in construction of the irrigation and hydroelectric works in the watershed.

Management/land tenure: Land use is distributed in natural pasture (37.2 percent), coffee (26.4 percent), intensive cultivation of beans, corn, pigeon peas, peanuts, bananas, and others (12.9 percent), field crop and cultivated pasture (8.9 percent), latifoliate forests (8.1 percent), coniferae forests (5.4 percent), and thickets (1.1 percent). If too much land is devoted to intensive cultivation, steps must be taken to avoid erosion of and damage to the soils.

The Nizao River is one of the major coffee producers. While only 6.8 percent of the surface is apt for agriculture, 56.7 percent is apt for coffee production and improved pasture. The rest (36.5 percent) could be dedicated to forest, natural pasture or natural reserve.

The area includes 8,200 homes, with a population density of approximately 50 inh/km^2 and very poor life conditions. Near half of the population live in houses with soil floors, built in wood or palm and roofed with cinc. They do not have potable water nor electricity, so they use firewood and in less proportion, charcoal for their energy needs. Firewood supply is scant in the more densely populated areas of the watershed.

Ninety-five percent of the population depend upon farming activities for subsistence, including direct producers (78 percent), salaried, agricultural workers (10 percent) or traders (5 percent). The area includes 6,300 agricultural and livestock concerns, of which 1,600 (25 percent) are small farmsteads of less than two ha. Three-thousand-eight-hundred concerns (60 percent) are small producers with 33 percent in holdings of 2-to-5 ha. Twenty seven percent are in holdings of five-to-12.5 ha.

The aforesaid indicates an elevated atomization of the land, where 85 percent of the small farmstead owners use 41 percent of the farm's surface and the other 15 percent -- owners of medium-sized and big farms -- control 60 percent of the farming land.

Status/pressures: The watershed presents serious problems in the area of natural-resources management. These problems could negatively affect adequate water development and both the existing and in-process infrastructure. A loss of soils of 125 ton/ha/year is estimated, equivalent to 1.84 cm/year (Hartzhorn, 1981. Perfil Ambiental de la República Dominicana).

This situation suggests urgent intervention on the part of the state and responsible institutions and encourages NRM programs.

Activities/agencies: Both institutional policies and various persons interviewed give the Nizao River watershed the highest priority for intervention. But no signs indicate an active presence on the part of the institutions responsible for its conservation.

INDRHI has made initial actions in terms of erosion control on the slopes of the recently built roads. And FIRENA and the Junta of San Jose do Ocoa have taken some small actions in the high area of the watershed. But no other vigorous or permanent activities on the part of government or non-governmental agencies address the multiple needs of

the physical, biotic, social, economic and institutional problems facing the watershed area. This year, the Presidency of the Republic created the Comite para el Manejo de la Cuenca del Rio Nizao (Committee for the Management of the Watershed on the Nizao River), constituted by INDRHI, FORESTA, SURENA, Direccion Nacional de Parques and the JUNTA de San Jose de Ocoa. But the committee has not yet begun operations.

Rate of change/urgency: The movement of deprived farmers inside the watershed, searching for work opportunities, attracted by the construction of the big, hydroelectric complex make urgent the need for the state to regulate the new settlements and stop migratory farming.

Actions related to community organization, soil conservation, improvement of homes, increase in production and productivity, farm planning, promotion of forest farming systems, reforestation and the improvement of access, roads, physical infrastructure and basic services for the population could be implemented in the watershed.

Impacts/costs of trends: Problems include erosion, deforestation and sedimentation of the basins and the diminishment of their useful life. Potential ecotourism is declining while unemployment and poverty are on the up-swing. The basins are eutrophicating, and a decline is expected in both hydroelectric generation and power to incorporate more land for irrigation.

Practicality: Successful intervention is probable, due to qualified human resources available for the holistic management of the watersheds. Also helpful will be the experience gained in other projects, especially in the area of San José de Ocoa with the MARENA and FIRENA projects of the SEA. And because this is an area of great interest for the Government of the Dominican Republic, host-country cooperation is likely.

Watershed Site 3: Artibonito Watershed

General description: The Artibonito Watershed is the largest watershed on the island of Hispaniola (9,292 km2). It begins in the central mountain range of the Dominican Republic and empties in the sea at the Gulf of Gonave in Haiti. Only about 30 percent of the watershed lies within Dominican territory.

Distinguishing hydrological/geological characteristics: In terms of annual runoff, the Artibonito Watershed has the fourth largest volume in the country, and the Artibonito River is the one of the four largest rivers. The watershed is geographically divided into upper and lower sections by the Peligre Canon in Haiti. A convenient political division, however, is the site named, Dos Bocas, at the confluence of the Artibonito and Macasía rivers, where the Artibonito crosses into Haiti. Two of the main tributaries of the main body of the Rio Artibonito, the Rio Artibonito and the Rio Joca, both begin near the Loma Nalga de Maco.

Distinguishing biological/ecological characteristics: The areas of the watershed below 500 mbsl are classified as subtropical, wet forest, with sections of subtropical, dry forest. The higher portions of the Artibonito are classified very wet, subtropical and very wet, low-mountain forest. The higher portions of Macasía are low-mountain, wet and low-mountain, very wet. The Loma Nalga de Maco is wet forest with cloud forest on top, and it possesses two types of forest never described before - dwarf forest and Bosque Sloanca ilicifolia. The mountain top itself is reported to have very high bio-diversity and is now thought to be only slightly degraded.

Socioeconomic importance: The Rio Artibonito and the watershed are important as a shared resource with Haiti. They represent a potential for cooperation among the nations. As the main body of the Rio Artibonito essentially divides the two countries, the area is a conduit of illegal immigration. Interests within the Dominican Republic encourage development of the Artibonito River for hydropower and irrigation. Preliminary studies by the Organization of American States (OAS) have indicated, however, that only one such project is cost-effective -- construction of a tunnel to carry water for irrigation from Rio Jaco and Rio Lorino to the Valley Sabana Mola. The Artibonito watershed is more economically important to Haiti than to the Dominican Republic. The Artibonito River feeds Lac de Peligre, created by a dam. The dam represents the largest source of hydropower in the country and the water source for large, rice-irrigation schemes in the lowlands.

Management/land tenure: Land ownership is unknown, as is management in the highlands. It is presumed, however, that ownership in the highlands is largely the State Sugar Corporation, as is the case throughout the country. The valley lands are mostly in small, farm holdings.

Status/pressures: The Artibonito Watershed has a fairly low population density as compared to the rest of the country (59 hab./km. compared to the national average of 142.2 hab./km.). The area has 148,000 inhabitants, an estimated two percent of the

national population. Most of the inhabitants live in the valleys, with the hills still fairly uninhabited. In particular, the historically inaccessible Loma Nalga de Maco is believed to still be fairly intact. The situation has not been closely studied, however, and immigration to the area, from both Dominican Republic and Haiti has been reported.

Activities/agencies: The hydrology of the watershed has, for the past year, been the topic of a study conducted by OAS and INDHRI. They have also examined the feasibility of irrigation and hydroelectric projects; one irrigation project has been assessed as cost-effective. (See above.)

Rate of change/urgency: While the situation is not considered urgent, immigration into the area may warrant further study and attention.

Impacts/costs of trends: Degradation of the watershed would affect irrigated agriculture in the valley. Degradation of the upper cloud forests would represent an irreversible loss of bio-diversity. Haiti would suffer the greatest loss from degradation, including sedimentation of the Lake Peligre Dam, with resulting repercussions to hydroelectricity, local fishing and irrigation.

Practicality: Preliminary studies by INDHRI/OAS facilitate work in the area, and access by level roads from the capital is fairly easy.

Wa[illegible] 4: Laguna de Rincon

General description: The site is important for fisheries and for water fauna, migratory birds, and an endemic turtle species, the Jicotea. The needs of the people, the fisheries and agriculture are reportedly conflicting. And fish are claimed to be infested with a parasite that is not killed with cooking. As a result, local fisherman now travel to Sabana Yega to fish.

Distinguishing hydrological characteristics: A canal from Rio Yague del Sur is the only water supply. It is frequently diverted for irrigation of the extensive agricultural lands surrounding the lake. Water-diversion scheme is poor, and its use is reportedly inefficient. During a site visit, it was apparent that the lake has been experiencing dry-down; it covered a much smaller area than in the recent past.

Distinguishing biological characteristics: The lake is one of only a few freshwater lagoons in the country. Large numbers of migratory birds use the lake edges. The lake is also home to the largest population of the endemic turtle, Jicotea.

Sociocultural importance: The lake was the primary fishery for the large, surrounding population. But reportedly, fish are now contaminated, and the lake is no longer fished.

Economic importance: No estimates describe the economic value of fish-catch.

Management/land tenure: Land use is agricultural, including extensive areas of sugar cane on the northern shore and mixed areas of sugar and plantains on the south, all showing visible signs of active cultivation and irrigation.

Status/pressures: Expected to continue are pressures from surrounding agriculture uses and conflicts for water supply. These problems may also increase, as potential exists for expansion of agricultural lands.

Activities/agencies: Unknown.

Rate of change/urgency: The need for attention to the problems of this site is moderately urgent. There is a probability that conditions may worsen with the growing population and increased cultivation of fallow lands.

Impacts/costs of trends: Economic costs are unknown, but if the reports of contaminated fish are true, the collapse of the fishery represents a serious economic impact to the surrounding fishermen. Biological costs could be important if, indeed, the lake is a stopping-off point for migratory birds and the lake is contaminated to the point that fish are no longer edible.

Practicality: The extremely large area includes many and diverse uses. Thus, competition exists for water and the resources of the lake. Solving the problems of the area would require a well-funded and well-planned project to address, not only the physical aspects of water supply and watershed management, but also social and educational aspects, as well.

Watershed Site 5: Valle Nuevo

Valle Nuevo is at the center of the Dominican Republic in the central mountain range. The valley is an alpine plateau, located at 2,200 meters above sea level in the Constanza municipality and La Vega Province.

During February of 1983, one of the greatest forest fires in the history of the Dominican Republic took place in Valle Nuevo. The fire was initiated when campesinos cleared and burned the vegetation from land where a Dominican millionaire would build his exclusive Summer Home. Since historic times, Valle Nuevo has been considered as a high-risk, forest area. As a result of this fire, hundreds of thousands of pines and the Pescozón stream disappeared. To compensate for the loss of the pines, a large pine (pinus occidentalis) nursery was established. Unfortunately, the seeds were collected from the lower valleys of the country, and the seedlings grew to be small and weak.

The Natural Valle Nuevo Scientific Reserve was created by Presidential Decree 1315, 11 August 1983 to protect the flora, fauna, and water resources of the area. The Reserve encompasses the valley and its surroundings and is 409 square kilometers (40,000 hectares) in size. It contains one of the most complex and interesting mountainous ecological systems of the country. Its flora is rich in endemic species with unique alpine characteristics. Predominant in the valley are coniferous species (Pinus occidentalis), endemic species, juniper species (Junniperus gracilor), and important broad-leaf species, such as cedrella and magnolia (Magnolia pallescen). The latter produces a valuable timber, and it is an endangered and endemic species.

Vegetation surveys conducted on one-third of the valley indicate 249 plant species classified under 65 families of the 162 families known to occur in the country. Of the species studied in El Valle Nuevo, 39 percent are endemic to the valley. The reserve's fauna has been poorly studied. Sixty-four bird species have been identified. The wild rabbit (Orictolagus cuniculus) and the little, freshwater crab inhabit Valle Nuevo. The latter has not been classified, yet. The crab is found in river currents and wetlands.

Given Valle Nuevo's geographical, climatological (temperatures below 5°C) and geological conditions, vegetation is primarily scrubby but has not been studied. It exhibits characteristics similar to those of the Scandinavian Peninsula. The Valle Nuevo's Plateau and its high valleys present evidence of the last Glaciation (Wisconsin), and recent data indicates this area was volcanically active during the Pleistocene. Valle Nuevo may have the answers to the questions about the evolution of the Hispaniola and the Greater Antilles.

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Life zones in the area are:

- Lower montane, moist forest (bh-Mb)
- Montane, wet forest (bmh-M)
- Lower montane, wet forest (bmh-MB)
- Lower montane, rain forest (bp-MB)
- Lower montane, wet forest in transition to lower montane rain forest (bmh-Mb= =bp-MB)

Valle Nuevo has all the characteristics of a cloud forest, where most of the water that reaches the forest floor is not from the rain, but from the clouds that pass through the forest canopy. As a result, most of the rivers of the central mountain chain and throughout the country originate in Valle Nuevo. The Yuna and Nizao Rivers, two of the four most important rivers in the country, originate in the Natural Valle Nuevo Scientific Reserve.

In addition, five micro-watersheds vital to the Dominican Republic are located within the Reserve:

1. Río Las Cuevas
2. Río Grande - tributaries of the Yaque del Sur River
3. Río Nizao
4. Río Tireo
5. Río Blanco

The importance hydrological system of the Reserve can be valued based upon the following data:

1. Source of potable water for the Constanza Municipality.
2. Source of irrigation for the fertile Constanza Valley, the country's main producer of garlic, potatoes and vegetables.
3. Source of water of Sabana Yegua, Jiguey-Aguacate and Valdesia Dams.
4. Source of irrigation for the Yuna Valley (east region of the Cibao Valley). The Yuna Valley is the major rice producer in the country.

As can be seen, the Government of the Dominican Republic must consider conservation of the Valle Nuevo a high priority. While, however, some of the country's strictest regulation of protected areas specifically addresses the Reserve, very little or no enforcement exists there. Valle Nuevo should be dedicated to scientific research and have restricted access to the public. The area, however, includes exclusive summer homes, potato crops (sponsored by the Secretaría de Estado de Agricultura), and exotic plant and vegetable crops. These activities are conducted by businessmen and wealthy people who have economic and political power. It is assumed that these obvious conflicts of interest are the reasons why the Dirección Nacional de Paques has not initiated any management activities in the Reserve, which was established eight years ago.

In the mean time, the Valle Nuevo watersheds are greatly deforested and dam-regulating reservoirs -- nurtured by the Valle Nuevo's rivers -- are dangerously silted. The electricity generated by these dams is limited, due to diminishing water flow. Irrigation of cultivated areas has been restricted. The largest body of fresh water, Laguna (Lake) de Rincón o Cabral, is fed by a water channel. This condition is due to the lack of vegetation on the lake's surrounding mountains, as well as the area's critical economic, social and ecological value to poor populations in the southeast portion of the country. The loss of forest cover in the Valle Nuevo upper watershed has reduced the lake to a third of its original size.

It is difficult to calculate the enormous economic cost caused by the abandonment of the Natural Valle Nuevo Scientific Reserve by the Government of the Dominican Republic. Those costs include food importation, petroleum use to generate electricity and soil erosion. The economic, social and ecological consequences can only be evaluated through long-term studies.

Watershed site 6: Falconbridge

General description: Falconbridge is a Canadian-owned, ferro-nickel mine. The open-pit mine includes 70,000 ha, of which 12,000 ha are known to contain ore. Two-thousand and five-hundred of these have been mined-out and reforested. Another 3,800 are open and being mined. Large quantities of slag are deposited daily due to the 15,000 tons mined each day.

Distinguishing hydrological characteristics: Quantities of water drawn from the river are unknown. The artificial Lake Rincon is nearby on the Jima River.

Distinguishing biological characteristics: Reforestation by Falconbridge uses Australian Pine (casuarina) almost exclusively.

Sociocultural importance: With 2,000 employees on its payroll, the mine is by far the biggest employer in the region. Employees generally work full-time at an average rate of $RD20 per-hour. About 150 temporary employees work each night in rotating clean-up crews.

Economic importance: In today's terms, the mine is a $1 billion investment working at 50-percent capacity because of depressed world prices for ferro-nickel. The salaries, compared to those paid for similar work, are the highest in the island. It is not known how much the company pays in royalties or whether significant economic benefits, beyond salaries, accrue to the Dominican Republic.

Management/land tenure: All land containing ore is owned by the mine.

Status/pressures: Severe pollution impacts from smoke emissions have been alleged for years by, among others, those whom the company labels, "left-wing-environmental people." A company-sponsored evaluation in 1991 found high levels of heavy metals and other contaminations in vegetation, soil and animal skins. Levels of contamination were found to decrease with distance from the mine.

Activities/agencies: To counter allegations of the mine's negative impact on agriculture, the company is running a model farm about 500 meters upwind of the smokestacks.

Rate of change/urgency: Pollution continues at a fluctuating rate. The industrial activity is pronounced; one-hundred heavy trucks and other vehicles are in operation, and the company produces 200MW of electricity in its thermoelectric plant. Water pollution appears controlled by a containment ditch and seven large sedimentation ponds. Water effluent appeared clear.

Impacts/cost of trends: Permanent alteration of the landscape in a large area already exists and is increasing. Health impacts among workers and in downwind settlements are unknown, but potentially serious. The company's evaluation report denies that the company has created any major pollution downwind from the plant. The report attributed

observed crop failures there to both problems among farm-animal populations and to inferior farming techniques.

Practicality: Involvement in any project in this area could be difficult because of the important role the company plays in the area.

Watershed Site 7: Dole Plantation

General description: Thirteen thousand acres are under lease from National sugar Association, and rent is variable, but includes 3 percent of gross sales. Pineapple cultivation accounts for 7,900 acres. The project started in 1987 with the first harvest in June 1989. The operation is year-round., and production is organized in three-year cycles, where each plant is harvested three times before replanting.

Distinguishing hydrological characteristics: The site drains into the Rio Payabo, which runs through the length of the tract. All storm runoff is directed into the surface water of the river. Most of the riparian area is vegetated and consumes between 55 percent and 58 percent of the land area. (Land occupied by Bateyes is included in this area)

Mulch from harvested plants generally remains on the ground and is disked into the soil within one month of harvest. During final preparation for planting, soil remains bare for no longer than one week out of the three-year cycle, thus minimizing potential soil erosion.

Fields are not irrigated. Water for the packing and juice plant, as well as for potable supplies for human consumption is collected from three watersheds totaling 1200 acres east of the tract. Water is chlorinated, and the supply averages 170 gallons-per-minute.

Distinguishing biological characteristics: Supposedly, no pesticides are used in the fields, only in the packing plant. But this supposition is doubtable. Information on fertilization was unavailable, but it is likely equivalent to other operations. Water for agronomic chemicals is withdrawn from the river. Vegetated riparian habitat has obvious water-quality, wildlife and aesthetic benefits.

Sociocultural importance: The operation employs 2,300 employees with a combined payroll of three-million pesos per-month. Average minimum wage is 5.50 pesos/hour for a 44 hour work week. Prior to the Dole operation, the same area of sugar cane employed 500 people. The company reports that increased business activity in the local communities is a result of expanded employment and payroll.

Dole also emphasized the importance of building schools and clinics and helping to solve some of the existing social problems of the area. Dole has built public latrines and improved streams where the local population obtains water and washes cloths.

Economic importance: The entire crop is exported, 60 percent as fresh fruit and 40 percent as juice. Dole reportedly also purchases some fruit from local growers. However, since the company is foreign-owned, little more than the in-country salary and currency derived from expenditures for fertilizer, chemicals and miscellaneous goods and services are captured by the Dominican Republic.

Management/land tenure: The land is managed for maximum yield on a three-year crop cycle. Nearly 15 percent of land is in roads and other infrastructure. About 55 percent to 58 percent of land is in riparian habitat.

Status/pressures: The most critical problems loss of soils and erosion due to agronomic practices and use of agronomic chemicals and their potential runoff. While little pressure or incentives exist to decrease erosion rates, maintenance of vegetated riparian areas will mitigate some potential sedimentation problems. Whether these areas were farmed in the past or have been allowed to re-vegetate since being abandoned by sugar is unclear.

Activities/agencies: A $30,000 feasibility study has been proposed to examine reforestation of the surrounding hillsides. The potential for growing fruit trees there has been discussed. But such groves do not serve the same function, in terms of building and maintaining soils and preventing erosion, as would a diverse forest canopy.

Rate of change/urgency: Little change is expected in the rate of erosion or use of agricultural chemicals.

Impacts/costs of trends: Increased sedimentation in downstream locations has resulted from loss of soils. Sediments and chemicals in the river channel pose threats downstream. But because the tract is located in the headwaters of the Rio Payabo, marine impacts may be nominal.

Practicality: The site offers potential for an integrated approach to solving the many problems associated with development due to increased population pressure on land-based resources, especially the impacts of hillside agriculture practiced by the local population. Possible approaches to water-quality issues include use of constructed wetland-detention and filtration systems for chemicals and sediments, the introduction of best-management practices to minimize erosion and runoff of agronomic chemicals and reforestation of surrounding hillsides.

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Watershed Site 8: FRUDOCA

General description: Four-thousand-eight-hundred acres are under lease from the National Sugar Association at approximately $100 per-acre. Pineapple cultivation accounts for 2,300 acres. The project started in 1979. Eighty acres are planted per month in a year-round operation. Production is approximately 40 tons/ac on a two-year planting cycle.

Distinguishing hydrological characteristics: The site drains into the Lacumbra River, which runs through the 17 km long tract. Storm runoff is directed into the surface water of the river. Mulch from harvested plants generally remains on the ground and is disked into the soil. During final preparation for planting, the soil remains bare for approximately two months out of a two-year cycle. This practice decreases potential for soil erosion. Fields are not irrigated.

Distinguishing biological characteristics: Two pesticides are utilized: Diazinon and AMDRO. They are applied on an as-needed basis. A growth enhancer is used to induce florescence once during the planting cycle. In addition, fertilizer is applied about once each month. Water for agronomic chemicals is withdrawn from the river and seems to be mixed in sprayer tanks within or along the banks of the river.

Sociocultural importance: The operation employs 100 permanent employees and 400-to-800 contract employees at an average minimum wage of $100 per-month. Contract employees work on a three-month rotation, for a total of six months of employment per-year.

Economic importance: Almost all production is exported to USA and Europe. Since the company is foreign owned, little more than the in-country salary and currency derived from expenditures for fertilizer, chemicals and miscellaneous goods and services are captured by the Dominican Republic.

Management/land tenure: The land is managed for maximum yield on a two-year crop cycle. Nearly 25 percent of land is in roads and infrastructure (It is unclear whether this percentage is based on 4800 acres or 2300 acres). Numerous out-parcels within the tract cannot be farmed because they are occupied by individuals who claim some sort of legal title to the land.

Status/pressures: Loss of soils during the fallow period and erosion resulting from other agronomic practices pose the most serious problems. Little pressure or incentive exists to decrease erosion rates. Riparian channels appear unprotected and void of significant vegetation.

Activities/agencies: Bamboo has been planted in some streams and may be planted the main river channel at the request of the Department of Agriculture. Some evidence indicated contour plowing. For the most part, however, little attention was given to minimizing erosion potential. Hill slopes greater than 15 percent are not planted.

Rate of change/urgency: Little change is expected in the rate of erosion or use of agricultural chemicals.

Impacts/costs of trends: Increased sedimentation in downstream locations resulting from loss of soils. Potential downstream impacts in the river channel and on marine environments from sediments and chemicals.

Practicality: Management seems cooperative. The site offers potential for constructed, wetland-detention and filtration systems for chemicals and sediments, as well as for the introduction of best-management practices to minimize erosion and runoff of agronomic chemicals.

URBAN WATERSHED SITE DESCRIPTIONS IN ORDER OF FINAL RANKING

Urban Watershed Site 1: Rio Ozama/Isabela

General description: The river runs from the Cordilera Oriental to Santo Domingo, where it splits the city and goes into the Caribbean sea.

Hydrologic importance: The Ozama River is fed by water from several tributaries. The 3,150 km^2 in its watershed annually receives and produces 4,8000 cubic meters and 1.5 billion cubic meters precipitation and runoff, respectively. Inside the city, before the river reaches the ocean, it converges with the Isabela River. Together, these two rivers receive all the runoff and untreated sewage and industrial waste from the eastern portion of the capital. Considerable amounts of solid waste and sediments are also carried with stormwater. Aggravating factors are the rivers hydrological regime, determined by its small slope, and water retained by a jetty at the river mouth. This structure reduces the flow of freshwater into the ocean and helps to concentrate sediments and other pollutants in the delta.

Ecological/biological importance: The Ozama River has great ecological and biological importance. River deltas, where freshwater and saltwater mix, are diverse and productive ecosystems. Deltas provide both habitat and nutrients for many aquatic organisms. But concentrations of pollutants and pathogens, discharges of hot water, fermentation of organic matter and other chemical processes in the Ozama River delta pose a serious threats to both public health and aquatic fauna.

Untreated sewage can result in the spread of diseases such as hepatitis, typhoid, paratyphoid, dysentery, amoebic dysentery, giardiasis, cholera and gastroenteritis. Fermentation increases the chemical demand for oxygen (COD) and reduces its availability for biological processes (BOD). Sea currents may transport pollutants, affecting large areas of both the Caribbean sea and coastal areas of the Dominican Republic.

Socioeconomic/cultural importance: The river has important industrial and shipping activities and is used to discharge all industrial and human waste to the ocean. Settlements of low-income people are established along its margins. The combination of these activities has created a potentially explosive health problem.

The Ozama River provides fluvial access to the colonial portion of the city, providing the area great potential for tourism. This potential, however, is jeopardized by the deterioration of the environment, including settlements of impoverished people, bad odors, industry and floating debris.

Finally, the river can significantly contribute to the water supply of Santo Domingo.

Management: In spite of the rivers' importance, little has been done to protect these valuable water rescurces. Sewage and industrial waste are discharged, untreated and solid-waste collection and disposal for the area is insufficient. As a result, uncollected garbage can be observed all over the city. When it rains, garbage removed with the runoff floats on the river and is discharged into the Caribbean sea. Sea currents transport this waste to beaches in the country.

Poor solid-waste management poses a possibility of contamination from landfills. Two landfills in use in an old, abandoned landfill were built with little site preparation. Leeching from decomposition of the solid waste is quite possibly leeching into the river. The Guaricamo landfill, built next to the Isabela River, is especially critical.

Activities/agencies: Several government institutions share responsibility for maintaining the river. Legislation also provides a framework for its protection. However, very little is being done. The main factors determining this situation are lack of both resources and an organization capable of effectively coordinating activities to determine the extent of the problem and to establish mitigating actions.

Rate of change/urgency: If no actions are soon taken, dame to these resources may have serious consequences for future development of the Dominican Republic. The contamination process is likely to increase due to accelerated demographic and industrial growth.

Impact/cost of trends: Use of the river for transportation and boating is impaired due to excessive sedimentation, especially in the Isabela River, where boats can no longer enter. Serious losses in aesthetic value have already occurred. Bad odors, floating debris and sunken boats are common. Fish and other aquatic animals have disappeared from this river. The potential impact on public health and the economy is great, especially in the cholera epidemic reaches the country. Other possible losses are the contamination of the aquifer due to concentration of pollutants in the river delta and negative affects on fishing and related activities.

Practicality: A project to protect and improve the utilization of the Ozama and Isabela rivers has potential to produce tremendous benefits to the Dominican Republic. Therefore, this project should be considered as a high priority.

Key sources of information: "Diagnostical de la Contaminacion del Rio Ozama." This document, prepared in July 1991, is under review. It was created by the Secretarido Tecnico de la Presidencia in cooperation with the Agence pour la Cooperation Technique, Indistrielle et Economique. INDRHI also has reports on networks to monitor water quality of Ozama-Yabacao, Yaque del Norte, Yaque del Sur and Haina rivers (a recent work by Ing. Oscar Natale, consultant). INDRHI also has continuing studies of sediment production and limnology of the rivers Ozama-Yabacao, Yaque del Norte and Higuamo. These documents can be obtained through official means.

Urban Watershed Site 2: Barahona Free Trade Zone

General Description: This is a typical free trade zone containing ten buildings all devoted to textiles of fur manufacturing. Seven of the buildings are leased by one individual who dyes fabric. The sewage from the entire free trade zone (including domestic wastes) is discharged into the open waters of Bahia de Neyba. A 30 cm diameter pipe carries waste directly from the FTZ to the beach about two kilometers down slope where it is discharged onto the beach and flows immediately into the surf zone. Since the waters are full of dye, the surf zone for 1000 meters in the direction of shore currents is tinted. Also noted on the beach was a heavy accumulation of biogas from the sugar mill.

Distinguishing hydrological characteristics: The estimated flow of the discharge at the time of the site visit was about 1 to 1.5 m^3 per minute. The FTZ uses 227,300 liters per day of potable water.

Distinguishing biological characteristics: Several hundred 55-gallon drums of the following chemicals were observed in storage in the FTZ at road side locations: ferric chloride, sodium hydroxide, hydrogen peroxide, and acetic acid. The waste water can be expected to be extremely acidic, probably on the order of a pH level of 2 or 3, depending on the relative amounts of wastes from the dying process and other waste waters.

Sociocultural importance: The FTZ was constructed in 1988 and opened in 1989. There are 10 buildings under lease. Seven are leased to a Korean firm, one to a Dominican concern, and two to a Canadian firm.

Economic importance: The free trade zone employs more than 1600 people. However, as nine of the ten buildings under lease are occupied by foreign firms, most economic benefit is accrued through salaries paid only to local hires.

Management/land tenure: A management staff on site handles provision of potable water and waste removal. Solid wastes are dumped in an open landfill about one kilometer from the FTZ.

Status/pressures: The liquid wastes are unsightly and presumably contain high levels of of the above-mentioned chemicals. Mixing at the surf zone is reportedly effective yet there are some health hazards in the near-shore environment.

Activities/agencies: More than 30 groups reportedly have tried to draw attention to the discharge in the hopes of getting the FTZ to discontinue the practice.

Rate of change/urgency: An increase in the discharge is not expected. In reality, the sugar mill 1000 meters to the south of the textile outfall probably represents a far greater impact.

Impacts/costs of trends: In all likelihood there is an immediate impact on sea life in the area of the outfall, yet the impact is relatively small in extent because of the dilution with sea water and effective mixing in the surf zone. The practice should be discontinued, however, for aesthetic and social reasons.

Practicality: An adequate land area exists immediately upslope from the discharge point. Construction of a wetland treatment system would help to minimize any impacts in the surf zone.

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Mixed Site 1: RIO HAINA

General description: This river begins on the east side of the road that connects Bonao and Altagracia. It runs to the southeast, parallel to the road going to Santo Domingo, and discharges it's waters into the Caribbean Sea, 11 kilometers west of the capital.

Hydrological importance: The estimated size of the Haina's watershed is 563 km^2. The area receives and produces an average of $1.09 * 10^9$ and $0.35\ m^3 * 10^9$ of rainfall and runoff per year, respectively. In the upper part of the watershed the river runs through an inter-mountain area characterized by high rainfall and steep slopes. This combination makes it an area where sound watershed management practices are required to avoid excessive soil losses and sediment production.

Ecological/biological importance: The Haina's watershed is an area rich in bio-diversity. Small areas of subtropical lower montane rain forest can be found in the upper part of this watershed. The average rainfall in these areas exceeds 2200mm per year. The river crosses both subtropical wet forest and subtropical moist forest areas before discharging water into the Caribbean Sea. As with any other important river, the Haina provides habitat for many aquatic life forms.

Socioeconomic/cultural importance: The Haina is an important river for the Dominican Republic. It is a thoroughfare that provides access to two tax free industrial areas and a thermoelectric complex. It also has an important urban population surrounding the mouth. The river also provides more than one m^3/sec to the water supply of Santo Domingo. There is also important agricultural activity in this watershed.

Management: In spite of the importance of this river, few efforts are being made to guarantee the sustainability of its resources. High soil losses and sediment production are occurring as a result of current agricultural activities. Intensive farming of pineapple and oranges, and production of annual crops in small farms are the primary agricultural activities in this area. These activities are conducted with little regard for the environment. During the visit to this area it was observed that one of the containers used to apply pesticide was being recharged in the river. In addition, the river receives untreated industrial waste from a government-owned recycling cardboard factory (CORDE), other industries, and sewage from the urban population near the mouth.

Status/pressures: Degradation of this river is not serious as yet. However, it is escalating at a high rate due to abundant economic activity within it's watershed and due to it's proximity to the largest urban center in the country. This is one of the critical areas demanding immediate action or very valuable resources may be lost forever.

APPENDIX 3
Description of International Agencies

DESCRIPTIONS OF INTERNATIONAL AGENCIES

I. Agencia Espanola de Cooperacion Internacional (AECI)

Address/Phone/FAX: Pedro Henríquez Ureña 171, Esq. Abraham Lincoln, 565-1870, 541-6119, 544-0311 (FAX)

Key Contact: Antonio Morales M. Coordinador General de la Cooperación
Carlos Cano C., Biólogo (in charge of P.N. del Este)
Rafael Camara A., Biólogo (in charge of P.N. los Haitises)

Agency Mandate: Watershed Management, Pollution Control, Coastal Zone Management, Water Supply and Sanitation, Waste Management, Soil Erosion, Water Planning and Management (including dams), Institutional Framework:

1) Reordinacion Agrohidrologica del Rio Nigua - A study of the situation is just three months old. Excavation for gravel and sand is occurring along the river. They will implement a reforestation project along the margins of the river.

2) In Los Haitises development of a management plan for all of the national park is under way. There are three pilot projects being developed for certain areas of the park - 1) part infrastructure and visitor route for the western part of the park, 2) research program, studying the vegetation, the caves, the cultural patrimony, 3) a guard program.

3) Parque Nacional del Este - AECI has just begun a re-study of the situation in order to implement a program of public use, recuperation, and protection. They will begin to implement the most important programs from the 1980 management plan that was never implemented and are beginning to inventory the flora and fauna, determine the most important areas and state-of-the-art resources, and to classify the land according to land use zones; will begin to put in park infrastructure.

Participating Government Agencies/PVOs: Direccion Nacional del Parques - for national park activities.

Studies:

1) Planning to conduct a study of biological contamination (faecal coliform) of four rivers - Isabella, Ozama and Yacque del Norte. Have not yet hired anyone.

2) Planning a study of Monte Cristi Nacional Parque - the pressures, uses, conflicts; have not yet hired anyone.

II. Coopération Française, Service Commercial - French Embassy

Address/Phone: Av. George Washington 353
689-2161

Key contact: Yves Legaigne, Directeur, Service commercial
Ave. Francia 125, Edificio Prieto Tours (ème)

Agency mandate: Stimulate private sector projects to be carried out by French firms in collaboration with local firms.

Potential role: The French firm Pont-à-Mousson (#1 worldwide) has just supplied and is involved in the installation of CAASDs new main pipes in Santo Domingo ($10M). It appears possible that French sponsorship for potable water and/or drainage pipes could be developed in other areas.

Counterparts: All projects involving French participation must go through the Embassy which than assigns them to either one of the Service Culturel or the Service Commercial. Some of the contacts are with personnel in the French Overseas Departments of Martinique, Guadeloupe and Guyane.

Agency priorities: It appears that exporting French goods and French expertise is really the highest priority.

Other notes: The French have just sponsored the Diagnostico de la contaminacion del rio Ozama which is much more than that: It contains a 9-option proposal for a major solution to the sewage problem of Santo Domingo which includes high-tech, expensive elements.

Other projects in the planning/execution age include development of an International Convention Center on the Sans-Souci Beach of Santo Domingo ($100M) for which studies start in February 1992, and tourist developments at Casa de Campo, Marina Puerto Chiquito (Sosua) and Marina de Barahona.

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III. Canadian International Development Agency (CIDA)

Address/Phone/Fax: No office in the Dominican Republic
562-6291 (Mercedes is secretary of William Snow)

Key Contact: William Snow is in charge of small projects sponsored by Canada.

Agency Mandate: Principal Canadian governmental agency implementing projects and programs, comparable to USAID.
CIDA has no large projects in the Dominican Republic at this time.

Potential role: Any project with distinct small components can solicit CIDA funds (up to $20,000) which are reputed to be easy to get. FIRENA seems to have access to more than just that. For a project such as SODIZUR/IDI this is an excellent route to finance a small activity.

Counterparts: William Snow is the contact. However, via Padre Quinn, the FIRENA director, and other contacts could be developed.

Agency priorities: CIDA has had serious cuts in staff and budget over the last few years and is now hesitant about getting into any big projects alone. The agency is increasingly participating in multilateral programs since it lacks the administrative capacity to work alone.

Other notes: About $300,000 per annum is spent in the Dominican Republic on small projects. Increases are unlikely. All projects are one-shot, non-renewable. Priority is given to private entrepreneurs and PVOs.

V. Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ)

Address/Phone/FAX: Cesar Nicolás Penson No. 143
Apartado Postal 21636
685-3597

Key Contact: Ms. Dietmut Kiehl, Director, Servicio de Administración de Proyectos

Agency Mandate: Watershed Management, Pollution Control, Coastal Zone Management, Water Supply and Sanitation, Waste Management, Soil Erosion, Water Planning and Management (including dams), Institutional Framework:

1) Water resources project with INDHRI, Proyecto "Fortalecimiento del INDRHI en las actividades hidrologicas" - began in 1986; institution strengthening and technical assistance to INDHRI; assisting with development of a water resources inventory - creating measurements stations for precipitation, flow rates, some groundwater, and a data base; advisory role in how to cope with water problems - technical, institutional, and legal; have prepared a series of over 75 reports (computer printout list).

3 other water or coast-related projects:

1) Rational Management of the Dry Forest, Manejo Racional de Bosques Secos - rural development project in Azua; trying to find alternatives for the people living in this dry area to cutting the forest for charcoal; development of house gardens, goat nurseries, and water supply; doing forest research - a forest inventory; determination of sustainable cutting rates, what should be replanted.

2) Rural Development in San José de Ocoa with Asociación para el Desarrollo de San José de Ocoa - work in health care, irrigation, reforestation, vocational training exclusively through and within the Asociación; started working with the organization in April '89; first assisted in organizing the structure and operating procedures of the group; assisting in the developing the irrigation program which ties irrigation assistance to reforestation.

3) Fishing project - The main office is in Barahona, with a satellite office in Pedernales. The GTZ hopes to open one in Bani and Azua to cover the entire south coast. Fisheries development - how to fish more efficiently (higher volumes per unit time), and how to organize fishermen for fish marketing and processing. There is also a scientific component - investigations into marine biology - to study the status of the waters, fish movements and feeding habits, and they will soon be conducting a real inventory with a new boat in order to determine sustainable exploitation, i.e. how the new technologies are impacting the resource.

Additional environmental projects:

1) Urban Improvement, Mejoramiento Urbano - ongoing project begun in 1981; model project in El Caliche in Santo Domingo near the zoo; organized community groups, a health center, small school, transportation, waters systems (including canals for drainage of waste water); people now have regular community meetings to tackle common problems.

2) Proyecto Nim - in San Cristobal with Instituto Polytechnico Loyola, started nurseries of the nim tree and distributes seedlings to small scale farmers; shows them how to fabricate a natural pesticide with the seeds; the tree grows very fast,

in three to four years can start harvesting the seeds; the natural insecticide is not dangerous for people or animals.

Participating Government Agencies/PVOs: Asociación para el Desarrollo de San José de Ocoa, INDHRI, Instituto Polytechnico Loyola

Studies:

1) Water resources inventory and development of data base with INDHRI.

2) Studies of dry forests.

3) Studies of marine biology, including fish movements and feeding habits; will soon undertake a comprehensive inventory.

4) Preparing a proposal to conduct a water quality monitoring program for the four biggest watersheds - Ozama, Rio Yaque del Sur, Yaque del Norte, and the Yuna; will monitor everything relevant to water quality; exactly which pollutants monitored will depend on the river; in order to prepare this proposal, GTZ hired a consultant to do a study of the major sources of contamination and the location of these sources; due to the lack of available or accessible data, he had to rent a boat and go up the rivers, find the industries, and talk to the local people.

Technical Assistance/Equipment: GTZ provides individuals to various groups as technical assistance to accomplish certain tasks. One such person is Dr. Sagawe Thorsten, provided to the Ayuntamiento Municipal de San Pedro de Macoris (529-7815) to help the community learn how to dispose of their solid waste.

V. Inter-American Development Bank (IDB)

Address/Phone/FAX: Torre BHD (Banco Heporticano Dominicano)
A:P. 1386
562-6400, 562-2607 (FAX)

Key Contact: Mario R. Mejía, Sectoral Specialist

Agency Mandate: Watershed Management, Pollution Control, Coastal Zone Management, Water Supply and Sanitation, Waste Management, Soil Erosion, Water Planning and Management (including dams), Institutional Framework:

1) Technical Cooperation - now undertaking the feasibility study for the management of the Rio Bao watershed - a series of dams on this river serve as the major generator of electricity in the country, also for irrigation; planning a project to protect and manage the watershed - works to protect and in some cases to recuperate the watershed. The study began in October 1991 and will last 18 months.

2) Project - Desarrollo Agricola de Valle de San Juan - is now under development, should be approved in the second semester of 1992, and begin works the first of 1993; the implementing agency will be INDHRI; $50 million for the whole project that will include a) watershed protection for the Presa Sabaneta, b) soil conservation in the mid-level watershed with the planting of coffee and cocoa; c) irrigation/agriculture improvements in the valley with loans and technical assistance for improved water management, seeds, and fertilizer.

3) Project - Tourism development to increase tourism capacity in the Dominican Republic through the construction of hotels and resorts; loan is to the Banco Central who makes sub-loans to developers; sub-loans are not reviewed for environmental impact, although environmental standards were developed as part of the technical cooperation that served as background to the project (see studies). No central legislation or organization obliges these projects to be reviewed environmentally.

4) Plan Sierra is now soliciting IDB for an environmental project; the loan proposal is going through the IDB project cycle; the country has guaranteed the loan.

Participating Gov't Agencies/PVOs: INDHRI, Banco Central

Studies: Technical Cooperation (1987-1990) - an extensive study that developed a national plan for tourism development; part of this study included an inventory of the areas most suitable for tourism development, and an examination of limiting environmental factors (e.g., contamination of water). The study was conducted in collaboration with the Secretaria de Turismo.

Technical Assistance/Equipment: Technical assistance for the IDB is only given through a technical cooperation or as part of project activities.

II. Japanese International Cooperation Agency, (JICA)

Address/Phone/FAX: Ave. Bolivar No. 818
P.O. Box 1163
682-4703, 682-9635, 686-0441, 688-2425 (FAX)

Key Contact: Mr. Yoshiro Yanai, Chief of Technical Cooperation

Background: JICA is responsible for the technical cooperation aspect of Japanese international assistance, which is entirely in the form of grant aid. The Overseas Economic Cooperation Fund, OECF, is responsible for the financial or economic cooperation which is entirely in the form of official soft loans. The OECF has not loaned any money to the D.R. since it lost its international credit rating some three years ago.

JICA activities are divided into four main programs: 1) dispatch of experts, 2) support for training of Dominican technicians in Japan, 3) feasibility studies to develop projects or programs, 4) supply of equipment and materials. A fifth program called a project type cooperation includes 1,2, and 4 over a 3 to 5 year period.

The Japanese Overseas Cooperation is similar to the Peace Corps. The JOC has about 50 volunteers in the D.R. now, of which two or three are in forestry.

Feasibility Studies: Four feasibility studies related to water resources completed or underway.

1) A feasibility study for a rice irrigation project draining into the Rio Nigua and Rio Yuna, Proyecto del Desarrollo Agrícola del Area AGLIPO (El Pozo). Feasibility was completed January 1982; project was completed some years ago.

2) A feasiblity study for a hydro-electric dam, "El Torito y los Vegános". Even though the loan was signed and approved by both the OECF and the CDE (Compañía de Electricidad), Congress did not approve the loan and the dam was never constructed.

3) The Feasiblity Study on the Constanza Valley Irrigation Project was completed in March 1990. Was conducted with the participation of INDHRI. This project would require a sum of RD$109 million to implement; the D.R. would like grant monies from JICA.

4) A feasiblity study, "Groundwater Development Project in the Western Region Dominican Republic", is now underway and expected to be completed in June 1992. Phase I is estimating groundwater potential and identifying potential areas for groundwater development; Phase II will analyze and evaluate the groundwater. This study is being conducted with INAPA.

Participating Gov't Agencies/PVOs: INDHRI, INAPA

Technical Assistance/Equipment:

1) Two technicians from INDHRI and one from INAPA are in Japan receiving training.
2) A Japanese expert has been in INDHRI for two years.
3) The Dept. of Natural Resources has one Japanese expert in fisheries.

VII. Organization of American States (OAS)

Address/Phone/FAX: 533-8024, 533-1962, 532-1788

Key Contacts: Mr. Fernando Cavada, Director
Mr. Eugenio Lobo, Dir. Int'l de Proyecto Ordenamiento de Recursos Hidricos
Mr. John Gould, Consultant
Ing. Pedro Julio Bona P., Consultor

Agency Mandate: Watershed Management, Pollution Control, Coastal Zone Management, Water Supply and Sanitation, Waste Management, Soil Erosion, Water Planning and Management (including dams), Institutional Framework: See the studies described below. OAS only conducts studies, and does not implement projects per se.

Participating Gov't Agencies/PVOs: INDHRI is collaborating with OAS on the water resources studies (below).

Studies: The OAS has just completed a study, the Frontier Development Project, which identified potential development projects in the zone along the border with Haiti. As the study evolved, most of these projects tended to focus on the Artibonito watershed. An analogous study was conducted by OAS on the Haitian side. In this study, a proposal has been made to develop agroforestry as the main component of watershed management. As a next step, IDB will finance a $500,000 to $1 million feasibility study for the watershed management project on the Haitian side.

OAS has plans to conduct a comprehensive study of water resources for the entire Dominican Republic, Plan de Ordenamento de los Recursos Hidricos de la Republica Dominicana. They are waiting for the final approval of financing. Without financial assistance, OAS has already undertaken a small component of this study, an investigation of the hydrology of the Artibonito watershed and the feasibility of various irrigation and hydroelectric projects. Investigations over the past year have concluded that only one

project would be cost-effective at this time - a project that would convey water through a tunnel from the Rio Jaco and Rio Lorino to the Valley Sabana Mola to improve irrigation.

Technical Assistance/Equipment: A senior consultant from Chile, Ing. Eugenio Lobo, has been provided to INDHRI as technical assistance for the hydrological studies of the Artibonito watershed.

III. United National Development Program (UNDP)

Address/Phone/FAX: Ave. Nacaoña 9
531-3403

Key Contact: Matilde Desoto, Coor. de la Unidad de Programación

Studies:
1) Are in the final stages of preparation of a three-year study of the optimal use of the water resources of the Rio Jacque del Sur. The final report should be available early 1992. They are in the initial stages of a similar report for the Yaque del Norte. INDHRI and the WMO participated.
2) Supported the national effort to prepare a report, 'Informe Nacional - Republica Dominicana', for the United Nations World Conference on Environment and Development to be held in Brazil in 1992. Various national consultants participated in the preparation of the report.

X. World Health Organization (WHO)/Pan-American Health Organization

Address/Phone/FAX: Apartado 1464, Santo Domingo
567-3639, 566-2705, 544-0322 (FAX)

Key Contact: Ing. Luis A. Leal, Ing. de Pair

Agency Mandate: Watershed Management, Pollution Control, Coastal Zone Management, Water Supply and Sanitation, Waste Management, Soil Erosion, Water Planning and Management (including dams), Institutional Framework

The WHO, in conjunction with the organizations listed below, has prepared a proposal ($US 103.2 million) to implement a national plan for potable water and sanitation for high risk populations in rural and marginal urban zones. The plan, 'Republica Dominicana - Plan Nacional de Agua Potable y Saneamiento para Poblaciones de Alto Riesgo de Zonas Urbano-Marginadas y Rurales', has recently been finalized and is ready for presentation to potential donors.

Participating Gov't Agencies/PVOs: SESPAS, Provincial Health Services, Civil, Cultural and Religious NGOs, INAPA, CAASD, and CORAASAN.

Studies: The WHO has been participating with INAPA and others in studies of potable water quality over most of the country. This study is nearly complete. They have been measuring all the usual parameters of drinking water quality, i.e., pH, dissolved solids, BOD, faecal coliform counts, but have not been testing for heavy metals or complex organics. This study was in partial preparation for the proposal described above.

APPENDIX 4
Other Issues of Relevance to the Study

Other Issues of Relevance to the Study

Issues covered in this section of the report concern some of the social-scientific bases of successful development activities. They refer to the method, rather than to the content of development work. Content is important (e.g., the technical definition and solution of a problem such as soil erosion), but an adequate choice of method is indispensable if any technical solution is to have a positive affect. Through the experience of countless ill-conceived foreign aid projects, designers have learned that when promoting development, cultural and political traditions of target populations should be respected, but it is not often explained why this should be so.

Cultural traditions govern access to and control over resources. In all societies, there is a fine balance between the level of power and the amount of resources an individual or a group controls. Any type of power can be used to control resources. Cultural tradition will legitimate and regulate the use of power and force to control resources. The state is a mechanism (or a form of political culture) which mitigates the direct determination of power. If a farmer steals land, water or animals from his neighbor, the state will intervene. The power to trigger such intervention, to mobilize state power, is itself an important resource. Few individual peasants would be able to mobilize state power alone, but an organization of peasants will frequently be able to do so.

The presence of foreign donors changes the balance of resources, often by the addition of new resources. Unless the addition of resources includes a higher level of empowerment, impoverished and powerless target populations will lose the new resources. The resources (tools, pumps, seeds, schools, trees) will be stolen, sold, misallocated, sabotaged or otherwise captured by these powerful elite groups. The local system of social stratification will efficiently take care of money, food and health as well as of the illusions of impatient foreign technocrats.

Basic health and education are means to empower individuals, while community organization is a means to protect resources. If the three operate simultaneously, then an increase in individual-level resources is feasible. Such simultaneous operation is contingent upon individual motivation to participate, and such motivation is in turn contingent upon an individual's perception of justice (including equity). Hence, the chain of causality leading to successful foreign-sponsored development work starts with the issues of justice and equity.

Equity as a condition for control of deforestation and erosion

Deforestation and accelerated soil erosion are expressions and consequences of rural poverty. Impoverished peasants have few options in their struggle for survival, and one of their most widespread, short-term survival strategies in the past has been a form of

slash-and-burn economy, which is itself a form of intermittent use of land. But what in the past had been a successful adaptation to conditions of abundance of some resources such as land, and scarcity of others such as legal title, capital and inputs no longer works for either peasants or the nation as a whole. Land has become scarce because the bottom land occupied by larger holdings is unavailable to most peasants. Small holders, now five times more numerous than at the turn of the century, are mostly cultivating land on slopes. The removal of the vegetative cover triggers a rapid process of degradation. Land use is no longer intermittent and even occasional fallow cycles are disappearing. Short-term survival needs dictates a permanent and destructive use of the land.

The impoverishment of peasants is the result of political actions, investment patterns, and taxation. Urban bias is evident in all of them. Political actions and governmental institutions are so centralized that most of their services and benefits inevitably accrue to cities where their budgets are controlled. Fore example, in the Dominican Republic, investments in infrastructure and housing have greatly favored cities, mostly in the Distrito Nacional (Aleman, 1982: 200-215). Taxation is mostly indirect and hence, non-progressive. Peasants are de facto the most heavily taxed segment of society. The cumulation of such relative disadvantages over the years has led to ever increasing rural/urban discrepancies. The results are visible everywhere as a great polarization in levels of wealth, health, political power, and general well-being. The polarization between the 90 percent of farmers who are poor and the ten percent who are not, and between rural and urban areas in general.

Rural-urban migration is the principal mechanism relieving some of these discrepancies. Migration has led to a transfer of human resources to the city as rural areas keep subsidizing the city even in terms of human capital.

A grossly inegalitarian distribution of resources is counter-productive for development. At a macro-level, cross-national comparison reveals much superior development performance in societies redistributing wealth from higher to lower strata (World Bank, 1991: 161). At a regional (i.e., Latin American) level, smallholders have repeatedly been shown to produce more goods per hectare than large estates, even where livestock is included. The great success stories of the newly industrializing countries (NICs) such as Thailand, Taiwan and Korea characteristically include economic take-offs started by first redistributing resources to small farmers (George, 1986). The agricultural boom has preceded the industrial take-off.

Inegalitarian land-tenure patterns accelerate the destruction of the hillsides. An increasing number of peasants in the Dominican Republic own little or no land and must resort to one of two options. Either they work much of the time on land which is not theirs, or they increase labor input on their small parcels. Both options tend to accelerate soil erosion. Under present conditions, sustainable erosion control measures can only be implemented on privately owned land, and increasing labor input means switching to annual crops and suppressing fallow cycles. Human poverty produces poor and eroded soils.

Equity can be justified on philosophical grounds, but this is not what is being done here. The argument here is purely practical. Equity is important because it provides one of the indispensable motivational prerequisites of action in the collective interest. As long as peasants perceive that the benefits of collective action will be distributed equitably, they can be motivated to participate in the land maintenance and protection to prevent soil erosion. Equity in this context means that they can be certain to profit individually, and in the relatively short term, from investments made on their land. It also means that they see an equitable distribution of benefits accruing from investments made collectively. Luckily, the Dominican rural development experience contains proof of the efficiency, for both erosion control and income generation, of such equitable distribution of benefits.

There is also ample proof of the inefficiency of other attempts to control erosion. Public forests have been planted and disappeared, state land has been terraced and the terraces have disappeared, and irrigation systems have been built and lost again. There is a real danger for any resource held or controlled in common to be considered an "open access resource", rather than a common resource. Whether the resource in question be trees, water, soil, or even harvests, it is sure to be abused, stolen, burned or neglected as long as it is "open access". Scores of eroded public land, burnt state forests, washed-away terraces, roads and bridges bear a sad testimony to this. The protection of "common good resources" can only be assured if the benefits are distributed equitably at the local level.

The work of the San José de Ocoa organization provides a vivid illustration for this analysis. Its efforts are based upon the following assumptions and analyses:

Problem: Rapid deforestation and erosion of a mini-watershed.

Cause: Poverty. Having no other land and few other options, the local population produces charcoal and converts unsuitably steep land to agriculture. Each farmer is acting in a rational manner, but on the aggregate, these strategies become irrational.

Technical solution: Reestablish vegetative cover on the steep (80 percent) upper slopes of a mini-watershed and control erosion of the lower (30 percent) slopes by terraces and appropriate agricultural practices.

Incentive: Provide irrigated land to the whole population. This is the single greatest asset for agricultural producers who are highly motivated to gain access to this.

Means: Organize a publicly recognized and legally binding land exchange in the community. All of the upper land (80 percent slope) comes under community management and is converted to wood production under an

agro forestry scheme. The use rights of lower (30 percent slope) land is redistributed among all community members.

Equity: Equity considerations come in at two levels: distribution of resources and risk. The (wealthier) previous owners of the land accept a reduction of access to landholding in exchange for irrigation, which triples profits per hectare and eliminates climatic risks. Furthermore, these previous owners are given a contractual guarantee that should the community fail to provide water for irrigation (through protection of the watershed), they could regain control of any land lost in the swap. The poorer and the previously landless farmers accept the terms because in exchange for labor spent on agroforestry and terracing, they now have rights in perpetuity to private plots of irrigated land, a resource otherwise denied them for life. They accept one risk (having to assure water supply) in exchange for another (low and irregular income from marginal land under uncertain tenure).

Four observations concerning this model come to mind immediately. First, the "technical solutions" applied, reforestation and terracing, are the very same which have failed in dozens of other projects in the Dominican Republic, Haiti and many other places. The design problems in other projects was not the technical packages, but the social and institutional conditions of applying the solution. Second, questions of equity and equality have been addressed and solved in a manner acceptable to both the (relatively) rich and the poor. Access to highly valued resources are now distributed in a more equal way, and are of comparable quality, though not quantity for rich and poor. Third, community organization is the key to (a) assuring a legally-binding exchange of land, (b) productive management of the upper slopes, and (c) protection of the land from intrusion, theft and damage by outsiders. Fourth, a significant demographic change is taking place. While the project's success has prompted some population increase, the population no longer lives on the steep slopes. Instead, it is concentrated in villages and spends most of its agricultural work on plots where agriculture can be sustained.

Everyone wins in this example: all individual farmers will have higher and more regular cash incomes, and the community wins a measure of autonomy, power and prestige, which has already been used to secure the provision of other services such as a health clinic, schools, roads, which before had been unavailable.

Under conditions of high population density in the Dominican Republic, poverty is at the beginning of the causal chain leading to soil erosion. Reducing poverty is the "trick", or incentive which in the San José de Ocoa project, has led to the control of soil erosion and deforestation. It has also led to improvements in school accessibility and health levels. The World fertility survey of 1978-1986 has proven beyond any doubt that prosperity, education, and health are among the most significant determinants of lower fertility levels. For those who think that population density is also a factor in deforestation and soil erosion, this is good news indeed.

Relevance of basic health care and education

Governmental reorientation of investment and allocation policies since 1986 has lead to a serious deterioration of public services in health and education, especially in rural and poor urban areas. The education budget of 1970 represented 2.4 percent of GDP while the 1989 budget represented only 1.4 percent. Private schools have taken up some of the slack, and local populations have shown a willingness to make considerable sacrifices to ensure the schooling of their children. This trend should be a matter of concern since numerous experiences around the world have established irrefutable causal links between health, education, economic development and the reduction of fertility levels (World Bank, 1991:65-72). Investments in primary education are particularly productive. It has been estimated that every additional year of average schooling level in a Third World population raises the per capita GNP by up to 9 percent. The costs of improved educational services are high, but they pale in comparison with overall economic gains achieved.

Low health levels also carry a heavy economic toll. The annual income lost by adult morbidity has been estimated as 2.1 percent in Jamaica, 3.1 percent in Peru and 4.4 percent in urban Bolivia (World Bank, 1991:62). Several other costs have to be added to this estimate such as the opportunity cost of premature death, the cost of lower productivity, the loss of non-salaried labor and the private and public cost of medical treatment. Public health systems are no doubt costly, but not in comparison to their direct and indirect economic benefits.

Public investments in health and education have to be targeted carefully, especially at the lower levels of institutional and economic development. The marginal benefits per dollar invested appear to be highest in the lower half of the systems concerned. Public health measures such as potable water supplies and simple, rural dispensaries tend to drastically improve health levels. One example would be the work of SODIZUR, a PVO working in the La Zurza barrio of Santo Domingo. It has systematically monitored several health indicators and has seen them improve by more than 50 percent since the installation of services taking care of garbage, sewage and maternal and child health.

Local populations value education services very highly and respond rapidly to opportunities for the schooling of their children. This is evidenced by the rapid increase of enrollment rates, such as the change in the Dominican primary enrollment rate from 87 percent to 101 percent between 1965 and 1988. The rates alone, of course, do not guarantee the value of education, especially in a situation where unsupervised primary schools grow rapidly. This points to the importance of governmental budget allocations to the education sector. Even if the ministry cannot build and run all of the schools, it must have funds to supervise and assure the quality of curricula, teacher training and school materials used.

The importance of basic education and health services is so critical that foreign donors should use all their political and financial leverage to help the Dominican government take

its responsibilities seriously in these fields. But even the target populations can be incited to perform work on a variety of fronts (such a erosion control) if project benefits include such highly valued goods as a potable water supply and a school. A major donor such as USAID, is in a position to affect significant improvements in the fields of health and education by leverage alone and should include these as a matter of course in whatever activities are supported. In the past, these improvements in human capital have sometimes been the only tangible positive effects of foreign-sponsored development activity.

Importance of community participation

To organize community participation takes much time and energy. In view of the urgency of many water-related problems in the Dominican Republic community, development work can only be justified under the following conditions:

Community work is efficient

> Community work is not an efficient way to build a port, plantation or factory. But community work can be an efficient and cost-effective way of improving the quality of life around such investments and protect them from sabotage and abuse.

Community work is indispensable

> Some of the most critical collective goals are directly at odds with individual short-term interests. It is pointless for a farmer to terrace his land unless land on the same slope above and around his own is also terraced. Piecemeal work in the protection of water and soil resources is a waste of money. As scores of development professionals have found out, community mobilization is indispensable for any work in reforestation, erosion control, irrigation and many other fields. The "social technology" of erosion control is every bit as critical as the hydrological, agronomic and geological technology.

Community participation has three important components. The first is individual motivation. For example, an individual farmer will adopt a measure of erosion control (plant a leucaena hedge for example) if this investment will (a) bring him/her a higher income or other tangible advantages, (b) present him/her with no more than manageable costs, and (c) does not increase the risks involved in this or any other of his pursuits. The community is an efficient mechanism for directing the initial flow of information concerning techniques, models, experiences, prices, risks and profits towards individual farmers. Instead of a sales pitch from agents of government, foreign donors or agricultural, input merchants, none of whom, as the farmer knows very well, will suffer the consequences of bad decisions, the farmer will receive information from other farmers who are also his neighbors and relatives and are known to carry similar risks. Prices and profits are powerful motivators but profit maximization is not the farmer's highest goal (Lipton, 1968).

Risk avoidance is much more important if one is operating near the bare minimum required for survival.

Again, using erosion control as an example, the second component which links community work and this societal goal is the element of social control. It is not by accident or romantic dedication to social values that a 1,000 year old community in the Andes or in South-east Asia can maintain 1,000 year old terraces. The community's whole culture is structured so as to preserve this base of its economic activity and the life of all individuals. Compliance with rules for terrace maintenance is enforced, and offenders are sanctioned most severely. In the young, fragmented and reconstituted cultures of the Caribbean, such compliance cannot be expected, and such terraces will not be maintained. But communities will exercise control over individuals at a (lower) level, commensurate with community power and tradition. Examples of this can be found in the case of two small irrigation systems built and run by INDRHI near Azua. Locally powerful individuals quickly appropriated this resource for their own ends, causing sabotage, neglect, and poor efficiency overall. However, once local water councils were given affective control by a disillusioned INDRHI, the systems started to work much better. The communal organization can achieve what a governmental bureaucracy and some wealthy farmers had been unable to achieve.

Empowerment is the third link between community and achievement of societal goals. Community organization will empower individuals to protect their newly acquired or augmented resources. For the protection to be effective, the organization must be representative, as the examples of Dominican coffee cooperatives have shown (Marchetti cited in Aleman, 1982: 61). The motivational and behavioral effects of community organization can only be achieved if there is a true transfer of power to the community level. Budgets, staff, vehicles come under the control of local organizations if these organizations are to make their indispensable contribution to erosion control.

Planners are sometimes tempted to favor alternative forms of control over communal control mechanisms. Two such alternatives are physical force and financial incentives. Neither appears to have produced attractive results in the field of deforestation and erosion control. The use of armed forces has been an expensive and inefficient means to prevent deforestation and have regularly become passively or even actively involved in cutting timber and producing charcoal. Financial incentives have been used to plant millions of trees on this island, but those trees seem to disappear soon after the incentives. The principal incentive, high prices for domestic annual food crops compared to coffee and other perennial crops which afford better soil protection, tends to backfire.

To the individual farmer, the risks of erosion control measures lie in the reallocation of resources. Temporary short-term income loss by individuals is often replaced by some form of foreign donation; this replacement is a new resource which must be protected. Long-term income gain will accrue to the individual only if he/she is afforded an increment of political power, commensurate with his income gain. In both instances, it is the

community which must protect these new resources. Given the conditions of the Dominican economy, control of deforestation and erosion will only be achieved via the empowerment of local communities.

APPENDIX 5
Analysis of Data Sources

ANALYSIS OF DATA SOURCES

A common constraint facing short-term consultant teams in the Third World is the paucity or absence of reliable data upon which to base its findings. The following is an analysis of the data sources which this team used during its intensive survey of the Dominican Republic.

Demographic/Socioeconomic

Oficina Nacional de Estadistica (ONE)

ONE is found within ONAPLAN and is charged with conducting a census every ten years. The last census was conducted in 1981, the next is scheduled for 1992 but is in jeopardy due to lack of finance and advance planning.

Centro de Estudios Urbanos y Regionales (CEUR)

CEUR is thought to be one of the most reputable entities doing demographic and geographic/social research in the country. The group is finalizing a study on agricultural systems, environmental degradation, and rural poverty utilizing LANDSAT imagery and to produce an atlas of maps (unavailable as of December 1991). The study has been extended to a multi-year data collection exercise financed by CIDA in collaboration with the University of Sherbrook.

Guida de la Poblacion Dominica

The 'Guida de la Poblacion Dominica" was published by PROFAMILIA and is one of the better books on population issues in the Dominican Republic.

Agriculture/Agricultural Economics

Probably the most complete source of information for statistics in the Dominican Republic is '"La República Dominicana en Cifras", published by ONE (Oficina Nacional de Estadistica) in 1990. This publication has information on planted and harvested areas of primary crops and all productive activities of the country (i.e., industry, mining, fishing, and tourism). A problem incurred was that harvested areas often appear greater than planted areas. This inconsistency indicates either mistakes or methodological aspects that need to be reviewed. A government budget (1991) published by the Secretaría de la Presidencia is also available.

Another important document is a publication from the Departmento de Inventario de la Secretaría de Agricultural (DIRENA) on production costs of the main crops of the Dominican Republic (1990). The document contains budgets per crop for level of

technology and region. Little information on livestock production is available, though efforts to improve that situation are currently underway by PRODELESTE (Programa Lechero del Este, PAO/PNUD). PRODELEST has been conducting a survey over the last two years and has the most reliable statistics on this activity.

Natural Resources

The first attempt to compile a comprehensive inventory of natural resources was completed by the OAS in 1967. This study resulted in a three volume work (including maps). Since that time, various attempts have been made to partially update the information and improve the inventory which is now largely discredited. Most of these studies have been performed within or with the collaboration of various Departments of the Subsecretaria de Recursos Naturales.

The best mapping of natural resources is taking place within the Departmento de Inventario (SURENA/SEA) and the Cartographic Department of the Navy. An aerial photo base for the entire country was completed in 1983-84 (1990 for the city of Santo Domingo).

The USAID-funded MARENA project helped encourage the development of data collection and institutional strengthening through training, providing equipment, and funding exercises such as aerial photography. Natural resource, socioeconomic, and demographic information has been collected for the Nizao, Rio Grande or del Medio, Maquaca, Chacuey, and Guaybin watersheds.

Water Resources

The Departmento de Inventario, with INDRHI and the Dominican Navy, has developed a detailed data base of all watersheds and sub-watersheds. This base was developed using maps based on aerial photography. No ground truthing has yet occurred to verify the photo-interpretations.

Since 1986, GTZ has been assisting INDRHI to collect rainfall statistics and river flow rates. The validity of this data is suspect, and INDRHI itself does not rely upon it. The planning department of INDRHI commissioned a study (Generacion de Caudales en Cuencas de la Republica Dominica, December 1991) to develop a new data collection model to replace the existing one.

Forest, Flora, and Fauna

Other than good descriptions of the parks and reserves, and lists of endangered and protected flora and fauna, the A.I.D. Biological Diversity Assessment (1988) contains little information about the status of biological resources. Since that time, the Departmento de Vida Silvestre has conducted a study of bio-diversity in the Dominican Republic (1991)

that gives detailed information on the names, characteristics, and locations of forest types in the country. Since 1985, the department has also been conducting studies of the flora and fauna of various areas recommended for protection (Lago Enriquillo, 1985; Sierra de Baoruco, 1985; Dunas de Bani, 1985; Loma Quita Espuela, 1988; sierra Neiba, 1990; Loma Remigio and Loma Trocha de Pay, Costa del Este, and Loma Nalga de Maco, 1991; Loma Diego de Ocampo, Playa Chiquita, and Loma La Herradura, 1992)

Coastal Resources

CIBIMA has been conducting coastal research for the past 35 years and is currently trying to analyze and synthesize the information in a way that will be useful to the public. Other planned products of the research is an annotated bibliography, a data base, and maps. Some coastal information has already been mapped by CIBIMA, however the maps still need to be checked for accuracy. Various organizations and university faculty are planning to conduct an analysis of the status of resources reported in the literature but no synthetic efforts has been made tc date.

Fishery

Fishery data is seriously inadequate. The Fishery department of the GODR can only provide estimates of total catch by port for each month over the last two years. Data are collected by field technicians who meet boats at the dock and "estimate the catch." Reporting of data was patchy since most technicians do not have access to telephones.

While studies have not been conducted for the various fisheries (conch, lobster, shrimp), and no estimates are available regarding their condition (over-fished, under-fished), suggestions were made indicating a decline in the total yield. A graph plotting yields had been initiated, but was subsequently stolen and the effort dropped.

INDOTEC's inventory of fishery resources (1980) appears to be well done, but its reliability is suspect since it was based upon data obtained from the fishery department. If the figures for total yields are accurate, they are several time that which is considered sustainable (Hartshorn et al.,1980).

Soil Erosion and Sedimentation

The best data available comes from Juan Ignacio Fadon (AECI), who applied a model to calculate soil erosion in the Sabaneta watershed (La Ordenacion Agrohidrologica de la Cuenca Alimentadora del Embalse de Sabaneta: Applicacion de una Matodologia para la Panificacion de Cuencas, 1990). INDRHI has requested his assistance to apply his model to other areas. The team was not able to access actual measurements of sedimentation, nor other estimates.

Pollution

Interest and data collection on various forms of water pollution is relatively new in the Dominican Republic. INDOTEC has conducted studies for various industrial clients, but the reports are confidential.

The Comision Saneamiento Ecologico has collected a considerable body of data on industrial pollution which was to have been made available to A.I.D. The reports were not obtained however, so their quality could not be ascertained.

Several groups, including the Comision Nacional para el Medio Ambiente, the French and the Germans, have produced reports on pollution on the Isabela and Ozama rivers. The GTZ collected information as part of a proposal to conduct monitoring of pollutants in these and other rivers. The proposal and data was not available at the time of the study.

The team learned of one other comprehensive evaluation of pollution in the Ozama River conducted as part of an engineering degree by three students at the UNPHU (Gonzalez et al, 1991). According to the professor who contacted the team, most of the lab analysis was conducted in the US since the reliability of results from some types of tests from any laboratory in the Dominican Republic is questionable.

Laboratory Capabilities

CIBIMA Laboratory (Un. Autonoma de S.D.) could be upgraded with small investment in laboratory equipment, to conduct studies of water contamination; they were analyzing water for its potential for aquaculture, and making use of a U.V. spectrophotometer to study the chemical structure of natural chemicals with potential pharmaceutical use. The lab's gas-chromatograph (necessary to determine pesticide contamination in low concentrations) was not functioning, and the does not have the equipment necessary (nuclear absorption spectrophotometer) to verify heavymetal contamination. Lab personnel believe that at the Instituto de Estudios Nucleares. A simple test for water toxicity involved the use of an indicator microfauna species, Artemia Salina. The lab had a small generator, and a capable, energetic administrator (V.Alvarez, M. Vasquez, personal communications). INDOTEC - is one of the few laboratories in the country with the guaranteed steady supply of electricity necessary to do accurate coliform counts; they can also test for biological oxygen demand (BOD) and dissolved oxygen (DO), as well as test for nitrates and phosphates. The lab does not have the capability to conduct analyses of organochlorides and other pesticides, or heavy metals. The Sec. de Mineria has a nuclear absorption spectrophotometer (Gomez, personal communication).

APPENDIX 6
List of Contacts

LIST OF CONTACTS

Institution	Name of the Person
GOVERNMENT	
Acuario Nacional	Lic. Enrique E. Pugibet B., Director
Comisión Nacional para el Medio Ambiente	Lic. Antonio Thomén, Director Ejecutivo Lic. Andrés Sallent, Member
- Comisión Nacional de Saneamiento Ecológico	Ing. Tobías Rosario, Director Técnico
Comisión Nacional Técnica Forestal (CONATEF)	Lic. Ivonne García, Sub-Secretaria Técnica Ing. Gustavo Tirado, Secretario Ejecutivo Enrique Sánchez, Técnico Nicolás Montero, Técnico
Corporación del Acueducto y Alcantarillado de Santo Domingo (CAASD)	Ing. Ricardo Canalda, Director
- Unidad Técnica de Operación	Ing. Leonel Marión-Landais, Director
- Laboratorio	Ing. Patria Marte, Encargada
Dirección Nacional de Parques	María Los Angeles D'Ocampo, Assistant to Director
Instituto Cartográfico Militar (Marina de Guerra) - Mapas y Fotos Aéreas	Capitán César A. Batista V., Director Félix M. Gil U., 1er. Teniente, Encargado
Instituto Dominicano de Tecnología Industrial (INDOTEC)	Lic. Josefina Gómez
Instituto Nacional de Agua Potable y Alcantarillado (INAPA)	Ing. José Alberto Infante, Sub-Director
Instituto Nacional de Recursos Hidráulicos (INDRHI)	Ing.C. Augusto Rodríguez Gallart, Director Ejecutivo
- Departamento de Planificación	Ing. José E. Tiburcio, Director
- Distribución de Riego	Ing. Tomas Gonzalez
- Hidrología	Ing. Reynoso, Asesor Ing. Añil

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- Hidrología y Meteorología	Ing. Murillo
- Data Collecting	Ing. Julio Llinás
- Pollution Sampling	Ing. Agustina García
- Cuencas Hidrográficas	Ing. Felipe Vicioso, Director
- Head of the Office for Watershed Management	Ing. Felipe Vicioso
Marina de Guerra	Contralmirante Víctor F. García Ste A., Sub-Jefe de Estado Mayor
	Ing. Luis Troncoso, Sub-Secretary
Secretaría de Estado de Agricultura (SEA)/ Subsecretaría de Recursos Naturales	
- Departamento de Educación Ambiental	Ing. Alfredo Fernández, Director
- Departamento de Tierras y Aguas	Raúl Méndez, Director
- Departamento de Vida Silvestre	Biól. Emilio A. Bautista M., Director
	Biol. Bienvenido Santana, Técnico
- Departamento de Recursos Pesqueros	Marina Tejera, Directora
. División de Pesca	Ing. Pablo Socorro, Encargado
	Enrique Saladín, Asistente
. Difusión Técnica	Gladys Rosario, Encargada
. División de Aguas Interiores	Magaly Peña, Encargada
- Departamento de Inventario	Ing. Agro. José Miguel Martínez G., Director
- Sanidad Vegetal	Ing. Agro. Manuel E. Féliz
- Sub-Secretariat of Natural Resources, Head of the Inventory Deparment	Ing. José Miguel Martínez
UNIVERSITIES	
Universidad Autónoma de Santo Domingo (UASD)	
- Centro de Investigaciones de Biología Marina (CIBIMA)	Venecia Alvarez, Directora
	Idelisa Bonnelly de Calventi, ex-Directora
Universidad Nacional Pedro Henríquez Ureña (UNPHU)	
- Departamento de Recursos Naturales	Dr. Marcos Peña F., Profesor
- Departamento de Química	Lic. Andrés Sallent, Químico
In Santiago:	
Pontificia Universidad Católica Madre y Maestra (PUCAMAIMA)	Mons. Agripino Núñez C., Rector
	Ing. Nelson Gil, Vicerrector Administrativo
	Ing. Rafael E. Yunén, Vicerrector Académico

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PVOs/NGOs

Federación Dominicana de Asociaciones Ecologistas (FEDOMASEC)	Héctor López, Director
Fondo Pro Naturaleza (PRONATURA)	Fernando Durán, Director Ejecutivo
Fundación Ciencia y Arte, Inc.	Dr. José Serulle Ramia, Presidente Dra. Jacqueline Boin, Directora Ejecutiva
Grupo Jaragua, Inc.	Sixto J. Incháustegui, Presidente
- The Nature Conservancy	Ing. Juan Mancebo, Gerente de Proyectas Domingo Marte, Representante para República Dominicana
Asociación para el Desarrollo de San José de Ocoa, Inc.	Padre Luid Quinn, Presidente
- Director of the Fondo de Inversiones en Recursos Naturales (FIRENA)	Ing. Carlos Bonilla
- Proyecto FIRENA	Carlos José Bonilla, Director Sr. Quintanilla
Barceló Industrial (Pro-Foresta)	Jerry W. Dupuy
FLORESTA, Inc.	Ing. Eldon García, Director Ejecutivo Ing. Fernando Campos
Junta de Regantes	Ing. Fernando González
Plan Sierra	Lic. Inmaculada Adames, Directora
Progressio	Fernando Domínguez Aquino, Gerente General
PRODELESTE	Ing. Chimics, Director Internacional Dr. Bolívar Toribio, Director Nacional

Fundación Dominicana de Desarrollo (FDD)	Dr. Eduardo Latorre, Director Ejecutivo
Centro Dominicano de Organizaciones de Interés Social (CEDOIS)	Lic. Carlos Pimentel R., Director Ejecutivo

INTERNATIONAL ORGANIZATIONS

Agencia Española de Cooperación Internacional/ Instituto de Cooperación Iberoamericana	Carlos Cano C., Biólogo Rafael Cámara, Biólogo
Agencia de Cooperación Internacional del Japón (JICA)	Yoshiro Yanai, Encargado de Cooperación Técnica
Banco Interamericano de Desarrollo (BID)	Mario R. Mejía, Especialista Sectorial
Food and Agriculture Organization (FAO)	Serge Michón, Representante
Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) - Servicio de Administración de Proyectos Instituto para el Desarrollo del Suroeste (INDESUR) (Manejo Racional de Bosques Secos)	Dietmut Kiehl Lic. Ludger Cheele, Coordinator
Proyecto Hidrología alemana (INDRHIGTZ)	Geert Soer, Director
International Research and Training Institute for the Advancement of Women (INSTRAW)(UN)	Eleni Stamiris, Sub-Directora
Organization of American States (OAS)	Ing. Cabada, Representante Eugenio Lobo, Encargado de Proyectos
World Bank	Ms. Madeline Devan, D.R. County Officer
World Health Organization (WHO)/ Pan American Health Organization (PAHO)	Ing. Luis Leal

PRIVATE

Junta Agroempresarial de Consultoría y Coinversión (JACC)	Margarita Gil

INDIVIDUALS

Arq. Pedro Borrell (Marine Resources)

Dr. Plinio Cabrera (PhD. Environmental Impact Assessment, Consultant)

Ing. Roberto Castillo T. (Ingeniero Sanitario)

Dr. Julio Santos Cayado (Ingeniero Civil e Hidráulico)

INDUSTRIES

DOLE Dominicana	Enrique Graugnard, Superintendente de Tierras y Diversificación Agrícola Carlos A. Marranzini, Gerente de Tesorería Ing. Antonio Guerrero Báez
Falconbridge Dominicana	José M. Aponte, Director-Relaciones Públicas Angel Espinal (results of water quality analysis)
FRUDOCA	David Ligrize, Superintendente

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APPENDIX 7
Demographic Data

TABLE 1: POPULATION FACT SHEET: DOMINICAN REPUBLIC

POP. COUNT	1920	1950	1960	1970	1980	1990
RURAL	746151	1627464	2124980	2416159	2678956	2964532
URBAN	148514	508408	922090	1593299	2751923	4205313
TOTAL	894665	2135872	3047070	4009458	5430879	7169845
IN PERCENT						
RURAL	83.4	76.2	69.7	60.3	49.3	41.3
URBAN	16.6	23.8	30.3	39.7	50.7	58.7
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
POPULATION DENSITY (INH./KM2)						
	17.9	44.1	62.9	82.8	111.4	148
URBANIZATION						
% URBAN OF TOTAL	16.6	23.8	30.3	39.7	50.7	58.7
SANTO DOMINGO AS % OF URBAN POP	20.8	35.7	40.1	42.3	44.6	53.0

OTHER POPULATION PARAMETERS: RECENT TRENDS AND EXTRAPOLATIONS TO 1995-2000

		TOTAL	RURAL	URBAN
TOTAL FERTILITY RATE	1980-1985	4.21	5.08	3.54
	1985-1990	3.75	4.49	3.28
	1990-1995	3.34	4.08	2.92
	1995-2000	3.00	3.79	2.63
CRUDE DEATH RATE	1980-1985	7.49	8.42	6.62
	1985-1990	6.78	7.42	6.27
	1990-1995	6.20	6.7	5.86
	1995-2000	5.80	6.21	5.54
RATE OF NATURAL POPULATION INCREASE	1980-1985	2.6	2.8	2.4
	1985-1990	2.5	2.6	2.3
	1990-1995	2.2	2.5	2.0
	1995-2000	1.9	2.2	1.7
TOTAL ANNUAL POPULATION GROWTH RATE	1980-1985	2.4	0.5	4.0
	1985-1990	2.2	0.5	3.6
	1990-1995	2.0	0.3	3.0
	1995-2000	1.7	0.5	2.4

SOURCES:
1) REPUBLICA DOMINICANA EN CIFRAS, VOL.IX, 1980; VOL.XVI, 1990
2) CENSO NACIONAL DE POBLACION Y VIVIENDA 1981, VOL.I, 1985 (DISTRICTO NACIONAL)
3) BANCO MUNDIAL, INFORME SOBRE EL DESARROLLO MUNDIAL 1991

BLE 2: RURAL AND URBAN POPULATION ESTIMATES BY PROVINCE, 1970, 1980 AND 1990 (IN '00)

PROVINCE	1970			1980			1990			1980-90 % GROWTH		
	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL
AO												
JAT	1137	267	1404	1240	398	1638	1352	470	1822	9.1	18.0	11.2
ND MONSENOR NOUEL	2309	626	2935	2528	1370	3898	2768	1509	4277	9.5	10.2	9.7
ATA	1409	451	1860	1377	641	2018	1377	920	2297	0.0	43.5	13.8
IAGO	2124	1731	3855	2349	2979	5328	2598	4450	7048	10.6	49.4	32.3
E	1438	566	2004	1368	909	2277	1368	1249	2617	0.0	37.4	14.9
TRINIDAD SANCHEZ	783	188	971	733	263	996	733	518	1251	0.0	97.0	25.6
O	756	135	891	780	161	941	805	297	1102	3.2	84.6	17.1
9 SAMANA	425	108	533	505	140	645	600	130	730	18.8	-7.2	13.2
Z RAMIREZ	937	124	1061	927	271	1198	927	479	1406	0.0	76.8	17.4
N	385	125	510	375	170	545	375	266	641	0.0	56.5	17.6
RISTI	446	244	690	521	310	831	639	317	926	16.8	2.4	11.4
GO RODRIGUEZ	407	86	493	414	147	561	421	194	615	1.7	31.9	9.6
DE	381	387	768	437	508	945	501	613	1114	14.7	20.6	17.9
TE												
	478	564	1042	440	339	779	440	433	873	0.0	27.7	12.1
A	546	564	1110	617	796	1413	697	827	1524	13.0	3.9	7.9
A	185	141	326	154	204	358	154	276	430	0.0	35.3	20.1
	47	76	123	69	85	154	101	87	188	46.8	2.0	22.1
A	690	214	904	806	602	1408	942	1012	1954	16.8	68.2	38.8
AS PINA (ESTRELLETA)	456	79	535	488	130	618	522	204	726	7.0	56.7	17.5
JUAN	1452	453	1905	1552	762	2314	1659	1007	2666	6.9	32.2	15.2
TE												
NACIONAL	1449	6685	8134	2428	12978	15406	4068	20050	24118	67.6	54.5	56.5
A	913	368	1281	1140	550	1690	1423	445	1868	24.9	-19.2	10.5
L AND MONTE PLATA	2550	696	3246	2963	1486	4449	3443	1513	4956	16.2	1.8	11.4
HATO MAYOR	1015	335	1350	994	522	1516	994	759	1753	0.0	45.4	15.6
A	644	237	881	607	352	959	607	505	1112	0.0	43.5	16.0
AMA	187	395	582	156	913	1069	156	1536	1692	0.0	68.2	58.3
O DE MACORIS	599	454	1053	654	823	1477	714	1264	1978	9.2	53.6	33.9
AL	24148	16299	40447	26622	28809	55431	30354	41329	71684	14.0	43.5	29.3

TES:
- DATA FOR 1970 ARE CENSUS COUNTS; DATA FOR 1980 ARE LINEAR ADJUSTMENTS OF 1981 CENSUS COUNTS.
- TOTAL POPULATION FOR 1990 IS ESTIMATED BY USE OF THE COMPONENT METHOD.
- RURAL POPULATION FOR 1990 IS ESTIMATED BY LINEAR EXTRAPOLATION OF 1970-80 RURAL GROWTH
- URBAN POPULATION FOR 1990 IS ESTIMATED ON THE BASIS OF THE 1990 TOTAL AND RURAL POPULATIONS
- CONSTANT RURAL POPULATION IS ASSUMED 1980-1990 WHERE 1970-1980 RURAL GROWTH APPEARED NEGATIVE (PROBABLY DUE DUE TO CENSUS METHODOLOGY CHANGES).
- INCONSISTENCIES BETWEEN THIS TABLE AND OTHER CENSUS-BASED EXTRAPOLATIONS HAVE NOT BEEN CORRECTED

OURCES:
- CENSO NACIONAL DE POBLACION 1970.
- CENSO NACIONAL DE POBLACION Y VIVIENDA 1981, VOL. I (1985), II (1989), III (1990)
- REPUBLICA DOMINICANA EN CIFRAS 1988.

TABLE 3: POPULATION OF TEN LARGEST CITIES AND URBAN PRIMACY INDICES, 1970, 1980 AND 1990

CITY	1970	1980	1990
[illegible]GO	668507	1254566	1938305
[illegible]	155240	267420	399525
[illegible]NA	38281	86726	148389
[illegible]E MACORIS	42680	75300	115661
[illegible]CO DE MACORIS	44271	63030	91205
[illegible]AL	26332	55594	56595
[illegible]A	30466	50435	55579
[illegible]N DE LA MAGUANA	34049	48335	63899
[illegible]A	36501	48167	50046
[illegible]ATA	32080	44142	65506
PRIMACY INDEX 1	81.2	82.4	82.9
PRIMACY INDEX 2	73.9	74.5	74.5

NOTES: - 1980 DATA ARE LINEAR EXTRAPOLATIONS BASED ON THE 1981 CENSUS.
- 1990 DATA ARE EXTRAPOLATED FROM 1981 CENSUS DATA BY ADJUSTING FOR PROVINCIAL URBAN GROWTH RATES 1980-90.
- PRIMACY INDEX 1 REPRESENTS THE FIRST CITY'S PERCENTAGE OF THE TOTAL POPULATION OF THE TWO LARGEST CITIES.
- PRIMACY INDEX 2 REPRESENTS THE FIRST CITY'S PERCENTAGE OF THE TOTAL POPULATION OF THE FOUR LARGEST CITIES.

SOURCES: - 1970 AND 1981 POPULATION CENSUS AND REPUBLICA DOMINICANA EN CIFRAS 1988.

TABLE 4: COMPONENTS OF URBAN GROWTH, 1970 TO 1990

	1950-60	1960-70	1970-80	1980-90
PERCENT OF NATIONAL URBAN GROWTH DUE TO MIGRATION ALONE	33.3	43.0	40.8	26.2
PERCENT OF NATIONAL URBAN GROWTH DUE TO NATURAL POPULATION INCREASE ALONE	30.3	39.7	51.5	58.7
PERCENT NOT EXPLAINED BY THIS MODEL	36.4	17.3	7.7	15.1

NOTE: - ESTIMATION BASED ON THE KINGSLEY DAVIS (1965) MODEL.

SOURCES: - 1950 TO 1981 CENSUS AND ESTIMATES GIVEN IN PREVIOUS TABLES.

ABLE 5: POPULATION BY PROVINCE AND MIGRANT STATUS ACCORDING TO THE 1981 CENSUS

PROVINCE	TOTAL RESIDENTS	RESIDENT NATIVES	RESIDENT IN-MIGRANTS	OUT-MIGRANTS	NET MIGRATION	RESIDENT NATIVES AS % OF 1981 RESIDENT POPULATION	OUT-MIGRATION AS % OF 1981 RESIDENT POPULATION	IN-MIGRATION AS % OF 1981 RESIDENT POPULATION	DIRECTION OF NET MIGRATION
AO									
ATILLAT	164017	149615	14402	69757	-55355	91.2	42.5	33.7	NEGATIVE
AND MONS. NOUEL	385043	344046	40997	96654	-55657	89.4	25.1	14.5	NEGATIVE
LATA	206757	192214	14543	88992	-74449	93.0	43.0	36.0	NEGATIVE
	550372	466244	84128	96318	-12190	84.7	17.5	2.2	NEGATIVE
E	235544	204144	31400	85789	-54389	86.7	36.4	23.1	NEGATIVE
TRINIDAD SANCHEZ	112629	91937	20692	36489	-15797	81.6	32.4	14.0	NEGATIVE
O	99191	89235	9956	40971	-31015	90.0	41.3	31.3	NEGATIVE
MA	65699	58798	6901	20781	-13880	89.5	31.6	21.1	NEGATIVE
EZ	126567	103512	23055	37517	-14462	81.8	29.6	11.4	NEGATIVE
	57709	45475	12234	20579	-8345	78.8	35.7	14.5	NEGATIVE
I	83407	68331	15076	26269	-11193	81.9	31.5	13.4	NEGATIVE
RODRIGUEZ	55411	50345	5066	25340	-20274	90.9	45.7	36.6	NEGATIVE
DE	100319	75165	25154	25920	-766	74.9	25.8	0.8	NEGATIVE
E									
	78636	73036	5600	21444	-15844	92.9	27.3	20.1	NEGATIVE
A	137160	127386	9774	54279	-44505	92.9	39.6	32.4	NEGATIVE
A	38768	34309	4459	13314	-8855	88.5	34.3	22.8	NEGATIVE
	17006	10354	6652	2553	4099	60.9	15.0	24.1	POSITIVE
A	142770	128600	14170	25905	-11735	90.1	18.1	8.2	NEGATIVE
AS PINA (ESTRELLETA)	65384	61729	3655	18711	-15056	94.4	28.6	23.0	NEGATIVE
JUAN	239957	230589	9368	68044	-58676	96.1	28.4	24.5	NEGATIVE
TE									
) NACIONAL	1550739	832103	718636	57654	650982	53.7	4.4	42.0	POSITIVE
A	168123	158868	9255	53303	-44048	94.5	31.7	26.2	NEGATIVE
OBAL AND M.PLATA	446132	363582	82550	82422	128	81.5	18.5	0.0	POSITIVE
AND HATO MAYOR	157866	131977	25889	57202	-31313	83.6	36.2	19.8	NEGATIVE
ACIA	100112	75300	24812	32476	-7664	75.2	32.4	7.7	NEGATIVE
	109769	65882	43887	15163	28724	60.0	13.8	26.2	POSITIVE
DE MACORIS	152890	110725	42165	32273	9892	72.4	21.1	6.5	POSITIVE
TOTAL	5647977	4343501	1304476	1216119	88357	76.9	21.5		
TOTAL WITHOUT DISTR. NAC.	4097238	3511398	585840	1148465	-562625	85.7			

NOTES: - ALL PUBLISHED CENSUS 1981 FIGURES CONCERNING MIGRATION ARE BASED ON SAMPLES RATHER THAN THE FULL CENSUS.
- MIGRATION REFERS TO LIFETIME MIGRATION AS DETERMINED BY COMPARING PLACES OF BIRTH AND RESIDENCE.
- INTERNATIONAL MIGRATION IS ONE OF THE REASONS WHY THE TOTALS FOR IN-MIGRANTS AND OUT-MIGRANTS ARE NOT IDENTICAL.

OURCES: CALCULATIONS BASED ON REPUBLICA DOMINICANA EN CIFRAS 1990, VOL. XVI, P.95.