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WATER, DEVELOPMENT AND ENVIRONMENT IN LATIN AMERICA

This report comprises a part of a CEPAL/UNEP project on the relationships between water resources, development and environment in Latin America. Its release, as a restricted version is for the purpose of review and comment to provide the bases for revision prior to general distribution.

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INTRODUCTION

This report is addressed to those in government who are concerned with the planning and management of water use, and to professionals engaged in related research, education and in-service training activities. It presents the principal findings of a Latin American regional enquiry designed to contribute to the improvement of planning and management of water resources with specific recognition of the need for reconciliation between requirements for accelerated economic development and environmental protection. The project was commissioned by the United Nations Environment Programme (UNEP) in February 1975, with co-sponsorship of the Economic Commission for Latin America (CEPAL), and was carried out over the period September 1975 through December 1976 by CEPAL in collaboration with a number of national institutions and United Nations specialized agencies.

1. Genesis of the project

The study stems from a growing conviction among Governments and development specialists that greater attention should be paid to environmental quality in the pursuit of economic and social development objectives; that this requires, among other things, innovative approaches to natural resource management; and that such approaches are well illustrated by questions associated with water use. The 1972 Stockholm Conference on the Human Environment focussed attention on what is now a widely recognized need to broaden the evaluation of development policies and projects to incorporate the behaviour of natural systems and certain socio-economic consequences which traditionally have been overlooked. The activities of UNEP over the past four years have prompted new interest in the relationship between the use of renewable resources and management of environmental quality and long-run maintenance of the services provided by man's life support system, and CEPAL has shared this heightened interest in the environmental dimension of development.

/While the

While the broad concern has been to generate among planners, managers and policy-makers in the natural resource field a greater awareness of the need to give more attention to environmental aspects, it was decided to select a single resource as the topic of a more focussed evaluation. One can hardly claim any resource is more important than other. However, mismanagement of water may be expected to have more far-reaching and critical consequences for society than many other resources. It appeared logical to start with water since it is probably better studied and is more universally applicable in development than other resources through a wide range of public policy and management measures. It promised more immediate impact because of public interest in flooding, urban water supply, contamination, hydroelectric energy and food production from irrigation. In addition, a study of water provides a sound basis for expanding and deepening research on environmental management.

The underlying questions of concern to both UNEP and CEPAL in the present study are: (a) what sort of modifications in analytical approaches and the decision-making structures may be feasible which would enable fuller consideration of environmental quality in the quest for accelerated economic growth through a more intensive use of water; (b) what would be the staffing and training implications of such modifications; and (c) what constructive directions could international assistance agencies pursue in this field in order to help to build national capacity to identify issues, and design and execute water development policies which take due account of quality? Since environmental aspects of water management in Latin America had not been critically evaluated, it was hoped that the results of this study would be of interest and value to government agencies which must confront these questions in their on-going management, planning and project design in relation to water use, and also to international development institutions.

/2. Objectives

2. Objectives

The prime purpose of the study was to examine past experience, current evidence and new ideas in Latin America as the basis for developing both improved information and practical guidelines useful to those engaged in planning, implementing and evaluating programmes for the use and development of water resources. Although the study was not expected to yield answers to environmental questions arising in water management, it was intended to identify avenues whereby planners and decision-makers may evaluate any given situation in a broader perspective, to identify a wider range of alternative actions, and to evaluate more systematically the short-run and long-run environmental implications of various options.

Specifically, the objectives of the study were:

(a) to analyse the main environmental effects, both positive and negative, of the management of water and associated resources (soils, woods, etc.) in the region, on the basis of available information and the study of selected cases;

(b) to provide information which will assist in the introduction of new directions in planning for the exploitation of the above resources;

(c) to present the results of the above work at a seminar and to disseminate them in a report.

3. Study organization

Four main steps were taken in the research. First, discussion were held with specialists in national and international agencies to gather information and ideas on applicable methodology and key questions which would guide the relative emphasis in determining the scope of the study, as well as suggestions on possible cases to be examined. Second, working papers were prepared on the state of knowledge, in the field of environmental quality analysis and its relation to economic development and to the more restricted area of water resource management. Third, an extensive effort was made to assemble data on water availability, past, present and projected uses

/of water

of water and administration of water resources in Latin America. Two special studies of water quality and legal and institutional aspects of water use were undertaken by the Centro Panamericano de Ingeniería Sanitaria y Ciencias Ambientales (CEPIS) and the Argentine Instituto Nacional de Economía y Legislación de Aguas (INELA) respectively. At the outset it was planned that the first three steps would enable selection of a set of cases for detailed examination to illustrate the more important environmental issues in water management in the region. The preparation of data relating uses to specific water bodies proved to be a much larger task than anticipated. Accordingly it became necessary to initiate the fourth and most important step, the case studies, on the basis of the first two steps alone. Finally, the evidence and ideas assembled in the previous steps were reviewed and evaluated in the preparation of the present report.

The case studies constitute the main empirical basis for the analysis contained in the report, though additional evidence from other projects and sources has also been used. Originally it was planned to include four cases in the study. However, it became apparent that a wider range of situations should be examined if the study were to capture the more important resource and institutional settings existing in the region. It was decided that execution of these studies should be handled by national consultants, in a range of disciplines, allowing considerable margin to each in the specification of the system examined and in the evaluation of environmental questions. It would have been impossible to impose a single analytical formula on such a diversity of situations or to obtain standardized quantitative data for comparative purposes.1/

The Latin America and Caribbean region covers an area of 20 million km2 extending 10,000 km between latitudes 55° South to 30° North, and comprises 38 countries and territories with a combined

1/ The consultants submitted independent reports and are in no way responsible for the interpretation of the case experiences reflected in this document.

/population in

population in the order of 325 million (1975). It is therefore evident that water management in the region is characterized by a wide diversity of natural resource, economic, cultural and institutional situations. A study of published information and an analysis of a limited number of cases cannot pretend to offer a formula for all scenarios. Nevertheless, it is believed a few general principles can be assessed which may be useful in suggesting new policy directions, and which may offer a point of departure for cumulative evaluation aimed at progressively improving the guidelines for water management decisions.

4. Scope and method

The enquiry is concerned with improving water management practices in Latin America through a fuller consideration of environmental questions. This calls for an exploration of how water resources have been developed and used in the past, and of the management issues which arise from this experience. Such an exploration provides a basis for identifying the nature of possible improvements in planning and management, and how such improvements might be incorporated.

The water management environmental quality relationship centres on two interrelated questions: (a) the impact of management of the water system on the environment; and (b) the impact of management decisions in the environment which either directly involves water services, or indirectly affect the quality or quantity of water in the system.2/ The definition of the water system and the environment will vary according to the role of the particular decision-maker. In formulating the scope of the present study, the limits were set by the needs of managers and institutions closely concerned with these two aspects.

2/ It will be evident that, depending on how a particular water system is defined, management decisions may have an impact on water resources outside the system.

/The first

The first category of decision-makers, and principal clients for this report, are those responsible for planning and management decisions on design, construction and operation of works for the control and use of water, such as: diversions for urban, rural, industrial, mining or agricultural use, flood-control dams or dykes, ground-water extraction, drainage, navigation channels and dams and associated hydroelectric and irrigation works. The environmental consequences of management decisions related to such works are of major concern in the study. Here the environment may be interpreted in its broadest sense. Thus, manifestations of environmental degradation may range from reduced capacity of other components of the natural ecosystem (e.g. fish, soils) to yield goods and services demanded by man, to social issues such as income distribution or cultural questions like the extinction of endangered species.

The decisions and decision-makers in the second category, i.e. those outside the water system who affect the functioning of the system, are considerably more difficult to define. The point of departure taken for establishing the important management decisions of this group is evidence of environmental damage in the water system. This may be divided into two classes: (a) changes in the chemical, biological or physical properties of water due to discharges from the urban, industrial, mining and agricultural sectors; and (b) changes in flow régime and sediments due to management of agriculture, forestry and construction (e.g. roads, urban infrastructure) in the catchment area. In the case of water quality the issue of control over discharges into water bodies is the concern of agencies concerned with downstream uses of water. On the question of sediments control over use of the catchment area may be assigned to agricultural (and forestry) ministries and regional or river-basin authorities. Decision-makers in agencies concerned with both aspects are also considered clients for the study.

It is relatively straightforward to trace the cause-and-effect relationships, providing one is prepared to accept that the cause is the physical intervention in the water system for development purposes,

/or indirect

or indirect effects as outlined above. However, it may be argued that one cannot leave the causal relationships between use of water (or related resources) and manifestation of environmental change at this level. The implication here is that the environmental manager must move back one step in the decision-making hierarchy and question why the decision to develop a specific water system was made in the first place. He would need to examine the structural roots of environmental degradation such as poverty, and patterns of income distribution, production and consumption which influence the choice of technology and spatial distribution of population and economic activity. However, policies for fundamental changes in the development style, required to rectify perceived environmental damage (and its attendant harmful economic and social consequences) in the water system, are considered beyond the scope of this enquiry. While national and regional planners are assumed to be among the audience for the report, their decisions clearly depend on considerations of a higher order than those analysed here.

Practical measures for introducing new directions which incorporate environmental dimensions in the planning and management of water resources in the region must be based on empirical evaluation of experience. Accordingly, the key element of the study is a series of case studies dealing with the management of intensified use of water systems. The cases were selected in the first instance on the ground that they have already been studied and reflect the thinking of regional research and water management institutions concerned with environmental dimensions. A second criterion for selection was a balanced representation of the two broad classes of environmental concern: water quality due to waste discharge from large urban-industrial complexes, and changes in natural ecosystems and socio-economic systems as a result of water diversion and regulation structures.

The cases were chosen as a purposive sample - a representative sample from which statistical inferences might be drawn would obviously be impossible. Their principal characteristics are summarized in table 1, and locations are shown in map 1. The interrelationship between the cases analysing the disparate experience within a general river-basin framework is illustrated in figure 1. The common threads are the technical considerations in assessing the need to modify approaches for corrective or preventive action for environmental protection, and institutional capability to identify and respond to environmental degradation.

5. Some underlying concepts

There can be no doubt of the accelerating pressure that will be placed on water resources in Latin America as a result of development, nor that this increase in intensity of use will bring environmental consequences. Between 1975 and 2000 the population of the region will almost double.3/ Projections of growth in gross output are in the range of 5 to 7 per cent annually and in per capita output 2.5 to 3.5 per cent, which implies a four-fold increase in production over the 25 year period.4/

Given the fluid state of knowledge and debate on the relationship between development and environment, and environmental impact assessment, it is important to outline a number of concepts which qualify the approach taken in the present enquiry. A further discussion of various approaches to environmental impact assessment (as applied to water resources) is given in annex C.

3/ "Boletín Demográfico", año IX, Nº 18, CELADE, Santiago, July 1976, p. 11.

4/ See "The Future of the World Economy", (ST/ESA/44), United Nations, New York, 1976.

/Map 1

Map i

LATIN AMERICA AND THE CARIBBEAN

LOCATION OF WATER MANAGEMENT CASES

Note : The fact that this map shows specific boundaries does not mean that they are sanctioned or accepted by the United Nations

Table 1

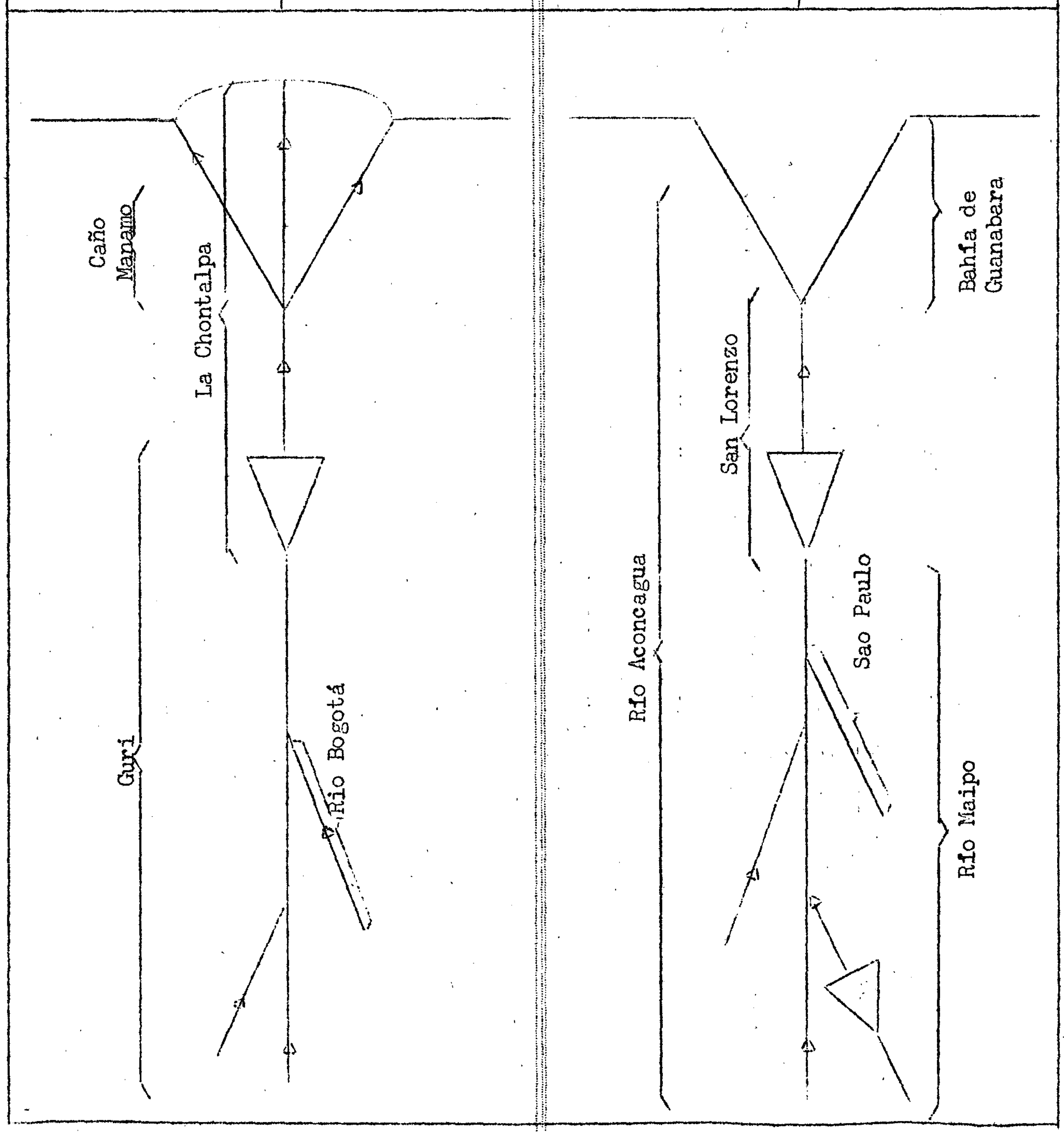
CHARACTERISTICS OF WATER MANAGEMENT CASES

	ms dominated by 'mplexes		Water systems dominated by regulation structures				
	Río 'aipo 'le)	Río Paulo (Brazil)	La Chontalpa (Mexico)	San Lorenzo (Peru)	Guri (Venezuela)	Río Aconcagua (Chile)	Caño Mánamo (Venezuela)
		x	x	x	x	x	x
		x					
				x		x	
			x		x		x
		x					
						x	
				x			
		x	x		x		x
		x				x	
				x		x	
		x	x		x		
			x				x
		x					
					x		
		x				x	
			x	x		x	x

Figure 1

CASES AND RIVER BASIN SYSTEMS EXAMINED

RIVER BASIN SYSTEM			
DELTAIC		ESTUARINE	
DOMINANT ELEMENT IN SYSTEM		DOMINANT ELEMENT IN SYSTEM	
REGULATION STRUCTURES (Cases)	URBAN USE (Cases)	REGULATION STRUCTURE (Cases)	URBAN USE (Cases)



/The field

The field of environmental quality management is clearly dynamic and there remains ample scope for the interpretation of terms. It would be difficult to sustain that there is an "accepted" approach; there are still contradictions, controversies and unresolved issues. There is a tendency to interchange the use of "ecological", "natural resource", "ecosystem" or "environmental" in qualifying the term "management". It is not always clear that the purposes of environmental management are anthropocentric. There is uncertainty about the relative weight that should be assigned to the welfare of the current generation vis-à-vis future generations, and about how far thinking should be oriented towards a planning frame of hundreds of years as opposed to the typical 25/40-year horizons of traditional project analysis. Another issue is whether anything can be done to improve the quality of the environment through a marginal adaptation of existing institutions and decision processes, or whether a thoroughgoing revision of national and international institutions is a necessary precondition.5/

Here the environmental quality considerations relevant to water management are taken to include socio-economic and institutional elements as well as physical and biological characteristics of water and related natural resources. It is taken for granted that management is anthropocentric and that inherent in the concept of environmental quality is a concern for the long-run capacity of natural systems to provide goods and services for the present as well as future generations. The analysis adopted here is directed towards improving the planning and management of water resources by existing institutions in the region; it is focussed on modifications and adjustments which could be made in the short-run rather than on major structural reorganization.

5/ See "Declaración de Cocoyoc", Simposio sobre Modelos de Utilización de Recursos, Medio Ambiente y Estrategias de Desarrollo, organizado por PNUMA y UNCTAD, Cocoyoc, México, 8 a 12 de octubre de 1974 (mimeo), pp. 3-6; and Ignacy Sachs "Ambiente y Estilos de Desarrollo", Comercio Exterior, Vol. XXIV, Nº 4, abril de 1974, pp. 360-375.

In the final analysis, environmental management may be considered global in scope. For practical management purposes, it is necessary to abstract from reality if workable guidelines are to be provided for introducing environmental factors into the decision-making structure. Abstraction from complex systems must be somewhat arbitrary and reflect the values of those who do the abstracting. In any study of environmental issues the methodology, choice of objectives, assumptions and definition of the bounds of the system addressed immediately expose the subjective judgements of the analyst.

The approach adopted in this study reflects a widely-held view of the importance of broadening the range of alternative courses of action considered in water planning and management through increasingly explicit provision in feasibility studies and management plans for avoiding or ameliorating undesirable environmental effects.

Management questions connected with the environment only arise where there is existing or foreseeable competition for water services, and environmental degradation only becomes an issue when it appears that the technical and institutional means for taking corrective or preventive action may become available.

In practice, the management of water systems will be qualified by social, cultural and economic circumstances in each particular situation. The differences are likely to lie in the importance given to environmental quality among the objectives towards which development might be directed. Positive effects are taken for granted, since they constitute the sole justification for development intervention. Concern is then with the range of possible harmful effects. The critical relationship in environmental management is between the intensity of water use and the capacity of the environment to sustain such use.

The question addressed in environmental management is what can and should be done to reduce environmental degradation. Environmental costs due to extraction or waste discharge are not anomalies in the economic system but rather are inherent in the production and

/consumption processes.

consumption processes.6/ The intensity of the effects on the environment will vary with the level of development and productivity and population growth. The choice is not between degradation and no degradation; rather, the objective is to find either the level of degradation or the level of resources devoted to environmental protection which is acceptable and consistent with the allocation of society's scarce resources to alternative activities (alternative to environmental protection) which also yield social utility.

The environmental manager's attention is directed to stress imposed on the natural system through population concentration and economic activity generated in the development process and which may: (a) extract excess biological productivity from the ecosystem; (b) over-load the system with waste or artificial stimulants to biological productivity; and (c) disrupt biological processes through the intrusion of wholly foreign substances.7/

Within this context the water manager is concerned with intensified water use as both a cause and a consequence of development. Environmental dimensions enter via the two interconnected aspects discussed above (impact of changes in water systems on the environment and impact of disturbances in the environment on water systems). It follows that intervention in water systems have consequences for human welfare in social and cultural, as well as economic, terms which cannot be ignored by the resource manager. Interdisciplinary teams may assist him in the evaluation and design of alternatives, but the choice between economically and ecologically efficient

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6/ See: Allen V. Kneese and Ralph C. d'Arge "Pigovian External Costs and the Response of Society", in The Analysis and Evaluation of Public Expenditures: The PPB System. A compendium of papers submitted to the Subcommittee on Economy in Government of the Joint Economic Committee, 91 Cong. I Session, 1969, pp. 87-115.

7/ Barry Commoner, "The Environmental Costs of Economic Growth", in Energy, Economic Growth and the Environment, S.H. Schurr (Ed.), John Hopkins Press, Baltimore, 1972, p. 34.

/management options

management options which result in different distributions of benefits and costs between groups in society and between generations, is governed by moral and ethical considerations.

6. Structure of the report

This introduction has explained the background of the enquiry which underlies the report - its origins, objectives, scope and methods. In chapter I recent and projected use of water is compared with availabilities in order to yield a qualitative overview of where and what environmental issues, stemming from intensified water use, may be expected to arise in the region. The current institutional and legal framework within which water is administered in the region is also reviewed. The chapter is entirely descriptive and makes no attempt at a diagnosis of the causes and consequences of environmental problems which may be attributed to some aspect of water resource administration and use; its principal purpose is to identify areas of potential stress on water systems in order to place the case studies in a broader regional perspective.

The bulk of the analysis is contained in chapters II and III. Chapter II is devoted to examination of the spectrum of critical environmental issues in management water systems which arise from intensification of use through flow diversion and regulation. In chapter III a similar analysis is made of the issues in systems dominated by large urban complexes. Evidence for this analysis is drawn from the material on 19 cities in Latin America with a population of over one million, and from the case studies of Río de Janeiro, Bogotá, Sao Paulo and Santiago.

The general conclusions and recommendations which emerge from the juxtaposition of the specific analysis in chapters II and III and the overview of the Latin American situation are drawn together in chapter IV. Although no attempt is made to identify environmental quality issues as problems, and much less to propose solutions, these issues are discussed in the context of their proper relation to the

/information, analysis,

information, analysis, professional capabilities, and institutional modifications which would enable environmental dimensions to be more effectively incorporated into water management decisions.

/Chapter I

Chapter I

PATTERNS AND TRENDS - THE RELATIONS BETWEEN WATER, DEVELOPMENT AND ENVIRONMENT IN LATIN AMERICA

In Latin America as a whole, the demands placed by human activities on the water resource have been expanding at a very rapid rate in recent years. Important factors in this growth have been the increase in population, at 2.8 per cent per year, and the expansion of production, results at almost 7 per cent per year. This expansion in demand has been accompanied by an equal, if not more significant, change in the structure of the demand for water and in the water-using technology. Unfortunately, the nature of the change cannot be measured directly but some appreciation can be gained by the consideration of two continuing specific economic and social developments. The first is changes in the structure of the economies of countries in Latin America, and the second, shifts in the spatial distribution of population and productive activity.

The most important change in economic structure from the viewpoint of water use has been the increasing role played by manufacturing industry in most economies of the region. Since 1960, in Latin America as a whole, while total production more than doubled the contribution of the manufacturing sector has risen from 21.7 per cent of the gross national product to 25.9 per cent in 1973. At the same time as the importance of manufacturing has increased, the structure of the sector has changed. The value added by the manufacture of intermediate and capital goods had become equal to that of food and other non-durable consumer goods in industries by 1971.8/

The expansion and structural change in the industrial sector has paralleled a significant shift in the distribution of population from the countryside to the city. Depending on the definition taken, it

8/ United Nations, CEPAL, La industrialización latinoamericana en los años setenta, Cuadernos de la CEPAL, Santiago, 1975.

can be claimed that Latin America is now at least as urbanized a continent as a rural one: by 1970, over 40 per cent of the population lived in urban centres with more than 20,000 inhabitants.9/ The nature of the change in population distribution has not been the same in every country and in many, even without change in the distribution of population, the growth of population alone has led to change in the relationship between man and his environment. In many parts of the region population pressure has increased in rural areas, as densities rose by more than 50 per cent between 1950 and 1970. This is particularly true in the poorer, less developed countries of Latin America and, within those countries, the regions of least development.

The effect of these multiple changes in the magnitude, spatial distribution and structure of both economic activity and population has been felt on the water resources through a change in the magnitude of man's interference with the hydrologic régime and the aquatic ecosystem. The most important changes have been in the impact of human activities on water quality through the expanding use of waterborne waste disposal systems for both domestic and industrial wastes, the regulation of stream flow, and the extension of urban and agricultural areas.

Two-thirds of the storage capacity in reservoirs has been built since 1960.

The creation of artificial lakes and the consequent changes in stream flow patterns have environmental consequences which at times may be more far-reaching than the transitory impact of pollutants. Stream régime is not, however, only affected by regulation; irrigation and drainage have their impact, as do changes in land use. The expansion of human activity tends to bring more land area into urban uses, expand arable and pasture lands at the expense of natural grasslands and forests and, on the whole, increase the rapidity of run-off. More rapid run-off tends to increase extremes in stream flow, raise sediment lands and, in general, offset the benefits sought by means of greater regulation.

9/ The proportions were 25.2 per cent in 1950, 32.74 per cent in 1960 and 41.2 per cent in 1970. CELADE, Boletín Demográfico, especial Nº 1, April 1976.

/The extent

The extent and significance of these changes, although much commented upon, have not been adequately measured, catalogued or analyzed. This chapter sets out to present such an analysis, although at a relatively preliminary level. It is hoped thereby not only to place the detailed studies of particular individual cases in context so that their importance as samples of the diversity of the situation in the region can be appreciated, but also to provide a general outline of the structure and nature of the environmental aspects of water resource management in contemporary Latin America.

This chapter covers three main topics: the nature of water systems in the region; the changing relationship between water use and the environment, with particular reference to the effect on human health; and a review of the contemporary nature of water management systems in Latin America.10/

1. Characteristics of water supply

Latin America is a humid region, in spite of the fact that the Atacama Desert is the driest in the world. Not surprisingly, therefore, until very recently water has been regarded as an abundant resource, perhaps to an even greater extent than in the rest of the world. In Latin America and the Caribbean the average precipitation, 1,500 mm, is 60 per cent above the world average, and the average annual run-off 370.127 cubic metres a second, is 30 per cent of the world total.

(a) Climate

The climate of Latin America is influenced by three fundamental characteristics: the very large range of latitude over which the region extends, 30°N to 50°S, although over half the area is within the tropics; the barrier to air mass movement of the long and high Andean mountain ranges for nearly all the length of South America; and in coastal regions, the offshore ocean currents, both warm and cold. The importance of the latter is increased by the peripheral location of the majority of the region's population.

10/ The information on which the chapter draws is presented in Annex B, The Water Resource and its Use in Latin America, A Regional Survey.

Annual temperatures decrease and the seasonal range increases towards the south, but the Pacific coast, south of the equator, is always cooler at the same latitude than the Atlantic coast. A further characteristic of the west coast, which strongly influences the climatic régime, is the rapid changes in altitude and exposure due to the cordillera. In general, tropical Latin America is frost-free but the Andean cordillera permits the juxtaposition of extremes of tropical rainforest and permanent snow, as in the Sierra Nevada de Santa Marta, near Barranquilla, Colombia. It is only in the highest areas of the Andes however, and in the exposed extreme south of South America, in Argentina and Chile, that temperature is a restriction on agriculture.

Rainfall is the most important climatic element. There are enormous differences in rainfall in the region as a whole (see map 2 and table 2) ranging from a long-term average of 1 mm in Arica, Chile, to an average of almost 8,000 mm in Quibdó, Colombia. Fortunately, the areas of extreme low rainfall are of relatively limited extension. Over 90 per cent of the population of Latin America live in areas which receive an average rainfall in excess of 500 mm. The dependability of precipitation tends to be inversely related to the amount (map 2). However, the impact on man of the increasing instability with scarcity is reduced by the low population density of these areas although, perhaps surprisingly, Mexico, Monterrey City, Lima and Santiago are in regions of such extremes (table 2). A similar annual variation only occurs in coastal Peru and Chile in areas with less than 500 mm of rainfall.

(b) Water resources systems of Latin America

It is perhaps fortunate, from the viewpoint of water management, and particularly water quality, that the weight of the distribution of the population in Latin America is peripheral (map 3). Even where there are significant concentrations of human activities in the interior, few are far from the coast. The large river systems are, in general, very little developed and although an increasing number of water bodies, especially rivers and a few of the large lakes, are being devoted solely to the disposal of human and industrial effluents, demand on a regional scale remains minor.

/Table 2

Table 2

METROPOLITAN AREAS AND RAINFALL IN LATIN AMERICA

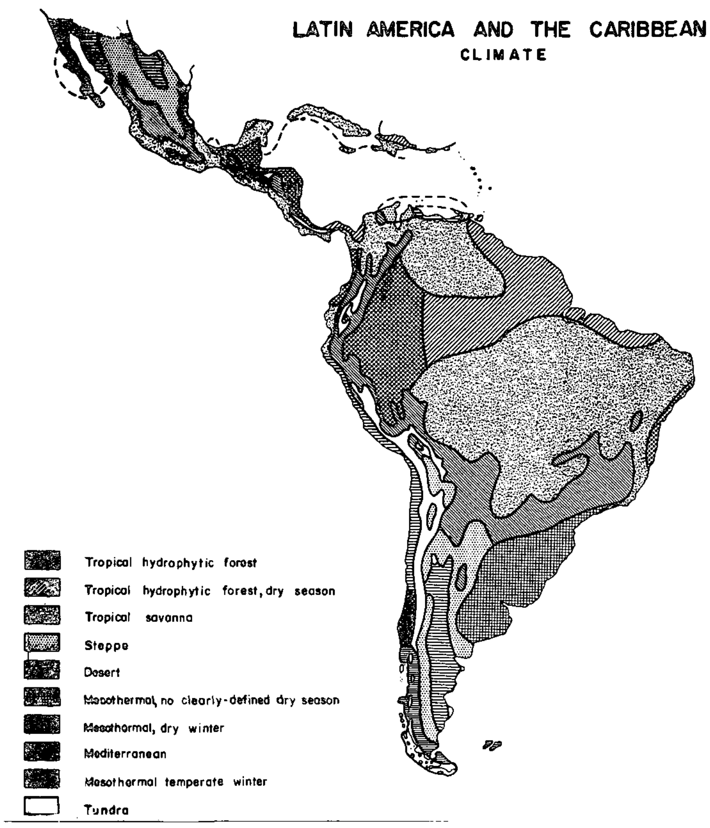
Metropolitan area	Estimated population 1975 (000's)a/	Rainfall	
		Variation %	Annual average b/ (mm)
Lima-Callao	3 901	40	29
Santiago	3 063	30-40	322
Mexico City	10 942	15-20	589
Monterrey	1 570	30-40	714
Caracas	2 673	20-25	820
Guadalajara	1 970	20-25	953
Bogotá	3 416	10-15	986
Buenos Aires	9 332	10-15	992
Montevideo	1 559	10-15	1 050
Cali	1 241	10	1 154
La Habana	2 269	10	1 157
São Paulo	9 965	10	1 270
Porto Alegre	1 809	15-20	1 291
Fortaleza	1 135	30-40	1 401
Medellín	1 427	10	1 410
Recife	1 967	30-40	1 437
Belo Horizonte	2 001	10	1 562
Río de Janeiro	8 325	10-15	1 590
Salvador (Bahia)	1 306	25-30	1 892

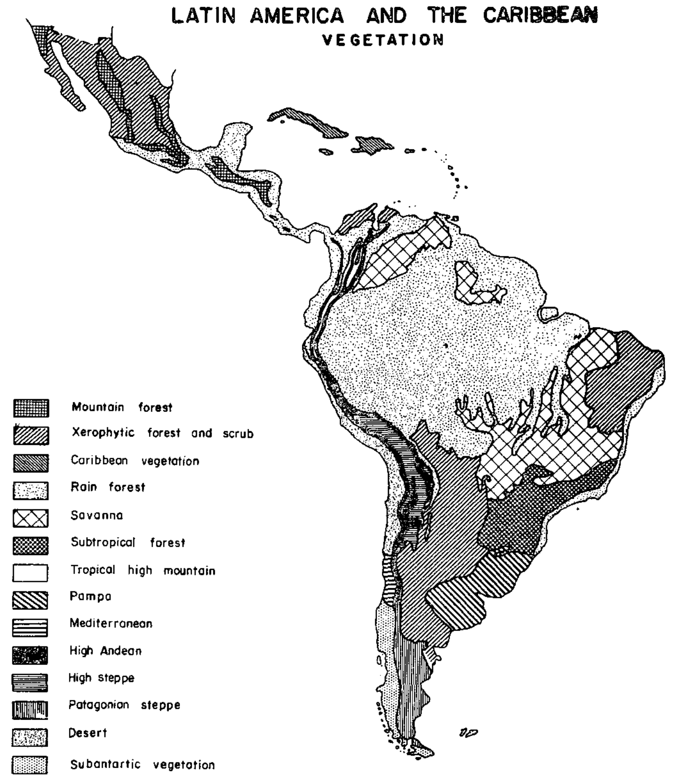
Source: a/ United Nations, Population Division, Trends and Prospects in the populations of agglomerations, 1950-2000, as assessed in 1973-1975, New York.

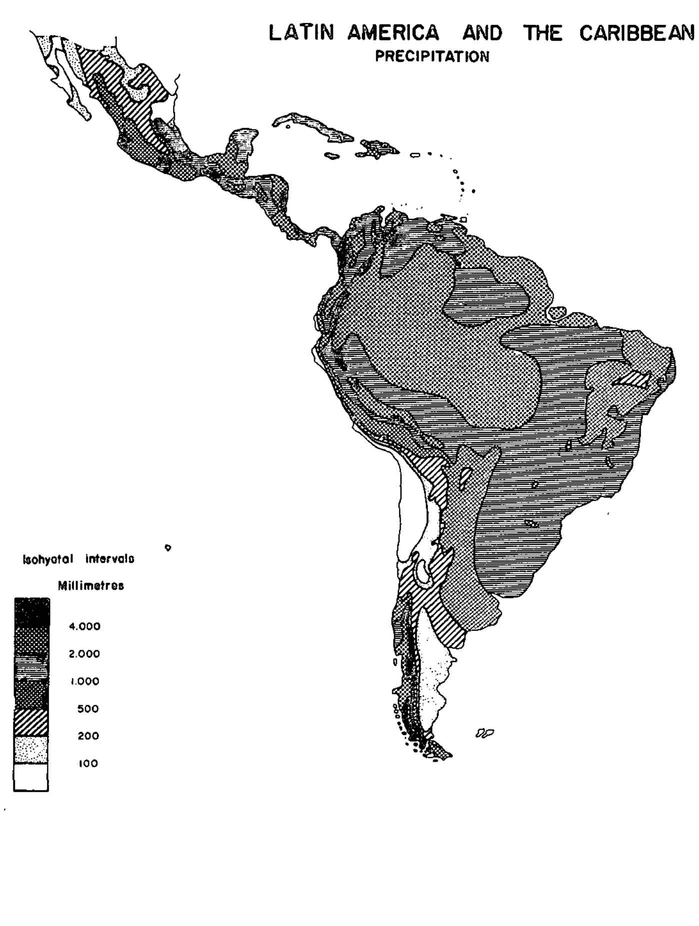
b/ Alberto R. Martínez, La Meteorología e Hidrología para el Desarrollo de los Recursos Hidráulicos a América Latina, CEPAL/TA/24, December 1973.

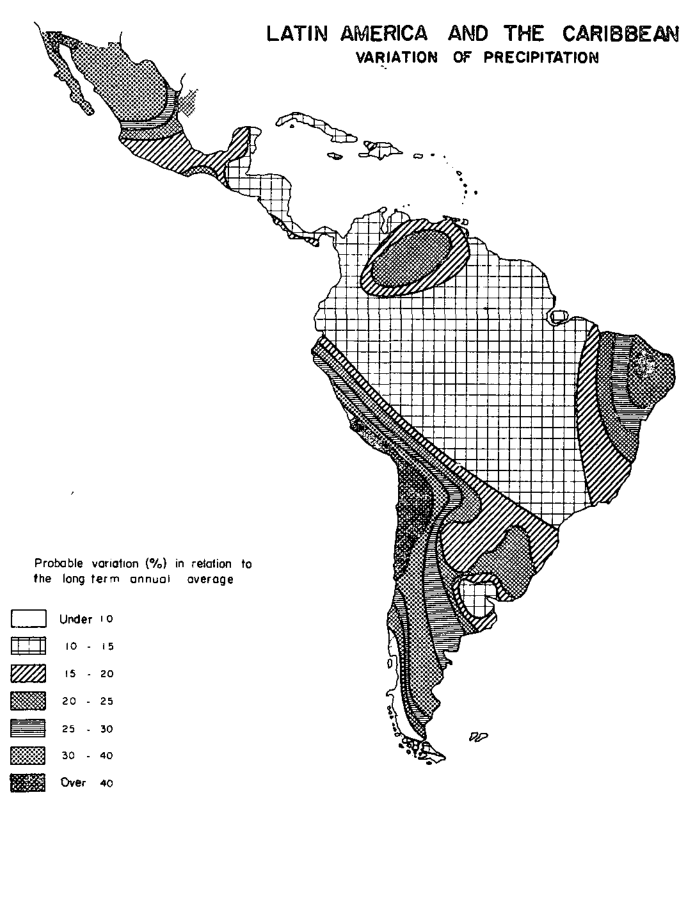
/Map 2

Map 2


LATIN AMERICA AND THE CARIBBEAN
CLIMATE
Tropical hydrophytic forest
Tropical hydrophytic forest, dry season
Tropical savanna
Steppe
Desert
Mesothermal, no clearly-defined dry season
Mesothermal, dry winter
Mediterranean
Mesothermal temperate winter
Tundra


LATIN AMERICA AND THE CARIBBEAN
VEGETATION
Mountain forest
Xerophytic forest and scrub
Caribbean vegetation
Rain forest
Savanna
Subtropical forest
Tropical high mountain
Pampa
Mediterranean
High Andean
High steppe
Patagonian steppe
Desert
Subantartic vegetation


LATIN AMERICA AND THE CARIBBEAN
PRECIPITATION
Isohyetal intervals
Millimetres
4.000
2.000
1.000
500
200
100


LATIN AMERICA AND THE CARIBBEAN
VARIATION OF PRECIPITATION
Probable variation (%) in relation to the long term annual average
Under 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 40
Over 40

Map 3

LATIN AMERICA AND THE CARIBBEAN

LOCATION OF CITIES
WITH OVER 100.000 INHABITANTS, 1975

Note: The fact that this map shows specific boundaries does not mean that they are sanctioned or accepted by the United Nations.

In relative terms the impact of man on riverine ecosystems through contamination is reduced in Latin America. Human activities related to rivers are heavily weighted to flow control and changes in watershed land use. In comparison, the coastal ecosystem, estuaries and bays, are widely used for the reception of effluents, as well as affected by land use changes and control structures both upstream and in their immediate vicinity.

The river systems in Latin America can be subdivided into three major types: the large systems flowing to the Atlantic, the short rapid streams of the Pacific and the irregular streams of the zones of internal drainage. The Caribbean islands, despite high levels of rainfall, do not have rivers with large volumes of flow. The majority of the rivers are entirely rainfed. It is only south of latitude 28° South that the upper basins of the rivers rising in the Andean cordillera receive a substantial quantity of water from glaciers and snow melt.11/ In consequence, variation in rainfall has a significant impact on streamflow. Both contamination and the need for regulation are affected by flow régime, as well as by the use made of the water. Consequently, the basic character of the natural régime is of importance in estimating the type and level of human interference to be expected, the degree of susceptibility to contamination and other environmental damage.

The three largest river systems in the region are the Amazon, the Orinoco and the Plata (map 4). The combined flow of these three systems represents more than two-thirds of the total run-off of the region.

11/ The relationship between precipitation and flow régime is shown for a selected number of rivers in Annex B.

These systems all drain towards the Atlantic. The river systems on the Pacific slope of South America are very much smaller and, due to the aridity of the mid-latitude zone, account for a relatively small proportion of the region's run-off. Of still less importance are the interior drainage basins of the Altiplano and Argentina. The region of greatest variation in streamflow is the 700,000 Km2 of northeastern Brazil. The rivers of this region are characterized by extreme variation in streamflow not only between the wet and dry seasons but also inter-annually.12/

In Mexico and Central America the division between the Pacific and Atlantic drainage basins is more even (1,044,310 Km2 compared to 1,078,478 Km2) with the remaining area accounted for by the interior basins of Mexico. The stream flow is still inevenly distributed, with 70 per cent of the run-off flowing to the Gulf of Mexico and the Caribbean. The most significant contrasts appear in Mexico where the rivers of the southeast, the Papaloapan, Coatzacoalcos, Tonalá and Grijalva-Usumacinta concentrate about half the total stream flow in less than 10 per cent of the land area of the country.

2. Patterns of water use and the environment

The use of water in Latin America is spatially sporadic and heavily concentrated in restricted areas (map 5). There are limited statistics on water use and the best index is probably population, allowing for both the relative differences in production structure of the economies of the region and the varying impact of different activities on the water resource. The principal attributes of population change in Latin America have been rapid growth, the increasing concentration of population in urban centres and sharp increases in population density in those areas which already were the most densely populated.

12/ For example, the average annual water deficit reaches more than 1,000 mm in this region, and nearly the whole area has a deficit in excess of 600 mm, Brazil Ministerio de Agricultura, Departamento Nacional de Meteorología, Balanço Hidrico do Brazil, Rio de Janeiro, 1972.

Map 4

LATIN AMERICA AND THE CARIBBEAN

AVERAGE ANNUAL STREAM FLOWS

Map 5

LATIN AMERICA AND THE CARIBBEAN

LEVELS OF USE OF RIVERS

This last characteristic can be seen clearly in the distribution of the most densely populated areas and cities with over 100,000 inhabitants around 1970 (map 3).13/

Such densely peopled areas can be divided into four types: urban areas growing rapidly through immigration, rural areas with high rates of population growth, and a few intermediate rural areas in the proximity of the major urban industrial centres with relatively stable populations. The fourth type is more restricted is spatial extension but more dramatic in the nature of the change in water use; the so-called growth poles, such as Ciudad Guyana in Venezuela and Paz del Río in Colombia. Each of these groups of areas has a distinct pattern of water use and a particular predominating characteristic of the relationship between man's use of water and the environment. In the first and last groups, the relationship is characterized by contamination and demand for recreation purposes, in the second by disruption of the hydrologic régime due to erosion, in consequent flooding and sedimentation in areas of greater rainfall, and in the third group by the demand to control and charge the hydrologic régime to facilitate the intensification of agricultural production. In each case, however, there are other significant aspects of the relationship, the occurrence of waterborne disease in the first two groups, the impact of dams and other flow control projects in all cases, the contamination of water courses with fertilizers and pesticides in the last.

During the next twenty-five years until the end of the twentieth century, the total population of Latin America is expected almost to double, urban population to more than double and total production to quadruple.14/ In such circumstances, it will not be surprising if overall water use increases at a rate at least equal to the overall rate of growth of production (figure 2), and for individual uses at even higher levels, in hydroelectric generation for example. Environmental quality is threatened as the intensity of the use of water bodies increases. In Latin America there is unquestionably a general trend of rapidly increasing intensity of water use.

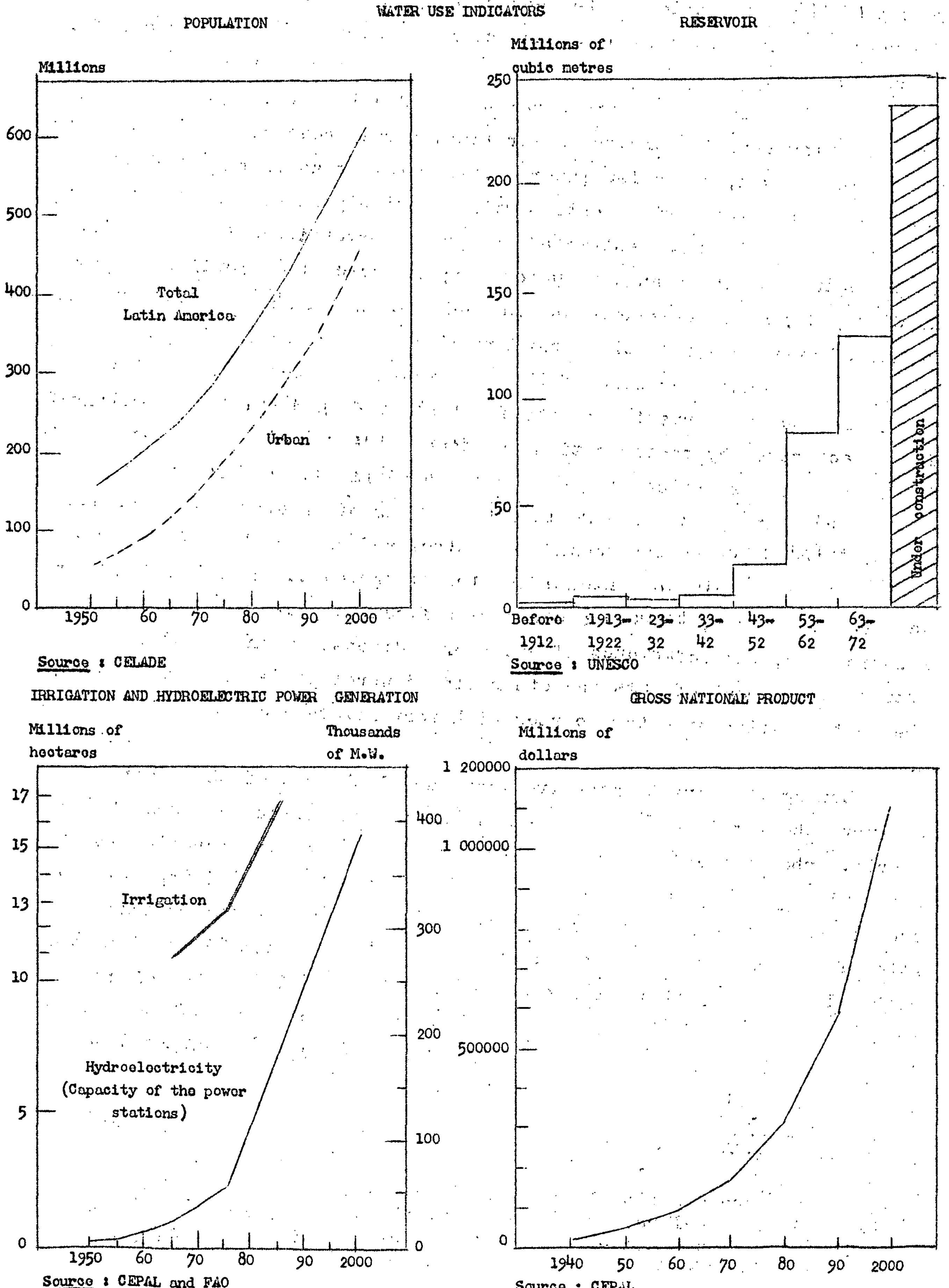
13/ Details of the distribution of water using activities will be found in Annex B.

14/ If the gross national product of the region increases at the average annual rate of 6 per cent, the minimum established in the International Strategy for Development.

/Figure 2

Figure 2

TRENDS IN SELECTED SOCIAL ECONOMIC AND WATER USE INDICATORS



/Table 3

Table 3

SELECTED CHARACTERISTICS OF THE POPULATION IN LATIN AMERICA
1950 TO 1970 a/

	1950	1960	1970
Total Population ('000's)	164 170	216 285	284 324
% population in densely b/ populated administrative units	42.7	51.2	65.5
% population in urban areas c/	25.2	32.7	41.2
Urban Population ('000's) c/	39 001	68 351	111 555

Source: CELADE, various demographic bulletins.

a/ Excludes Guyana, Surinam and French Guiana.

b/ Administrative units with a density of population of more than 25 persons per square kilometre.

c/ Settlements over 20,000 population.

/(a) Water,

(a) Water, environmental quality and urban expansion 15/

Although it is true that every large metropolitan region in Latin America presents a particular case, an example of water management issues without parallel, there do exist commonalities between all the metropolitan regions, and greater similarities if comparisons are restricted to those with similar geographical sites or of comparable size. The distinctive nature of the problem of waste disposal in the coastal and inland metropolises has already been noted. Obviously, a population of two million does not present the same issues as one of ten, and Lima's water management situation is rather distinct from that of humid Recife. At the same time, however, the qualitative and quantitative change in the management problem is similar in Buenos Aires, La Habana and Medellín. It is largely on this wider aspect of water management that attention must be focused if the phenomenon as a whole is to be understood.

The common pattern of water use exhibited by metropolitan regions in Latin America is one of increasing demands for domestic, municipal and industrial supply. This has led to the necessity to tap ever more distant sources of water, to the drawing down of ground water levels and to considerable lags in the provision of public supplies. Not surprisingly, the domestic consumer has suffered most from this situation and despite the advances made in recent years in most large metropolitan areas a considerable proportion of the population remains without a regular potable supply of water in the home.16/

15/ This section draws on a consulting report prepared for CEPAL/UNEP as part of the enquiry: José Pérez Carrión, "Estudio de Usos Sanitarios y Causas de la Contaminación del Agua en América Latina", Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente (CEPIS), Lima, February 1976.

16/ Under the Ten Year Health Plan for the Americas adopted at the Third Special Meeting of the Ministries of Health of the Americas in Santiago, Chile in 1972 following domestic water supply goal was adopted for urban areas.
"Provide water services with house connection for 80 per cent of the urban population, or as a minimum, supply half the population at present without services". Pan American Health Organization, Ten Year Health Plan for the Americas, Official Document Nº 118, January 1973, p. 103.

A corollary of the expansion of domestic and industrial demand for water has been the increase in waterborne waste discharges in terms of volume and concentration of contaminants. This increase in waste discharges has not been accompanied by an expansion of treatment facilities: São Paulo provides a good example, where of some 20 m3 per second of waste flow, only 0.8 m3 in treated. The obvious consequence of this situation is pollution of water courses, which is characteristic of every metropolitan region in Latin America. Even where discharge is direct to the sea, local pollution occurs almost without exception in every urban centre of more than 100,000 population. This is not to suggest that remedies must be applied as a matter of urgency. This pollution is not necessarily yet a threat to other water uses. If the water supply goals agreed to by the countries are met, then such discharges will increase very rapidly between now and the end of the century, and concentration of contaminants increase even more as industry expands and higher levels of consumption are achieved by the mass of the population.

The water supply and waste discharge situation for large metropolitan areas (see table 4) varies considerably in its detail; but as long as the location of the expansion in population and industrial activity continues its present trend, the demand for water supply and the volume of waste discharges will at least triple from each metropolis by the end of the century.

Water supply and waste discharge, although perhaps dominant, are not the only means by which metropolitan centres have an impact on the water resource. Such large concentrations of population and industrial activity generate demands to drain wet land, to protect built-up areas from flooding, to increase the rate of run-off from urbanized land and similar changes in the hydrologic régime. Examples are numerous: the filling-in of the margins of Guanabara Bay, the expansion of Guayaquil on the estuarine mashes of the Guayas, the canalization of almost all streams in urban areas and the steady expansion of land covered with buildings, roadways and other urban appurtenances (see table 5). It is estimated that in Latin America and the Caribbean in twenty five years time a total area larger than El Salvador will be urbanized, if present trends continue.

/Table 4

Table 4

SELECTED FEATURES OF WATER USE IN THE MAJOR CITIES OF LATIN AMERICA

	Population (1) (thousands)			Drinking water (2)		Sewerage (2) coverage (percent-age) a/	Recipient water body	Character-istics of the recipient water body b/	Flows (m³/sec.)		Estimated outflow of sewage in 1975 (m³/sec.)
	1950	1975	2000	Coverage (percentage) a/	Supply l/h/d a/				Minimum/anual	Average/anual	
México	2 872	10 942	31 616	78.7	360-527	57.7-69	Tula and Lerma/Panuco	I	1 100	3 350	54
São Paulo	2 450	9 965	26 045	55	270-293	30-35	Tiete and Lake Billings	I, II, III c/	12.0	87.0	22
Buenos Aires	4 500	9 332	13 978	85-91	852d/	52.4	De la Plata and tributaries	II	n.a.	20 425	96
Río de Janeiro	2 890	8 325	19 383	81.7	188-684	60	Guanabara Bay, Atlantic	II	n.a.	n.a.	34
Lima - Callao	614	3 901	12 130	80	359	-	Pacific Ocean	IV	n.a.	n.a.	16
Bogotá	655	3 416	9 527	71.5	304	70	Bogotá	I		27	10
Santiago	1 256	3 063	5 119	64.4-90	300-555	47	Mapocho, Zanjón de la Aguada	I	3.5	7.9	14
Caracas	677	2 673	5 963	75-100	300-388	56	Guaire and Tuy	I	1.20	27.7	11
Havana		2 269	4 451	97	500	56	Gulf of Mexico	IV	n.a.	n.a.	16
Belo Horizonte	370	2 001	5 732	58	261	17.7-62	Das Velhas and others	I			4
Guadalajara	401	1 970	6 176	90	314	78	Santiago	I	17.55	21.28	8
Recife	650	1 967	4 654	61	267	13.7	Atlantic Ocean	II	n.a.	n.a.	5
Monterrey	354	1 570	4 751	80.1	404	60	Santa Catarina	I			7
Montevideo	800	1 559	2 233	90.5	289	68	Atlantic Ocean	II	n.a.	n.a.	6
Medellín	328	1 477	3 743	80-89.1	340	78.5	Medellín	I	21.5	30	6
Salvador (Bahía)	395	1 306	3 174	66	266	0	Atlantic Ocean	IV	n.a.	n.a.	3
Curitiba	140	1 282	4 353	72	345	26.2	Belem	I			5
Cali	241	1 241	3 428	87.5	237	81	Cauca	I	50	400	4
Guayaquil	253	1 006	3 109	60	429	-	Guayas, Est. Salado	I, II			4
Córdoba	426	891	1 338	65	460	-	Primero	I	2.52	9.44	4
Barranquilla	276	795	1 808	68	148	55	Magdalena	II	1 770	6 871	1
Maracaibo	231	733	1 521	54-87.1	475	-	Lake Maracaibo	III	n.a.	n.a.	3
La Paz	321	664	1 649	65	177	30	De la Paz	I	n.a.	n.a.	1
Quito	206	645	1 841	84.8	286-301	-	Guaillabamba	I			2
Asuncion	207	574	1 637	52	160-350	-	Paraguay	I		1 500-3 000e/	1
San José	182	471	1 143	95	423	-	Virilla Grande de Tarcoles	I	27.53	101.87	3

Source: (1) United Nations Population Division: *Trends and prospects in the populations of agglomerations; 1950-2000 as assessed in 1973-1975*, New York.
(2) CEPAL estimates based on official statistics of the countries for various recent years.

Note: n.a. = Not applicable. l/h/d = litres per inhabitant per day.

a/ In cases of inconsistent data, ranges are given.
b/ I = Rivers and canals; II = Estuaries and bays; III = Lakes and reservoirs; IV = Seas and oceans.
c/ Includes the Baixada Santista.
d/ Only the federal capital.
e/ Since the period for which information is available is no sufficiently long, the extreme figures of variation have been included in the averages.

/Table 5

Table 5

URBANIZED AREA, 1950 THROUGH 2000 a/

	1950	1960	1970	1980	1990	2000
Urbanized area (Km2)						
Latin America	3 120	5 026	9 914	13 759	19 826	27 446
Mexico, Central America and Caribbean	776	1 171	2 737	3 975	6 030	8 777
South America	2 344	3 855	7 177	9 784	13 795	18 669
Urbanized area as a percentage of total area	0 015	0 025	0 049	0 069	0 099	0 137
Latin America, Mexico Central America and Caribbean	0 029	0 044	0 103	0 149	0 226	0 330
South America	0 013	0 022	0 041	0 056	0 079	0 108

a/ CEPAL estimates based on CELADE demographic data and estimates, excluding non-Spanish speaking countries and islands.

/The large

The large metropolitan regions are areas of relatively high personal incomes, which leads to the concentration of demand for certain consumption goods and services. In particular, this concentration generates a large demand for recreation much of which will always be directed towards water. This demand in turn requires a high quality of water and the consequent protection of water bodies from contamination. Less directly, the use of areas for recreation may conflict with productive uses or destroy the more fragile ecosystems. Examples of the latter are still rare in Latin America, but the former are to be found in almost every metropolitan region where recreational areas exist in close proximity to the urban area.

The panorama is one of increasing intensity of use by man of the water systems of metropolitan areas. Such intensification of use conflicts with the maintenance of a diverse aquatic ecosystem. This conflict may be either direct, as with contamination, or indirect as flow régimes change with the expansion of paved areas. This situation calls for increased intervention and the creation of management institutions capable of carrying out this intervention rationally and efficiently, preventing both undue damage to the aquatic ecosystem and unnecessarily high external costs in both economic and social terms.

(b) The regulation of flow régimes

Population growth and economic development do not become reflected in water use only through the demands generated by the major urban centres. The uses of rivers which involve control and regulation of flow also expand in line with the increase in the generation of hydroelectric power, irrigation, transportation, the need to protect the more intensively-used agricultural areas from flooding, etc. These uses call for the construction of dams and the formation of reservoirs, the diversion of flows into artificial channels or between river basins, the canalization of stream beds, the construction of dykes and other protective works, all of which will result in changes in the spatial or temporal patterns of flow.

/The impact

The impact of such changes is relatively limited in the region as a whole, although there are some regions where this interference in flow régime is concentrated (see map 6). Until now, interference has been restricted to relatively small river systems. The scale of interference is changing, however, as the countries of the La Plata basin construct a chain of reservoirs and dams for hydroelectric power generation on a scale large even by international standards.

Despite the long history of man-made lakes in Latin America, their study has been little developed.17/ In general, in Latin America there is a lack of systematic information on the direct or indirect environmental repercussions of régime regulation activities.18/ There is little doubt, however, that regulation is increasing at such a rate that management structures will have to make an effort to provide a sufficient response.19/ This is particularly the case with the expansion in the number of very large reservoirs constructed to provide storage for hydroelectricity generation: it is estimated that hydroelectric generating capacity will expand at a rate of 8.2 per cent a year between now and the end of the century. The largest concentration of such projects is in the rivers of the Plata basin in Brazil, Paraguay, Argentina and Uruguay.

In contrast, the rate of growth in irrigation projects is expected to be much slower, at least until 1985. High rates of expansion of irrigable areas are only expected to occur in countries where the present level of irrigation development is relatively low: Central America, Venezuela, Colombia and Bolivia. The areas involved will be relatively small except in Colombia although larger areas will be added in the countries where large areas are already irrigated: Argentina, Mexico, and to a lesser extent Brazil, Chile, and Peru.

17/ It is perhaps indicative that at the International Council of Scientific Unions Symposium on Man-Made Lakes held in 1971 only one paper was given on a man-made lake in Latin America, Lake Brokopondo in Surinam.

18/ A general picture of the situation is provided in CEPAL, El medio ambiente en América Latina, E/CEPAL/L.132, Santiago, 25 March 1976, but this is far from complete.

19/ This problem is well illustrated in the case studies undertaken for this project.

/The data

The data on gross irrigable areas provide only a partial view of future change in the water use situation in irrigation. Much of the anticipated expansion in crop production will be achieved not through expansion of area but by means of changes in factor combinations, including greater fertilizer and pesticide inputs and improvements in the efficiency of water application. Such changes may have profound environmental consequences, particularly in regions of traditional irrigation farming. In such areas the ecosystem has adapted to a particular water-using pattern, even though far removed from the original natural régime.

A further aspect in the future evolution of the utilization of the water resource in Latin America is the increasing frequency of multiple and successive use of water courses. This situation has not existed in the past to the extent that there has been a need to intervene actively in the management of the river or other water body. Intervention has been restricted to management of individual uses. A new epoch is opening, and the pace and level of development are forcing notice to be taken of the wider environmental repercussions of water management actions.

(c) Water and health

One particular aspect of the relationship between water and the human environment is the occurrence of water-related diseases. Water-related diseases can be classified into four major groups.

(i) waterborne (typhoid or infectious hepatitis)
(ii) water-washed (trachoma, scabies, shigella dysentary)
(iii) water-based (schistosomiasis, guinea worm)
(iv) water-related insect vectors (orchocerciesis, malaria)20/

Diseases within all four groups are of significance in almost every part of the region. Perhaps the most serious is the occurrence of enteritis and other diarrheas, diseases of the first group amongst very young children. They are the reason for the continuation of high infant mortality rates in most of the region, and a principal cause of death in

20/ This classification is taken from Gilbert T. White, David J. Bradley Anne U. White, Diseases of Water, Chicago University of Chicago Press, 1972.

/Map 6

Map 6

LATIN AMERICA AND THE CARIBBEAN

LOCALIZATION OF DAMS WITH A CAPACITY OF OVER 100 MILLION M^3

1972

19 of the 34 countries belonging to the Pan American Health Organization.21/ There appears to be little doubt that this situation can be directly related to the deficiencies in the domestic water supply.22/ Other waterborne diseases are significant in the region, particularly other forms of dysentary, amoebic and bacillus, which are found in all the tropical countries; infectious hepatities, even more widespread in occurrence, and likewise typhoid fever. The latter is particularly prevalent in South America although it has tended to decline in recent years.

There exists an important group of diseases that can be related not to the contamination of water supplies or food but to changes in hydrologic régimes. In general, these diseases, largely transmitted by insect vectors living in particular water environment, are restricted to tropical areas. The diseases of this type reported in Latin America are dengue, yellow fever and malaria. Only the temperate regions are free from these diseases. There is no information on the relationship between the occurrence of these diseases and any particular water management actions, but the potential connection should be borne in mind.

Water-washed diseases seem to be of little importance in Latin America, but one water-based disease, schistosomiasis or bilharziasis, is endemic to the eastern and central parts of Venezuela, a large part of Brazil, central Surinam and many Caribbean islands. It has been estimated that more than six million people are infected, largely in rural areas.23/ Unfortunately, the occurrence of the disease is under-reported but its relationship to the construction of reservoirs and

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21/ Details of morbidity and mortality statistics of water-related diseases are given in Annex B.

22/ The Pan American Health Organization study of childhood mortality demonstrates "that lack of water services has a direct relationship to excessive postneonatal mortality and is an important measure of unfavourable environmental conditions", Pan American Health Organization, Patterns of Mortality in Childhood, Scientific Publication, No. 262, Washington, 1973, p. 314.

23/ Pan American Health Organization/World Health Organization, Health Conditions in the Americas, 1969-1972, Washington, 1974, p. 40.

/drainage and

drainage and irrigation networks in particular, which provide the relatively slow-moving water environment where the snail flourishes, has been well documented in Africa. It would be unlikely that a similar situation would not be found in Latin America.

The control of the role of water in disease transmission is relatively simple where such transmission is through domestic water supply or food. This is not to suggest that it is actually to achieve this control, when public services are only one amongst many competitors for scarce resources. Much more complex, however, is the control of diseases transmitted through other members of the ecosystem. The chain of actions and reactions is often very lengthy in the latter case, and difficult to master, especially since the means to do so are not well understood.

3. Water and environmental management in Latin America

Every country in Latin America has had programmes of water management for many years. These have been developed, in most cases, in close co-operation with international agencies. With one or two notable exceptions these programmes have not given rise to long-term national strategies for water resource development and use. In general the current management situation in the various countries of Latin America can be described (in the language of the institutional analyst) as one of the prevalence of single-purpose and single-means strategies with isolated occurrences of both multiple-purpose and multiple-means approaches. Translated, this signifies that one or more individual government agencies, sometimes ministries, more commonly, autonomous corporations, dominate the water resource management system. The consequence is that the water resource is devoted to a limited number of ends, normally the production of hydroelectric power irrigation and the provision of urban water supply. Machinery to resolve conflicts is rare: at the river basin level, in water resources, as in all activities, public decision-making is centralized.

(a) Water management systems in Latin America 24/

The water management situation in Latin America may be interpreted according to different sets of criteria, for example whether there exists in any one particular system of administration, fragmentation or consolidation of functions, centralization or decentralization of decision-making authority, etc. It is also possible to classify institutions by means of the territorial unit in which they operate, national, provincial or local. In the region as a whole, the application of such criteria is more difficult and a more descriptive approach is required.

The water management systems of the different countries of Latin America can be grouped into three general types.

(i) Countries where many agencies are active in water management and there is no one dominant institution.

(ii) The concentration of water-management activities in one institution but some significant functions are carried out elsewhere.

(iii) The concentration of the administration of the water resource in one centralized institution.

The situation most commonly found is that the administration of the water resource is divided between various institutions, each responsible for one specific use of the water resource. No one institution dominates the water management system. This is the case in Argentina, Bolivia, Chile, Colombia, Guatemala, Paraguay, Nicaragua, Uruguay and Venezuela. The co-ordination of activities between institutions or across sectors and uses is by various types of inter-institutional bodies. These may be inter-ministerial councils or specific ministries of co-ordination. There are cases, however, where no formal means of co-ordination exist. In Argentina, for example, at the federal level there is no co-ordinative commission or council. Even

24/ This section is based on a consulting report prepared for CEPAL/UNEP as part of the enquiry: "Panorama Descriptivo de la Administración de los Recursos Hídricos en América Latina", Instituto de Economía, Legislación y Administración del Agua, Mendoza, April 1976.

/where such

where such formal machinery does exist its effectiveness varies according to not so much the nature of the legal structure as the actual distribution of financial resources in the annual budget.

Within these systems that might with justification be termed fragmented in terms of function, there is considerable variation in relation to centralization or decentralization of decision-making authority and of the territorial units in which different institutions operate. Nearly everywhere decentralization of specific functions to autonomous public agencies is common, particularly in hydroelectric power generation, public water supply and irrigation. Territorial decentralization, outside the federal countries, Brazil and Argentina, is less common and decentralization of decision-making power outside the bureaucracy of the public sector only notable by its rarity. The latter is related solely to irrigation agriculture, and even then only found in Chile and Peru. Participation of water users in advisory councils is, however, more common; examples exist in Brazil and Argentina, and is proposed for the new regional agencies in Mexico.

An alternative institutional system is that where, in place of a single unified water management agency, one institution predominates over all others. Brazil, Costa Rica, El Salvador, Panama and Peru posses an institutional system of this type. In Brazil, the majority of water management activities are concentrated at the federal level in the Ministry of the Interior. Co-ordination tends to be limited to the formation of inter-ministerial committees to deal with one specific water use, such as "GEIDA" the inter-ministerial group formed in 1968 to co-ordinate irrigation development activities in the Federal Government. In Peru, a unitary State, the centralization of authority in the water management system is even greater. The Dirección General de Aguas e Irrigación, the Ministry of Agriculture, has authority over not only irrigation use of the water resource but the management of the resource itself.25/

25/ Julio Guerra, Legislación de Aguas en el Perú, paper presented at the Seminario sobre Aspectos Legales e Institucionales del Desarrollo de Recursos Hidráulicos, Mérida, Venezuela, 27-30 May 1974.

/There are

There are four countries in the region, Cuba, Ecuador, Honduras and Mexico, where the administration of the water resource is centralized in a single institution. There are differences between these countries, but the important feature is the consolidation of the water management system. The classic example is provided by Mexico. The basic water management institution, the Secretaría de Recursos Hídricos (SRH), is wholly responsible for the development and conservation of the water resource. The SRH possesses the necessary authority to define policies, plan uses and execute the necessary works to implement its policies and plans. The SRH also carries out research into all areas related to the use and conservation of the water resource. The SRH is divided into three major divisions responsible respectively for planning, construction and operations, and its activities cover all aspects of water management. The only significant use outside its direct activities is hydroelectric power generation, but even here overall policy is in the hands of the SRH.

(b) The river basin agency

It is in Mexico, within the centralized Secretaría de Recursos Hídricos, that the river basin agency approach to water administration has been most highly developed. River basin commissions are being used as administrative devices elsewhere, notably in Colombia and Brazil. In both cases, the use of the river basin authority is limited to individual examples, the Cauca being the most outstanding in Colombia and the São Francisco in Brazil. There are no examples in Latin America of any attempt, so far, to use the river basin agency type of institution for water quality control, although in Colombia, for example, the Cauca and Bogotá regional corporations have always had responsibility for conservation programmes.26/ Recently, these powers have been extended

26/ David R. Daines and Gonzalo Falcón H., Legislación de aguas en los países del grupo andino, resumen y comparación, 1975, p. 100. ff.

/to include

to include the protection of the environment under the recently promulgated Código de Recursos Naturales Renovables y de Protección del Medio Ambiente.27/

Still more recently, the creation of Regional Water Agencies (Organizaciones Regionales del Agua) has been proposed in Mexico, although these are not defined on the basis of individual river basins. The creation of these organizations would imply a substantial decentralization of the authority of the Secretaría de Recursos Hídricos. They would comprise councils on which local as well as federal interests would be represented.28/

Regional responsibility for water management remains largely a novelty in Latin America, and the experience gained has not, in general, been very widely disseminated.

(c) Environmental considerations in water management

In almost all countries of Latin America, water quality has been regarded as synonimous with the quality of water for public water supply systems. Consequently, the Ministries of Health have traditionally been given responsibility for the control of water quality. The interest in water quality has spread more recently beyond the direct protection of human health to include wider environmental quality considerations. This expansion of interest has not yet led to significant change in the water management system in most countries.

There are some exceptions however, in Colombia and Venezuela, general codes of environmental protection have been enacted. In both countries the code includes the protection of the environmental quality

27/ CEPAL, Reunión Regional Preparatoria para América Latina y El Caribe de la Conferencia de las Naciones Unidas sobre el Agua, Informe de Colombia, Documento informativo No. 11, Lima, Peru, 30 August - 3 September 1976.

28/ See Mexico, Secretaría de Recursos Hídricos, Subsecretaría de Planeación, Plan Nacional Hidráulico, 1975, pp. 107-116, for a complete discussion of this proposed innovation in Mexican Water administration.

/of water

of water and related resources.29/ Again, both codes envisage the creation of a commission to ensure compliance with the regulations established under the laws. The nature and effectiveness of the form of response and the proposed institutions remains to be seen, as in neither case have the regulations or the institutions been established to put the legislation into effect.

Less wide-reaching changes under a more general quality legislative umbrella in the water management system, to permit greater emphasis on environmental quality, are exemplified by the situation in Mexico. Within the Secretaría de Recursos Hídricos, a Dirección General de Usos de Agua y prevención de la Contaminación has been created to administer the regulations for the prevention and control of water pollution and to manage the water quality control programmes developed to meet the goals established in the National Water Plan.30/

In Brazil, in contrast to Mexico and perhaps more typically, water management agencies have remained largely outside the environmental quality management process. The major impetus has arisen, at the federal

29/ See for example, Article 3, Clause 3 of Ley Orgánica del Ambiente in Venezuela: "The creation, protection, conservation and improvement of national parks, forestry reservations, natural monuments, conservation areas, virgin land reserves, hydrographic basins, national water resources; refuges, sanctuaries and reserves for woodland wildlife, open country or intensive-use recreation parks, green areas in urban centres or any other areas governed by a special régime in the interests of ecological equilibrium and collective welfare". Venezuela, Congreso de la República, Ley Orgánica del Ambiente, Gaceta Oficial, Número 31.004, 16 June 1976.

30/ The three objectives for the period 1977-1982 are:
a. To solve the pollution problems in the following priority river basins, San Juan, Nazas, Lerma Santiago, Panuco-Guayaleyo, Conchos, Balsas, Culiacán, Fuerte, Coahuayana, Blanco and Coatzacoalcos.
b. To install waste treatment facilities in those cities classified as having priority due to their urban-industrial development or location.
c. To ensure the treatment of waste discharges in the steel, pulp and paper, sugar, textile, chemical and petroleum industries so as to maintain 1970 levels of contamination.
Mexico, Secretaría de Recursos Hídricos, Subsecretaría de Planeación, Plan Nacional Hidráulico, 1975, Segunda Parte.

/level, through

level, through water supply and sewage programmes managed by the Departamento Nacional de Obras de Saneamiento of the Ministry of the Interior, the Ministry of Health and the Banco Nacional de Habitaçao. More recently, the Secretaría Especial do Meio Ambiente was created in the Ministry of the Interior,31/ largely to harmonize environmental management activities developed at the state level.

The most innovative development are taking place perhaps at the State level, where the activities under the water supply and sewage programmes take concrete form. State sanitation companies exist for the provision of water supply and sewage in sixteen States. In addition, in São Paulo and Río de Janeiro, comprehensive multi-purpose environmental quality protection agencies have been set up through recent administrative reforms.32/ Both agencies have broadly based responsibility over the environment and are empowered to undertake research, develop policy programmes, execute projects and enforce control regulations.

Water management strategies in Latin America are still very mixed. The simplest single-purpose approaches co-exist with the most sophisticated not only in the region, but sometimes within the same country. Few countries have achieved homogeneity in water management practice due to a lack of central co-ordination of activities in the management process. It is not surprising, therefore, to find that the incorporation of environmental considerations in the water management decision-making process is similarly heterogeneous. A typical situation is to find the water management agencies somewhat side-stepped in the environmental management process, except where they are particularly strong. Consequently, environmental considerations tend to be imposed on the water resource management process from outside, from Ministries of Health, general codes of environmental conduct enforced by financial agencies, both national and international, etc. As yet, environmental considerations have not been assimilated into the process of water management.

31/ SEMA was created by Decreto No. 30.000, October 30, 1973.

32/ These are respectively, in São Paulo, Companhia Estadual de Tecnología de Saneamiento Basico (CETESB) and in Río de Janeiro, Fundaçao Estadual de Engenharia do Meio Ambiente (FEEMA).

/Chapter II

Chapter II

ENVIRONMENTAL ISSUES IN WATER MANAGEMENT SYSTEMS DOMINATED BY DIVERSION AND REGULATION STRUCTURES

In Chapters II and III the evidence gathered from the case studies on intensified use of water systems in Latin America is examined critically to gain insights into some operationally useful lessons for the incorporation of environmental issues into water planning and management. Since the programmes reviewed constitute but a fraction of the total experience in the region, the general observations and conclusions must allow for many exceptions. This chapter deals with environmental issues arising from increased regulation of river systems. Chapter III addresses the question of management of water systems where virtually all decisions are subordinate to the requirements of a large urban-industrial complex for domestic and industrial use or for transport of residuals. This division is necessarily somewhat arbitrary, as a number of major issues cut across both situations. However, this division does characterize two recognized development-environment issues in the region: the social, economic and ecological consequences of the changes in the quantity of water and suspended solids; and similar consequences stemming from changes in water quality.

1. The water management cases

The cases presented here deal with a broad array of water diversion and regulation situations with distinct organizational patterns in arid, semi-arid and humid tropical conditions.

/(a) La

(a) La Chontalpa 33/

A significant portion of the lowlands bordering the Gulf coast of Mexico is subject to extensive flooding. One of these areas is the Usumacinta-Grijalva delta, a humid tropical forest region (rainfall 2,200 mm) in the State of Tabasco, 600 km east of México City (map 7), where over a million hectares were inundated periodically. In 1951, following a series of damaging floods, the Grijalva Commission was formed as a river basin authority empowered to carry out integrated development of the Usumacinta-Grijalva-Tonalá basin. The principal water management questions which confronted the Commission were: (i) control of floods which inhibited development of intensive agriculture on the fertile flood plain and caused considerable property damage in urban as well as rural areas; (ii) promotion of settlement and intensive use of lands subject to flood protection, involving drainage, land clearing, physical infrastructure and colonization; (iii) development of hydroelectric power and recreation, tourism and fisheries related to the reservoirs; (iv) protection of the catchment area through regulation of agricultural and forestry activities in the upper reaches; and (v) productivity of forest resources and of riverine and coastal fisheries connected with the basin.

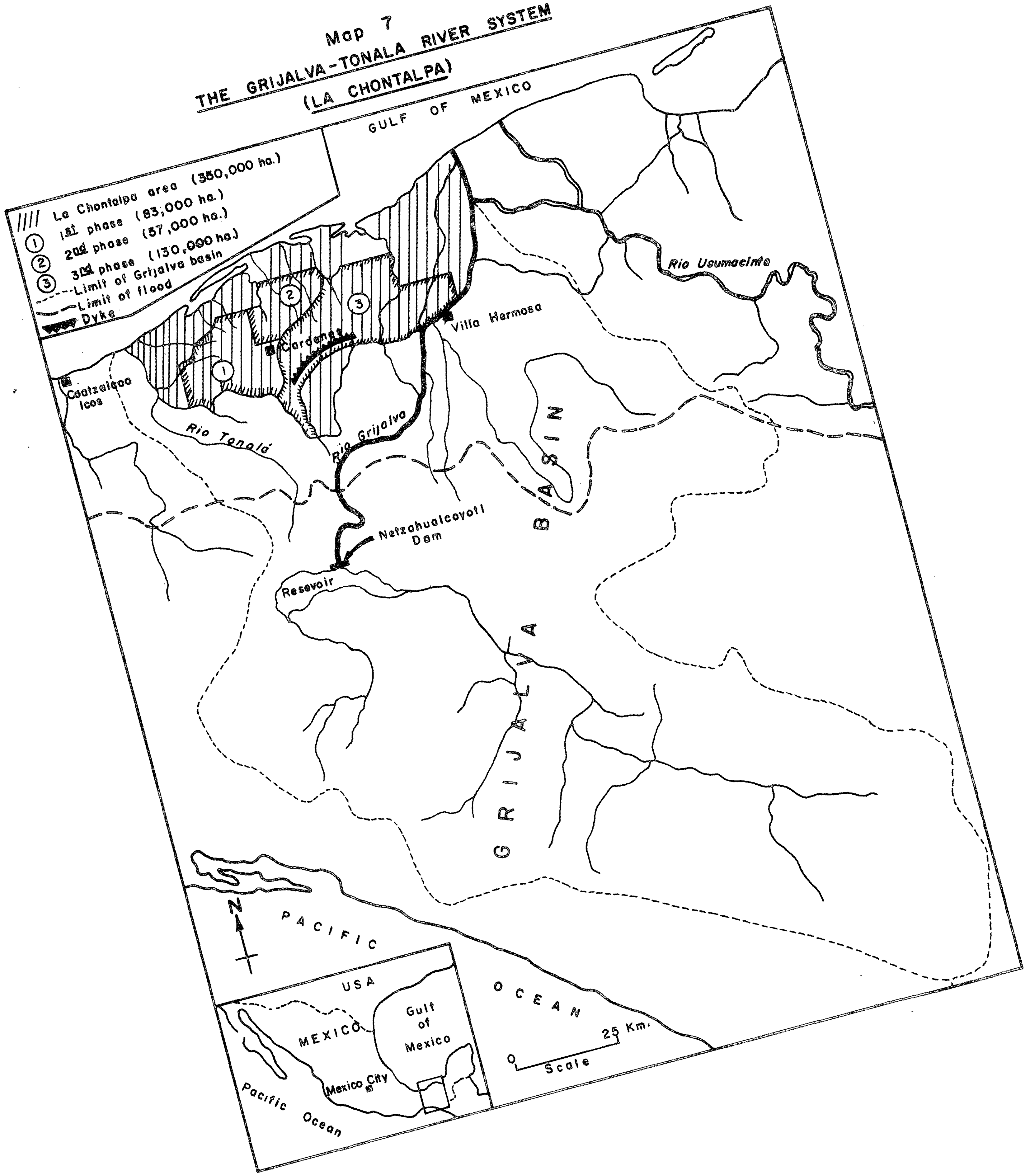
33/ This description of the case is based on the consulting report prepared for CEPAL/UNEP as part of the project: Rosario Casco de Avilés, "Control de Crecidas y Drenaje, Impacto de un Proyecto de Desarrollo en la Selva Tropical: La Chontalpa, Tabasco", Centro de Ecodesarrollo, Mexico City, May 1976 (mimeo).

/Map 7

Map 7

THE GRIJALVA-TONALA RIVER SYSTEM

(LA CHONTALPA)



The basic element in the management scheme is a multipurpose flood control and hydroelectric dam (Netzahuatcóyotl) on the main stem of the Grijalva, 300 km from its mouth, which was completed in 1969. The reservoir covers 29,000 ha, formerly occupied by 300 families, and has a capacity of 13,000 million m^3. The power plant has a capacity of 200 MW. Flow regulation afforded by the dam provides flood protection to about 800,000 ha of coastal lowlands, including the lower Tonalá basin which formerly received part of the Grijalva overflow. Within this area 352,000 ha were identified as suitable for intensive agriculture, and initial plans were made for reclamation and development of 7 units of approximately 50,000 ha. The final plan called for a two-phase development of 270,000 ha - the first phase (140,000 ha) to be undertaken in two stages over an eight-year period.

The La Chontalpa project is stage one of the first phase, covers 83,000 ha, and comprises the following activities: a 32 km dyke along the west bank of the Grijalva, 300 km of primary and 900 km of secondary drains, 780 km of paved highway and 600 km of unpaved roads, clearance of jungle from 44,000 ha, land levelling and irrigation infrastructure for 10,000 ha, construction of 22 population centres with all urban services for 6,250 families and restructuring of tenure of lands held by 4,680 farmers (2,590 ejidatarios and 2,090 small holders) into 22 collective ejidos.

The project was planned and managed by the Grijalva Commission in collaboration with a number of federal agencies. The relationships between the ecosystems and the hierarchy of public and private institutions whose decisions impinge on the project are shown in figure 3. This is a modified Venn diagram illustrating the linkages between major ecosystems, which are generally taken as river basins, e.g., the Grijalva and Tonalá, and the jurisdictional bounds of institutions connected with water management, e.g., ejidos and the Grijalva Commission.

/Construction, land

Construction, land clearing and resettlement was started in 1966 and completed in 1974. In the process it was decided to expand the area in permanent pasture from 32,000 ha to 48,000 ha which made necessary a 20 per cent reduction in the total number of families benefited. Aside from this alteration and the deferment of the construction of an irrigation system for 8,000 ha, the programme was essentially carried out as planned. The changes wrought in the natural and social system prevailing on 83,000 ha in the short space of ten years have been of major proportion. In spite of the fact that the project took twice as long as expected, the execution of such a complex programme required a remarkably high degree of technical and administrative ability.

(b) San Lorenzo 34/

The San Lorenzo project encompassed irrigation and settlement of 45,000 ha in the Piura valley. It subsequently became a component of the Chira-Piura scheme for integrated development of surface and ground water in these two adjoining basins to provide adequate water for irrigation of 147,000 ha, 76,000 ha of which were partially or fully irrigated prior to initiation of the phased expansion in 1948. The project is located in northern Peru in a tropical semi-arid region (annual rainfall 140 mm) at the northern limit of the Atacama Desert, 800 km south of the equator. The principal physical elements of the system are shown in figure 4.

34/ Description of the case is based on a consulting report prepared for CEPAL/UNEP as part of the project: A. Cornejo, H. Yap, C. López, A. Brack and W. Iglesias, "Modificación de un Ambiente Desértico por Irrigación: Proyecto San Lorenzo", Lima, June 1976 (mimeo).

/Figure 3

Figure 3

PHYSICAL AND INSTITUTIONAL BOUNDARIES RELATED TO THE LA CHONTALPA PROJECT

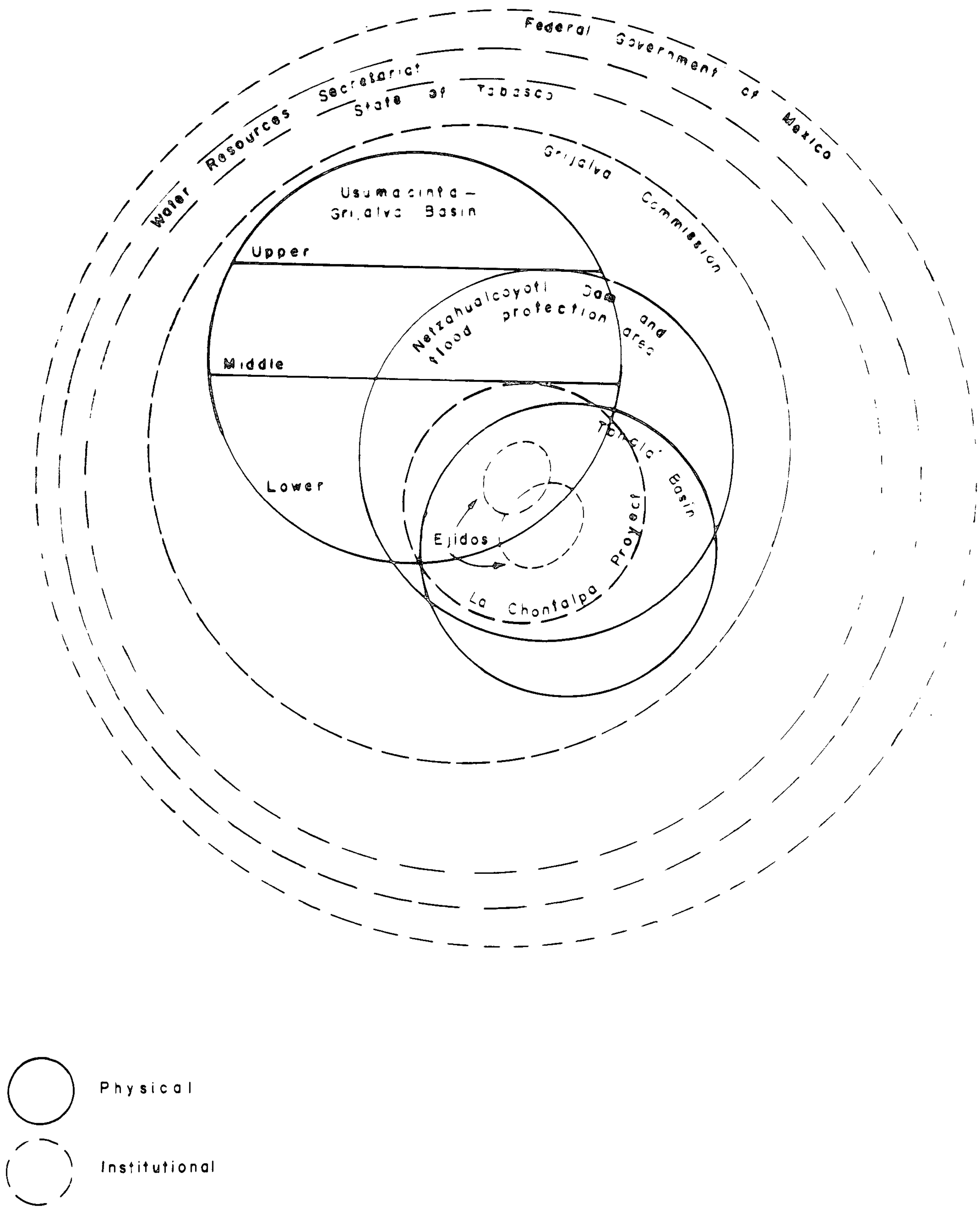
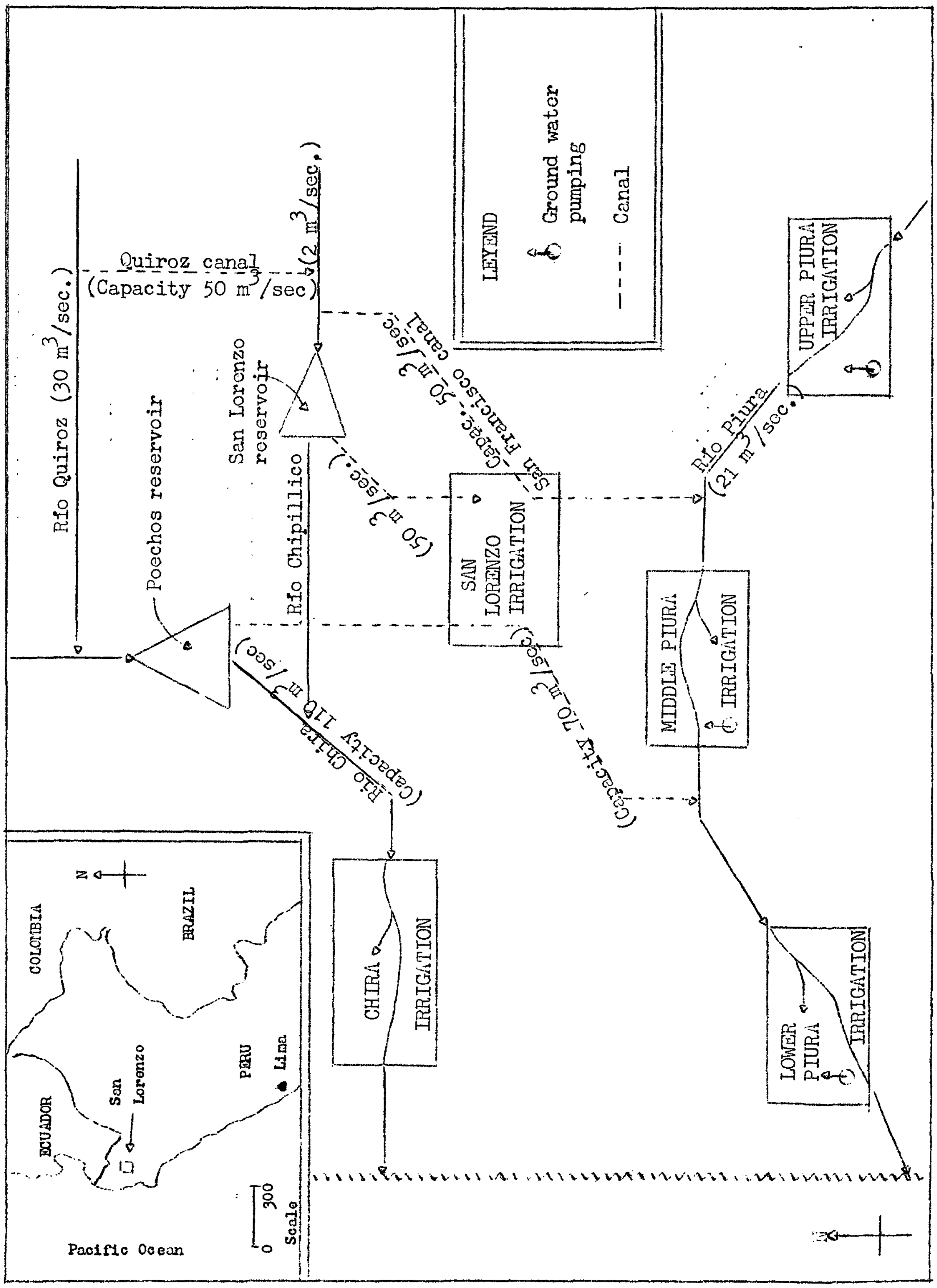


Figure 4
WATER USE SYSTEM IN THE CHIRA-PIURA BASIN (SAN LORENZO)



/The original

The original scheme envisaged diversion of 600 million m^3 of water annually via the Quiroz canal from the Quiroz to the Chipillico river (both tributaries of the Chira) and thence via the San Francisco canal into Piura basin to irrigate 20,000 ha and supplement supply to 31,000 ha in the middle Piura. The canals were completed in 1954; meanwhile plans for new irrigation were expanded from 20,000 to 45,000 ha. The principal hydraulic works for this phase were a storage dam with a capacity of 258 million m^3 on the Chipillico river (San Lorenzo reservoir), a diversion canal with a capacity to transfer an additional 50 m^3/second from the Chira to the Piura basin, and irrigation canals for the new area. Construction was completed in 1959 but for a variety of reasons colonization was not initiated until 1962. In the interim the increased supply of water encouraged spontaneous expansion of irrigation in the middle and lower Piura. Thus, when colonization did get underway conflict arose over the use of water and implementation of the agrarian reforms. The shortage which ensued, combined with the unexpected salinization of water used on the San Lorenzo Project which reappeared (via the quifer) in the middle and lower Piura systems, caused considerable soil salinization problems throughout the basin, and also resulted in water-logging in some areas from the San Lorenzo runoff. In consequence only 36,000 ha on the project were actually put into production, and of this area 4,000 ha were subsequently abandoned because of salinization and excessive water requirements on porous sandy soils. Salinity complicated management and reduced yields in other areas, both on and off the project, particularly since there was insufficient water for washing soil to get rid of salt.

In order to resolve the conflict and utilize idle irrigation infrastructure on 15,000 ha of the project, representing an investment of 30 million dollars, the Chira-Piura scheme was put into construction in 1972 with the prime purpose of storing 1,000 m^3 of water in the Chira (Poechos dam and reservoir) and diverting a further 70 m^3/second from the Chira to the Piura.

/The institutional

The institutional relationships in the execution of the various facets of the phased development are shown in figure 5. In terms of the ecosystem, the management of the phases was in no case concerned with the upper catchment. Nor was consideration given to potential interrelationships between population, which increased from about 2,000 to 40,000 as a result of the project, and the altered natural system - e.g., increase in malaria and over-exploitation of vegetation in the upper basin for fuel.

(c) Guri 35/

The Guri project is an extremely large hydroelectric power scheme which is being constructed by the Corporación Venezolana de Guayana (CVG). The Raúl Leoni dam is located on the Caroní river, 95 km above its confluence with the Orinoco and 300 km south of the Caribbean coast, in the heart of a humid tropical forest region which is largely unexploited (see map 8). The project is planned in two phases. The first phase was finished in 1968 with an installed generating capacity of 2,000 MW. The second phase, expected to be completed in 1983, will increase capacity to 8,750 MW and create a reservoir of 425,000 ha. Total investment, including transmission lines to Caracas and eastern Venezuela, is estimated at 3,000 million dollars.36/ It is projected that the power will be consumed primarily in domestic and industrial use in the region; major investments are planned in the steel and aluminium industries and urban population in the region is projected to increase from 400,000 in 1975 to 1.4 million by 2000.

35/ This description of the case is based on a consulting report prepared for CEPAL/UNEP as part of the project: J. Rabinovich, "Guri: Un Conflicto de Intereses en el Uso de los Recursos Naturales en una Cuenca Tropical", Caracas, November 1976.

36/ Unless otherwise stated, all values are expressed in United States dollars (1975). While the procedure has obvious disadvantages, it does provide a measure of comparability.

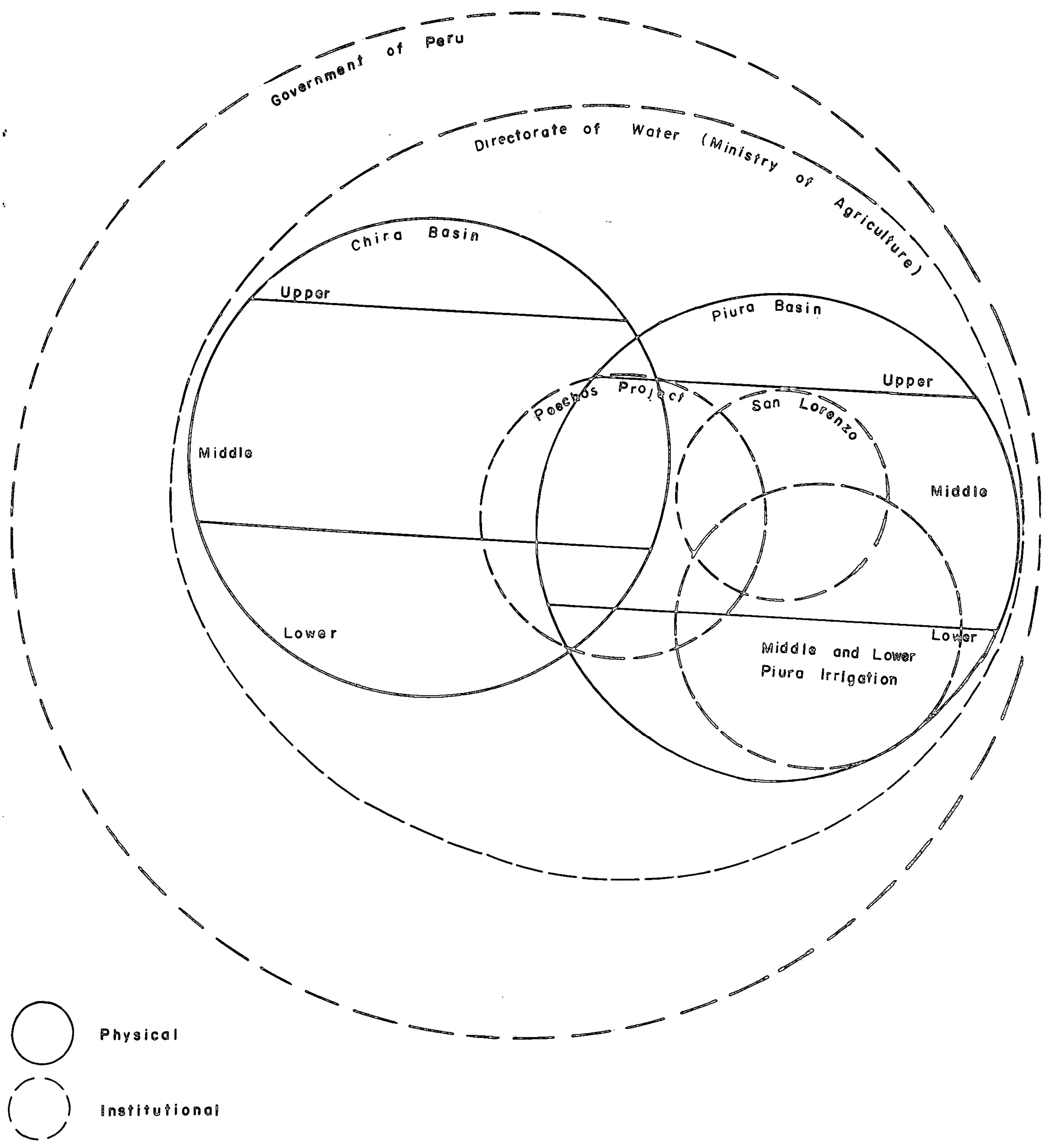
With the opening up of the isolated forest area for the dam through construction of an access road in 1964, there was a major inflow of entrepreneurs to exploit timber resources. These enterprises carried out selective logging and consequently there was little change in the forest cover and no change in water régimes (run-off and percolation rates) or sedimentation. However, colonists followed the logging roads, clear-cutting the forest for crops and pasture and thus introducing a slash-and-burn system of agriculture which, if extended over a large part of the 10 million ha Caroní watershed, could bring serious erosion. Such changes in the ecosystem clearly involved long-range effects on agricultural and forestry productivity as well as altered water run-off and percolation rates and sedimentation of the river. Possible results of widespread transitory occupation of land in the basin include: (i) virtual destruction of the productive capacity of the soil and forest resources; (ii) higher average flows in the Caroní, since there is less evapotranspiration from the vegetation; (iii) much higher peak flows in the Caroní since there will be no forest to impede run-off and percolation through the soil will be more rapid through the decaying root systems of the destroyed forest; (iv) low flow in the Caroní will be lower, since little water from the wet season will be carried over to the dry season by soils in the catchment areas; and (v) sedimentation of the river will be increased, which could result in more fish production and at the same time progressively reduce the storage capacity of the Guri reservoir.

Figure 6 shows the relationship between the CVG's jurisdiction and the Caroní and Orinoco watersheds. In the case of the Caroní it has sole authority, and thus was faced with the long-run issue of how to manage the water, forest and land resources of the Caroní basin (given the existence of the dam and generating plant) to provide a high and sustained flow of services of benefit to the people of Venezuela - services such as electricity, forest products, fisheries and agricultural production. A further management question centred on inter-temporal trade-offs between provision of immediate employment and subsistence and maintenance of the long-range productive capacity of the natural system. In view of the uncertainties of the situation, it was decided in 1975 to close the basin for logging and settlement.

/Figure 6

Figure 5

PHYSICAL AND INSTITUTIONAL BOUNDARIES RELATED TO THE SAN LORENZO PROJECT



Map 8

THE GURI PROJECT

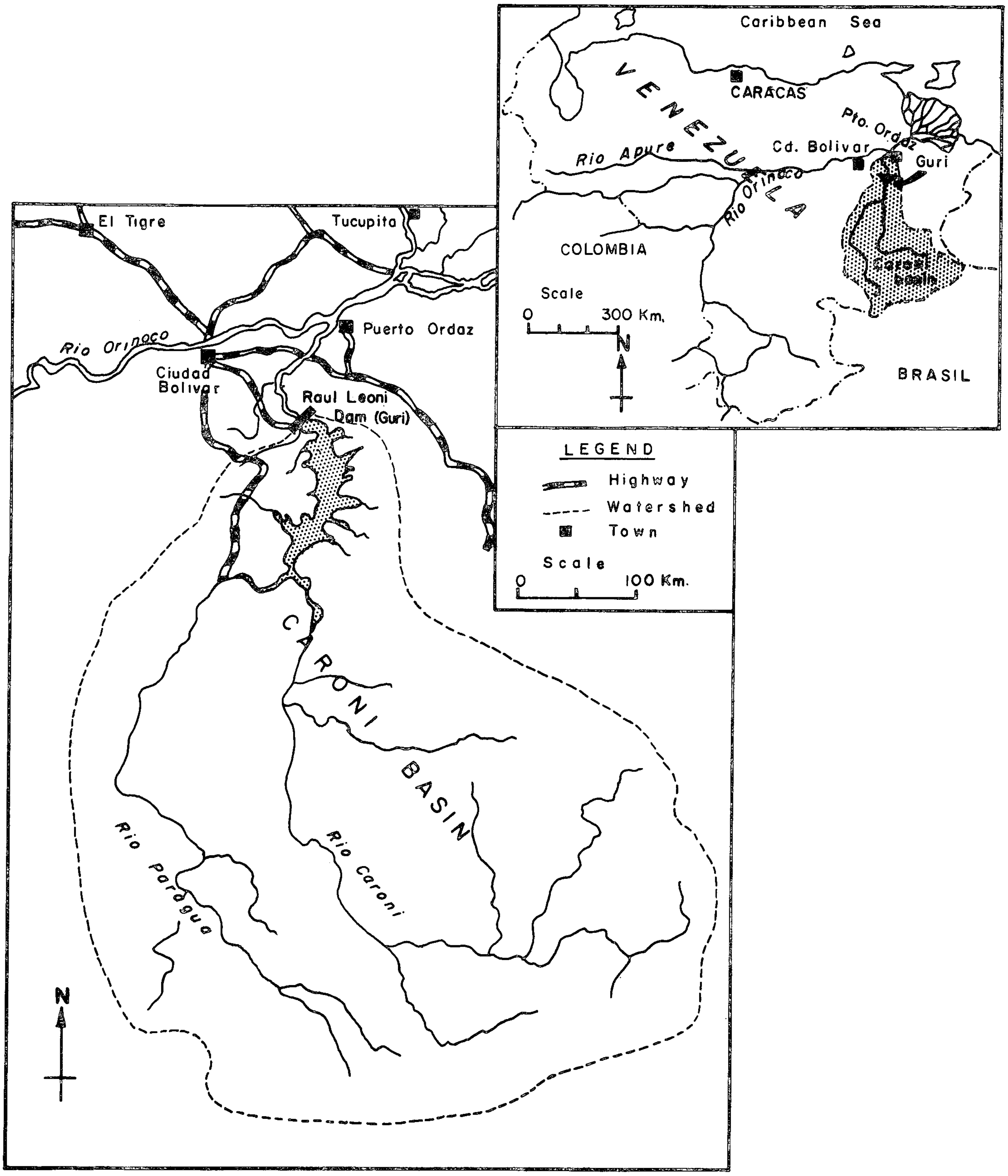
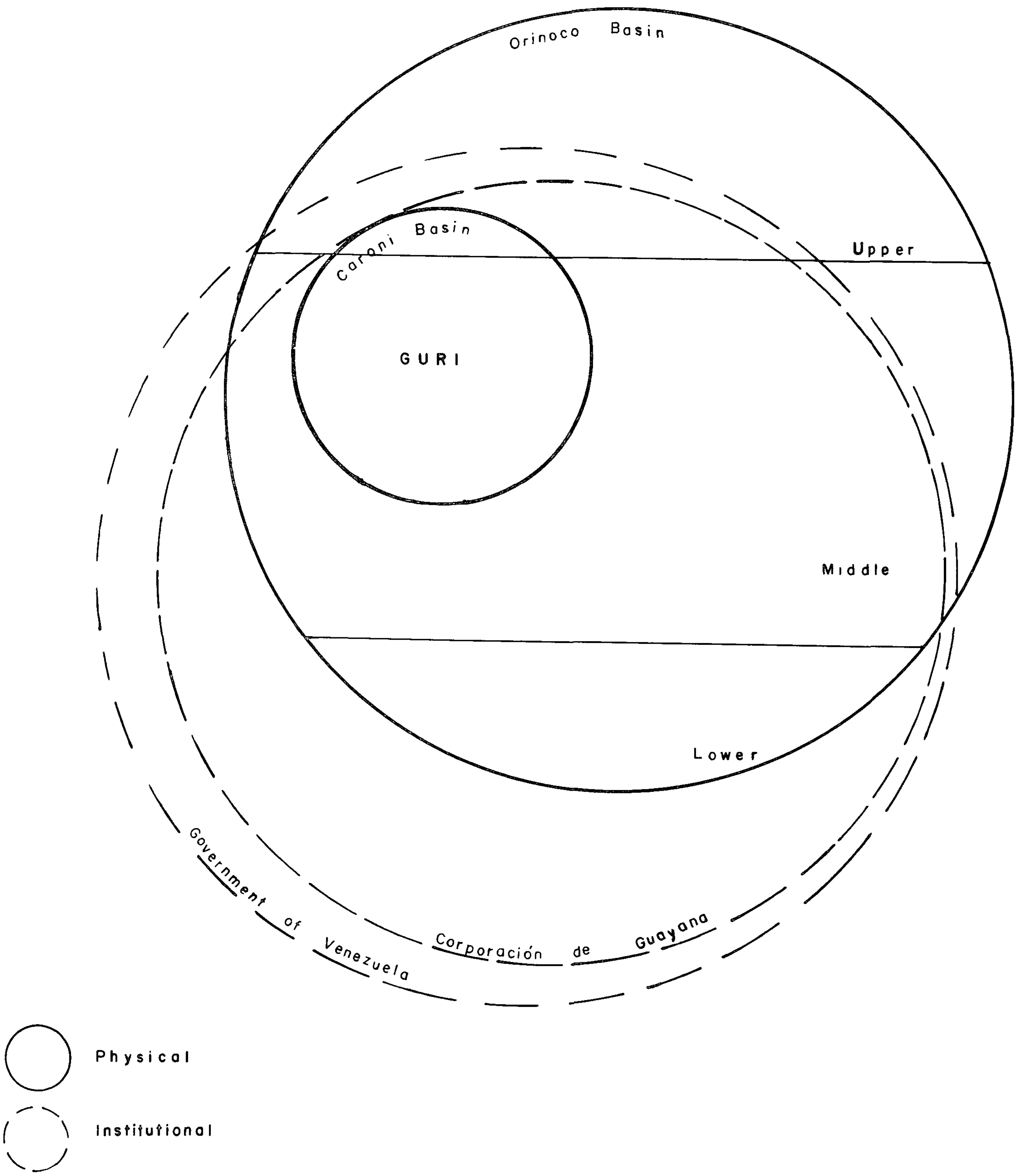


Figure 6

PHYSICAL AND INSTITUTIONAL BOUNDARIES RELATED TO THE GURI PROJECT



(d) Aconcagua 37/

The Aconcagua valley is located in a temperate semi-arid region (annual rainfall 350 mm) of central Chile, 70 km north of Santiago (see figure 7). The area of the basin is 7,640 km^2 stretching 190 km between the Andes and the Pacific coast, and average flow in the middle section is 30 m^3/second. Virtually all land in the valley which is suitable for irrigation is irrigated (72,000 ha). Approximately 20 per cent of this area is dedicated to vegetables, 20 per cent to fruit and 60 per cent to annual crops and pasture. The trend is to intensify fruit production for export.

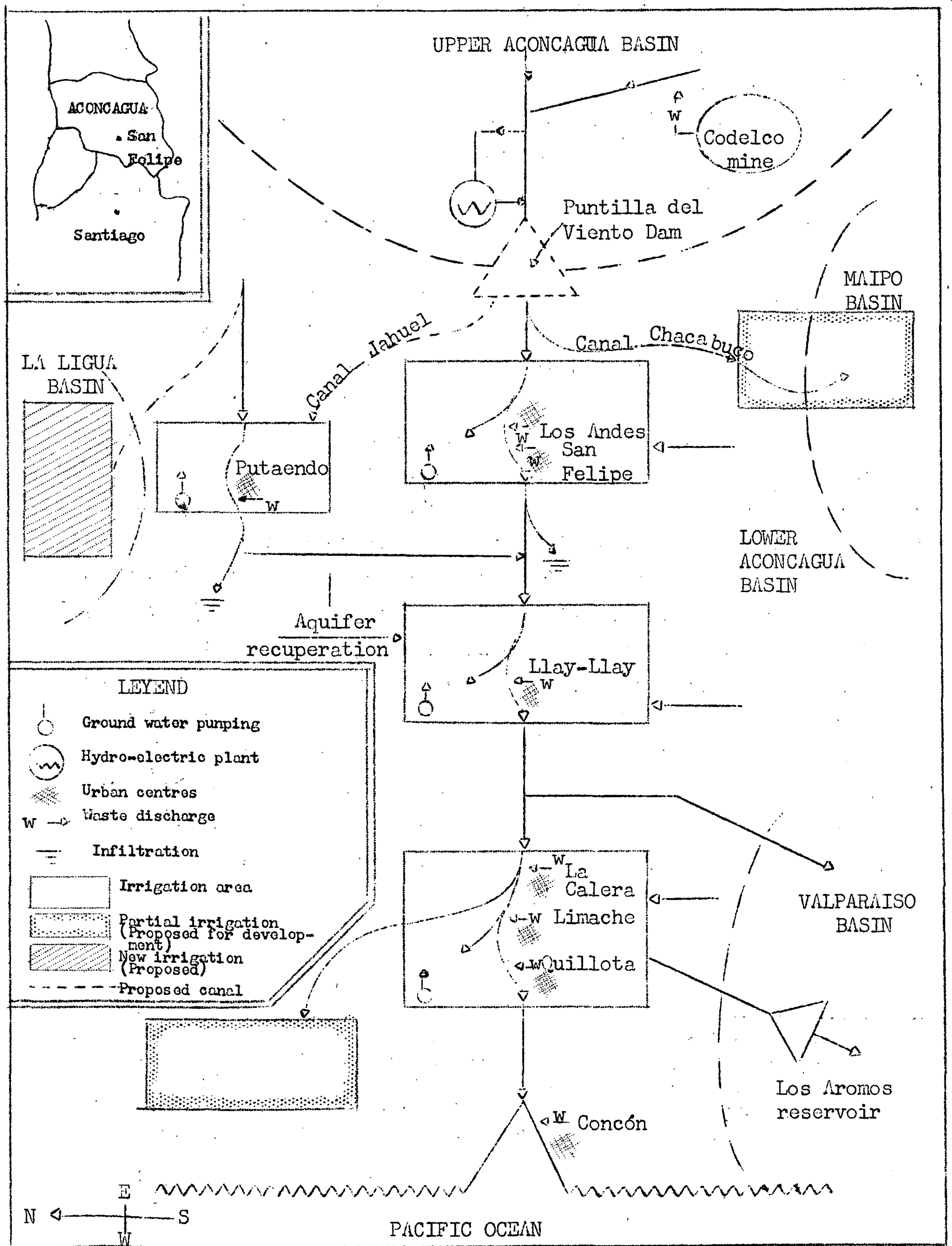
The principal questions faced in management of water in the basin are: (i) seasonal and inter-annual irregularity of flow which affect uncertainty in agriculture, particularly with respect to fruit, where fixed investment in orchards is at risk in the event of prolonged drought; (ii) increasing competition to irrigated agriculture from other water users in the valley, notably urban, industry and mining; and (iii) increasing pressure to transfer water to neighbouring water-scarce basins - the Maipo, Valparaíso and La Ligua-Petorca. Under current conditions agriculture in the valley is managed flexibly through a hierarchical assignment of land to progressively lower-value crops or pasture, which can be sacrificed successively from the low end in case of drought. However, the physical system of distribution, irrigation management and the institutional structure governing rights and use of water between distinct sections of the river, result in an overall efficiency of water use in irrigation of about 40 per cent in the valley.

37/ This description of the case is based on a consulting report prepared for CEPAL/UNEP as part of the project: J.A. Poblete, A. Palma, A. Forno, H. Gaete and L. Escobar, "Análisis de Alternativas de Uso Optimo de los Recursos Agua y Tierra en el Valle del Río Aconcagua - Chile", Santiago, May 1976.

/Figure 7

Figure 7

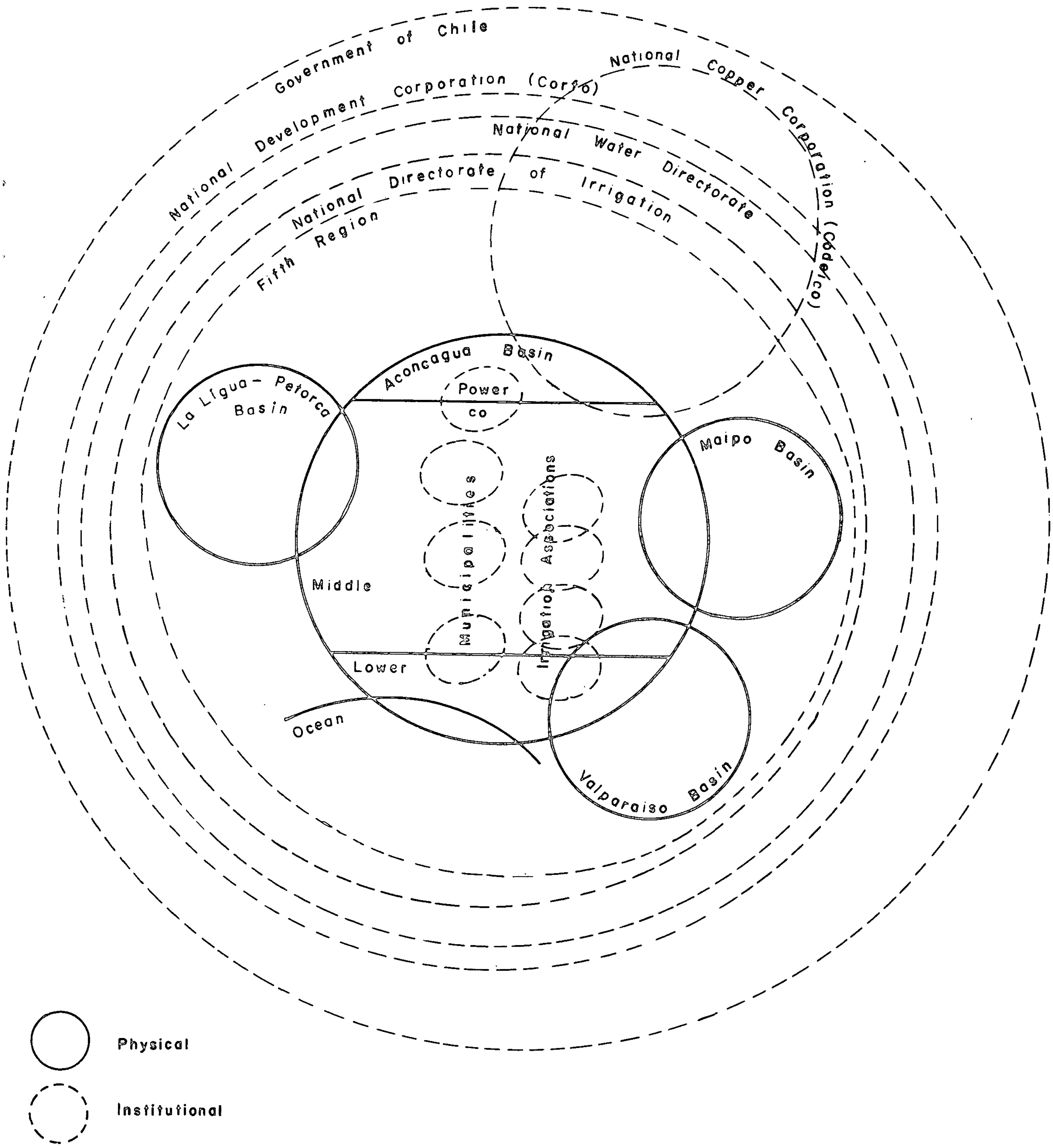
SYSTEM OF WATER USE IN THE ACONCAGUA VALLEY



/Figure 8

Figure 8

PHYSICAL AND INSTITUTIONAL BOUNDARIES RELATED TO WATER MAGNAGEMENT IN THE ACONCAGUA BASIN



Losses in primary and secondary canals are estimated in the order of 10 to 20 per cent. Intra-basin distribution between four irrigation zones is governed by a regulation under which the upstream users have unlimited right to the available supply. Under such conditions there is little incentive to conserve water and there is a natural tendency for excessive use in the upper valley, although this is not as prejudicial to overall efficiency as it might be, due to high rates of downstream recharge through the aquifer.

The valley is faced with the prospect of sharply-increasing intensity of water use. The economic incentive to expand the area in high-value crops (vegetables and tobacco) and permanent crops (fruit), with associated development of processing industries, calls for greater security in supply of irrigation water. It is to be expected that a move in this direction would be accompanied by a quantum jump in the use of agricultural chemicals, with a potential impact on the quality of water in the aquifer; expanding population and accompanying increase in urban needs; rising industrial requirements for processing water and, more important, for transport of wastes; aesthetic and fisheries demands for maintenance of a minimum flow at the mouth to preserve water quality in the estuary which receives substantial industrial discharge; and irrigation and urban demands from adjoining basins. In this situation water management requires some combination of three measures: (i) modification of the present fragmented institutional structure for regulation of water quality and allocation of water both in the valley and between valleys (see figure 8); (ii) improvement in irrigation technology which could release significant quantities of water for other uses; and (iii) flow regulation, with particular focus on run-off and erosion in the upper catchment and on the Puntilla del Viento dam with 50 million m^3 storage capacity on the main stem providing regulation for over 95 per cent of the potential use.

/(e) Caño

(e) Caño Mánamo 38/

Caño Mánamo is the most westerly distributary of the Orinoco delta. It gives its name to an extensive land reclamation programme in the upper Delta, in which the key structure is a diversion dam accross the Caño Mánamo near the point at which it divides from the main river (see map 9). The project is located in a humid tropical forest zone (annual rainfall 1,300 mm) subject to extensive flooding during five months of the year, and lies 500 km east of Caracas. The Orinoco Delta covers 2.25 million ha of which about 70,000 ha is estimated to be class I-III, suitable for intensive cropping. Almost all of this potential agricultural area (64,000 ha), plus about 120,000 ha which could be used under specialized management, lies within the zone protected from flooding by the diversion dam and the system of downstream dykes. The area protected is 410,000 ha and comprises the islands of Guara, Cocuina, Manamito, Macareo and Tucupita.

The project was undertaken by the CVG as part of its programme to intensify and develop agriculture in general within the region, also having in mind regional self-sufficiency in supply of food for the rapidly expanding urban population centred primarily on mining and processing of minerals. Studies of the Delta were initiated in 1959, and in 1965 a decision was made to proceed with development. The Caño Mánamo dam was finished in 1966 as a complete closure, but was modified the following year to allow flow regulation primarily to control salinity which had advanced 50 km in the distributaries affected. In 1968, as a result of continuing studies, Isla Guara (23,000 ha) was selected as a pilot area for agricultural development, and the area was officially placed under the jurisdiction of the CVG in the same year. In 1972 and inter-ministerial agreement was signed for development of the area subject to flood protection, to be co-ordinated by the CVG (see figure 9).

38/ This description of the case is based on a consulting report prepared for CEPAL/UNEP/ADEMA as part of the project: E. Buroz and J. Guevara, "Aprovechamiento de las Regiones Deltaicas: su Efecto sobre el Ambiente: Un Caso en el Delta del Río Orinoco", Caracas, November 1976.

/Map 9

Map 9

CAÑO MANAMO PROJECT: ORINOCO DELTA

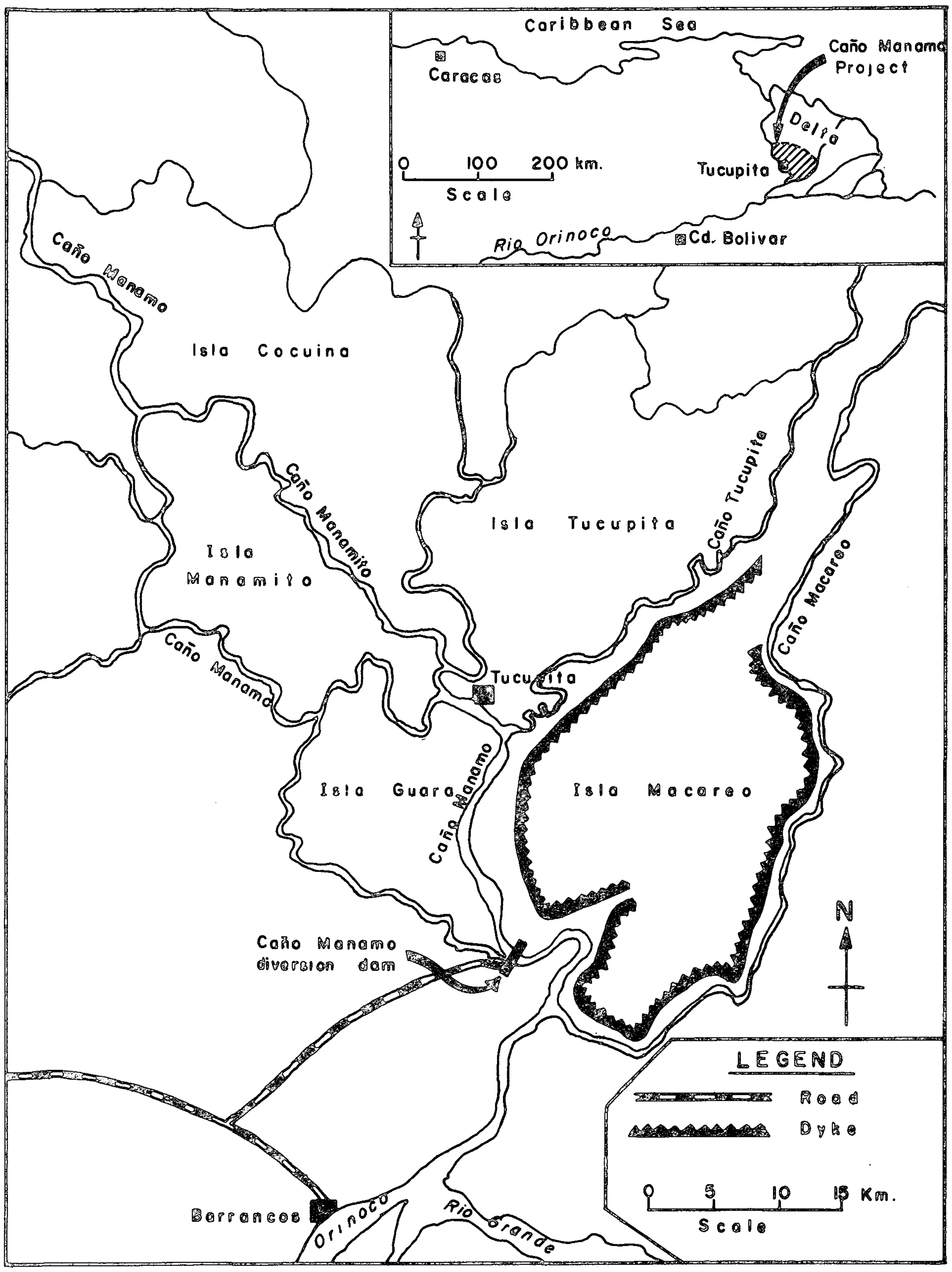
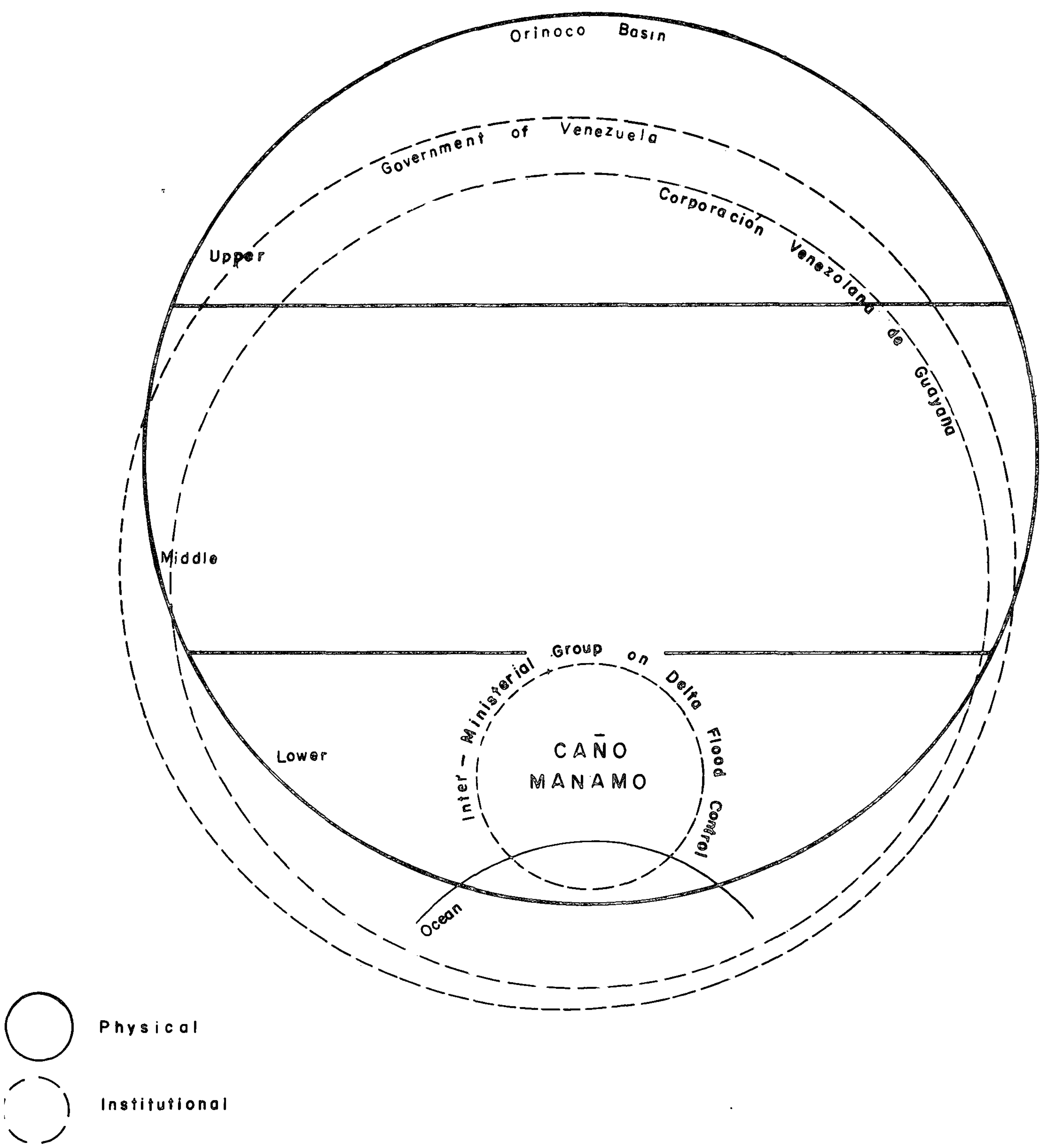


Figure 9

PHYSICAL AND INSTITUTIONAL BOUNDARIES RELATED TO THE CAÑO MANAMO PROJECT



In 1968 land use in Isla Guara was 700 ha in crops, 1,100 ha in intensive cattle production and 12,300 ha in extensive grazing. Potential was placed at 7,000 ha in crops, 4,600 ha in intensive and 7,000 ha in extensive cattle production, which could be achieved over a 20-year period through drainage. During the first seven years 2,200 ha and 2,500 ha were put into crop and intensive cattle production, respectively. However, in spite of the project employment in agriculture continued to decline in the Federal Amacuro Delta Territory between 1961 and 1971. In the course of development a number of difficulties were encountered in the management of relationships between water, soil and vegetation. The principal problems were: oxidation of soil with drainage and formation of acidity and a level of aluminium toxic to plants; subsidence of soils with loss of organic matter; and excessive burning of native pasture leading to loss of palatable species. It became apparent that careful regulation of the ground-water level was necessary to control acidity. This calls for construction of a tertiary drainage system; and in 1973, in a second-phase development of other islands, the polder system was adopted to enable greater control. Evidence of changes in the Delta outside the project has been more difficult to measure. Increased flows in other distributaries have affected vegetation, including mangroves, in some areas.

2. Areas of environmental concern

Environmental concern derives from uncertainties inherent in the disturbance of water-flow régimes for development purposes, which subsequently manifest themselves in the functioning of natural or socio-economic systems. One set of concerns is related to the properties of aquatic and related ecosystems, i.e., soil-water-flora-fauna relationships. Physical and chemical manifestations are per aps the most readily indetified - salinization of soil and water; oxidation, acidification, concretionary layering and the build-up of toxicity

/in soils;

in soils; flooding; erosion; and transport and deposition of sediments. Biological concerns include: soil and water nutrient balance affecting aquatic flora and fauna; threat to the biotic gene pool; and predator-disease relationships affecting humans, animals and plants.

A second set of concerns relates to the behaviour and values of the socio-cultural system, and may be manifested in: aesthetic factors; nutrition status; security with respect to physical danger, subsistence requirements or economic status; relationship between control and independence of individuals; and equity. Another area of concern, which cuts across both the above sets is the potential impact of unexpected migration into a region as a consequence of water development. This increased population may in itself give rise to environmental issues.

3. The setting of planning objectives and priorities

The environmental dimension is most likely to be introduced into management decisions on building and operating water regulation and diversion structures via planning and project appraisal and design. The question of defining objectives which touch on environmental areas of concern such as those reviewed above, shall be dealt with in terms of: planning; national and institutional goals; time horizons; equity; and the approach to risk and uncertainty.

(a) Planning

For the purposes of this discussion, planning is taken to involve the following sequence: (i) definition of the problem structure; (ii) specification of objectives, which requires quantification of uncertainties and the decision-maker's preferences;39/ (iii) specification and evaluation of alternatives; (iv) selection of

39/ The quantification of uncertainties requires that uncertainty about the results of particular actions must be specified and probability distributions attached to each outcome. In practise this step has rarely been applied. (See Annex C.)

/the optimal

the optimal alternative and integration into a unified programme; and (v) monitoring and evaluation of performance and feedback to management and project design. In the case of the Aconcagua valley, since no agency is, in effect, responsible for overall planning of water use, these steps could only partially be followed for segments of the system. In the other four cases, which were susceptible to this procedure, it would appear that steps (i) to (iv) were implicitly or explicitly taken but not rigorously applied. There was certainly no explicit quantification of uncertainties. However, step (v) was implemented to varying degrees in all of these cases. On Caño Mánamo the CVG set up an agricultural experimentation station which undertook extensive research on the soil problems and adaptation of plants and animals to the pre-drainage and post-drainage situations. It also monitored yields and management practices and carried out training programmes for potential settlers in the Orinoco delta. In the case of the Guri project, the CVG undertook or commissioned a series of studies dealing with limnology in the reservoir and the ecology of the Caroní basin. In San Lorenzo, the project office conducted surveys and undertook statistical reporting, and the World Bank sent in periodic evaluation missions. On the La Chontalpa project, the Grijalva Commission maintained extremely detailed records on land clearing, agricultural inputs, production, settlement, water levels, costs, etc. In addition, it set up an agricultural experimental station under contract to the National Institute for Agricultural Research (INIA) which was also responsible for training of colonists and management of agriculture on the project.

It may therefore be concluded that monitoring was efficiently executed and feedback has led to substantial management changes. In the case of Caño Mánamo, there was a rapid management response to the monitoring. The diversion dam was operated initially to reduce the average flow in the distributary from 300 m^3 to 60 m^3/second. After one year regulation was changed to permit a flow of 185 m^3/second during the wet season and 210 m^3/second during the dry season in an effort to control the freatic level and saline intrusion in the river.

/In addition,

In addition, tertiary drainage canals and polders were introduced as a means of gaining better control over the water level. In San Lorenzo, the feedback set in train an extensive sequence of engineering works for drainage, new irrigation, ground water exploitation, increased water storage and inter-basin transfers already described. In the case of the Guri project, increasing unease about the possible risks attendant on agricultural development in the Caroní (i.e., some ex-post assessment of uncertainties from step (ii)), in combination with on-going research, led the authorities to close the catchment area to loggers, colonists and land developers. On La Chontalpa, modification of management plans were more a consequence of economic factors than anything else. Market constraints dictated that the area planned for bananas should be reduced by 80 per cent, and the planned area for other crops by 30 per cent, to be replaced by pasture.

In spite of the demonstrated flexibility in management, particularly in modifying engineering designs, it is not clear that there has been a systematic accumulation of information aimed at identifying and elucidating key issues which would reduce uncertainties and provide inputs for the planning and design of new projects. In addition, there is a fundamental question of avoiding catastrophe, for which a gradual and progressive feedback of information to adjust decisions may be inadequate. Thus, resource managers may experience increasing anxiety about the feasibility of taking remedial measures.

(b) National and institutional goals

National development and water resource planning are beyond the scope of this enquiry. However, there is a question of the degree to which regional or river basin authorities and other water management institutions receive clear guidelines, or criteria by which to assess goals, from agencies engaged in such planning. In the five cases discussed above, some broad national goals are discernible: employment, equity (agrarian reform) and improved balance of payments (export expansion) in San Lorenzo; regional decentralization, establishment of territorial sovereignty and consolidation of rural population in an area with a history of declining population in Caño Mánamo; reduction

/of rural

of rural population pressure on land in the highlands (transmigration), collectivization of ejidos and export expansion in La Chontalpa; increased efficiency and output from irrigated agriculture to expand exports and reduce consumer prices in the Aconcagua case; and in the case of Guri, massive power generation as a basis for nationwide industrialization and processing of mineral resources in the region. The thrust behind the Guri and Caño Mánamo projects was to furnish support, in the form of power and food respectively, for a regional development pole around Ciudad Guayana.

While general objectives such as income distribution, employment, production and national security dictate where public resources will be invested in the intensification of water use, indications from these cases suggest that the specific objectives and project design, which determine the extent to which environmental concerns are taken into account, are established primarily by the executing institutions. It is therefore the institutional goals and the planning and project design capability of these entities which appear to play a decisive role in setting the planning and management goals in question.

The case experience suggests that water management programmes have been founded on a narrow vision of objectives and processes, whereby regulation and use of water may promote economic and social development. Agricultural production and power generation have been regarded as overriding objectives. This aspect has been further stressed in the case of the three land reclamation projects (La Chontalpa, Caño Mánamo and San Lorenzo) by the relatively high unit costs and the desire to show satisfactory economic returns. For example, in La Chontalpa no effort was spared to introduce the most advanced land-clearing and agricultural technology to bring the project into full production rapidly and achieve high yields in order to justify project investments of over 1,000 dollars per ha. At the same time, the project had as a specific objective a five-fold increase in the economic status of about 6,300 poor rural families (4,700 who lived on the project area and 1,600 to be settled from other areas). The San Lorenzo project had a similar objective - settlement of 4,000 relatively

/poor rural

poor rural families. In contrast, a primary objective of the CVG in Caño Mánamo was to secure a local supply of food for the growing industrial urban centres within the region administered by the Corporation, along with benefits to the rural population. Thus, the decision criteria tended to stress regional self-sufficiency with somewhat less emphasis on the raised economic and social status of the potential food producers or consumers as a result of the project. In the Aconcagua basin the primary objective of water management appears to have been improvement of water supply to existing farmers, with little consideration of the potential increase in demands on water by other users in the valley - urban and industrial supply, and transport of residuals from urban, industrial and mining sources.

The foregoing discussion should in no way be interpreted as implying that short-run production goals are unimportant, or that resource management agencies are always unaware of long-run potential consequences. The SRH in Mexico and the CVG in Venezuela, for example, have sponsored extensive research on both physical and social aspects of intensifying water and land use. The potential conflict between short- and long-run goals will not disappear with better planning; it will merely become more explicit in decision-making.

There is some indication that on occasion objectives are dominated by what might be termed a "construction syndrome" where, although a variety of objectives are proclaimed, the driving force is the building of major engineering works. The distinction is not always clearly drawn between means (regulation structures), intermediate goals (production of food or electricity and environmental quality standards) and final objectives in the form of benefits and costs to society. Consideration of the ultimate beneficiaries of the decision process raises the question of distribution objectives both over time and within society at any point in time.

/(c) The

(c) The time horizon

A critical element in the setting of objectives, which centres on the issue of resource conservation and development, is the intertemporal flow of benefits expected to result from diversion or regulation of water systems and management of associated resources. There is a question of the extent to which objectives are oriented towards maximum short-run utility on the one hand and long-term goals on the other. The issue is well illustrated in the decision faced by the CVG in the management of the Guri reservoir and the upstream catchment area. The project itself was based exclusively on hydroelectric power generation, and even allowing for upstream development, power is likely to be the overwhelming source of benefits from renewable resource development in the Caroní basin. Over a 50-year period the net present value (NPV) of the stream-of-power benefits, discounted at 8 per cent, under a wide range of alternative levels of forestry and agricultural development in the basin, accounts for 97.9 to 99.4 per cent of total net benefits (see Annex A). On the extreme assumption of rapid upstream forest and agricultural exploitation, leading to massive erosion and depletion of about 10 million ha over the period, there would be no impact on power output until year 23, when capacity would be reduced to 50 per cent. In year 33, capacity would be cut further to 30 per cent, and in year 50 the generating plant would be closed. With no upstream agriculture, operating capacity would be unaffected for about 300 years. The trade-off for this loss of generating capacity, equivalent to 60 million dollars (NPV), is a gain of 50 million dollars (NPV) from agriculture. The debit side must also include the replacement cost of the generating capacity lost between years 23 and 50, estimated at about 80 million dollars (NPV). In these circumstances, the decision on upstream conservation is clear, and forest income of 20 million dollars (NPV) should be foregone if this is a necessary condition.

/However, the

However, the decision is heavily influenced by four factors: (i) the time horizon adopted; (ii) the discount applied; (iii) assumptions made about agricultural productivity, technology and ability of the region to compete with other areas in Venezuela; and (iv) the importance assigned to sustained yield.

If the time horizon, or project life, is reduced to 20 years for the purposes of project analysis, there will evidently be no loss of generating capacity. Furthermore, unless it was explicitly recognized that the generating capacity of the project would be of limited duration thereafter, there would be no trade-off against agricultural benefits obtained during the first 20 years. In addition, if high discount rates in the order of 15 per cent (which may approach a market rate) are applied in project appraisal, this would encourage management to accelerate forestry and agricultural development in the early years, assuming no market constraints. In a stream of benefits discounted at 15 per cent a quintal of corn with a present value of 10 dollars becomes 5 dollars in year 5 and 0.01 dollars in year 50. The same relationship holds for a kWh of power, the only difference being the absence of an option to produce more in the early years and less later.

The question of agricultural productivity would further complicate the decision if it was probable that benefits might be higher and sustained for longer periods or even that a technology might evolve which would reduce the rate of erosion. Thus one could conceive of a situation in which agricultural benefits were sufficiently high to offset the loss of generating capacity: the higher the discount rate, the more likely such a conclusion. The competitiveness of agriculture in a region such as the Caroní is in large measure determined by national policy affecting such questions as tariffs, transport and input and product prices. All these affect the long-run expectations about benefits which might be derived from agriculture (or forestry).

The final element, sustained yield, cuts across the three other elements. It automatically involves a long-term time horizon - certainly in excess of 50 years. If the concept of NPV is to be applied as a

/criteria for

criteria for management of the project, including the catchment area, it becomes necessary to adopt a social discount rate substantially lower than 15 per cent or 8 per cent. The probabilities and conditions would have to be considered under which agriculture might be developed in such a way that the rate of erosion would be substantially reduced.

It may be concluded from the foregoing discussion that in economic analysis the concepts of "conservation" and "depletion" carry no connotation of efficiency or waste respectively: either one may yield the most favourable cost-benefit ratio, since the measure of efficiency is gained from the discounted stream of expected private and social costs associated with a shift in resource use in one direction or the other. If an objective concerns the welfare of future generations, then value judgements must inevitably be introduced in setting conservation policy; in other words, there are no rigorous procedures for evaluating long-term time horizons. Where the environment is to be included as a variable in water management, there is little alternative to the use of extended planning periods. Ecological processes, reaction to disturbance, soil formation or community stability in general require well over a hundred years for completion.

In the Guri case, the authorities have imposed a conservation measure prohibiting further logging and agricultural development in the Caroní basin. In so doing they have opted for a distribution of benefits over generations rather than a depletion policy which may yield short-run gains, and possibly even improve income distribution, for the current generation.

(d) Equity

Much of the literature on environment since the Stockholm Conference has focused on the question of the international and intra-national distributive consequences of the current management

/of natural

of natural resources, and on the need for structural changes to yield a more equitable distribution of consumption and improved environmental protection in the interests of providing for the long-run needs of mankind.40/

National policy and the political commitment to redistribution of economic wealth and political power sets the general framework for equity objectives. However, it may be maintained that water planners and managers cannot escape some responsibility for the distributional consequences of alternative management scenarios, and a strong case can be made for having such aspects explicitly introduced into the objectives.

From the standpoint of who benefits and who pays, the cases illustrate two classes of equity issues - those associated with some form of degradation of the natural ecosystem; and those related to the way development of water and related resources is administered. In the first category, the issues centre on the failure of redistribution benefits to materialize for the intended beneficiary groups when these are selected from among the poorer strata in society. In the San Lorenzo case, for example, the reduction in yield on 4,000 ha and the abandonment of another 4,000 ha on the project, due to problems of salinity, drainage and excessive water requirements, clearly imposed social and economic costs on the beneficiaries. Since the latter were formerly landless peasants settled under the agrarian reform programme, these costs detracted from the distributional goals of the project. The situation is similar in Caño Mánamo, where there are indications that expected economic gains to the relatively poor farmers benefited by the project have not been as great as expected, due to chain effects which followed the lowering of the water table.

40/ See: "Declaración de Cocoyoc", op.cit., and "Catastrophe or New Society? The Latin American World Model", A.O. Herrera, et.al., IDRC-064e, Ottawa, June, 1976.

A variation of this issue is the typical upstream-downstream conflict, when benefits derive to those upstream at a cost to downstream users. Water and land management, stemming from the successive derivations and regulation of water in the Chira-Piura basin, has lowered agricultural productivity in the middle and lower Piura valley. The equity consequences depend on the economic status of those affected. It is evident that such cases are not "Pareto-optimal" as one group benefits at the expense of another. Clearly, the Pareto criterion need not be met, since in fact redistribution must automatically prejudice higher income groups; but it is unlikely that one would plan to improve equity by designing projects to reduce the productivity and income of wealthy downstream users.

The displacement of people by reservoirs presents a wholly different case of costs arising from the degradation of an ecosystem. In unexploited tropical areas like Guri, or arid regions such as those flooded by the Poechos or Puntilla del Viento dams, resettlement issues hardly arise. However, in some humid and semi-humid areas where dams are built for flood control or hydroelectric purposes, the question of displacement of population takes on significant proportions: for example, 22,000 people from the 52,000 ha flooded by the Miguel Aleman in the Papaloapan basin of Mexico; 5,000 in the 150,000 ha flooded by the Brokopondo hydroelectric project in Surinam, and 20,000 in 30,000 ha of the Angostura reservoir in the upper Grijalva basin. On the surface it would appear that the question can readily be solved through adequate indemnization. Experience suggests that there are two principal issues. The first is economic and ecological in nature, where campesinos move their farming operations from the flats bordering the river, which are flooded by it, to the adjacent uplands. This has occurred with many of the 3,000-4,000 families displaced by the Angostura dam. Here the concern is with the threatened loss of timber resources due to spontaneous colonization, and eventual downstream consequences of accelerated runoff and erosion (flooding and sedimentation). The second is social in nature, in the form of the anxiety and insecurity imposed on those families who are neither equipped nor disposed to start anew in a strange locale. More than 3,000 Masateca families found themselves in this position following the flooding behind the Miguel Aleman Dan in 1954. The Papaloapan Commission found itself obliged to engage in a massive resettlement programme which lasted seven years - a process which was painful for all concerned.41/

Distributional effects which stem from the way development is administered are probably the more important of the two classes of equity issues. The San Lorenzo project was specifically set up as a part of the agrarian reform programme. However, since land expropriation, and settlement did not take place until 7 years after completion of the Quiroz diversion, the larger land-owners earned high profits from increased yields, and they expanded irrigation on their lands in the interim. As a result, considerable resistance to the agrarian reform developed, which effectively slowed the whole process of settlement by landless campesinos during the period 1964-1969, thereby detracting from the distributional impact. The benefits received by the intended beneficiaries were further reduced by the inability of the project administration to provide the necessary credit and technical assistance to enable the colonists fully to exploit their lands and cope with the problems of salinity and drainage as they arose.

The distributional consequences of the La Chontalpa project were social rather than economic. Although the project has only achieved 60 per cent of its production goal the income of the beneficiaries has tripled. The primary issue is the social cost of the switch from individual management of a shifting agriculture enterprise with 3-5 ha in production to a collective, technology-intensive system with outside management and the obligation to live in an urban centre.

41/ See: J. Ballesteros, et.al., "La Colonización del Papaloapan", Editorial Imprenta Casas S.A., Mexico City, 1970, pp. 31-127.

/In addition,

In addition, there is evidence that the changed consumption patterns have resulted in a deterioration in the nutritional status of children despite economic gains.

A common feature of the above cases is that the distributional consequences of water development, which frequently detract from equity objectives, largely result from unforeseen events for which no provision has been made.

(e) Risk aversion

Examination of the cases yields useful insights on how the responsible institutions have weighted risk and uncertainty among their objectives. With the benefit of hindsight, it would appear that project designers are often unduly optimistic about the probability of unplanned events which may alter project performance; and about the technical and administrative capability of the project authority to correct such events if they should arise.

In the case of Caño Mánamo, early studies raised the question of the complexity of soil management without investigating the physical and chemical process of potential damage. Uncertainty about the behaviour of this component of the system was apparently not considered sufficient to warrant further investigation prior to the construction of the diversion dam across the entrance of Caño Mánamo. The same was true of the *ex ante* assessment of the difficult relationship between geology and hydrogeology and the altered pattern of surface and natural conditions for drainage in the San Lorenzo project. In La Chontalpa a series of unplanned social and market phenomena caused modifications in the performance and execution of the project. It seems that the project designs did not explicitly recognize any of these uncertainties, or include steps to avoid the potential risks.

4. Issues in the incorporation of the environmental dimension in alternative strategy formulation

This section discusses some of the principal issues which cut across the specific areas of environmental concern and the objectives of water management discussed above, and which enter into the planning, design and management of water systems in cases where regulation

/structures are

structures are crucial instruments in development. These issues are closely interrelated, but for purposes of presentation they are grouped in five major areas - system boundaries, chain effects, irreversibility, foreclosure of options and controlability.

(a) System boundaries

The limits of the water system subject to planning or operation should be specified as a starting point for addressing the environmental management question. The bounds of a system may be defined spatially and functionally.

(i) Physical boundaries. A resource management system may be characterized by three principal kinds of spatial boundary: the bio-physical or natural ecosystem boundary; the jurisdictional limits of institutions; and the bounds of the socio-economic system. The ecosystem and institutional boundaries in the five cases considered were shown in figures 3, 5, 6, 8 and 9.

The watershed sets the boundary of water, nutrient and chemical flows and is usually associated with a low exchange of biological elements. It is important in the case of major flow regulation structures whose functioning will both be affected by upstream management and affect downstream use of water. In the case of the Guri reservoir the reduction of storage due to sedimentation and changes in flow régimes for power generation are related to watershed management affecting vegetative cover and associated runoff, percolation and erosion. There is likewise the potential long-run impact on the operation of the San Lorenzo project and the whole Chira-Piura system from the accelerated exploitation of the vegetation in the catchment area for wood charcoal to meet the fuel needs of the increased population attracted by the economic opportunities created by more and better irrigation. The La Chontalpa project is an integral part of the Grijalva-Tonalá flood plain protected by the Netzahualcóyotl dam, and thus by definition management affecting storage and flow in the upper basin is crucial to the project. The relevance of the river-basin boundary is reinforced in the cases of the Aconcagua valley and San Lorenzo by the downstream relationships. In the Aconcagua all

/productive uses

productive uses of water, except limited power generation and waste disposal from the Andina copper mine, are located below the Puntilla del Viento dam (see again figure 7). In the case of San Lorenzo, management of water and associated colonization and agriculture has led to increased salinization in irrigated areas on the project itself and in the middle and lower Piura valley.

While the river basin appears to be the most appropriate boundary for the Guri, San Lorenzo, Aconcagua and La Chontalpa cases, Caño Mánamo illustrates an ecosystem, the Orinoco delta which is smaller than a river basin. However, this is probably exceptional and it is more common to move from the river basin ecosystem towards multi-basin systems. Three of the five cases examined involved inter-basin transfers of water.42/ In the Aconcagua there are plans to transfer water for irrigation into two adjacent valleys and for urban supply into a third (see again figure 7). In San Lorenzo and Chira-Piura the volume transferred from the Chira to the Piura basin is almost triple the annual flow of the Piura. The La Chontalpa case is the reverse: natural transfer between the Grijalva and Tonalá basins during the flood season has been reduced by the flood regulation structures.

It is axiomatic that institutional boundaries are critical to water management, since public and private entities are responsible for setting management objectives and controlling social and economic activities. However, such boundaries are often difficult to identify, since most water regulation activities are governed by a complex of overlapping and hierarchic institutions, and it is not always easy to distinguish the more important boundaries in terms of the effectiveness and power of the institutions with the greatest effects on the environmental areas of concern.

In San Lorenzo there was no integrated planning or management authority for the Chira-Piura basin. A semi-autonomous project

42/ In the study as a whole, seven of the nine cases involve inter-basin transfers.

/authority was

authority was set up within the Ministry of Agriculture, with prime responsibility delegated to the irrigation department (Directorate of Water). It had no powers outside the site of the San Lorenzo reservoir, diversion canal and 45,000 ha irrigation zone.

The La Chontalpa project exemplifies a well-defined hierarchic system of institutions (see again figure 3). Land ownership and exploitation organized into 22 ejidos and management is now in the hands of a trust whose directorate contains representatives named by the union of ejidos, the State Government of Tabasco and the Grijalva Commission. The planning and development of the project from 1961 to 1974 was the sole responsibility of the Grijalva Commission, which co-ordinated the activities of several other national agencies such as the Secretariat of Agriculture and the Federal Power Commission.

In contrast, management of the Guri and Caño Mánamo projects is essentially single-tiered; the CVG has full authority and responsibility for planning, construction and operation.

A totally different model is the Aconcagua valley, where management is handled by a series of loosely interacting institutions and the distinction between water users and managers is not always clear. Although the National Water Recources Directorate is empowered to co-ordinate the use and development of water in the basin, it does not, in fact, exercise this power. Thus within the basin a number of public and private agencies operate largely independently. A private electricity company and the State Copper Corporation (CODELCO) use the upper basin for power generation and waste discharge respectively. Exploration of ground water is handled by the National Development Corporation (CORFO). New irrigation structures such as the proposed Puntilla del Viento dam are built and operated by the national Directorate of Irrigation within the Ministry of Public Works. The great majority of the irrigation works in the middle and lower valley are owned and operated by four user associations. In addition, there are several municipal authorities which use the river for domestic supply and waste transport.

/(ii) Functional

(ii) Functional limits of the system. Clearly, within the physical boundaries, the biological, social and economic functions which may or may not be considered for planning and management purposes, are as important as the spatial dimension in specifying the limits of a water management system. In practice the extent to which such aspects are incorporated will depend on the institutions' concern and technical capability for dealing with the behaviour of social, political, economic and bio-physical components within their geographic sphere of responsibility.

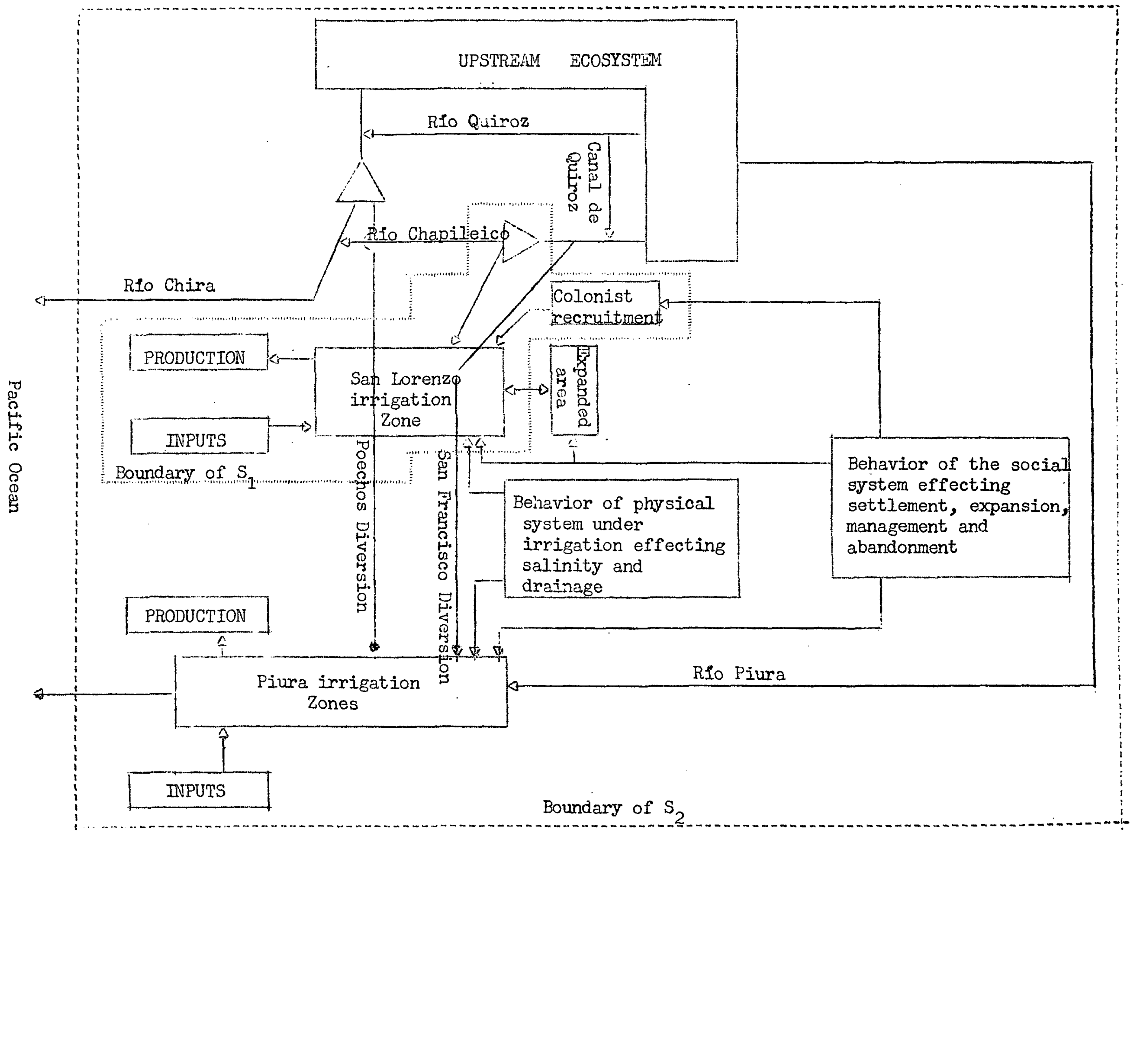
The relationships between the different boundaries may be illustrated by the San Lorenzo and Guri cases.

- San Lorenzo project. Figure 4 indicates the more important ecosystem and institutional boundaries. Figure 10 suggests some of the connexions between the physical limits of the system and some of the functional bio-physical and social components.

The project was basically conceived as the construction of hydraulic works to permit irrigation of 20,000 ha (subsequently increased to 45,000 ha) in which colonization and land reform were regarded as necessary elements. The components of the system as originally designed are shown within s_1 in figure 10, components of the larger system which have been progressively incorporated as the various environmental impacts have become apparent lie within s_2. Fifteen years' experience suggest that if the project had encompassed s_2 rather than s_1 a number of costly economic and social consequences might have been avoided.

/Figure 10

Figure 10
TWO INTERPRETATIONS OF BOUNDARIES OF THE SAN LORENZO SYSTEM AND ITS ENVIRONMENTS



/Failure to

Failure to take account of the nature of the physical system (topography, permeable saline sub-strata and impermeable sub-strata) and its relationship to cropping and irrigation water management resulted in salinization and a continuous drop in agricultural productivity on 4,000 ha in the project itself and in additional irrigated areas downstream in the middle and lower Piura valley. Insufficient information on the hydrology of the Chipillico-Piura systems, combined with increasing pressure on water due to the settlement and cropping patterns adopted, resulted in reduced flow in the lower Piura. As a result of water shortage, 8,500 ha with irrigation infrastructure was not put into production. An inadequate understanding of social behaviour [affecting irrigation management, exploitation of the upstream ecosystem, and decisions on expansion of settlement beyond the project limits and finally abandonment of farms] contributed to: uncontrolled settlement and irrigation of 26,000 ha outside the project, which aggravated a situation where water was already insufficient for the project area;43/ agricultural management unable to adjust to the changing situation with respect to water availability, salinity and waterlogging; over-cutting of vegetation and over-grazing of the upstream ecosystem by settlers attracted to the region by the project; and, a high turn-over of colonists and eventual abandonment of 4,000 ha on the project, together with its spontaneous extension.

While it would have been difficult to have foreseen the various problems which arose from this sequence of events, the experience does raise a legitimate question about how far one should try to expand the bounds of a system in the initial design of a project. At the same time the issue remains whether certain of the components such as

43/ Due to expectations of increased water availability over the 20-year period 1948/1967 there was a spontaneous increase in irrigation of 15,000 ha in the area directly benefited by the engineering works (around the periphery of San Lorenzo and in the middle and lower Piura). An indirect effect was the irrigation of an additional 11,000 ha in the upper Piura based on the expectation that downstream demands could be met by an inter-basin transfer.

the spontaneous expansion of irrigation are, in fact, manageable even with extensive prior knowledge. Where it is probable that unmanageable situations will arise, the project design and even the desirability of undertaking the project should be reassessed.

- The Guri project. This case illustrates the same set of issues but in a wholly different context. Unlike the San Lorenzo, La Chontalpa and Aconcagua cases, where water use has been intensified primarily for agricultural purposes and in areas which have a long history of human occupation, the Guri project was initiated solely for large-scale hydroelectric power generation in a humid tropical forest ecosystem which was virtually uninhabited. The physical and institutional boundaries are readily definable, as shown in figure 6. However, the functioning of the components within these limits remains an unknown. The sequence of events in the development of the system has not yet unfolded sufficiently to yield insights on the behaviour of these components. The case study (see Annex A) deals with the ecological relationships between vegetative cover, erosion and sedimentation and flow régime in the catchment area of the Guri reservoir which may affect the long-run output of electric power. Other management questions also bear on the short-run and long-run flow of other products and services, and enter into the specification of the functional bounds of the system. These include the advisability of permitting major changes in the watershed vegetation uncertainties about potential causes of change and probabilities of such change actually taking place, less disruptive management alternatives and possible downstream effects.

The above discussion illustrates the importance of careful specification of boundaries and system components for water resource planning and management in order to incorporate environmental dimensions.

(b) Chain effects

The interaction between functional components within the system, subject to the boundary conditions discussed above, form the basis for chain effects which can have a significant impact on the final outcome of intervention to develop and intensify water use. The tracing of this potential sequence is among the critical elements in the assessment of environmental impact (see Annex C). Many of the significant first-round linkages are conceptually straightforward. For example, reliable estimates of probability distributions of downstream regulation from structures such as the Guri, Netzahualcóyotl, Puntilla del Viento and San Lorenzo dams, were obtained from the relationship between storage and simulated flows and withdrawals. However, the ways in which some of the consequences of increased or reduced flows occur are often complex and little understood, and predictions of impact contain a high degree of uncertainty.

The experience of La Chontalpa and Caño Mánamo illustrates the effects of changes in the flood régime on the physical and chemical properties of the soil and flora and fauna in delta ecosystems. In both cases, the lowering of the water table led to the hardening and cracking of the soil, with disruption of root structures. In Caño Mánamo the reduced moisture in the soil also led to some surface subsidence and permitted the formation of acid sulphate conditions and consequent aluminium toxicity, so that agriculture was abandoned in some areas. In addition, in some of the humid savanna areas, suited to cattle production, the lowered water table led to brush invations. Reduced flows in the Aconcagua case (due to high consumption of water in irrigated agriculture) and in Caño Mánamo (due to diversion) have led to salt-water intrusion. In Caño Mánamo saline water entered 50 km up a number of delta distributaries affecting agriculture which used water siphoned from the river for irrigation in the dry season. In the Aconcagua this estuary intrusion may eventually affect aquifers used for domestic water supply. Low flows at river mouths whether caused by flood control (La Chontalpa and Caño Mánamo) or high consumption (Aconcagua) can also affect fish productivity through changes in water levels, water nutrients, aquatic flora and fauna and salinity or through reduced dilution of industrial and urban wastes. This latter situation applies to the Aconcagua estuary where it appears that insufficient dilution of industrial discharge into the estuary has played a role in reducing coastal fisheries for several kms to the north of the river mouth.

/Chain effects

Chain effects in the Chira-Piura basin, as a result of changes in the flow régime and use of water, took the form of salinity and water logging both in the San Lorenzo project itself and in irrigated areas of the middle and lower Piura. A further important factor which may affect San Lorenzo, is the development of pest and disease problems following the irrigation of new lands in relatively isolated arid and semi-arid areas. Increased incidence of malaria has been reported in the region, which may well be due to the enlargement of swamp areas caused by the increased irrigation overflow. Special microclimates of the San Lorenzo type also favour monocultures such as cotton or rice which may have limited genetic resistance and carry inherent risks. A chain reaction may be set in motion whereby pest build-up is encouraged by the trend towards well-fertilized monoculture. The response is often a massive use of pesticides which in turn destroys natural control agents and elicits pest resistance. The end result may be a dramatic crop loss, as occurred in the Cañete Valley in Peru.44/ A similar situation could occur in the Aconcagua valley where the apparent hydrologic stability provided by the Puntilla del Viento dam could encourage fruit monoculture which might have limited resilience to pest attack. The role of the different contributing factors in these instances is not yet clear.45/

The foregoing ecological chain effects are frequently amplified by individual or institutional responses to the new physical conditions. On Caño Mánamo cattle raisers on the humid savanna areas protected from flooding were inadequately prepared to adapt their management to the new situation. There was over-grazing which resulted in loss of the most palatable species. Also, the dryer conditions permitted burning of the native pasture which initially yield fresh growth for cattle, but repeated burning further reduced the palatable vegetation.

44/ See: R.F. Smith, "The New and the Old in Pest Control", Proc. Accad. Nazion dei Lincei, Nº 366, 1969, pp. 21-30.

45/ R.F. Smith, "The Impact of the Green Revolution on Plant Protection in Tropical and Sub-tropical Areas", Bulletin of American Entomological Society, Nº 18, 1972, pp. 7-14.

/A different

A different type of chain effect is illustrated by the sequence of development in the Caroní basin following the opening up of the area by the Guri dam. Access provided by the road to the dam, and subsequently by the reservoir, enabled exploitation of timber in the upper basin by enterprises which built their own access roads. These roads were subsequently followed by spontaneous colonists and land developers who started to clear and burn the forest for agriculture. Indications are that the physical conditions of much of the area can only sustain viable crop production for a very limited period, and that the forest may not regenerate thereafter. This potential sequence of events, was not taken into account by the designers of the dam; the runoff and flow régimes were calculated on the assumption that the catchment area would remain in forest.

The economic consequences of a chain effect is well illustrated by experience of the Brokopondo dam in Surinam. The dam was built in the early 1960s and the 150,000 ha reservoir was filled by February 1964. Almost immediately water hyacinth, which formally had been rare in the region, started to cover the reservoir surface: by December 1964 5,000 ha were covered; 17,900 ha by June 1965; and 41,200 ha by April 1966. At that time a herbicide control programme was initiated at an annual cost of 250,000 dollars.46/ No estimates are available of possible second-round chain effects stemming from the use of herbicides, such as changes in fishery, other aquatic flora or evapotranspiration rates.47/ Similar experiences are reported from Mexico; ten reservoirs have suffered hyacinth invasion ranging from 5 to 100 per cent of the surface area, the most recent case being the 30,000 ha Angostura reservoir.48/

46/ See: P. Leentvaar, "Lake Brokopondo" in: Man-made Lakes: Their Problems and Environmental Effects, W.C. Ackermann, et.al., (Eds.), William Byrd Press, Richmond, 1973, pp. 186-196.

47/ See: J.P. Milton, "The Ecological Effects of Major Engineering Projects", in: The Use of Ecological Guidelines for Development of the American Humid Tropics, IUCN Publications new series, Nº 31, Morges, 1975.

48/ "Plan Nacional Hidráulico 1975", Segunda Parte, Secretaría de Recursos Hidráulicos, Mexico City, 1976, pp. 179-186.

/Finally there

Finally there is the issue of positive chain effects such as fishery development and tourism in reservoirs, or increased productivity of deltas or estuaries due to accelerated nutrient flows as a result of erosion.49/ The San Lorenzo project illustrates two distinct types of such effects. The first is the complementarity between irrigated agriculture, notably forage and feed by-products from cotton and rice, and dryland livestock production which should enable more efficient use of the rangeland. The second is the training of technicians and resource managers provided by the project. At present, virtually all the senior specialists in irrigation and colonization in Peru gained their experience on the project between 1954 and 1970.50/

(c) Irreversibility

Chain effects from water regulation and management of related resources which have led to irreversible situations are difficult to document, at least from the cases examined (see Annex C for a theoretical treatment of potential consequences). The discussion here is restricted to irreversible changes in the physical and biological characteristics of the system.

One aspect of the issue is the deliberate loss of potentially valuable resources as a consequence of the development process, e.g., the flooding of 425,000 ha of forest land by the Guri reservoir, clearance of xerophytic vegetation from 45,000 ha for the San Lorenzo project, changed vegetation on Caño Mánamo or destruction of 35,000 ha of virgin tropical forest on La Chontalpa. In this instance the choice is straightforward: destruction of the resource, or cancellation of the project. If there is reason to believe that such resources are

49/ The concept of positive environmental effects raises a semantic question. On one hand positive effects such as fisheries or recreation may be included among the objectives of a dam, along with irrigation or hydroelectric power. On the other hand, if an anthropocentric view is taken there exists no criteria by which to evaluate a positive effect on the environment.

50/ See: A.O. Hirschman, "Development Projects Observed", The Brookings Institution, Washington D.C., 1970, p. 60.

/irreplaceable and

irreplaceable and constitute a gene pool of species which, through some future technological innovation, might make valuable future contributions to human welfare, then there can be little doubt that the project should be reconsidered. In the four cases mentioned above there appears to be no reason for rejecting or changing the projects on such grounds.

A second, more fundamental, aspect of the issue of irreversibility concerns the resilience of the ecosystem where the productivity of the project itself may be at stake. There is some evidence that drainage on the Caño Mánamo project has resulted in oxidation and acidification of soils in some areas to the point that it would be difficult to rehabilitate them for agricultural use. The Guri watershed offers another example of potentially irreversible change: experience suggests that removal of the forest cover followed by three or four years in crops may result in virtually permanent deterioration of the soil, which will be unable to sustain crops, pasture or forest.

Aside from permanent biological changes, physical changes may be effectively irreversible because of the cost of rectifying them. For example, the Anchicaya hydroelectric project in Colombia, completed in 1975, lost 70 per cent of its 5 million m^3 reservoir storage capacity in its first ten years of operation due to sedimentation. It was estimated that storage reduction had risen to 80 per cent by 1967. The accelerated sedimentation has been attributed largely to spontaneous settlement in the upper Anchicaya watershed following construction of the Simón Bolívar highway through the region. The road itself also contributed to instability of soils and landslides. A flood in 1950 carried an estimated 200,000 m^3 of material into the reservoir and swamped the power house.51/ In a strict engineering sense the loss of flow-regulating capacity, and eventually the power-generating capacity,

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51/ See: R.N. Allen, "The Anchicaya Hydroelectric Project in Colombia: Design and Sedimentation Problems", in: M.T. Farvar and J.P. Milton (Eds.), The Careless Technology: Ecology and International Development, Doubleday and Co., Natural History Press, Garden City, 1972, pp. 318-342.

/is not

is not irreversible. The sediments could be pumped out, but there are the practical questions of the cost in money and energy terms and the potential downstream consequences. If pumping is ruled out, it must be asked whether the project could have been designed and managed to have at least attenuated the damage to the bio-physical system, thus lengthening the life of the project; and what are the marginal costs and benefits associated with alternative management scenarios for the system in order to achieve different distributions of benefits over different time periods.

(d) Foreclosure of options

The consequence of negative chain effects and the development of irreversible situations is the progressive foreclosure of management options leaving the decision-maker with less and less room for manoeuvre.

The sequential development of the Chira-Piura basin provides some insight into one form of option foreclosure. Until 1954 irrigation in the region was based on run-of-the-river diversion. The Piura flow (an average 675 million m^3/year) was fully utilized and the bulk of the Chira flow (an average 3,470 million m^3/year) was unutilized. The diversion of 600 million m^3 annually from the Chira to the Piura basin on completion of the Quiroz-San Francisco canal in 1954 clearly left ample margin for further diversion. Water supplied by this diversion proved insufficient to meet its objectives, i.e., improved irrigation on 31,000 ha in the middle Piura and 20,000 ha of new irrigation. Accordingly, a regulation dam was built in 1957 on the Chipillico, a tributary of the Chira, with a further diversion capacity of 50 m^3 per second. Under this scheme the area planned for new irrigation was increased from 20,000 ha to 45,000 ha (San Lorenzo project) and the canal system was completed in 1959. Spontaneous expansion of irrigation, salinization and high-water use rendered the second stage insufficient to meet the demand and correct the salinity problem. Consequently a third regulation and inter-basin diversion scheme was initiated. This called for a regulation dam (Poechos with 1,000 million m^3 storage) on the main stem of the Chira, diversion of 1,200 million m^3 to the Piura basin, new irrigation on 36,000 ha increase in the capacity of the

/San Lorenzo

San Lorenzo reservoir from 254 to 312 million m^3, improved drainage for 8,000 ha in San Lorenzo and 30,000 ha in Chira, and development of underground water for 35,000 ha already partially irrigated in the upper Piura.

These successive adaptations have been made to cope with demand uncertainties as they unfolded. Thus the water managers have found themselves in the position of reacting to a series of uncontrolled events. It is fortunate that at the outset they were in a position to make step-by-step modifications by increasing inter-basin diversions. Without this option, environmental, economic and social problems might have been considerable. In such situations, if uncontrolled events continue to distort the relationship between demand projections and reality, a stage is reached where the remaining alternative can only be implemented with great difficulty. In a technical sense inter-basin transfer is always an option.52/ In San Lorenzo, the next stage would require water transfer from the Huancabamba river in the Amazon watershed. The exercise of this option may be constrained by economic and financial considerations. Aside from economic and financial viability there is the question of the scale and indivisibility of such an ambitious project.

The Aconcagua case suggests two further ways in which options may be foreclosed, or, at least, flexibility substantially reduced. The first is the tendency in the valley to switch to permanent fruit cultivation from the existing multi-crop system, with a relatively high proportion of annuals, which is designed to cope with the vagaries of water supply. Such a tendency would be accelerated, for economic reasons, by the reduced risk of water shortage as result of regulation provided by the Puntilla del Viento reservoir. Aside from the question of resilience discussed above, the large-scale development of permanent crops reduces flexibility to react to uncertainty. The available options may also be reduced by a commitment to extensive transfers to the

52/ The California Water Plan calls for a transfer of water from the Columbia river to the Los Angeles basin, a distance of more than 1,500 km.

/Maipo, Valparaíso

Maipo, Valparaíso and La Ligua basins, which are likely to lock in certain patterns of development in these neighbouring valleys, based on delivery of extra-basin water. While this is not in itself necessarily bad, the capacity of the overall system to deal with undertainty on future supply and demand for water in the basin would be diminished.

This raises the question of scale effects in water resource development. Where there is little discounting for risk and uncertainty, project analysis frequently demonstrates economies of scale. However, where there is uncertainty as to the behaviour of the natural system under perturbation, and the reaction of the social system to change, big projects may be accompanied by large diseconomies in environmental impact. This points to the advisability of phased development, as in the case of Caño Mánamo or pilot projects like La Chontalpa.

Caño Mánamo provides a further illustration of option foreclosure. The diversion dam has increased flows by about 10 per cent in the rest of the Orinoco delta and average water levels have risen by a few centimeters, enough to change the composition of vegetation in some areas and drown certain forest tree species, the most important commercially being the ceiba (Ceiba pentandra). This sequence was only recognized after the diversion dam had been in operation for two or three years. Correction through additional dyking would have been enormously complex and costly, and in all probability would have set in motion further negative chain effects. Thus, all options to do anything about this loss appear to be closed. The fundamental issue is whether some options can be kept open when intensifying water use so as to be in a position to carry out preventive action rather than costly corrective modifications imposed by unforeseen phenomena.

(e) Controlability

In the event of a high degree of uncertainty about the behaviour of the natural, social and institutional systems as a result of disturbance to an aquatic system, the question arises of the amount of control which is both desirable and feasible in order to reduce

/such uncertainties.

such uncertainties. Knowledge about physical flow regulation is generally sufficient to design structures which allow for most uncertainties. Excess capacity can readily be built in as a safety measure: in the Guri project, the reservoir was designed with a dynamic storage capacity equivalent to one and a half times the average annual flow of the Caroní river, thus amply ensuring the availability of water for power generation. Control over chain effects, however, becomes more tenous, although the difference is only one of degree. In the case of flow regulation, satisfactory estimates can be obtained on hydrology, engineering design is of high standard, and most agencies are fully capable of building and operating diversion and regulation structures. However, in the areas of colonization, forestry, fisheries or agricultural development associated with the flow regulation, which involve the functioning of natural, social and institutional systems related to water use, knowledge is scarce and the complexities often exceed the technical and administrative capacity of executing agencies.

It is axiomatic that without prior knowledge of the functioning of the ecosystem under a changed water régime no control measures can be instituted. Thus, given the status of knowledge on the soils of Caño Mánamo or the hydrogeology of San Lorenzo prior to development, no measures could have been taken to prevent the formation of acid-sulphate soils or salinity respectively. Most of the ecological chain effects discussed in the preceding section could not have been controlled due to lack of knowledge.

Even where prior knowledge about the functional relationships in the ecosystem exists, controls may be impossible because of knowledge gaps and the inability to deal with the social and institutional systems. This is most evident where experience suggests remedial measures which it is nevertheless difficult to put into effect. For example, in San Lorenzo once salinity manifested itself the treatment was self-evident, i.e., washing with large quantities of water and introduction of paddy rice every third year to ensure adequate disolution of salts. The constraint was the over-extension of irrigation and thus the unavailability of water without the imposition of severe controls

/on use,

on use, and the reduction of irrigation in areas not subject to salinization. Experiments in Caño Mánamo suggested that careful control of the freatic level could prevent formation of acid-sulphate soils, but the sophisticated level of management required proved extremely difficult to implant among settlers in the region.

Aside from the direct response of the natural system to an alteration of the water régime, there are questions related to the possible control of social and institutional components. The San Lorenzo project offers some interesting lessons. The delays in execution of the agrarian reform and colonization resulted in the spontaneous uncontrolled expansion of irrigation in all sectors of the Piura basin to take advantage of the additional water made available, and also on the periphery of the project itself. This process was greatly facilitated by the topography: the flat lands and reasonably good soils enabled individuals or groups to increase irrigation without the organization and capital required for major earth works. The project authority was thus overtaken by events; the only solution lay in bringing in more water. Another control factor dependent on the institutional structure lay in the difficulties encountered by management in providing adequate credit, technical assistance and marketing services to support the agricultural programme.

In La Chontalpa the chain effects in the natural system were perhaps less well-understood at the outset than in San Lorenzo; nevertheless, the control exercised over the social and institutional systems is markedly different. Absolute control was exercised over such questions as the relocation of original settlers in the project area; the restructuring of ejidos along collective lines; the creation of new ejidos; the reassignment of ejidatarios and settlement of each ejido in an urban centre; forest clearing; the area allocated to pasture, perennial and annual crops; the management of agriculture and forestry and the sale of output; and the operation and maintenance of the drainage and irrigation systems. In this manner much of the uncertainty which characterized the San Lorenzo experience was removed, i.e., uncertainty about the behaviour of the new colonists and settlers already in the area, and the performance of institutions providing inputs and services.

/A further

A further aspect of control demonstrated by the La Chontalpa experience is the relative efficiency of the Grijalva Commission in co-ordinating the role of other agencies during the development phase, thus overcoming the type of institutional lags which beset other projects. The difficulties of control are further emphasized by the disintegration of co-ordination in La Chontalpa when the Grijalva Commission withdrew from management of the project in 1974 on completion of an eight-year development phase.

The land-use controls instituted by the CVG to protect the Caroní watershed represent a special case of an institution exercising extraordinary regulatory powers. The Aconcagua case suggests yet another model of water management, where control is difuse: a number of institutions control different components of the system (see figure 8). Construction of the Puntilla del Viento dam is seen as a possible vehicle for imposing unified management and control over the system, since regulation of flow to all the principal water users may be expected to merge the various interest groups.

It may be argued that social and institutional behaviour patterns of the type described above for San Lorenzo and La Chontalpa are predictable and therefore need not constitute an element of uncertainty. In this case the critical issues are the explicit incorporation of these behaviour patterns into the decision process, and the creation of institutional capacity to take the necessary control measures. It is evident that if such controls are not induced, uncertainty about environmental protection or economic performance will be greater. In the case of control over the social system this reduction in uncertainty must be balanced against social costs, such as the coercion imposed in resettlement, and unexpected side-effects such as the decline in nutrition levels in La Chontalpa.

/5. Management

5. Management response to environmental issues

The principal theme of the foregoing discussion is the need for improved information, and better analysis of such information in planning and project design in order to cope with uncertainty in water-resource management. The environmental issues are a primary source of such uncertainty: unplanned and uncontrolled events, arising from components outside the systems as originally conceived, have disrupted project performance. In addition to project design, there is the question of how management should be organized to deal flexibly with the dynamics of chain effects and to institute control mechanisms.

(a) The systems approach to planning and project design

Methodological aspects of the evaluation of environmental dimensions in the development - water management nexus are discussed in Annex C. The primary purpose here is to examine the extent to which some of the theory has been applied, or is applicable, in the cases under consideration.

(i) Information. One of the principal conclusions which may be drawn from the case studies is that water regulation structures and associated developments were designed without information, or use of available information, on what experience has since shown to be highly relevant variables.

Exhaustive surveys and studies of flora, fauna, hydrology, soils, geology as well as the full range of socio-economic and legal aspects are costly, time-consuming and require qualified specialists who are in short supply in most Latin American countries. The political and social imperative of accelerated economic development must be reconciled with the long-run maintenance of the productive capacity of the natural system. Faced by this dilemma, most countries opt for immediate action in the expectation that corrective actions will be evolved before all options are foreclosed. Such a situation is evident in the cases of La Chontalpa, San Lorenzo and Caño Mánamo. In a number of instances, development projects are termed "pilot", thus carrying the implication that they will be experimental and that results will eventually be

/applied to

applied to development of much larger areas. La Chontalpa was launched originally as a pilot effort, as one of seven units in a phased development of 350,000 ha in the Usumacinta-Grijalva flood plain. The Isla Guara (23,000 ha) was also established as a pilot venture in a 400,000 ha reclamation scheme in the Orinoco delta. Extensive agricultural research and training were tied to both operations from their inception.

There is no easy answer to the questions of how much information to collect prior to a decision on whether or not to build; whether uncertainty dictates delay, thereby foregoing expected benefits from early development, while collecting more information; or the desirability of undertaking pilot projects and, if so, on what scale.

(ii) Interdisciplinary aspects. In the light of Section D, it would appear that in many cases the range of elements considered in decision-making should be enlarged.

This raises the question of the importance of interdisciplinary approaches in planning, project design and monitoring processes which might provide guidelines to resource managers. Experience suggests that decisions on water regulation have been dominated largely by engineering and economic considerations. There is probably agreement on the range of other disciplines which should be brought to bear in greater degree such as ecology, geology, anthropology, agronomy, law, regional planning, public administration, sociology, and political science; but, there is little evidence that these disciplines have played a significant role in project design monitoring or management. In Caño Mánamo it seems either that soil scientists were given insufficient brief to examine the acid-sulphate situation, or that their advice was considered unimportant in the final decision on the project design. In La Chontalpa, anthropologists do not appear to have been asked to examine the interests and motivations of the 4,800 families resident on the project area prior to development, or else their recommendations were overlooked.

/This is

This is not necessarily a criticism of project decision-makers. A bevy of reports on ecology, flora and fauna, sociological aspects, farm management, etc., might well have been available, but without criteria for evaluating the recommendations within a unified framework. In the absence of such a framework it is easy for individual specialists to adopt a narrow perspective which is not particularly useful to the decision-maker. For instance, a detailed survey of flora and fauna in the La Chontalpa ecosystem would be of little value unless it could be integrated into an assessment of impacts and change, in economic, social and environmental terms, from alternative strategies of development intervention.

(iii) Model-building. Environmental impact analysis, ecosystem simulation or management models of the type described in Annex A were not applied as a basis for decision and project design in the five cases examined here. Hydrology simulation models were used to estimate flow distributions in Guri, La Chontalpa and Caño Mánamo. In the case studies a Leopold matrix was applied to Caño Mánamo and a limited ecosystem simulation model was developed for the watershed of the Guri reservoir (see Annex C). In all cases cost-benefit ratios were calculated, and all were well within the acceptable range of what were considered economically viable projects.

Models may be classified, somewhat arbitrarily, into two types: (i) descriptive models, which attempt to explain the behaviour of a system, its individual components or the interrelationship between components, and may be used to predict the consequences of introducing a disruptive activity or of public intervention aimed at maintaining some predetermined environmental quality level; and (ii) management models, which are optimization models normally based on economic criteria.53/ The specification of such a decision model calls for the translation of multiple management goals into a mathematical objective

53/ For an application of energy criteria, see: G.A. Antonini, et.al., "Population and Energy: A Systems Analysis of Resource Utilization in the Dominican Republic", University of Florida Press, Gainsville, 1975.

/function and

function and a constraint set. Management models are normative, in that the objective function is established exogenously, and they employ programming techniques which yield a single value optimum solution subject to the constraints imposed. In contrast, the descriptive models are predictive, in that there is no objective function, and they employ simulation techniques to yield outcomes from scenarios which may incorporate alternative applications of policy instruments. These two types of models may be combined in various ways: for example, descriptive models may be used to qualify constraints used in a management model; or models may be used in sequence, the output from one being the input to another (see Annex C).

Experience in the cases considered suggests that where environmental questions are concerned the application of cost-benefit analysis needs to be carefully specified. For example, all the cases except Aconcagua involved relatively large-scale changes in the vegetation. If a decision has to be made on the preservation of irreplaceable species, standard discounted cash flows can only be of help in assessing the present value of a net income flow which would have to be foregone in order to preserve the species. In the Guri project, the net present values of cash flows may be assessed at different discount rates associated with alternative strategies for management of the Caroní basin, as well as the costs, or income foregone, of progressively more stringent conservation measures. In this case the aim is the maximization of net benefits (measurable benefits less measurable costs), or contribution to GNP, subject to a set of constraints imposed because of inability to monetize environmental impacts.54/ Environmental constraints could apply to the natural ecosystem socio-economic system and socio-cultural system. In the case of the ecosystem, constraints would be imposed primarily because of the risk of foreclosing future development options due to uncertainty about potential irreversible consequences of a course of

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54/ Mathematically these relationships are expressed as max. $\sum_{i=1}^{m} X_i = Z$ subject to environmental constraints $A_{ij} < \alpha, \ldots n$

/action and

action and the magnitude of the effects assumed to be irreversible.[55] Constraints imposed by the socio-economic system might include income distribution, nutrition, health, recreation and spatial distribution of population or economic activity. Socio-cultural constraints might include aesthetics, personal security, level of individual choice, or cultural stability.

The fact that a range of necessary disciplines has not been effectively incorporated into project design or monitoring in the cases examined is taken as prima facie evidence of the need for a different approach. It may be unnecessary, or even misleading, to build large models of complex natural, economic, social and institutional systems. However, if long-range, interdisciplinary integrative analysis is to be made of the objectives, cost, effectiveness, and risk and uncertainty associated with alternative water management strategies, there appears little alternative to the application of mathematical modelling techniques, where communication between disciplines is obligatory.

(b) Environmental standards

Since there is no readily available mechanism for determining an optimum level of environmental quality, the setting of objectives in this area becomes largely an arbitrary and intuitive exercise for the water manager. The question is what environmental constraints should be imposed on any optimizing process? Unlike water quality, standards which apply to the environment affected by water diversion and regulation are not readily quantifiable, and even if they were quantified, monitoring and control would present formidable difficulties. Many countries have laws governing conservation and depletion of natural resources, but it will probably be some time before such laws have

55/ See: A.C. Fisher and J.V. Krutilla, "Valueing Long-run Ecological Consequences and Irreversibilities", Journal of Environmental Economics and Management, Vol. 1, 1974, pp. 96-108.

/been sufficiently

been sufficiently tested to provide the water manager with a manual of standards which he can apply routinely in project design and the operation of water systems. In the meantime conservation measures, involving land-use zoning and restrictions on use of water, must be decided largely on a case by case basis.

The simplest standard to set and enforce is complete conservation. This has been the course followed by the CVG to protect the Caroní watershed. Experience from other tropical forest areas in Latin America suggests that it is virtually impossible to regulate forest destruction and soil degradation with any form of land settlement for agriculture or cattle. Even in temperate areas, such as the upland and highland areas of Mexico, Central America, and the Andes from Venezuela to Bolivia, which are readily accessible and have a long history of settlement, little progress has been made in implementing erosion control measures.

Only rarely will total conservation satisfy development requirements; even in the case of the Guri dam, 425,000 ha of forest land will be replaced by a lake. In the case of forest loss, which has occurred in La Chontalpa and Guri, it may be argued that as a minimum standard of rational resource use at least the millable timber should be extracted. In practice such measures are precluded by market constraints and the indivisibility of the project. Because of economies of scale, and in the case of Guri also because of development demands for power, the construction of dams and large drainage schemes cannot be phased over 20-30 year periods, which would permit commercial extraction of timber. Even then there would be a question of whether the wood products would be competitive with other more favourably located sources of supply. Since there are no long-run ecosystem productivity issues posed by the utilization of non-utilization of timber resources in either of these cases, a decision may be taken on the basis of the net present value of alternatives. There can be little doubt that economies of scale in both cases overwhelmingly favour rapid development regardless of whether timber is extracted previously or simultaneously.

/Again, in

Again, in San Lorenzo it is estimated that as a result of the project, population in the region increased from 2,000 to approximately 40,000. The fuel demands of the new population have put considerable pressure on the resources in the Chira-Piura basin. In 1973 controlled extraction of firewood and charcoal amounted to 7,000 m^3 and 550 tons respectively, while it is estimated that additional uncontrolled extraction of these products amounted to 50,000 m^3 and 600 tons. The sustained yields obtained by the original population are precluded by such high rates of extraction. Furthermore, continuing depletion of vegetation on the most accessible areas and the disappearance of the newly irrigated areas as a source of supply have forced local goat herders to move to grazing grounds in the upper catchment. This is a region of steeper slopes and heavier rainfall than the former range, and therefore more susceptible to erosion which could prejudice storage dams and irrigation canals through accelerated sedimentation.

The environmental standard in such a case may set maximum levels of extraction of wood and zone the area for grazing with maximum stocking rates. An alternative in this case, which would be consistent with development, would be total conservation. In either case the authorities would need to concern themselves with an alternate fuel supply for the region, relocation of the goat herders, and monitoring and control mechanisms.

The question of the drowning of ceiba trees as a chain effect of the Caño Mánamo diversion offers a further example of a situation where standards of environmental damage might have been applied. The level of destruction of these trees was considered acceptable. However, if enough had been known about the system prior to intervention, consideration could have been given to estimating the net present value of the loss for cost-benefit purposes, or alternatively to imposing some maximum level of destruction of ceibas as a constraint on the project design.

The more obvious environmental standards which might be set in the Aconcagua valley relate to efficiency in use of irrigation water and possibly grazing control and re-establishment of vegetation in the

/upper watershed.

upper watershed. Current irrigation efficiency is estimated to be in the range of 35-45 per cent. A 70 per cent level is believed to be feasible if investment is made in an improved distribution system, on-farm storage, land levelling, and more careful control of water application. A doubling of irrigation efficiency will clearly improve the flexibility of any management authority in dealing with conflicts and competition which will inevitably arise as the multiple demands on water intensity with development. In order to enforce these efficiency standards it may be necessary to resort to measures such as progressive water rates or taxation.

There is little point in establishing environmental standards if there is no capacity to enforce them. In fact, enforceability should be a criterion of the standards themselves. In the examples given above, little attention has been given to the question of the monitoring and effective implementation of conservation standards. It would appear that some attention should be given to this aspect on purely economic grounds. Because resource use cannot be monitored and controlled, projects may have to be over-designed, allowing for excessive water use in the Aconcagua valley, for example, or activities may be restrictive, such as the need to prohibit selective logging (which caused no significant damage to the ecosystem) in the Caroní basin as the only means of closing the area to land developers and colonists.

(c) Alternative technologies

Corrective measures of one sort or another have been implemented in the five cases examined, and it is probably safe to generalize that this is the rule rather than the exception. In some instances one may be tempted to infer that corrective action is taken with almost too much alacrity. There is a natural reluctance on the part of water management institutions to admit mistakes and an equally natural penchant for construction. Thus, if a project gets into difficulties because of environmental factors, corrective measures are unlikely to encounter much resistance; it is a relatively simple matter to establish economic justifications for marginal expenditures in additional works, considering

/the initial

the initial investment as a "sunk cost". A problem arises if the original concept and design is wrong, in which case ameliorative measures will tend to cause even greater distortions in the system.

The preventive measures suggested by the cases which, incorporated in future projects, might reduce the need for corrective measures and harmonize improved economic viability with acceptable long-run environmental quality standards, fall into two groups - the technical "fix", and adaptive technology.

(i) The technical "fix". In essence, the technical "fix" characterizes corrective measures, the only difference being that they would be built into the project design at the outset, and thus presumably forestall the environmental impact. In a situation similar to San Lorenzo there would be a need for tighter control of land and water use and land tenure to ensure adequate water and enable crop rotation including rice every third year in areas identified beforehand as susceptible to salinization. The drainage system would be an integral part of the initial project, as would a programme for the protection of the watershed and integration of livestock, which seasonally graze the range lands, into the production system of the irrigated area. On Caño Mánamo a great deal has been learned in the past 8 years about the management of acid sulphate soils when drained and protected from flooding. Again, the key is high technology and strict control. Provision must be made to wash the soils in the wet season and the freatic level should be carefully managed through a combination of drainage and irrigation so that it remains just above the strata of sulphur soils and thus impedes oxidation. Where these strata are too close to the surface, the sulphuric acid may be neutralized by heavy applications of lime. This delicate management operation is made easier by the use of polders of about 1,000 ha each. Crops should be chosen for their tolerance to acidity and aluminium toxicity. Both development and management of the system are sophisticated and costly.

(ii) Adaptive technology. Here, rather than concentrating on the assessment of environmental impact, planning and project design is oriented towards the selection of an ecosystem and, within

/the context

the context of the set of institutions which govern its use, the evaluation of alternatives to identify a development path which offers acceptable probabilities of: achieving sustained yield for long-run survival; providing a margin for flexible responses; and maximizing present utility within the above constraints.56/ The environment is regarded not as an intractable impediment but rather as a resource with beneficial attributes which can be utilized, extended and enriched.

To apply this concept requires a complete rethinking of the development approaches taken. For instance, one may ask in the case of San Lorenzo whether an alternative might have been to intensify the use of the ecosystem without massive water transfers, or whether some lower level of irrigated agricultural technology might have been more appropriate. Answers to such questions are largely governed by national policy and development alternatives. Caño Mánamo offers more concrete evidence of adaptive technology. It has been concluded that the high-technology approach described above could be applied only to a relatively limited area in the upper Orinoco delta. An alternative applicable over a much wider area in both the upper and middle delta, is adaptation of plants, animals and management practices to the hydraulic régime without resorting to diversion, dyking, drainage and polders. Development requires introduction of high-yielding crop and pasture varieties and improved livestock strains (water buffalo and capibara) which tolerate the seasonal fluctuations in water level. Evidence from the La Chontalpa experience is still insufficient to test any hypothesis on the advisability of flood control, the advantages of which have been questioned in other contexts and remain an open issue.57/

56/ G.A. Norton, "Toward a Concept of Strategic Resource Planning", Institutional Journal of Environmental Studies, Nº 4, 1973, pp. 189-199.

57/ See, G.F. White, "Natural Hazards. Research, Concepts, Methods and Policy Implications", in: Natural Hazards: Local, National, Global, G.F. White ed., Oxford University Press, London, 1974, pp. 3-16.

/Chapter III

Chapter III

ENVIRONMENTAL ISSUES IN WATER MANAGEMENT: SYSTEMS DOMINATED BY URBAN COMPLEXES

With urban population expanding at 4 per cent a year and expected to reach nearly 450 million by the end of the century, the water management problems of large urban complexes will become of increasing importance to the region. Already the managment problems posed by the largest urban complexes in Latin America are virtually without parallel. If current trends continue the world's largest metropolitan areas will be Mexico City and São Paulo. It is necessary, therefore, to focus on the particular physiology of the management questions posed by the urban water system.

Detailed studies are presented below on the contemporary water management issues in four of the major metropolitan centres in Latin America, Bogotá (Colombia), Santiago (Chile) and Río de Janeiro and São Paulo (Brazil).58/ At the same time, the experience of other urban areas will be drawn upon to illustrate specific points.

1. Bogotá 59/

Bogotá, in common with the majority of the large cities of Colombia, is located in the interior of the country, in the río Bogotá valley, a high plateau filled with lake sediments. The city was originally sited along the foot of the mountains on the eastern side of the plateau, but it has spread into the Bogotá savanna. Its populatior has been doubling every ten years and, not surprisingly, the physical development of the city has been disordered. It has spread not only

58/ These presentations will be based upon individual studies undertaken specifically for this project.

59/ This section drawns upon the following consulting report prepared for CEPAL/UNEP as part of the project, Jaime Saldarriaga Sanin, Análisis de la contaminación del río Bogotá y sus soluciones, Septembre, 1976.

/across the

across the savanna but onto the hills, tripling in area during the last thirty years (table 6). It is estimated that the city now occupies one-fifth of the original area of the savanna devoted to agriculture, and by the end of the century nearly all the remaining agricultural land will be built up, if current trends continue.

Bogotá, given its size, is a city of many functions and tertiary activities dominate the metropolitan economy. It is, however, an industrial centre of significance accounting for almost 30 per cent of the total manufacturing output of Colombia. There were 580 industrial plants in the city in 1970.

Table 6

BOGOTA, PHYSICAL AND DEMOGRAPHIC GROWTH

	Area (km^2)	Annual rates of increase: Area (per cent)	Annual rates of increase: Population (per cent)	Population (000's)
1950	42.10			620.4
		5.7	7.4	
1960	73.60			1 271.7
		6.3	7.1	
1970	136.10			2 526.0
		6.5	6.9	
1980	256.76			4 929.8

Source: Ligia Herrera and Waldomiro Pecht, Crecimiento Urbano de América Latina, BID-CELADE, Santiago, 1976.

/(a) The

(a) The city and the water resource

Bogotá, unlike the majority of the cities of Latin America, was not sited on a major water body. It was originally and still remains relatively distant from the río Bogotá. The relationship between the river and the city is, however, of significance. The river and its tributaries provide energy, water supply, a place of recreation and the means of transport of wastes for the city and its inhabitants. As the city has grown so has the use of the river, and future growth will demand that the river become a creature of the city. It will have ceased to be natural phenomenon and become a human one.

The river valley can be divided into three parts according to the uses made of it. These three areas are:

(i) The upper basin, extending from the source to the regulatory structure at El Espino which controls the level of the river at Tibito, where the main abstraction is made for water supply. The majority of the regulatory works are concentrated in this part of the basin. At El Espino a flow equal to 70 per cent of the annual average is guaranteed and the dominant use of the water in the upper valley is for municipal water supply. This area is lightly populated and population has declined in recent years (table 7).

(ii) The middle basin, between El Espino and the downstream regulatory structure at Alicachín, contains the city of Bogotá and receives discharges from the various tributaries that pass through the city. The proportion of the population served by both the water supply and sewage system is relatively high in Bogotá and the bulk of the waste load, both suspended solids and biological oxygen demand (BOD), are derived from domestic sources (table 8).60/

60/ In 1972, 71.4 per cent of the population had a household connexion to the public water supply and 68 per cent to the sewerage system. There were 322,295 connexions to the former and 300,000 to the latter.

/Table 7

Table 7

POPULATION DISTRIBUTION RIO BOGOTA BASIN, 1973

		Change 1964-1973
Upper basin	69 087	-0.2
Middle basin	3 098 558	5.7
Lower basin	161 039	-1.9

Source: DANE, XIV Censo Nacional de Población y II de Vivienda, resultados provisionales, Bogotá, 1974.

Table 8

ESTIMATED DAILY DISCHARGE OF POLLUTANTS IN THE BOGOTA RIVER VALLEY, 1970

	Domestic waste	Industry in Bogotá	Total of the basin
Volume of waste (thousands of m3)	382	000	403
Suspended solids (thousands of kilos)	152	12	173
DBO_5 (thousands of kilos)	132	30	175

Source: Estudios de contaminación del Río Bogotá, División de Planificación de la CAR, I Seminario sobre calidad de Agua y Desarrollo de Recursos Hídricos, 1975.

/It is

It is in this section of the river that human intervention is likely to reach its greatest development over the next few years. The future growth of population is expected to be such that the río Bogotá will not be able to meet the water supply needs. A project, Chinghaza I, is currently under construction to bring water from the río Guatiquía, by means of tunnels across the divide; it is expected to enter into operation during 1978. This extra flow, 135 cubic meters per second, will be a net addition to the flows of the Bogotá basin. The whole of this flow will enter the río Bogotá, as waste discharges, increasing yet further the problem of contamination below Bogotá.61/

At the reach of the river passing Bogotá, it and its tributaries, most notably the Tunjuelo, are subject to seasonal flooding. It has been proposed to straighten and deepen the river at this reach, to reduce this problem, as flooding cannot be controlled by means of upstream storage.

At the lowest point of this middle section of the basin stands the Muña reservoir, constructed to regulate the flow of the Muña, a tributary of the Bogotá. Water from the Bogotá is pumped into the reservoir to increase power production from the chain of generating stations below.

(iii) The lower basin begins with the rapid fall of the river between Alicachín, at over 2,500 meters above sea level and Mesitas, less than 1,000 meters above sea level. At times of low flow the bed of the main course of the river is often dry as all the water is diverted via the Muña reservoir to the hydroelectric generation system. At Mesitas the water conveyed through the hydroelectric generating system rejoins the river. Three small settlements, Anapima, Tocaima and Apulo draw their water supply from the río Bogotá. At the junction of the río Bogotá with the Magdalena is located the town of Girardot, which discharges its wastes into the Bogotá just below the junction.

61/ Although a considerable addition to the average annual flow of 26.4 meters per second at Alicachín, this flow is insignificant compared to the maximum flows: 10-year flood, 700 m3/sec; 50-year flood, 1,000 m3/sec.

/The quality

The quality of water in the river changes rather dramatically below the discharges of Bogotá, to recuperate somewhat through the detention in Muña and the 1,800 meter fall, only to be reduced again at the point of confluence with the Magdalena due to the discharge from Girardot (Map 10). Fortunately the average annual flow of the Bogotá is only equal to 3.7 per cent of that of the Magdalena.

(b) The management system and its response

The water management system for the río Bogotá and the city of Bogotá is composed of three major entities, the Corporación Autónoma Regional de la Sabana de Bogotá y de los Valles de Ubaté y Chiquinquirá (CAR), the Empresa de Acueducto y Alcantarillado de Bogotá (EAAB) and the Empresa de Energía Eléctrica de Bogotá (EEEB). There are, in addition to these three decentralized and relatively autonomous agencies, numerous other central and municipal government institutions whose activities touch on water management, but their influence on the decesion-making process is much smaller.62/ (Figure 11.)

CAR is a decentralized agency whose jurisdiction includes the authority to plan and develop the water resource and to operate and maintain the required works to achieve such development. CAR does not have, however, jurisdiction over the municipality of Bogotá nor of the entire course of the río Bogotá. Its authority only extends to the upper and middle parts of the basin and ends at the Tequendama Falls (see again map 10). Recently CAR has been designated the executive agency for the new Colombian Renewable Natural Resources and Environmental Protection Code within its sphere of jurisdiction.

62/ These include the Ministerio de Salud and various institutions of the ministry, the Ministerio de Agricultura especially the Instituto para el Desarrollo de los Recursos Naturales Renovables (INDERENA) and the Instituto de Hidrología, Meteorología y Adecuación de Tierras (HIMAT).

The water supply and sewage agency, the EAAB, is an autonomous public entity owned by the Municipality of the Bogotá Special District. It is in charge of planning, building and operating all water supply, sewerage and drainage facilities for the municipality. Under national policy the EAAB is expected to become financially self-sufficient and all customers are metered.

The power authority, the EEEB, is another autonomous public entity owned by the municipality. It supplies power to customers outside the municipality and forms part of the interconnected national system. It is responsible for the operation of the power plants on the río Bogotá.

Of these three agencies, only CAR has an interest in the water resource, itself. Both the EAAB and the EEEB focus on the provision of specific water-related services. The decision-making process has been dominated by the use of the resources of the basin for water supply and power generation. Coincidentally, the river has also been used to carry away of Bogotá's wastes, but the pollution resulting from this use has not been given much attention until recently, because of the weakness of the downstream users and their complete exclusion from the decision-making system.

It appears to have been the decision to bring water in from outside the valley to supply the city of Bogotá that focused concern on the contamination problem. Nevertheless, there is no authority which can be entrusted with responsibility for this problem due to the limitation of CAR to the Savanna and EAAB to the Special District. In the lower basin, water management is handled by central government agencies, INDERENA and the Ministerio de Salud, which are less influential locally.

Consequently, the major legislative response to the management of the environment, the Renewable Natural Resources and Environmental Protection Code, may be faced with some constraints in implementation in the Bogotá region due to the discontinuity of institutional responsibility.

/Map 10

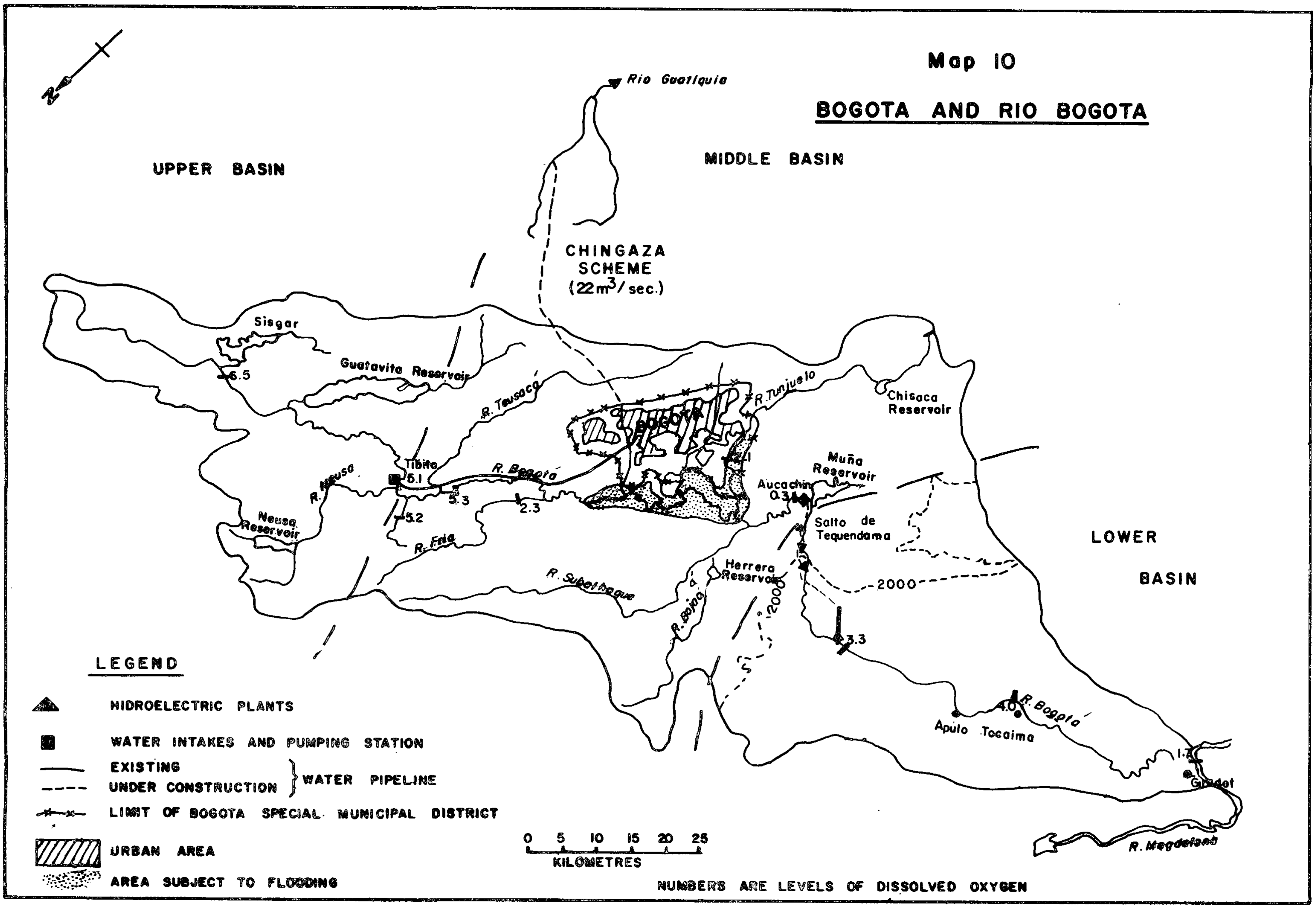
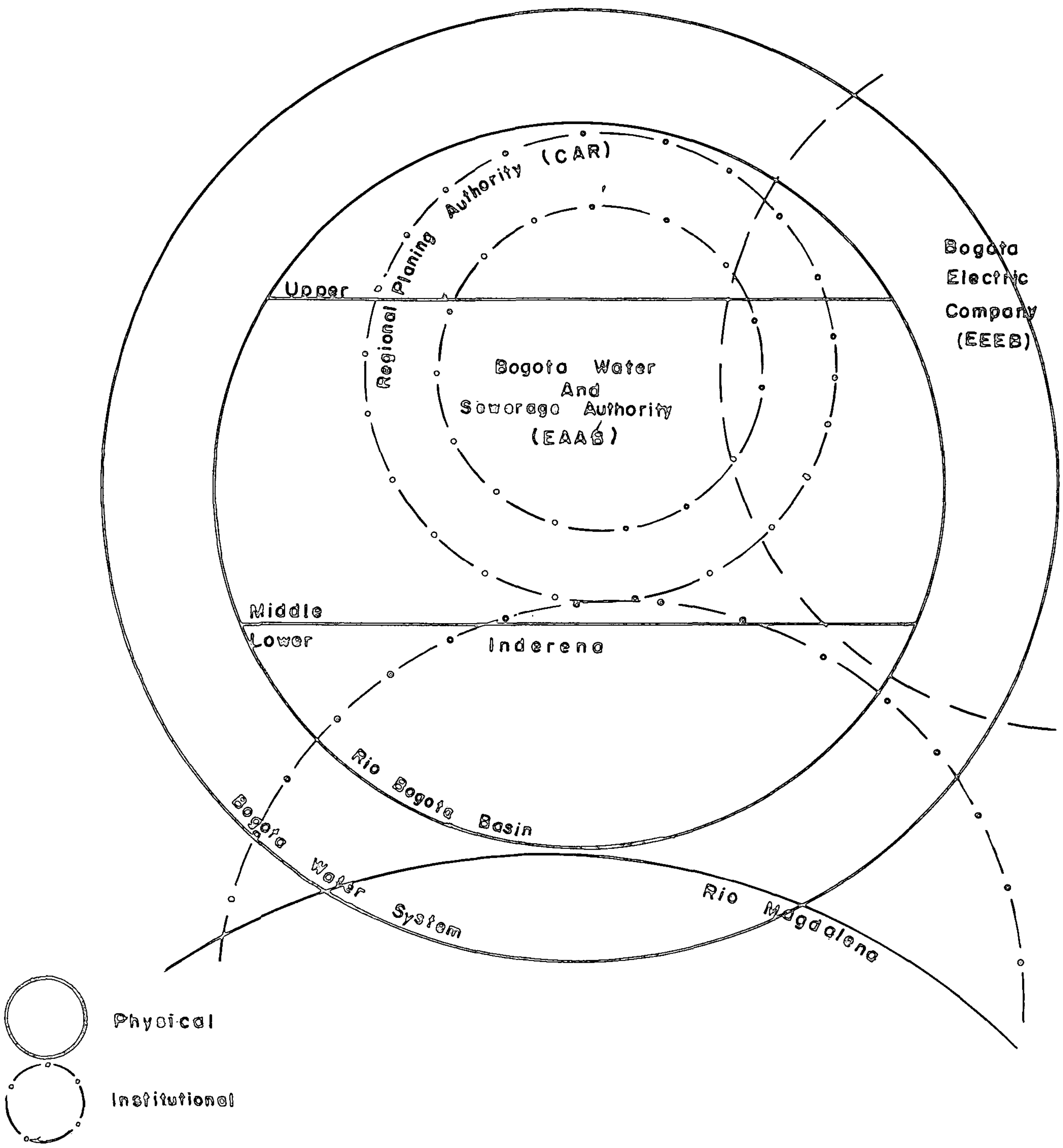

Map 10
BOGOTA AND RIO BOGOTA
UPPER BASIN
MIDDLE BASIN
LOWER BASIN
Rio Guatiquia
CHINGAZA SCHEME (22 m3/sec.)
Sisgar
Guatavita Reservoir
R. Teusaca
R. Tunjuelo
Chisaca Reservoir
BOGOTA
Tibito
R. Neusa
R. Bogota
Neusa Reservoir
R. Fria
R. Subachoque
Muña Reservoir
Aucachin
Salto de Tequendama
Herrera Reservoir
R. Bojaca
2000
Apulo
Tocaima
Girardot
R. Magdalena
6.5
5.1
5.3
5.2
2.3
0.3
3.3
4.0
1.7
LEGEND
HIDROELECTRIC PLANTS
WATER INTAKES AND PUMPING STATION
EXISTING
UNDER CONSTRUCTION
WATER PIPELINE
LIMIT OF BOGOTA SPECIAL MUNICIPAL DISTRICT
URBAN AREA
AREA SUBJECT TO FLOODING
0 5 10 15 20 25
KILOMETRES
NUMBERS ARE LEVELS OF DISSOLVED OXYGEN

Figure II

BOGOTA AND RIO BOGOTA:

PHYSICAL AND INSTITUTIONAL BOUNDARIES



2. Santiago 63/

Santiago is sited in the upper basin of the Río Maipo, on a major tributary, the Río Mapocho. The rate of demographic growth in Santiago has been relatively slow, at 3.8 per cent a year, for a large metropolitan centre in Latin America (table 9). Economically, Santiago dominates Chile, it is by far the most significant concentration of secondary and tertiary activities in the country and has grown at the expense of its nearest competitors, particularly Valparaíso, and in 1967 metropolitan Santiago accounted for 56 per cent of the total employment in the manufacturing sector.

The physical form of Santiago is dictated by the outlying hills of the Andean Cordillera and the coastal range. The urban area has grown in a star shape along the major highways in the plains between the various ranges of hills. The density of development is low and consequently the urbanized area large, 300 square kilometres in 1970. Santiago is surrounded by irrigated land on which it has steadily encroached from its beginnings; between 1956 and 1970, 12,254 hectares of irrigated land were incorporated into the urban area, and numerous canal systems have been absorbed into the urbanized area (Map 11).64/

(a) The city and the water resource

The relationship between Santiago and the Upper Maipo Basin reflects the complexity and importance of the hydrologic system to Chilean development. The limitations on the water resource in the Santiago metropolitan region signify that water management decisions must be given serious consideration (Figure 12).

63/ This section draws upon the following consulting report prepared for CEPAL/UNEP as part of the project, Luis Court Moock, René Gomez and Hernán Baeza, "Utilización del agua en la parte superior de la cuenca del río Maipo", Santiago, October 1976.

64/ For a description of this phenomenon, see Juan Escudero, et. al., Región Central de Chile: Perspectivas de desarrollo, CIDU-ODEPLAN, 1971.

/Table 9

Table 9

SANTIAGO, PHYSICAL AND DEMOGRAPHIC GROWTH

	Area (km^2)	Annual rates of growth		Population (000's)
		Area	Population	
1940	113.40	2.9	3.0	952.1
1952	159.70			1 353.4
		4.6	4.3	
1960	228.80			1 907.4
		2.5	3.8	
1970	194.80			2 779.5
		3.1	3.8	
1980	398.97			4 055.1

Source: Ligia Herrera and Waldomiro Pecht, Crecimiento urbano de América Latina, BID-CELADE, Santiago, 1976.

/Map 11

Map II

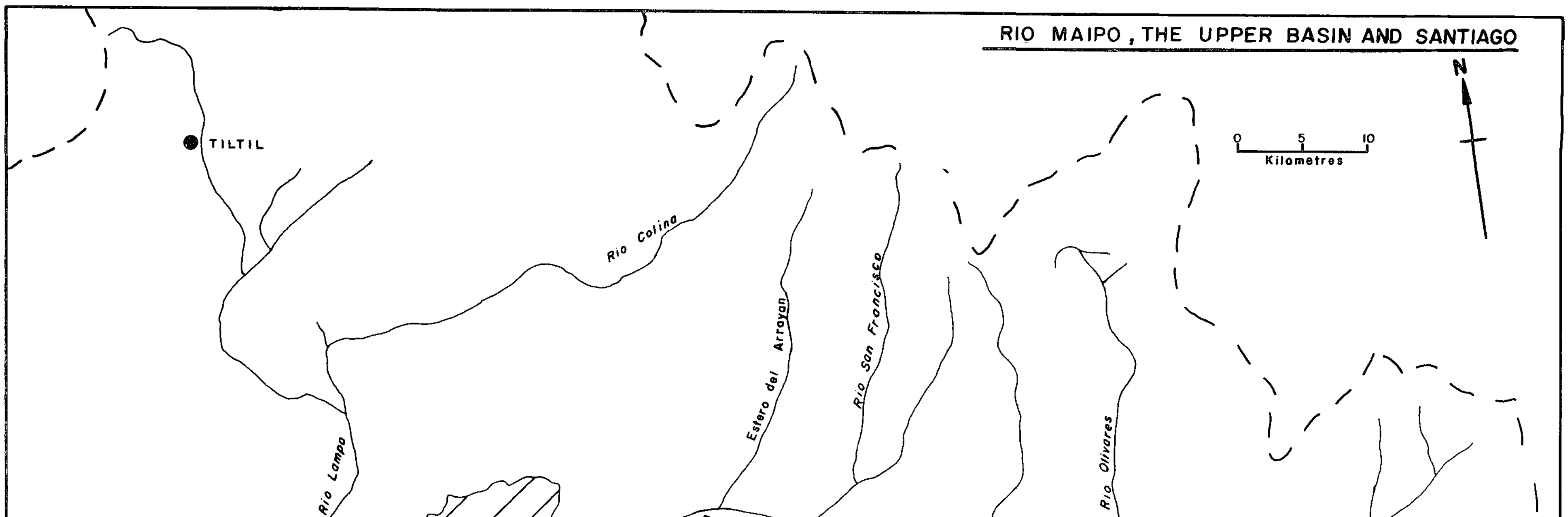
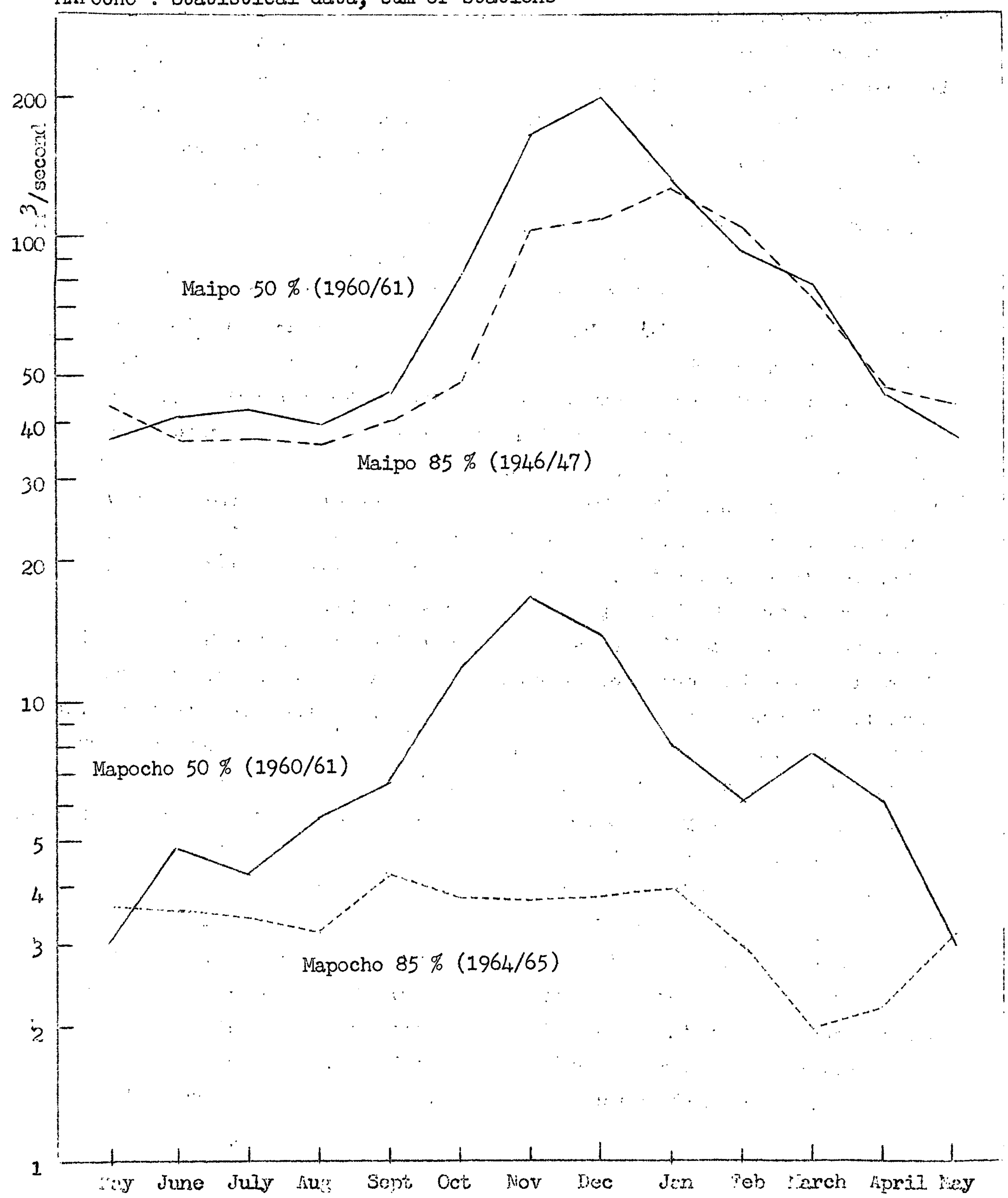

RIO MAIPO, THE UPPER BASIN AND SANTIAGO
N
0 5 10
Kilometres
TILTIL
Rio Colina
Estero del Arroyan
Rio San Francisco
Rio Lampa
Rio Olivares
Rio Mapocho
SANTIAGO
AREA IRRIGATED EXCLUSIVELY
FROM ZANJON DE AGUADA
Zanjón de Aguada
Canal San Carlos
Canal Las Perdices
Canal las Mercedes
Canal S. Joaquin
C. S. Pedro
Rio Colorado
Rio Mapocho
SAN JOSE
DE MAIPO
TALAGANTE
Canal Sirena
Rio Maipo
Rio Yeso
El Yeso Reservoir
Rio Maipo
BUIN
ISLA DE
MAIPO
Rio Volcán
Estero de Paine
Urban Area
Grand Santiago

Figure 12

MAIPO AND MAPOCHO RIVERS, MEAN MONTHLY FLOWS, FOR HYDROLOGICAL YEARS, 50 PER CENT AND 85 PER CENT PROBABILITIES

(Past years)

MAIPO : Measured at LA OBRA
MAPOCHO : Statistical data, sum of stations



/Although Santiago

Although Santiago is sited in the valley of the río Mapocho and only recently has continuous urban development reached the mainstream of the Maipo, there has been a long term relationship between the Maipo and the city. The Maipo is the source of the bulk of the public water supply and the irrigation canals drawing water from the Maipo, particularly the Canal San Carlos, contributes more than half the flow of the Mapocho through the city. The average flows of the Mapocho are far too small to be significant to the modern city. The Maipo has become, therefore, Santiago's river.

The water of the main stream of the Maipo and the upper tributaries, río Yeso, río Colorado and río Volcán is largely used for irrigation and Santiago's water supply. An average of almost 11 m^3 per second are withdrawn form the Maipo for the water supply system and it is estimated that this will increase to 24 m^3 per second by the end of the century, equivalent to almost one-third of the average annual flow (Figure 12 and table 10). The major part of the water supply reaches the Mapocho in the form of sewage discharges. These discharges, estimated to be equal to 12 m^3/second in 1975, are divided between direct discharge to the Mapocho as it passes through the city and discharge to the Zanjón de la Aguada, a tributary of the Mapocho which flows through the lower south-western part of the metropolitan area (Map 11). These discharges are far in excess of the average streamflow of the Mapocho (Figure 12). Fortunately, the level of contamination is somewhat reduced by the discharge of irrigation canals into the Mapocho, principally the Canal San Carlos although many others contribute some flow. In general, this water is of higher quality but contaminated by urban run-off and by illegal sewerage connexions.

Agriculture, apart from the domestic and industrial demands of the Santiago metropolitan area, is the major user of the water of the upper Maipo basin. Since 1940, irrigation has been steadily encrouched upon by the city. In 1975 there were about 109,500 hectares with irrigation infrastructure of which only 87,000 hectares were actually irrigated. It is expected that the irrigated areas will be

/reduced to

reduced to some 46,000 hectares by the end of the century due both to direct urban growth over irrigated land, swallowing up 10,000 hectares, and to the use of water for urban supply.

Table 10

SANTIAGO, SOURCES OF WATER SUPPLY, 1975-2000
(m^3/second)

	1975		2000	
	Average withdrawal	Maximum withdrawal	Average withdrawal	Maximum withdrawal
Río Maipo	10.7	17.0	24.3	37.4
Río Mapocho	0.7	1.0	1.7	2.6
Ground water	3.3	5.0	2.9	4.4

Source: L. Court, op. cit.

One particular aspect of the relation between the city and irrigation is the steadily increasing contamination of the water for irrigation downstream from Santiago. The most extreme example is a small area immediately west of the urban area which is irrigated by water drawn from the Zanjón de la Aguada (see Map 11). This water is of extremely poor quality and it is suspected that its use for the irrigation of vegetables for the Santiago market accounts for a large proportion of the high incidence of water-related diseases in the city.65/

Interaction between the city and irrigation also includes the presence within the urban area of numerous irrigation canals, some abandoned but many still in use. It has been estimated that there

65/ It is estimated that in 1975, there were 4,500 cases of typhoid and 67 deaths, 60,000 cases of infantil diarrhoea and 1,500 deaths, 1,800 cases of viral hepatitis and 36 deaths and 700,000 cases of parasitosis, L. Accatino, et. al., Contaminación Fecal de la Ciudad de Santiago.

/are some

are some 280 kilometres of canals of all types that should be filled in to remove the flooding and sanitary problems they currently cause.

In synthesis the upper Maipo basin presents a classic case of changing and conflicting water uses. A water system originally highly developed for irrigation has become dominated by urban uses, water supply for domestic and industrial users and waste disposal. These uses are in considerable conflict in a situation of relative scarcity; a conflict which continues into the lower basin as Santiago continues to increase its waste discharge.

(b) The management system and its response

The water management system of Santiago and the upper río Maipo basin is superficially clear. Under Chilean legislation, the use of the water resource is controlled by the Dirección General de Aguas of the Ministry of Public Works. In reality, the separation of functions between the Dirección General and other public sector agencies is not well defined. This lack of definition of functions has led to superimposition of activities and insufficient attention to the resource itself (see Figure 13).

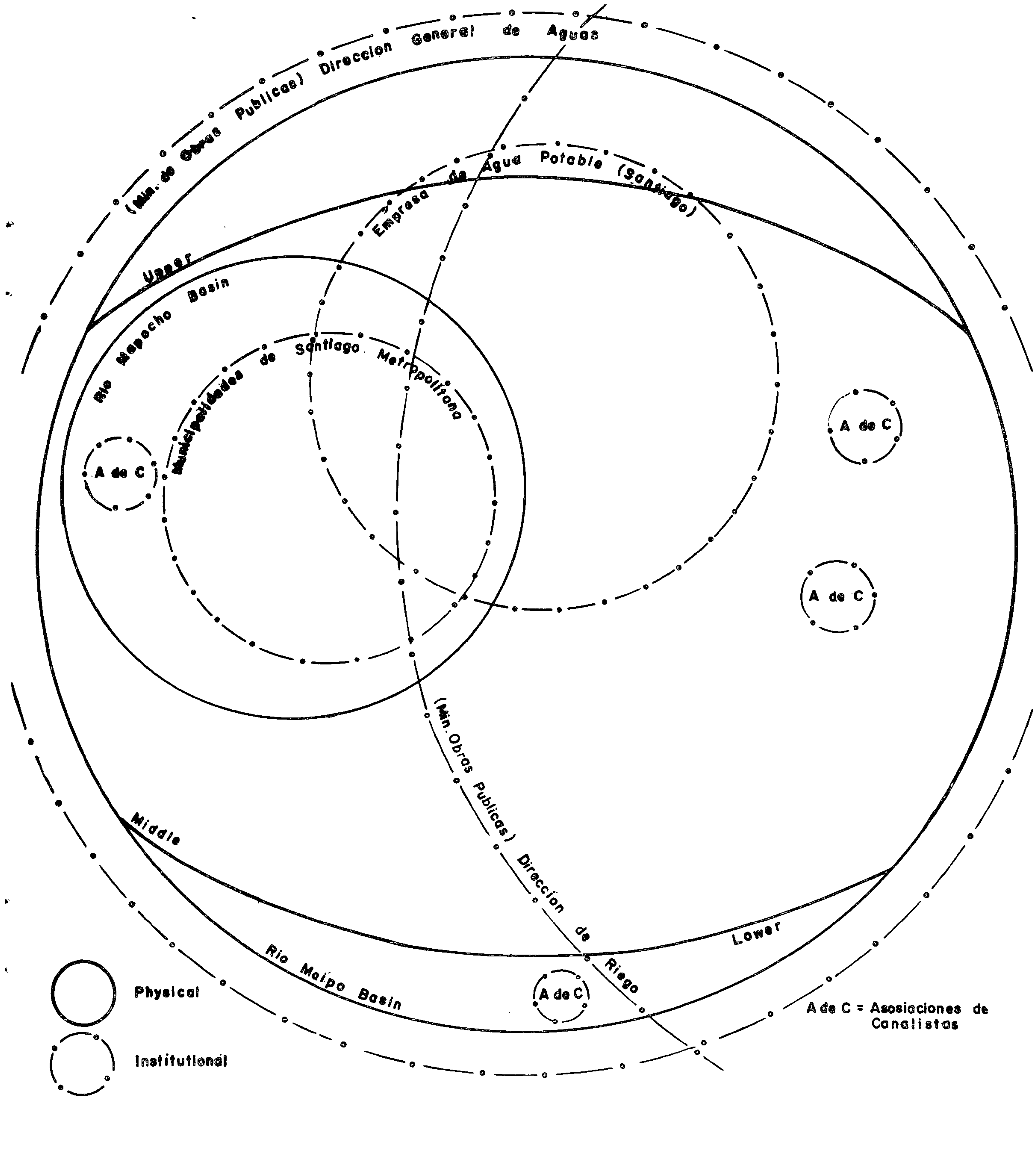
The conflict between irrigation and urban uses is far from solved. It has not even been possible to remedy the relationship between the use of the open sewer of the Zanjón de la Aguada, for irrigation and disease.66/ The Dirección de Aguas has not been able to co-ordinate other institutions, and the situation illustrated in Figure 13 is really a simplification of the problem since many institutions which are involved in water management are not shown. These include CORFO, the Health Ministry, other bureaux of Public Works and the Ministry of Agriculture and various of its autonomous corporations.

66/ Imaginative institutional co-ordination, rather than investment, would appear to be the most important ingredient for resolution of the problem.

/Figure 13

Figure 13

SANTIAGO AND RIO MAIPO: PHYSICAL AND INSTITUTIONAL BOUNDARIES



Given this situation, it is not surprising that the response has been to attempt to remove the conflict rather than resolve it. The proposed solution is to increase the water supply by means of diversion from the río Cachapoal, the next major river to the south.67/ This diversion would permit the supply of the needs of Metropolitan Santiago, the maintenance and even the expansion of the irrigated area, and further dilution of waste discharges. It would not, however, contribute in any major way to the resolution of the contamination problem.

3. Río de Janeiro 68/

Río de Janeiro is the old leading city of Brazil. It has recently lost its place as the most populous city to São Paulo but it remains a metropolitan centre with few peers. It is an industrial centre second only to São Paulo in Brazil, although its rate of industrial growth has been slower in the most recent period. In tertiary activities, Río, continues to dominate the Brazilian economy not only in commerce, but as a major port and the largest centre of tourism in South America.

The site of Río de Janeiro is Guanabara Bay, a magnificent natural harbour 381 square kilometres in extent. Originally situated relatively near the entrance, but inside the bay, the urban area has spread to the Atlantic coast across and around the bay and inland along the valley of the Iguaçu and other tributary rivers (Map 12).

67/ The río Cachapoal is the major headwater tributary of the río Rapel. The latter is used for hydroelectric power generation, as well as irrigation. It is possible any diversion from the Cachapoal would require replacement setting in motion a chain reaction of some considerable proportions as water is diverted successively further south.

68/ This section draws upon the following consulting report prepared for CEPAL/UNEP as part of the project: Victor Monteiro Barbosa Coelho and Maria Regina Monteiro de Barros da Fonseca, "Estudio do caso de poluiçao das aguas de Baía de Guanabara", Fundaçao Estadual de Engenharia do Meio Ambiente, Río de Janeiro, October 1976.

/The rate

The rate of population increase slowed during the 1960s, to 3.1 per cent per year, but in absolute terms the population increases at an annual rate of a quarter of a million (table 11). The urbanized area extends to over 850 km^2.

Table 11

POPULATION RIO DE JANEIRO METROPOLITAN AREA

	1940	1950	1960	1970
Northern suburbs	225 637	469 394	1 272 750	1 836 100
Río de Janeiro	1 764 141	2 377 451	3 307 163	4 315 746
Niteroi and São Gonçalo	231 935	313 585	496 754	754 517
Total	2 221 713	3 160 430	5 076 667	6 906 363

Source: V. Coelho, *op. cit.*

(a) The city and the water resource

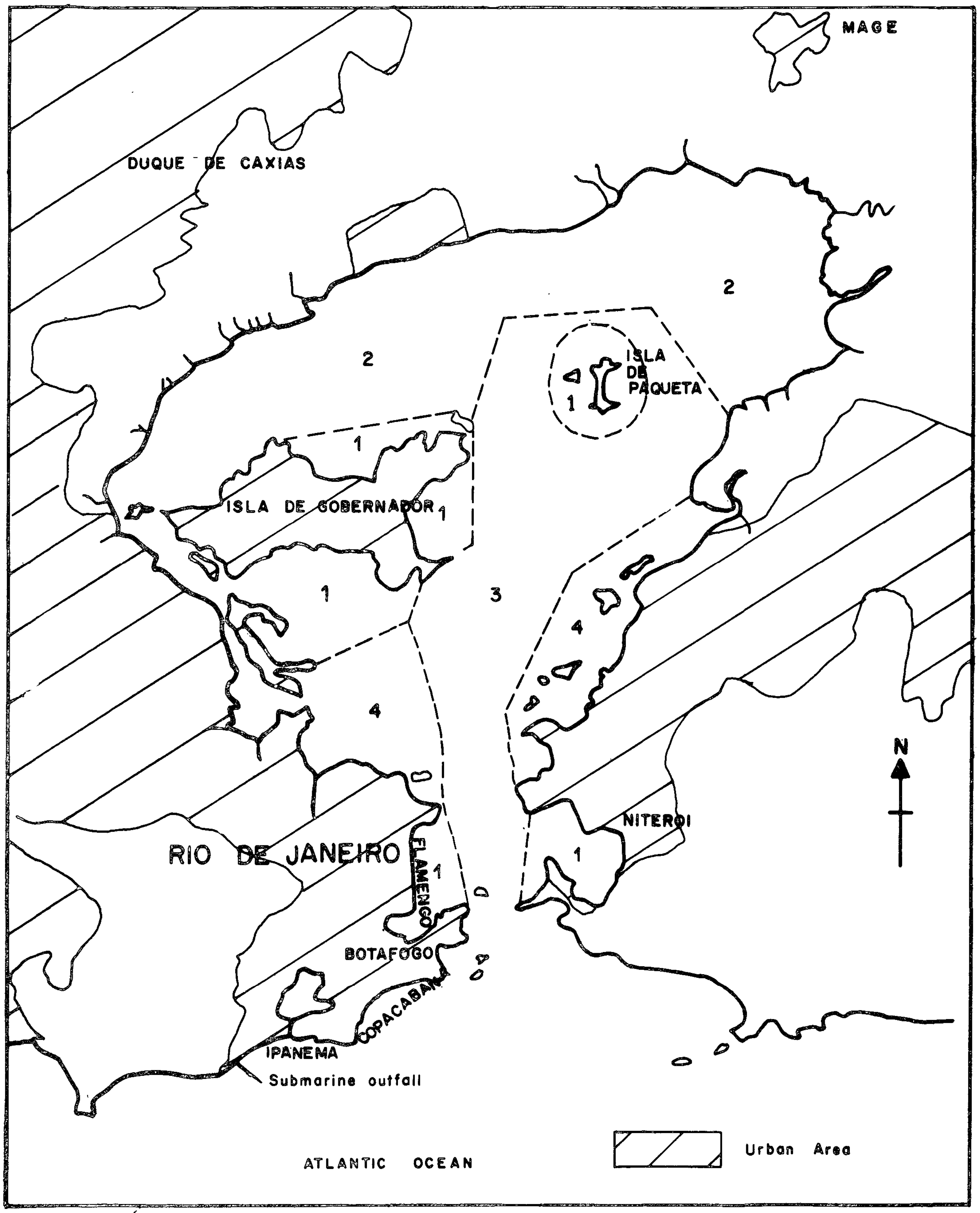
Río de Janeiro has an elaborate and complex relationship with Guanabara Bay. First and foremost, the Bay is one of the dominating elements in the magnificent site of the city. In addition, it is a resource for recreation of all kinds, a major harbour, a traditional fishing ground and the point of discharge for the majority of domestic and industrial wastes of the metropolitan region.

With the continuing growth of the metropolitan area, the Bay is being increasingly contaminated by domestic and industrial waste discharges, the dumping of waste solids, oil from ships and land sources and general urban run-off. The contamination, in certain areas of the Bay at least, has reached such a level as to restrict other uses. There is a growing threat to multiple use of the Bay, and this may spill over and tarnish the position of Río de Janeiro as a tourist centre for water recreation and disrupt the distinctive "Carioca culture".

/Map 12

Map 12

RIO DE JANEIRO AND GUANABARA BAY



Currently, domestic wastes are discharged to the Guanabara Bay and directly to the Atlantic Ocean by means of a submarine outfall off Ipanema beach.69/ The latter discharge is only equivalent to 7.1 per cent of the BOD discharged from the Río de Janeiro metropolitan area (table 12). The discharge to the Bay can be divided into that captured by the sewage system and that discharged directly either to the Bay or, more commonly, to a tributary stream.70/

Table 12

DIRECTION AND MEDIA OF SEWAGE DISCHARGES

(In terms of BOD, kilograms per day)

	% of total	Kg/day
Guanabara Bay	92.9	384 116
Through sewage system	20.5	82 937
Through tributary stream	71.3	297 690
Direct	1.1	3 489
Atlantic Ocean	7.1	32 189
Through sewage system	7.1	32 189

Source: FEEMA.

69/ A reduced proportion of these wastes are treated before a discharge, perhaps 2 m3 per second out of a total discharge ten times as large.

70/ It has been estimated that around 2.5 million inhabitants of the metropolitan area live in unsewered premises, and a further 1 million live in premises connected to the storm drainage system.

/These discharges

These discharges conflict with the continuing use of the beaches of the Bay for water recreation (see again Map 12). The average number of users of these beaches is around 1 million a month. The increasing contamination has also virtually destroyed the fishing industry in the Bay, restricting the catch to very low quality fish.

The only major part of the Río de Janeiro water resource system not affected by the contamination of Guanabara Bay is the public water supply. The water supply system is fed from various sources but the majority of the supply is taken from the río Guandú, which flows in to Sepetebia Bay to the west of the city. The Guandú is the ultimate recipient of the diversion of water from the río Paraiba do Sul at Barna do Piraí for hydroelectric power generation.

(b) The management system and its response

The management of environmental quality in the State of Río de Janeiro was reorganized in 1975. At that time a relatively centralized and compact system was established (Figure 14). The senior agency is the Commission for Environmental Control, CECA, responsible for ensuring that environmental regulations, quality criteria, and norms are observed in the State. This authority includes the issuing of licenses for all potentially polluting activities. In addition to CECA there are three operational agencies at the State level.

(i) The State Foundation for Environmental Engineering (FEEMA);
(ii) The State Superintendent of Rivers and Lakes (SERLA), and
(iii) The State Water Supply and Sewage Company (CEDAE).

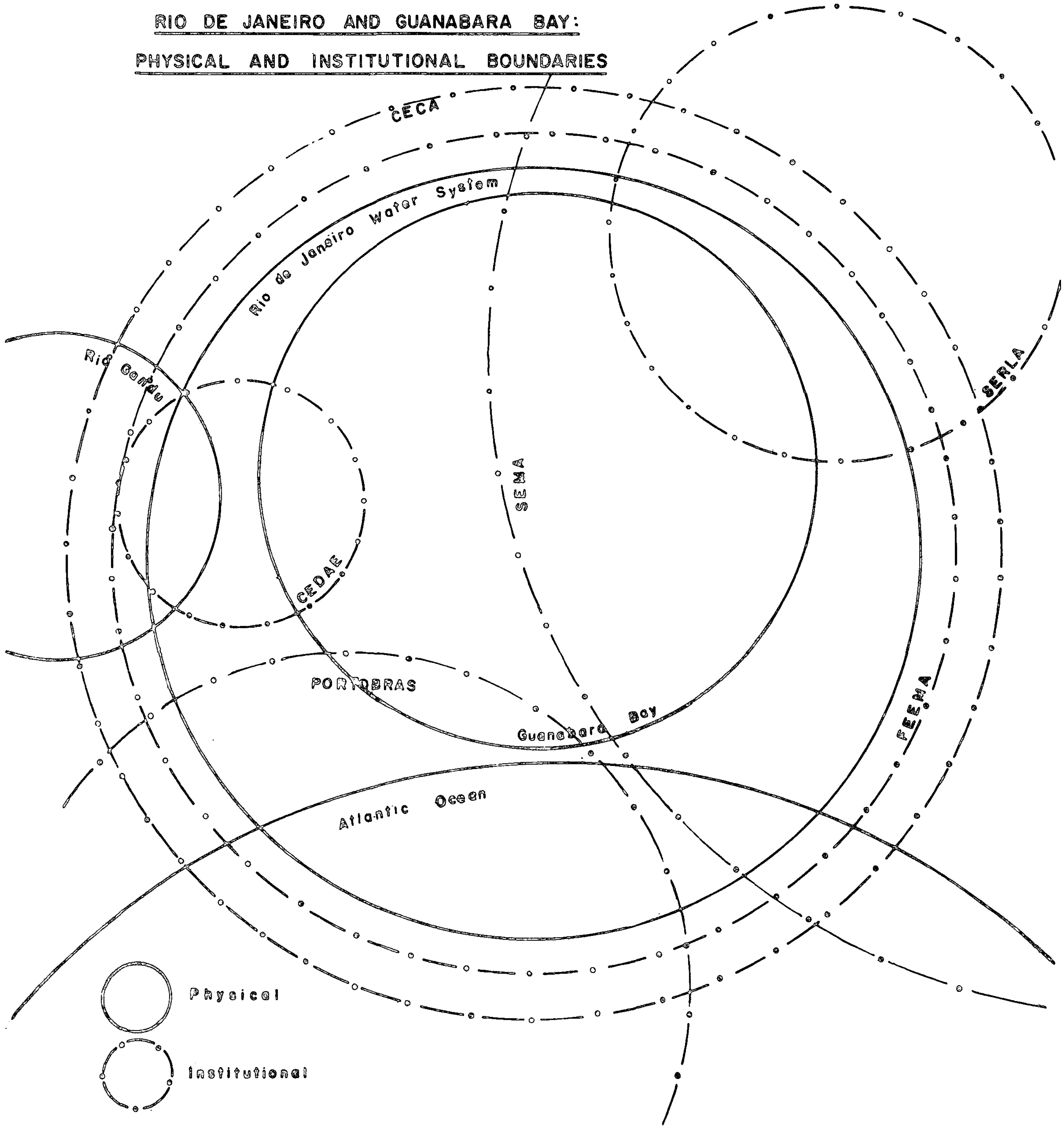
FEEMA is the executing agency for CECA and, at the same time, responsible for applied research into environmental problems and for the elaboration of standards and means of control. SERLA is the hydrologic statistical agency, and is responsible for works related to flow regulation. Finally, CEDAE, manages the water supply and sewage systems.

/Figure 14

Figure 14

RIO DE JANEIRO AND GUANABARA BAY:

PHYSICAL AND INSTITUTIONAL BOUNDARIES



The Federal Government plays a minimum role in environmental quality management in the Bay. The Environmental Quality Secretariat of the Ministry of the Interior, SEMA, does establish criteria for the quality of coastal waters which apply in Guanabara Bay. Two federal agencies are users of the Bay and are of some significance in the management process, the port authority, PORTOBRAS and the Navy. Both are involved with the control of pollution from ships, particularly oil discharges.

The management system has given a relatively high priority to consideration of how the environmental quality situation in Guanabara Bay might be improved. The particular aspect of environmental quality in which improvement is being sought is the control of the use of the waters of the Bay as a receptor for residuals.

In order to understand the impact of waste discharge on the Bay, FEEMA has developed simulation models of the behaviour of the Bay in terms of sanity, coliforms and dissolved oxygen and biological oxygen demand.71/ Using these models, the reaction of the Bay to discharge at various points can be simulated. It has been discovered that by the careful selection of the point of discharge coupled with sewage treatment it is possible to use the Bay as a receptor for residual and maintain a level of water quality sufficient to permit the continuance of other uses.

The problem posed is what is the optimum level of water quality. Given the existing uses of the Bay, a number of possible options for water quality have been established. These are: (i) a level of water quality sufficient to ensure the continuation of all uses, recreation, navigation, commercial fishing, industrial cooling and aesthetic, in all parts of the Bay; (ii) divide the Bay into use-zones (shown in Map 12) and establish water quality standards permitting different combination of uses such as: water recreation in Zone 1 and aesthetic

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71/ For a description of these models see, Victor Monteiro Barbosa Coelho and María Regina Monteiro de Barros da Fonseca, Modelos Bidimensionais de Qualidade de Agua e Economicos para a Baía de Guanabara - Río de Janeiro, 8º Congreso Brasileiro de Engenharía Sanitária, Seçao do Estado de Rio de Janeiro, Río de Janeiro, 14 to 19 December 1975.

/use of

use of Zone 3, navigation in Zone 4 and 2; commercial fishing in Zone 2, aesthetic use of Zone 1 and 3 and navigation in Zone 4; aesthetic use of Zone 1 and 3, navigational use of 2 and 4; only navigation in all the Bay.

The model demonstrates that the first option can be achieved only if the Bay ceases to be used as the receptor for the discharge of domestic wastes and all other sources of pollution are controlled. Moreover, technically speaking this option is cheap in comparison to other alternatives, as it requires only the construction of a submarine outfall and the necessary supporting sewage and drainage system to permit the discharge of all wastes untreated into the Atlantic Ocean. The estimated present value of total cost, capital and operation and maintenance, up to the year 2029 is estimated at 1.5 billion cruzeiros (105 million dollars), whereas the highest water quality alternative with discharge to the Bay would approximately double the investment required. The restriction seen by FEEMA on the adoption of the first alternative is that all the works must be built at one time. The discharge with secondary treatment alternative is more expensive but permits construction, and therefore investment, to be spaced out over a much longer period of time. The control of domestic discharges would be accompanied by control over both industrial discharge and contamination from the oil terminals.

4. São Paulo 72/

The São Paulo metropolitan area is the largest urban and industrial centre, in Brazil. The population in 1970 was 8,137,000, and the urbanized area some 7,950 km^2. Besides its size and the corresponding magnitude of the use of water, the most outstanding hydrologic characteristic of São Paulo is the complex hydraulic system developed to generate hydroelectric power.

72/ This section draws upon the following consulting report prepared for CEPAL/UNEP as part of the project: Roberto Max Hermann, "Recursos hidricos da area da Grande São Paulo determinaçao dos padrões otimos de qualidade d'agua", São Paulo, September, 1976.

/(a) The

(a) The city and the water resource

São Paulo is situated in the upper basin of the Tiête, a tributary of the Paraná, one of the major rivers of the La Plata system. The city is very close to the Atlantic Coast, at some 700 metres above sea level. This unique situation was exploited during the 1940s and 1950s with the reversal of the flow of upper reaches of the Tiête and diversion to the Atlantic Ocean. This reversal was achieved through the construction of a complex system of dams, reservoirs, pumping stations and canals. The system permits the diversion of 84 cubic metres per second of water for the generation of power on the Atlantic coastal plain; only 3 cubic metres per second continues to flow to the lower Tiête (Map 13).

The structure of the system is as follows: a dam at Pirapora, on the Tiête controls the flow from the Tiête and the Juqueri, a tributary which joins the Tiête at this point. The reservoir behind the Pirapora dam is at 648 m above sea level. From the reservoir the water is pumped by means of the Edgar de Souza pumping station back up the course of the Tiête to the Pinheiros Canal, formed by the canalization of a former tributary. This water is lifted again by two more pumping stations, at Traiçao and Pedreira to the Billings Reservoir at 746.5 m above sea level. This reservoir is at the height of the Coast/Interior drainage divide and dammed at the summit. From the Billings Reservoir the water flows by gravity to the Atlantic Ocean. The Cubatao power plant, is situated on this part of the system with an installed capacity of 860 MW. About 20 per cent, equivalent to 18.7 cubic metres per second, of the diverted flow through the Pinheiros-Billings system is used for São Paulo's water supply (table 13).

/Table 13

Table 13

SAO PAULO - SOURCES OF WATER SUPPLY

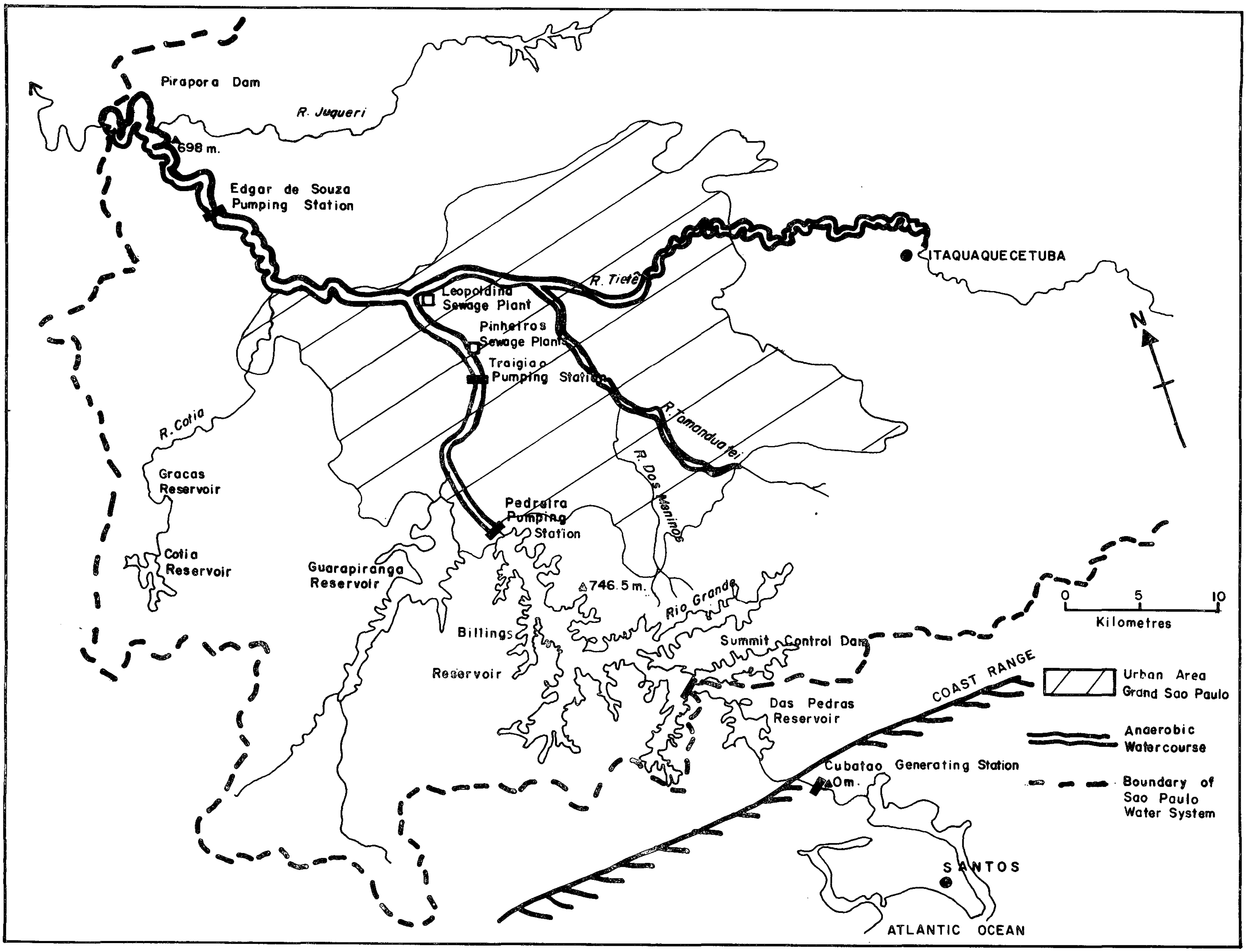
	%
Rio Claro	12.8
Rio Grande	11.3
Guarapiringa Res.	56.2
Cotia Res.	6.4
Cartareira	11.2
Others	2.1
Total	18.7 m^3/sec

Source: SABESP.

/Map 13

Map 13

THE SÃO PAULO WATER SYSTEM



It is estimated that currently some 20 cubic metres per second of wastes flow from São Paulo at the present time. Of this waste load only some 0.8 cubic metres per second is treated at the Pinheiros sewage treatment plant. The other sewage treatment plant in the city, Leopoldinha, has been out of operation since 1967. It is estimated that the connexion of deficiencies in the supply of water and collection of sewage would lead to an immediate increase in waste flows to 23 cubic metres per second. It is estimated that only one-third of the existing BOD load reaches the Tiête system through the sewage system.73/ Currently a large-scale extension of the water supply system is underway, but the extension of the coverage of the sewage collection system, beyond the existing 35 per cent of the population will be much slower. Even so, it is expected that by the year 2000 the waste flows will be almost 100 cubic metres per second, considerably in excess of the original natural supplies in the Upper Tiête basin.

Not surprisingly, all the water bodies in the Grand São Paulo urban area, with the exception of the protected Guarapironga Reservoir and the final six kilometres reach of the Billings Reservoir, are heavily contaminated. From the municipality of Itaquaquetuba to the Pirapora Dam and back following the pumped water along the Pinheiros Canal to the Billings Reservoir, and including all the urban tributaries of the Tiête downstream from Itaquaquetuba, the whole system is anaerobic in the dry season. In the wet season some parts reach levels of dissolved oxygen of one-third the saturation level. The water leaving the Billings Reservoir by the Rio das Pedras is, by contrast, of relatively good quality with a BOD of 1 to 2 mg/litre and dissolved oxygen level of 5.5 mg/litre.

The Billings Reservoir acts, therefore, as a large oxidization pond and sink for the contaminants of the metropolitan area.

73/ In 1972, 160 tons a day of BOD reached the river through the sewage system and 303 tons by disperse flows of wastes.

/(b) The

(b) The management system and its response

As might be expected, there are marked similarities between the management systems for São Paulo and Río de Janeiro. The institutional arrangments for environmental quality management in the State of São Paulo were revised recently to create a centralized system.74/

The core of the revised system is CETESB, the São Paulo Sanitary Engineering and Environmental Protection Agency. CETESB possesses authority to control all potentially polluting activities; to monitor the quality of the environment, including water quality; to design and evaluate techniques of pollution control; and to train the required specialists. It is an autonomous company of the State Secretary for Public Works and the Environment (SOMA). Its activities include the evaluation of all proposals for waste disposal in greater São Paulo. CETESB is not, however, responsible for the construction and operations of works. The latter are divided between two agencies, SABESP, São Paulo State Sewage and Water Supply Company responsible for water and sewage systems, and the Water and Energy Authority, DAEE, responsible for all other water-related construction. In addition, there are the major users of the system involved, including the company operating the Cubatao power plant (the Light). As in Río de Janeiro, there are federal agencies involved, headed by SEMA and, less directly, the National Housing Bank (Figure 15).

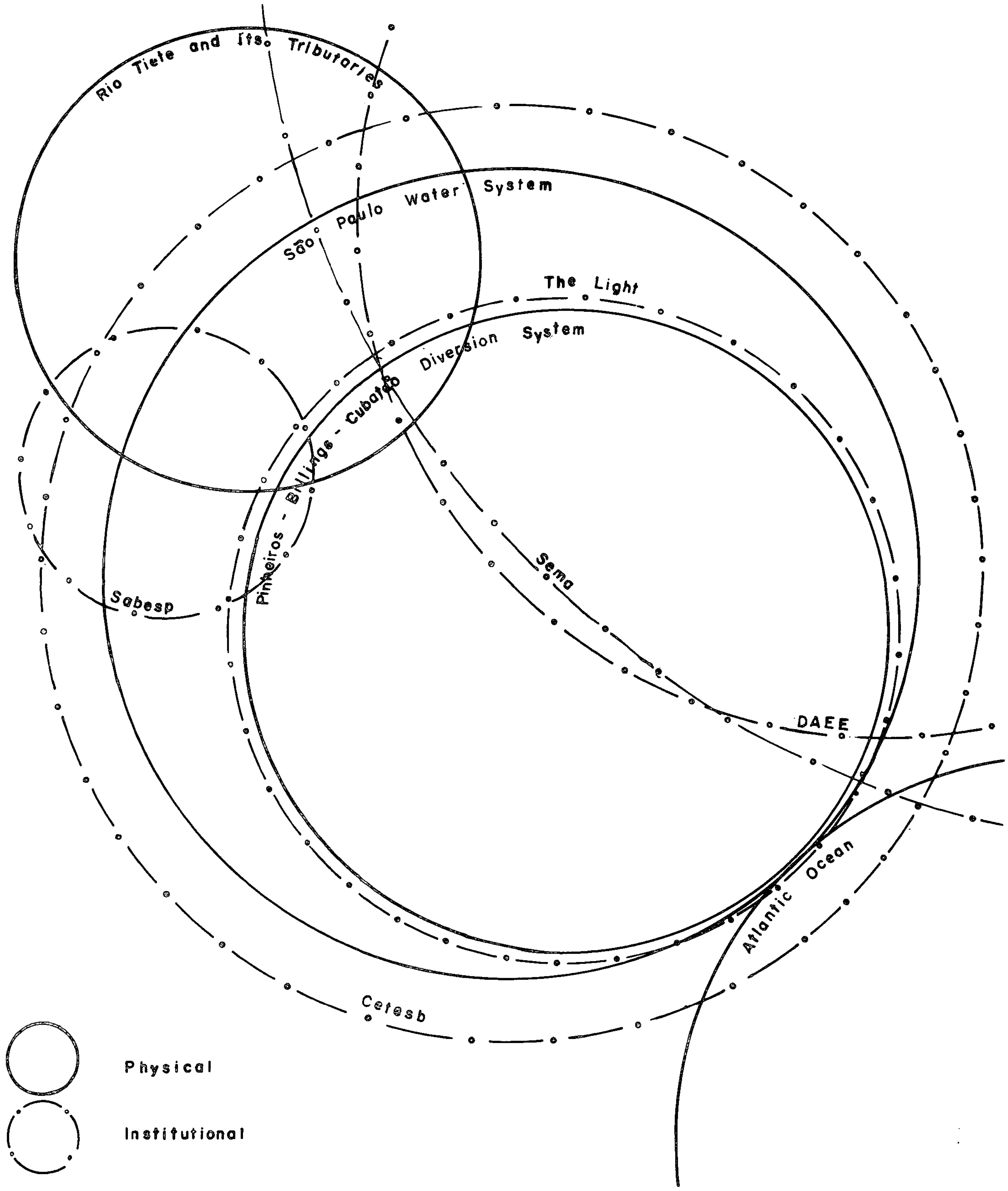
74/ These reforms of the State systems of environmental management were due in large measure to the pressure of the National Housing Bank (BNH) through the national water supply and sewerage programme (PLANASA).

/Figure 15

Figure 15

SÃO PAULO AND THE RIO TIETÊ:

PHYSICAL AND INSTITUTIONAL BOUNDARIES



The situation posed by the existing state of the water system of metropolitan São Paulo consists of the following elements: (i) the heavy contamination and unpleasant aspect of all water courses and the danger to health posed by flooding and access to these water courses; (ii) the increasing contamination of the Billings Reservoir which is a source of water supply and place of recreation for the inhabitants of the region; (iii) the need to remedy the existing deficiencies in both water supply and sewerage which will aggravate the contamination problem in general and, in particular, the conflicting demands being placed upon the Billings Reservoir.

The basic response to these issues has been to accept the need to remedy the water supply and sewerage deficiencies and to control contamination by separating the sewerage flows from the flows of hydroelectric power system. The objectives of management have been defined as follows: (i) the need to serve 95 per cent of the population of the metropolitan area with water supply by the year 2000 and to connect this population to the sewage system; (ii) the rationalization of the sanitary and storm drainage system by the construction of interceptor sanitary sources along all the main water courses; (iii) the need to subject the sanitary wastes collected in the interceptors to treatment before discharge into the "hydroelectric" flow.

The proposals for the achievment of these objectives can be divided into two groups: first, an earlier set of studies, proposing to discharge the wastes into the Billings Reservoir and to enclose some of the arms for use as stabilization ponds; and second, later studies which suggest discharging wastes into the Tiête at Pirapora. This latter proposal is the present official solution proposed by the State agency responsible for water supply and sewage, SABESP, in 1974.

The earlier solutions proposed pumping the collected sewage back to the Billings Reservoir from collection points at the Pinheiros-Tiête junction. This sewage would then undergo primary treatment at Pedreira and be released into the western arms of the Billings Reservoir.

/The SABESP

The SABESP proposal is to construct a tunnel between the Leopoldinha sewage treatment plant and the Jaqueri River and to use the lower reach of the Juqueri as a stabilization pond (see again Map 13).

At the same time, the arms of the Billings Reservoir would be cut off from the main stem and protected for water supply and recreation use. The water from the Juqueri stabilization pond would rejoin the existing Tiête-Pinheiros system through the Pirapora Reservoir.

The advantages claimed for the latest SABESP proposal are that it costs less, uses known methods rather than the unconventional technology of high pressure sewage lines, can be constructed relatively rapidly and is in conformity with existing regional development and land use plans and programmes. In particular, the scheme would remove the sewage from the urbanized area to the isolated valley of the lower Juqueri and, consequently, reduce the projected BOD load on the Billings Reservoir from 1,000 or more tons a day in the earlier proposals to 282 tons per day.

5. The common experience

It should be apparent from the preceeding review of the situation in four of the major metropolitan centres of Latin America, what are the common characteristics of the development of the city, the use of the water resource consequent upon that development and of this relationship to the quality of the environment. The similarity of situations faced by the metropolitan centres exists despite the differences introduced by the varying characteristics of site and institutional system. This uniformity of the urban development - water use - environmental quality relationship extends beyond the four cities analysed in detail in this study to all the larger urban agglomerations in the region without exception. In general the situation can be summarized as one where the provision of public water supply, and sewerage and drainage are deficient, the discharge of domestic and industrial water has seriously degraded the quality

/of the

of the water resource in the vicinity of the urban area and the increased and increasing urbanized area has had an impact on the hydrologic régime, in most cases adverse.

Equally, with a few important exceptions, the response of the management system to the physical conflicts that have arisen has been faltering. No more than a beginning has been made in adjusting the institutional and management systems for the water resource to take account of the emergence of the metropolitan region as the dominating water user and of the consequences for environmental quality of this development. It is only when the response has become more firmly delineated that attention can be given to the social consequences of the physical conflicts in water use.

(a) The physical conflict and its spatial extension

The most obvious physical conflict illustrated by the four case studies is the growing use of the water resource for waste disposal. The deterioration in water quality produced conflict in Bogotá with downstream use for recreation and water supply, in Santiago with irrigation, in São Paulo again with water supply and recreation and in Río de Janeiro with recreation. The conflict reported in each of the studies is serious and increasing in severity. It is fundamentally related to gross biological pollution, which can be controlled through waste treatment. Other problems known to exist elsewhere, related to the disposal of wastes on a massive scale, eutrophication, contamination by heavy metals, long chain hydrocarbons, etc., are not reflected in the case studies. This situation, however, is due less to their non-existence than to the lack of information. It is suspected, for example, that in parts of Guanabara Bay if the gross biological pollution was diminished eutrophication would follow.

The outstanding characteristic of the waste disposal conflict with other uses is not its existence but the limitation in the spatial extension of the effects. The nature of urban development in Latin America is such that the large metropolitan centres are isolated, self-contained societies, largely apart from the areas that surrounded

/them.75/

them.75/ The significance of this for the water resource and its management is that the adverse effects, or the external costs of the conflict fall almost entirely within the immediate metropolitan area and the "downstream" effects are normally of very restricted importance. Gastroenteric disease in Santiago is perhaps a classic example, but the feedbacks are almost always instantaneous. Buenos Aires, for example, although upstream from Montevideo, apparently does not contaminate the beaches of Montevideo. Montevideo's beaches are contaminated by Montevideo's own wastes, as equally are those of Buenos Aires by its wastes. This is only partially due to the size of the La Plata estuary.

The upstream-downstream conflict, traditionally the central problem in water management, is barely reflected in the case studies. As a general phenomenon the clash between upstream and downstrean interests has not yet arrived although incipient signs are visible in the case studies. For example, irrigation downstream from Santiago in the Maipo valley, as well as in the Mapocho valley, is threatened by the growing demands for water of the Santiago metropolitan area. In the case of Bogotá, at present the oxygen demands of Bogotá's wastes are not felt in the Río Magdalena although admittedly there is no information on heavy metals, long chanin hydrocarbons and other forms of potentially toxic contamination.76/ Even São Paulo's water-use system is largely self-contained at present, despite its magnitude. The waste flows from the metropolitan area contaminate the water of

75/ Only in south-eastern Brazil is there an urbanized region of the magnitude of those found in Europe or North America. See, for example the discussion in P.O. Pedersen, Urban-Regional Development in South America, UNRISD, Mouton, The Hague, 1975, especially Chapter 5, and also that in Ruben D. Utria, Hacia un enfoque más integrado de los problemas y las políticas de Desarrollo Regional en América Latina, Siglo XXI, Mexico, 1974, pp. 301-320. (See also Map 5 in Annex B.)

76/ There is little monitoring of this kind of contamination anywhere in Latin America apart from that connected to the control of the quality of public water supply. This reflects the lack of need for such monitoring in the past and in many areas at present.

/the rivers

the rivers and canals in the urbanized area, the Billings Reservoir and the beaches at Santos.

Only if the existing water system were changed and the reversal of the Tiête ended would the contamination affect water users outside the metropolitan region, downstream on the Tiête. It has not been our intention to suggest through this discussion that the relationship between water use and the environment is limited solely to contamination and water quality. There are other, far more varied conflicts: the competition with irrigation in Santiago is not restricted to the results of the use of insalubrious water; there are also restrictions on supply and competition for land. Similarly, in Bogotá there is a conflict between the natural régimes of the river with its very high peak flows which lead to flooding of the Savanna and the dedication of this land to urban uses. In these examples too, however, the diseconomies are all within the metropolitan region. Irrigation agriculture around Santiago produces for the Santiago market, and the flooding problem on the Bogotá Savanna is within the metropolitan region. This restriction does not occur primarily because downstream interests are negligible but because of the nature of the distribution of economic activity and population.

It is clear, therefore, that in physical terms the externalities are internal to the metropolitan regions, although, in most cases, they are not taken into account in the decision-making process. The case studies all show that a single economic unit encompasses all the benefits and costs or consequences of urban water management decisions. This physical situation is not, however, reflected in the managerial understanding of the issues or in the managerial response to these same issues.

(b) <u>The management issues</u>

The urban demand for water is no longer competing with that of other users but monopolizing the resource, and non-urban users can only exploit what remains after the city has had its fill. These physical conflicts in water use are not the only aspect of the

/environmental consequences

environmental consequences of water management actions within the large urban agglomerations of the region. It has often been claimed that the most important environmental quality problems of the region, as in the other developing areas, are not found in the relation of man to the physical environment but in the social environment of human settlements.77/

There are very few large cities which do not possess large deficits in the supply of potable water to the population and even larger deficits in the provision of adequate sewerage and drainage systems. This situation is clearly illustrated in the case studies. The provision of water supply is normally more widespread than connexion to a sanitary sewage system. Even so, it may be expected that one-third of the population in any city will not be served. In the case of sewerage the proportions tend to be reversed. Naturally, it is the poorer sections of the population that do not enjoy services and their absence forms part of the total poverty syndrome. There is, at least, an implicit conflict between the assignment of resources to extension and improvement of water supply and sewerage networks and to the treatment of the waste discharges from the public systems, the control of the deposition of industrial residuals in water bodies or the monitoring, analysis and control of the effects of urban expansion on the hydrologic régime.

77/ In the fourth paragraph of the Declaration adopted at the United Nations Conference on the Human Environment it is stated that: "In the developing countries most of the environmental problems are caused by under-development. Millions continue to live far below the minimum levels required for a decent human existence, deprived of adequate food and clothing, shelter and education, health and sanitation."

Specific reference has been repeatedly made to the importance of the provision of water supply and sewerage, in Latin America, see for example the resolutions agreed to at the Regional Preparatory Meeting of the Countries of Latin America and the Caribbean for the United Nations Water Conference, CEPAL, E/CEPAL/1020, November 1976.

In a recent Chilean study, the absence of water supply and sewage connexions in the dwelling was taken as a characteristic of poverty, ODEPLAN - Instituto de Economía, Universidad Católica, Mapa de Extrema Pobreza, Santiago, 1975.

The means to solve this conflict and the optimal assignment of resources between these various activities have not been examined in this study. In many metropolitan centres, including those studied, the resources available for water management are not unlimited. In addition, it is not common to find an institutional system that permits the question of the assignment of resources to be adequately studied, so that it would have been difficult, even to have raised such issues had they been included in the scope of the study.

There is a need, however, to provide some clear idea of the magnitude of investment likely to be required in water supply, sewerage and water quality control in Latin America. Without such an estimate of the resources needed to obtain, at least, a minimum control over the relationship between water use and the quality of environment a meaningful context for the rest of this discussion will be lacking. Precise estimates of total future costs in such gross terms are not possible. From the various estimates that have been made, the order of investment required to meet the goals set by the Ministers of Health for water supply and sewerage would appear to be between 7 and 10 billion dollars by 1980.78/ The total costs of maintaining water quality through treatment of domestic wastes and other controls are impossible to estimate. Sewage treatment, including the original investment, maintenance and operating costs, can be expensive but the alternatives are legion and even the estimates that are available provide little guidance.79/ It should not be expected, however, that the cost of protecting the quality of waters receiving wastes will be

78/ The goals are: for urban areas, 80 per cent of the population served by a house connexion for water and 70 per cent connected to a sewerage system; in rural areas, 50 per cent of the population supplied with a protected water source and a sanitary waste disposal system. For further details, see PAHO, Ten Year Health Plan for the Americas, Washington, 1973, p. 50.

79/ The costs of treatment vary by type, which in turn depends on the level and type of contamination, ambient water quality standards, etc.

/of the

of the same order of magnitude as the provision of water and sewerage services. For example, in Bogotá of the total estimated investment in the water, drainage and sewage system between 1976 and 2000, the equivalent of only 92 million dollars will be required for sewage treatment, out of a total of almost 1.4 billion dollars.80/ The total cost of water quality protection would be higher, as those estimates refer only to public investments in physical facilities. Similarly, in São Paulo sewage treatment investment is estimated to equal 36 million dollars out of a total estimated investment of more than 1.2 billion dollars in the storm and sanitary drainage system by the end of the century.81/

It would appear from the information available that investments in measures to improve the quality of the environment will provide little significant conflict with the water services in resources assignment. Resource assignment conflicts are more likely to arise between the priorities given to the water services and similar investment in social overhead facilities. There is no support, in the case studies, for the commonly expressed fears of the high cost of environmental quality protection, but the evidence is not sufficiently strong to prove the argument invalid.

The perception or awareness of the nature of the problem presented by the expansion of the metropolitan centres is in itself a major issue for water managers. The change in the scale or volume of water use in step with development and the consequent effects on the environment is a particular aspect of the general question of the effect of changes in the scale of problems on institutional effectiveness

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80/ Jaime Saldarriaga, op. cit.

81/ Companhia de Saneamiento Básico do Estado de São Paulo, Plan Diretor de Esgotos da Grande São Paulo, Soluçao Integrada, São Paulo, 1974.

/The result

The result of this failure in urban management, in general, is physical chaos and institutional confusion.82/ Fortunately, water resource management seems to have been able to adjust relatively well, although there are obvious examples of shortfalls in the process of adjustment.

One such shortfall lies precisely in the failure to consider environmental effects in the decision-making process. The form taken by this particular shortcoming in institutional effectiveness varies widely, as is illustrated by the case studies. For example, even where, as in all the four cases considered in this study, in formal terms the managerial system contains all the basic administrative machinery, there arises the problem of the coincidence, or lack of coincidence, of boundaries. This question arises in addition to and apart from the absence of institutionalization, but it may not always be simple to separate the one from the other as they are closely related. The superimposition of institutional boundaries in the management of the Upper Maipo valley seems to reflect failure to grasp the nature of the change that has occurred in the water management problem, rather than inefficiency, on the part of the institutional system. This is in contrast to the situation in Bogotá where the lack of coincidence between institutional and physical boundaries, and particularly the relative autonomy of the city versus CAR, obviously hampers the decision-making process.

82/ A recent CELADE study distinguishes between "Grandes ciudades and ciudades grandes" and although the issue is presented in terms of its physical consequences, there is always institutional and managerial failure related with the physical deficiencies: "With an almost total lack of urban services for large parts of the area they cover; with many inhabitants living in unsatisfactory dwellings and in areas where poverty and the lack of minimal formal education reign; covering too large an area for their population, with innumerable problems as a result, the Latin American cities are increasingly big cities without being great cities", Ligia Herrera and Waldomiro Pecht, Crecimiento Urbano de América Latina, BHD-CELADE, Santiago, 1976, p. 79.

/In Brazil,

In Brazil, it seems to be both the better coincidence of institutional and physical boundaries and the better comprehension of the nature of the issue that has contributed to the more detailed consideration of the environmental aspects of water use both in Río de Janeiro and São Paulo. A fundamental step in this process in Brazil was the development of the national sanitation plan (Plano Nacional de Saneamiento - PLANASA), which has led to the complete overhaul of the water supply and sewerage administrative system and the concentration of the necessary financial and human resources.83/

The internalization of the external diseconomies of water use in the metropolitan region stemming from restrictions in the spatial extent of the physical conflicts in question does not mean that the effects fall equally on the whole population. It means, in the normal case, that the poorer sectors of the population suffer these costs. The decline in the quality of the water resources tends to reinforce the burden of the lack of urban services. The equity aspects of the conflict are not, however, between assignment of resources to treatment or extension of basic services but rather the whole adjustment of the social system to spread equally the costs of the diseconomies brought by urban expansion and industrial growth. It is the beaches inside Guanabara Bay which are contaminated by the waste discharges from Río de Janeiro. These beaches are frequented more by low and middle-income families while the wealthier inhabitants prefer Copacabana and Ipanema on the Atlantic Coast. Usually, it is the districts of the metropolitan region inhabited by the poor that lack water supply and drainage facilities. There are, therefore, questions of equity involved in the assignment of resources to the resolution of physical conflicts which arise in the relationship between the urban centre and the water resource, although perhaps not quite

83/ For a description of this scheme, see: José Roberto de A.P. do Rego Monteiro, Water Supply at the National Level, a Permanent Solution, BNH Information Office, Río de Janeiro, 1972, and various other publications of the National Housing Bank, and a recent special edition of Ingeniería Sanitaria, Vol. XXIX, Nº 1 to 4, July 1975-June 1976.

those that might be expected. The equity aspects of these conflicts is not related to the assignment of resources between environmental quality control and alternative investments more beneficial to the lower income groups. The decline in the quality of the water resource in the immediate vicinity of the city affects the poor more than the better-off. Again this would suggest that some reconsideration is necessary of the thesis that environmental quality is a concern of the wealthy.

Finally, after the necessary adjustment in the perception of the management problem has been made and institutional boundaries adjusted to conform to the physical boundaries, and it has been accepted that environmental quality is not only a matter of concern to the rich, the question remains of what should be done. What should the response be? Can the experience of other societies be applied with little or no modification? Or should there be a distinct Latin American approach taken to what is a particular variant of the more general management issue of how to incorporate environmental considerations into the water management process?

(c) The management response

The brief review of the issues presented above establishes a platform upon which an analysis of the observed response of the management systems in each of the four cases can be presented and, perhaps, some conclusions drawn about its appropriateness. The comparison of the response observed in the four case studies shows considerable difference between them and probably, represents the range of responses found in the region. It should be noted at the outset of this discussion that in none of the four cases has the response been a complete absence of action. In every case the management system has taken a positive decision. This does not mean, of course, that this decision has been either adequate, appropriate, or of the same kind in each situation.

In none of the cases has the response yet amounted to a complete resolution of the management issues. In general, it has not yet reached the stage of large-scale initiation of actions to protect the quality of the environment. The response can largely be characterized as, either or both, (i) administrative adjustment to permit an improved perception of the nature of the issue, i.e., the adjustment of institutional boundaries to the changed nature of the physical system to be managed; and (ii) the initiation of investigation into the nature of the physical impact of urban expansion on the aquatic ecosystem.

Of the four cases studied, it is in Río de Janeiro and São Paulo where the management response has incorporated aspects of both elements. There have been adjustments of administrative boundaries to reflect the changed percpetion of the physical system and incorporate it in the centralization of environmental quality regulatory and monitoring activities in CETESB and FEEMA. In Bogotá, the response has been more limited, although studies to establish the nature of the physical problem and possible solutions have been undertaken. Locally, the administrative system is fragmented, and there is a lack of coincidence between institutional and physical boundaries, with the restriction of the CAR to the upper and middle parts of the Río Bogotá basin, excluding the sanitary area of the city of Bogotá. At the national level in Colombia, legislative adjustments have been embodied in the recently enacted "Código Nacional de Recursos Naturales Renovables y Protección al Medio Ambiente", although as yet no regulations have been promulgated. In Santiago, in formal institutional terms there is no boundary problem, since institutional boundaries coincide with physical uses, but the <u>de facto</u> system does not work in conformity with the <u>de jure</u> situation. The water resource management agency, the Dirección de Aguas of the Ministry of Public Works, has found it difficult to co-ordinate or control the activities of the major users, some of which are, themselves, public sector institutions. Its relationship with the private sector has hardly been more successful, and aside from the direct water users its influence has been negligible. In terms of management action the response in Santiago has been limited to a little investigation of the water quality problem, although other

/aspects of

aspects of water management are well understood. There has not been as yet a deep consideration of the environmental repercussion of either urban growth or expanding water use on the water resource.

From the standpoint of understanding the relationship between urban and industrial growth and the water resource undeniably the most complete response has been that adopted in Río de Janeiro. Here alone has the investigation of the issue been based on the development of water quality models.84/ Technical emphasis has been placed on the understanding of the relationship between waste discharges and the pattern and nature of the quality of water in the receiving water body.

The models permit the varying response of the Bay to be simulated as patterns and levels of waste discharge change. Equally, the relationship between discharges and the establishment of ambient water quality standards can be calculated, and this relationship will be eventually translated into financial and economic terms in the form of the different investments required to maintain the standards.

In São Paulo and Bogotá no such relationship has yet been thoroughly investigated and made central to the technical understanding of the management issue presented. A beginning has been made, however, on the collection of the necessary data, and in the case of São Paulo the response of parts of the receiving waters to variations in waste discharge is understood. This is the case with the Billings Reservoir, for example. In Santiago, there does not appear to have been any systematic collection of the necessary information.

84/ It is not meant to suggest that water quality or quantity models is invariably a necessary element in an adequate response. Such models do require however, a thorough monitoring of the physical system. In Río de Janeiro, FEEMA is extending the modelling activities to encompass economic aspects of the water use-water quality relationship.

/(d) A

(d) A final comment

Neither the adjustment of the institutional system for water management nor the undertaking of sophisticated technical studies are sufficient, although they are necessary conditions for the successful introduction of environmental considerations in the water management decision-making process. There are many other factors of crucial sginificance, some of which have fallen outside the scope of the case studies.

One such issue, touched upon earlier in this discussion, is the transfer of technology in the form of investigation and control of environmental quality of water and related resources. This matter was not specifically addressed in the case studies, but the experience that they embody would suggest little technical difficulty in technological transfer. Models developed elsewhere can be applied in Latin America, the necessary treatment techniques do not vary, ambient water quality standards are of almost universal applicability, and it is not in such areas that social adjustment is difficult.

Adjustment is difficult, however, in the area of institutional systems, legal regulation of water use practices and the entire mode of introduction and operation of an environmental management system. The construction of this system and its development must be tailored to the particular circumstances of each case and depend upon the allocation of sufficient resources both human and financial, to the investigatory and management system, and thus the establishment of a monitoring system to collect the necessary information.85/ If sufficient resources are not forthcoming the perfection of the design of formal systems of administration will not be successful. Technology cannot be applied without the wherewithal to apply it, and the training and

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85/ In Río de Janeiro FEEMA has spent 20,000,000 cruzeiros (2,000,000 dollars) since 1973 on the research and monitoring activity necessary to permit the development of the water quality models of Guanabara Bay.

allocation of the necessary human resources is the key element in the whole process. Unfortunately, no analysis has been made of this situation in the case studies, but past experience in the construction and operation of waste treatment facilities, for example, is not particularly encouraging, even though waste treatment is perhaps the easiest of all environmental quality control mechanisms to introduce and maintain.

Chapter IV

CONCLUSIONS

The thesis developed in this study is, firstly, that water management in Latin America can be improved by taking greater account of environmental quality, and that failure to do so will impose unnecessary economic and social burdens on both current and future generations; and secondly, that improvements are likely to stem from a more systematic interdisciplinary approach in the iterative processes between research, planning, project feasibility and design, and management of water.

In the conduct of the enquiry, the theme water, development and environment elicited a range of reactions from those engaged in research, planning and management of water resources in the region. In some quarters uncertainty was expressed as to the nature of environmental dimensions. Others viewed the issue as conservationist and obstructive to the real needs of development. Yet another position was that environment is nothig more than a glorified name for aspects which should be incorporated routinely in sound management of water and related resources. That such aspects have not always been introduced was freely admitted. However, it was held that the special status conferred by the introduction of the term "environment" has resulted in the whole idea being "oversold", thus distorting the decision process. The foregoing positions are basically unsympathetic to the view that environmental quality deserves explicit attention in water management, and that such attention may require new approaches to planning, project design and operation of water systems. There were other positions which were wholly sympathetic, usually in institutions which are once removed from the actual management of water, such as planning offices, national environmental protection agencies, or public institutions responsible for research or monitoring of water quality.

/Given the

Given the diversity of opinion, this Chapter opens with a restatement of the principal concepts which lie behind the study, to set the stage for drawing together the main themes and conclusions of the report. Specific conclusions concerning particular topics are to be found in Chapters II and III; we shall now attempt to highlight the broader findings. The generalizations which follow in some instances go somewhat beyond the data available and therefore should be taken as suggestive rather than conclusive. This applies particularly to experience from the cases which sheds light on the validity of conventional wisdom on planning and management of water resources.

1. Perspectives restated

The continuing growth of population and economic activity in Latin America has resulted in a greater number of hydraulic systems in use, and more intensive use of those traditionally utilized. The increased pressure by man on his environment has manifested itself through more and bigger engineering works for the deviation and regulation of water flows, higher levels of material wastes as by-products of urban concentration and industrial production, and changes in the use of land, forests and fisheries. This stepped-up use of water and related resources has had an exponential impact on the environment, a trend which is unlikely to be reversed in the near future. However, a basic premise of the study is that the changing relationships between water resource use, development and environment call for a change in concepts and approaches in the planning and management of water. The fundamental question is how to handle the increasing impact of water development on the environment and how to cope with the seemingly unbridled demands of expanding urban-industrial complexes.

At any level of development society draws goods and services from the environment to combine with labour and capital in the production-consumption-investment process. Man's impact on his environment takes two forms: firstly, direct competition with other members of the ecosystem through extraction of materials or services; and secondly, through the discharge of residuals. In any specific situation the nature of the relationship between society and environment will depend on the socio-economic and cultural characteristic of the former, and the bio-physical characteristics of the latter. One can generalize only to the point of stating that with increasing total consumption and rising productivity associated with higher per capita consumption, the level of potential adverse environmental impact increases. In these circumstances environmental damage must be tolerated, or society must be prepared to forego consumption either by extracting less from the environment and discharging less into it, or by diverting resources to environmental protection.

The key issue is therefore the management of environmental quality in the best interests of society. There are two goals - higher consumption and environmental preservation - which in the short-run tend to be competitive. In the long-run, environmental preservation must be consistent with society's overall consumption objectives. The management problem in the case of water resources is thus to seek out ways whereby water use can be intensified to satisfy the needs of a growing population which aspires to higher per capita consumption levels, without unnecessary damage to the environment. In addition, the manager must assess the threshold level of environmental damage which is unacceptable to society regardless of the short-run benefits which may accrue.

The management of environmental quality calls for decision-taking throughout the spectrum of social institutions. At the national level there must be agreement on goals for total production and consumption, spatial distribution of population and economic activity, income distribution, employment and intergenerational distribution of resources with its conservation implications. Again at this level there is the choice of political, social and economic measures which will be used to achieve the goals. These national goals and policy instruments constitute the framework of constraints within which water must be planned and managed. Among the water manager's principal concern

/is efficiency

is efficiency in the allocation of resources and the resolution of conflict in the process, where efficiency may be gauged by one or more ratios which compare the attainment of objectives with the various economic and social costs incurred, using whatever measures of objectives achievement and costs are deemed socially acceptable. Management in this case demands knowledge not only of the hydraulic, economic and engineering characteristics of water use but also of the behaviour of social, institutional and physical systems within which water is to be developed.

The study did not deal with structural reorganization which may be undertaken with environmental protection in mind. It has focused instead on the technical, economic, legal and institutional instruments currently at the disposal of the water manager, and how these may be used or modified so that environmental questions may progressively be incorporated into decision processes.

2. The incorporation of environmental issues in water planning and management

(a) Latitude and constraints

The adoption of new directions in the planning and management of water resources will depend on the organizational and professional capability of the agencies concerned to address the complex dynamic interrelationships between physical, social and institutional systems. Three themes recur throughout the report: (i) the need to retain a clear grasp of the issues where multiple objectives, adaptation to natural and social systems, and the existence of uncertainty are all explicitly recognized; (ii) the need to adopt a broad view which incorporates the behaviour of natural, social and institutional systems; and (iii) the need to integrate the range of public and private institutions involved in setting development and conservation objectives and in the subsequent management of water and related resources, with special emphasis on ways of giving the beneficiaries a greater role in decision-making.

/The capability

The capability of management to respond to these needs is governed by the sources of financial and decision power, which also determines the political will to fix explicit objectives and ensure that policies are designed and executed to achieve them. In addition, it depends on the technical and administrative capacity to undertake research, planning, monitoring, evaluation and operational activities; and on machinery for decentralization and interagency co-ordination. For instance, in the cases of the Maipo, Aconcagua and Bogotá the primary source of financial and decision power over water use rests with the user agencies, while the water management institutions have only limited technical, administrative and co-ordinating capacity. In contrast, in São Paulo and Río de Janeiro considerable power is vested in the management agencies. In Caño Mânamo, La Chontalpa and San Lorenzo the beneficiaries (users) of water regulation were only marginally involved in the decision processes. The management response to environmental issues may be expected to be markedly differen in the three situations.

The pressure to do something about environmental quality depends largely on political factors. If those who are prejudiced by a reduction in quality have little political voice, while others who are politically powerful either benefit from a particular management procedure which reduces environmental quality, or are unconcerned by the issues, there is unlikely to be much change. The Guanabara Bay case illustrates a situation where unrestrained intensification in use of the waters of the Bay gave rise to political pressures for the systematic settlement of conflicts betweem competing uses which led to the creation of FEEMA in 1974. The task of accelerating these political pressures and building a constituency for environmental qualit management falls within the sphere of fundamental structural change and "consciousness-raising", which goes beyond the present study.

Of all the questions related to the inclusion of environmental issues in decisions on water use and development, the most complex and difficult to resolve appear to be those associated with the planning and management of broader integrated systems. Organizational structures,

/the hierarchy

the hierarchy of command, latitude in decision-making at various levels and personnel policies all interact in the determination of institutional objectives, interest in and capacity for planning and project design, and the degree of integration feasible. Moreover, the managers operate amid constraints over which they have little or no control. These include, for example, national and regional development priorities, budgetary allocations, land tenure and water rights arrangements, fiscal and price policies, urban population and industrial growth, and the general political climate. Changes in any of these conditions may have a negative or positive effect on management performance. These constraints impinge on the activities of the water manager in varying degrees, but in general they provide some latitude for decisions on the type of action to be undertaken.

(b) Planning and project design capacity

Few countries have national plans, although a number engage in the programming of sectors such as energy, agriculture and transport, and in Mexico and Venezuela water sector planning is well developed. Projects are frequently screened and selected at the sectoral level, but environmental quality standards are generally not specified with sufficient precision to be of use to water managers in project design and the operation of water systems. The developmentalist and conservationist positions are not always well defined. Water management where the question is how to cope with a situation in which all uses of water and land are subordinated to the demands of a rapidly expanding city, is not susceptible to project design as applied to a dam, for instance. Here again, national and regional institutions are only starting to come to grips with the environmental quality issues involved. FEEMA and CETESB are examples of water management institutions which have developed considerable research and planning capacity to tackle these issues on a regional scale.

In the five water regulation case studies there is little evidence of strong directives from national planning agencies with respect to environmental questions which might be taken as constraints in project design or management. In these circumstances, if environmental factors were built into the project it must have been at the behest of the agency directly responsible for the project. Given the developmentalist orientation of most of these institutions at the time the projects were initiated, it is not surprising to find that little emphasis was placed on long-run preservation of environmental quality.

Virtually all water management and user institutions are well qualified to deal with the engineering aspects of design, construction and operation. They have also shown considerable ability to recognize deficiencies in performance, mainly attributable to initial uncertainty about the behaviour of social and physical systems, and to design and take remedial measures. The tendency has been to opt for engineering solutions, such as further regulation or interbasin transfers in Aconcagua, San Lorenzo and Caño Mánamo and secondary or tertiary treatment of sewage in Santiago and Bogotá, as being the simplest way of gaining control of the situation. In spite of their evident administrative and technical capacity, many institutions are not well equipped to undertake planning which considers a much wider range of management alternatives. Such alternatives might include less attention to major works of this kind and more emphasis on adaptation of management to the existing physical and social situation: for example, regulation of land use in areas irrigated by polluted water from Santiago as a substitute for sewage treatment, or changes in the cropping patterns of La Chontalpa or Caño Mánamo in place of increasingly complex systems of drainage, irrigation and water table management. On the surface such approaches may not appear economically attractive, but if due account is taken of the uncertainty of achieving long-range goals they may well turn out to be viable for inclusion in a development programme.

The knowledge gaps revealed by the case studies indicate a need for a more systematic accumulation of knowledge within a carefully structurated framework designed to identify key questions. Given the complexity of the questions posed with respect to the functioning

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of natural, social and institutional systems, it may be difficult in most instances to ask managers to delay action while scientists develop and test a series of hypotheses on system behaviour requiering extensive data collection. Nevertheless, without research and feedback through on-going monitoring and evaluation, experience will continue to be fragmented, action will not be planned to yield insights into what are believed to be critical relationships, and the information that does come to light will continue to reside in the archives of water management institutions.

If the necessary range of disciplines is to be brought to bear effectively and in an integrated fashion on environmental management questions in water use, there appears to be little alternative to the adoption of a broad "system view". This requires that planners and managers should interact with research teams. Because of the complexity of the subject the designers of the research and evaluation must make every effort to take advantage of operational experience in identifying key issues. If the research is to be truly interdisciplinary and permit exchange with water managers and the accumulation of knowledge from a range of projects, it should be based on modelling techniques which need not necessarily be mathematical, such as those applied by FEEMA, but in which the different disciplines are necessarily integrated.

A critical aspect of such planning is an integrated approach to multiple uses and objectives in water management. The factors which favour such an approach include: the use of planners, whatever their specialization, with broad vision who systematically appraise the comparative merits, limitations and feasibility of alternatives for achieving defined objectives; the absence of institutional pressures to focus the planning along specialized disciplinary and jurisdictional lines and prepare projects hurriedly for immediate action, tolerance among decision-makers of planning which pays attention to the longer-range implications and possible obstacles in implementation and makes provision for uncertainty, feedback and re-orientation during execution; and the existence of a co-operative spirit among planning staffs and leaders of public and private agencies concerned with water use.

These conditions may well be utopian; but if such a model is borne in mind by those responsible for planning and design of programmes and projects related to water use, improvement may come by successive stages. Little progress can be made if activities are planned on a project-by-project basis dictated exclusively by the internal staffing, budget, equipment and time schedule of a single institution and yet this has been the basis for water management in the majority of the cases studied. Such an approach provides little room for the clear definition of objectives taking into account the socio-economic and ecosystem contexts of development, or for establishing intended relationships with other activities related to development and use of the same water body.

Promising areas for improvement are: (a) greater integration of institutions to enable application of project design and planning procedures which allow broader perspectives closer linkages between monitoring and evaluation of action and its feedback to research and planning; and (b) the training of more broadly-qualified personnel capable of applying these procedures.

(c) Towards better integration

The experience of the cases suggests that more unified planning and management of water resources is necessary for reasons both of economic efficiency and of environmental quality. Firstly, the geographic limits of management agencies should be extended to include the upstream catchment area and the downstream interests affected by water regulation structures or water pollution; secondly, the functional scope of activities should be extended beyond the constructio[n] and management of engineering works to incorporate ecosystem and socio-economic factors; and thirdly, greater control should be gained over use of the ecosystem in order to restrict unnecessary environmental damage. The underlying conditions for effective operation appear to

/include a

include a degree of decentralization of public decision-making, an increased role in decision-making for those most affected by water development, and co-ordination of concerned private groups and public agencies involved.

The term co-ordination does not imply consolidation of functions in one organization; rather it means linking related components in such a way that their collective accomplishments will be greater than if they act separately. Fragmentation of efforts, both in research and operation, has been a serious handicap in dealing with environmental issues in a number of instances. Since a broad view must be taken of the system to be managed, a variety of institutions will be involved. The fact that a number of public and private agencies are engaged in activities for intensification of water use, or activities unrelated to water use but which affect its quality or quantity, may be a source of strength. In this connexion it is important to distinguish between water management and water user institutions. For example in the Río Bogotá or the Aconcagua, the CAR and Dirección Nacional de Aguas are management agencies and the EAAB, EEEB, municipalities and irrigation associations are users. The agencies have specialized management knowledge and a diversity of ideas and approaches. However, viewed within the context of a water system, particularly a river basin, the individual pieces created by the different organizations have not added up to a coherent whole. This is particularly true in the cases of the Maipo, Aconcagua and Bogotá rivers. In order to acquire a larger common vision of the whole, integration machinery must be created to demostrate the disadvantages of individual action and the mutual benefits of closer collaboration.

Agencies with responsibility for water regulation structures - hydroelectricity, irrigation and flood control - enjoy considerable autonomy. Their objectives in terms of physical output are clear, and the economic and financial viability of projects is relatively easy to establish. Accordingly, they tend to be immune from pressures to place their activities within a wider decision-making framework.

/A similar

A similar situation applies to urban water - using institutions - water supply, sewage and drainage. Although coverage is deficient these institutions charge for their services and consequently have a considerable degree of financial autonomy. The concern for integration frequently derives from ministries of health or environmental protection agencies such as the Sub-secretariat of Environment within the Ministry of Public Health in Mexico, where the primary focus is on water pollution by industrial and urban domestic waste discharge. However, with the notable exception of FEEMA and CETESB the financing and authority of such agencies has been limited.

The organization of water management in the nine cases reflects a wide diversity, none inherently superior to the others. At one extreme, management in the Aconcagua valley is highly compartmentalized according to the particular use of water, and co-ordination is largely on an ad hoc basis, except in years of severe drought where a degree of integrated management has been imposed by the National Water Directorate. Although this institution is legally empowered to control water resource use it has not had the financial and technical backing to exercise such powers. Environmental issues in the valley are likely to arise from competition for use of water and land resources which affect planning for control of erosion and sedimentation, regulation of the river for hydroelectricity, irrigation and dilution of effluents from agriculture, industry, urban centres and mining, expansion of irrigation (including transfer to other basins), satisfaction of rising urban and industrial demands, and control of water pollution. While the individual agencies may be sensitive to environmental questions, it is neither feasible nor probably in its best immediate interests for a single agency, unilaterally, to plan preventive or corrective action. Planning designed to incorporate the potential consequences of greatly intensified water use in the valley has not yet begun.

The Guri case is in marked contrast - the CVG has responsibility for development of a large geographic area, which includes the Caroní basin, and is therefore in a position to achieve any degree of integration it deems necessary.

/The complexities

The complexities of integrated management where use of the water system is virtually monopolized by a city is perhaps best illustrated by Río de Janeiro. In addition, Guanabara Bay offers an interesting model of institutional integration for environmental protection under the State Commission for Environmental Control. FEEMA acts as executing agency for the commission and operates in association with the state agencies responsible for control of rivers and lakes, sewage and water supply, in planning, setting standards, licencing industrial pollution and monitoring water quality. Undoubtedly the two regional authorities - CVG and Grijalva Commission - have been able to exercise the greatest degree of control over resource use. On the other hand there is probably greater participation by the farmers in the Aconcagua valley in decisions on water management than in the other three agricultural cases.

A recurring theme has been that programmes of water development tend to be founded on a narrow vision of objectives and of the water "system" being managed which has failed to consider potential environmental consequences. Here again it is important to distinguish between water user institutions which, by definition, have limited objectives, and management institutions charged with taking a broader view. In some instances the confined view is reinforced by bureaucratic isolation from other activities which influence water use, and by the limited perception of water use by those responsible for planning and project design. One problem is that few agencies responsible for one or another aspect of water management combine all the required talents on their own staff for the broad view. Where each agency sets out to acquire a full complement of skills this automatically leads to duplication and waste of scarce professional and financial resources. In some instances institutions have tried to avoid multi-purpose water projects because of the difficulty of negotiating and executing interagency agreements. There are cases of little or no co-ordination between irrigation programmes and extension and land reform agencies. In one instance, three ministries simultaneously became engaged in separate land reclamation projects

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in the same region, each with its own planning, project design, construction and research capability. If such professional jealousies and bureaucratic obstacles can be overcome there would appear to be ample opportunity, based on existing facilities and talent, to extend the range of water management progressively to cover environmental aspects.

Repeated reference has been made to the need for better integration of activities among agencies concerned with water use and for adoption of broader disciplinary and long-range perspectives. The information flows, evaluative mechanisms, and provisions for co-ordination required for the integrated management of a water system simply do not exist in many instances. Although bureaucratic divisions of responsibility have exacerbated the situation, the cause has not been primarily lack of resources or institutional disagreement. Fundamentally it has been the lack of a unifying intellectual concept with an all-encompassing vision of the purpose of water resource management and of the research, planning and action required to accomplish that purpose.

A change of direction from a piecemeal to a more unified approach depends on changing entrenched institutional attitudes and behaviour patterns, which do not apply solely to the management of water systems. The key question is what conditions might be introduced to initiate a move towards better integration? Some advocate decentralization, greater beneficiary participation or co-ordinating groups. There is no one formula - strong regional or river basin authorities have a place, such as the CVG, Grijalva Commission or Corporación del Valle del Cauca; in addition, agencies such as FEEMA and CETESB which are capable of setting out the issues and evaluating alternative actions cay play an important role. Unless the agencies concerned are convinced of the need for an integrated approach and share a broad conception of the system, interagency co-ordinating committees are unlikely to improve the situation. If progress can be made along this line it should become more feasible to bring in all parties concerned in such a way that they have a stake in the decisions made.

/(d) Decentralization

(d) Decentralization

One of the most severe constraints on water management and its relation to environmental quality appears to be the universal resistance by governments to decentralization. Of necessity, large government buroaucracies must adopt rigid standardized procedures in order to be able to function. This rigidity is at variance with any design criteria aimed at flexibility, adaptation of large programmes to local needs and the harnessing of local support. Such attributes are precisely those which are believed to contribute to effective management of environmental quality. Nevertheless, the question of decentralization is by no means simple. It need not involve the beneficiaries at all, and where income distribution is a concern it may even worsen the situation by giving local oligarchs more power and influence. As G.L. Bell points out, "the simplistic notion that all will be well if power and initiative are devolved to the local level is based on a faulty diagnosis that the essential problem lies in centre-periphery relations. By contrast the argument here is that local power structures and their national linkages exercise a dominant influence over the balance and effects of policy measures. Thus decentralization must counteract rather than bolster the existing configuration of social structures at the local level".86/

In the case of water regulation the vehicle for decentralization is frequently seen as the river basin or regional authority. Latin American countries have experimented with different forms of such entities for many years. The experience of the CVG in co-ordinating water management is somewhat atypical in that there was little vested interest of other public agencies in the region and local interest groups were virtually not existent. Under such conditions co-ordination is more a technical than a political exercise. Perhaps a more relevant model is the Grijalva Commission which most certainly has had to contend with local interest groups as well as state and federal institutions

86/ G.L. Bell, in: "Redistribution with Growth" by H. Chenery, et. al., Oxford University Press, London, 1974, p. 67.

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concerned with development in the region. Although the Commission has wide powers with respect to water development and land use it has not become heavily involved in watershed management, and in the case of La Chontalpa it has functioned as a project authority, and the relationship between the project and overall development of the basin is not readily apparent.

The situation with respect to water systems dominated by large urban complex is quite distinct. Here the management issue primarily hinges on causes and consequences of change in water quality. In such cases responsibility generally rests with municipal authorities (e.g., FEEMA and CAR) and central government agencies, such as the Secretaría de Recursos Hidráulicos in México or SEMA and PLANSA in Brazil, which work through such authorities.

Of course, political consideration dictate the degree of autonomy which can be granted to local government, river basin authorities, or regional and project offices of central government ministries, and the extent to which authority and responsibility can be delegated to agencies operating in the field. Decentralization in water management poses a dilemma and therefore must be resolved by compromise.

(e). Beneficiary participation

Means should be found whereby concerned groups (the beneficiaries) may exercise a more effective voice in the decision process. An illustration of a move in this direction is the trust formed to administer the La Chontalpa project with broad-based representation of beneficiaries of the drainage and irrigation works and state and federal agencies. In both urban and rural situations affected by water use, there are sound reasons to seek a greater measure of local initiative in planning and decision making. Users sometimes have a better knowledge of the idiosyncracies of the natural system. Furthermore, if they have a say in decisions it is more likely that environmental impacts stemming from the social system, or adversely affecting a social system, will be self-adjusting, and that the necessary adjustments will be made more rapidly.

/The question

The question of beneficiary participation is extraordinarily complex. In the cases of Caño Mánamo, San Lorenzo, and La Chontalpa no effective mechanism was initially set up to allow the beneficiaries a voice in the decision process in such a way that some of the environmental damage which later occurred might have been attenuated. La Chontalpa provides the best illustration of the problem. It would probably have been impossible to explain to the project residents the complete change proposed in the agriculture forest ecosystem and social organization, in such a way that they would have a solid basis for decision and recommendation. Without a picture of the future, how could the beneficiaries rationally assess the proposals? The usual urgency for project execution precluded any attempt to answer such questions and local groups found themselves in no position to advise on the advanced development techniques adopted. The result was a social and production system which was of little interest to the beneficiaries and which they were ill-equipped to manage.

A fundamental issue is the pressure from the beneficiaries themselves to organize in their own self-interest. This in turn is governed by their perception of whether such organization will bear fruit in the institutional milieu within which it will have to operate. In an urban context FEEM was created in response to "user" concern about the declining quality of Guanabara Bay and its environs. In contrast, in La Chontalpa virtually all initiative for organization has been taken by the Grijalva Commission. The 22 new collective ejidos were essentially imposed during the early years of the project and the ejidal union was formed and encouraged to represent the ejidos on legal questions in dealing with public agencies as well as to provide marketing and buying services.

The concept of beneficiary in the case of water management needs to be broadened to include not only those who gain by a particular management programme, but also those who stand to lose in the process. In none of the cases did any formal mechanism exist whereby those benefited (upstream users) and those damaged (downstream users) might be represented in the resolution of conflict. Under these circumstances it would appear that there might be room for testing the applicability

/of public

of public interest law. The new environmental protection law in Colombia appears to offer a forum for such an activity and, in fact, a complaint has been filed by the downstream municipalities on the Rio Chicamocha against the Paz de Río Steel Corporation for contamination of the river.

(f) Staffing and training implications

Six questions arise with respect to staff qualifications of institutions concerned with water use: (i) does the institution know what questions to ask about its operations which would elucidate potential or existing environment issues and conflicts arising from intensified water use? (ii) does the institution know what professionals it would need and how to utilize them; either in formulation of questions or in obtaining answers to these questions? (iii) assuming the institution knows these questions, is it prepared to recruit the type of professionals in the range of disciplines necessary to plan, design and implement integrated programmes of water use, in conjunction with other agencies? (iv) can the institution offer salaries and career opportunities which are sufficient to attract and retain professionals of the necessary calibre? (v) are the professionals available? (vi) if professionals are not available, what sort of staff development and training is indicated?

In the first place the answers to these questions depend on the structure of water management and the competence, spirit and common sense of the leadership. Since the management systems in most countries are not currently in a position to think about or cope with environmental issues, one may ask why any agency would, on its own initiative, show interest in recruiting professionals to examine a range of components in the system which has traditionally been ignored. In part, the response is governed by consideration of the type discussed above such as political will and national planning and policy. However, if any move is to be made in the direction of incorporating broader environmental aspects into water use decisions through the modification and integration of institutional functions, a prerequisite will be the

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existence of some minimal core staff in the relevant agencies who can deal with the approach proposed. Furthermore, it is not entirely clear that initiative for new approaches resides exclusively with top management. One may sustain the hypothesis that ideas generated in the professional ranks may filter upward to the administrators. The testing of such a hypothesis has important implications for training.

Idiosyncracies of agency personnel systems and civil service salary structures and promotion procedures become a critical aspect of staffing. Of the cases examined seven were managed by national and two by state agencies. Several specialized agencies - Grijalva Commission, CVG, FEEMA and CETESB - have unusual autonomy and offer career opportunities and salaries which are considerably more attractive than those activities tied to civil service rules imposed on ministries of agricultire, public works, health and industry and commerce which were also connected with the cases to varying degrees. Vertical promotion rules in virtually all civil services work against decentralization of decision-making and initiative. Since the senior posts are generally in the capital, ambitious staff in the field must aspire to be transferred. The hurdle is that promotion of successful field staff without transfer automatically requires that they be given more authority and responsibility at the expense of the head office. In contrast, in the cases of the Grijalva Commission and CVG highly qualified people have been retained in the field, and career advancement of staff is in no way prejudiced by working at the local level. In addition, financial incentives are offered as a compensation for living conditions. A similar situation prevails in some Brazilian institutions

Major innovations in the civil service system of any country will be extremely difficult to bring about. Accordingly, it would appear that for practical reasons any modification aimed at a more imaginative approach to planning and management of water must be achieved within the existing regulations governing staffing.

National shortage of qualified man-power is difficult to assess. Water is not a sector in the same sense as agriculture, where a complete sequence of staff capacity-building can be traced through all

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levels of the formal and informal eduction system linked with research and extension. In such a situation one could visualize a unified staff development structure. One might recommend that high-schools and universities add more courses in ecology, anthropology, systems analysis, etc., but whether the people so trained would end up in water management is quite another matter. In addition, the education system of a country has a vast array of elements to consider in establishing priorities besides those which would enlarge the number and disciplinary range of qulified people who might offer themselves to government water management agencies for employment.

Given this situation, a rigorous assessment of training requirements for water management is out of the question. The central issues hinge on the type of university training most appropriate to prepare professionals to enter the resource management field in general, and the type of in-service training which might be offered to staff in water planning and management institutions in particular. With respect to the former, any recommendation would need to be based on a creful review of university programmes in Latin America in the full range of disciplines relevant to environmental quality management. There are a number of institutions in the region which offer specialized courses in environment, like the Universidad Javeriana in Colombia, CIDIAT in Venezuela and the Universidad Metroplitana in Mexico. Elsewhere the field of resources mangement is generally dealt with in departments of ecology and agricultural economics (resource economics). Since the field is vast and good university teaching and research programmes (in any field) in the region are limited, one approach might be to foster only one centre of excellence in each country which could provide the interdisciplinary complement to the specialty area. It may even be worth considering international specialization at the post-graduate level.

In-service training is less complex. The clientele in each country is readily identifiable. Unlike a university programme, in-service training can be established and built up to handle large numbers of trainees in a relatively short period of time and can be reduced or

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dismantled without undue disruption as one satisfies the peak demand. A priori a strong case can be made for generating such an activity at both the national and international level.

(g) The role of international collaboration

In considering international exchanges related to resource management there is a question of whether analytical and planning approaches, engineering design or management procedures can or should be either: (i) transferred from other countries (intra or extra-regional and applied directly; (ii) transferred and adapted prior to aplication or; (iii) developed wholly within the country or region? If there is a role for international collaboration it must be based on the premise that techniques can be transferred or adapted. While it may be necessary to develop indigenous technology there can be little doubt that much experience with water management and incorporation of environmental dimensions from countries within the region and elsewhere, is relevant.

Certain institutions in Latin America have developed a great fund of experience and expertise which would be invaluable to other countries in the region in broadening and strengthening approaches to water management. To draw only on the cases examined in this enquiry, FEEMA and CETESB have developed a great capacity in analysis of water quality issues. They offer interesting models of transference and adoption of techniques developed elsewhere in such a way as to build a highly qualified staff in each institution capable of modifying techniques, or developing new ones, to meet a local situation where cultural values, institutional structure, political objectives, or the availability of data are in marked contrast to those in the countries where the techniques were originally developed. The CVG, supported by a number of academic institutions in Venezuela (the Instituto Venezolano de Investigaciones Científicas, IVIC and the Universidad Central Venezolana UCV) has developed a vast amount of information on watershed management and problems of managing acid sulphate soils with drainage. Similar knowledge on water management and environmental impacts has been accumulated by the CAR and Corporación del Valle del Cauca, the Grijalva Commission and the Dirección de Aguas in Peru.

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In addition, there are a large number of international agencies active in the field: FAO in irrigation, forestry, inland fisheries and soil erosion in agricultural areas; WMO in precipitation and weather control; UNESCO in hydrology and the Man and Biosphere Programme; WHO in water quality and human health; UNEP in broad environmental consequences of changes in water quantity (flows) and quality; and the OAS in regional and natural resource development. There have been a number of individual river basin studies funded by national governments, the UNDP or OAS. However, there has been little progress in assuring that these studies are cumulative in their impact on research, planning, project evaluation, in-service and university training, and development of a cadre of professionals capable of identifying resource management issues (particularly those which incorporate management of the biological environment) and executing research and ongoing evaluation of action as a basis for improved decisions on development.

There is a clear need to institutionalize and disseminate the knowledge available. Multilateral and bilateral organizations are in unique position to undertake useful activities on a transnational basis, which individual countries cannot readily do on their own. This would include comparative research, collection and distribution of pertinent information, certain types of advanced training, and the bringing together of people from different countries with common problems to learn from one another's experience in workshops or seminars.

In the expectation that a forum could be generated for the exchange of ideas and experience among those engaged in research, planning and management of water resources in Latin America, a strong case may be advanced for pilot projects as one of the more promising areas for international collaboration. In the past such projects, applied to resource inventories, colonization, education, etc., have been carried out on the assumption that they would take root and become the basis for national programmes. This has not come to pass in many instances, for a variety of reasons, among which were the absence of prior assessment of their long-term viability and lack of sustained political commitment. In view of this experience it would appear that pilot

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projects in water management should derive from ongoing national activities which already have momentum and assurance of strong support. Projects might then be initiated to develop, test and monitor alternative approaches to management incorporating environmental dimensions.

The axis of any programme of international co-operation must be the development of human resources in the respective countries with a capacity to formulate and evaluate the water management questions, and to determine when and how to transfer, adapt or develop techniques appropriate to the task. In coming to grips with the operational dimensions of this issue, two questions must be addressed: (i) what are the advantages of building up international training institutions capable of providing specialized training in mangement of water resources and environmental quality, versus building up a similar capacity in a limited number of national institutions? (ii) what criteria might be used to select candidates for training - professional capability and experience, or the relative needs of the country from which an applicant comes? Neither question has a simple answer. The easy way out is to say that in (i) both types of training should be developed in parallel, and in (ii) there should be two streams, one advanced and open to all countries, and one less advanced, open only to candidates from countries with critical shortage in water planning and management capacity.

It would appear highly desirable to develop a few high quality interdisciplinary post graduate programmes in resource management in the region, although it would be difficult to visualize more than one or two specialized in water. At the same time there can be little doubt of the need for interdisciplinary in-service training courses which take a systems approach, and of a course designed around a case study or pilot project workshop. Such courses might last from one to five months with perhaps 15 to 30 participants. In both cases implementation depends: firstly, on availability of funds for an interdisciplinary staff of four to six professionals who would be expected to undertake research as well as teaching; secondly on funding

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of scholarships to enable region-wide participation (assuming that it would be self-defeating at this stage and probably financially and technically unfeasible to undertake training in every country); and thirdly, on the availability of cases or pilot projects where there is ongoing development and management of water resources, which would provide the basis for research, evaluation and course workshops.

A regional network built around a limited number of pilot projects, with provision for training, research, evaluation and exchange of experience between water managers, planners and research workers, has strong appeal. Such a goal for international collaboration would have to be approached by stages.

3. Unfinished business

The fundamental conclusion of this study is that approaches to water resource management in Latin America must be changed. This calls for a rethinking of ways of dealing with the natural and social systems to avoid the unnecessary environmental damage and shortfalls in economic performance which have manifested themselves throughout the region. With accelerating pressure on water resources as a result of rising population and development demands, it is likely that these impacts will increase exponentially in the absence of some reorientation. Much more attention must be given to the specification of social and economic objectives and to the need to sustain the long-term productivity of natural ecosystems. The implication here is greater knowledge of key questions in the functioning or behaviour of physical, social and institutional systems and their interrelationships, which govern how water will be used and the nature of the attendant environmental effects

The modifications will not come easily. Organizational structures staffing patterns and capacity for interagency co-ordination must all be adapted. Management needs to be convinced of the practical value of changes. Before this becomes a reality many unanswered questions will need to be addressed. Little has been said on the legal, institutional and political aspects of adding an environmental dimension to planning and management of water in the region. These are complex

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and sensitive issues. Where do the signals come from in the formulation of water policy and management decisions and how are they transmitted? Where are new ideas generated and by what mechanism do they become incorporated into decision-making by water management agencies? What steps might be taken to further explore means of achieving institutional co-ordination or decentralization? In addition, related to these institutional aspects are questions of analytical techniques and availability of reliable data which yield convincing projections on the probabilities of various outcomes from alternative courses of action. It is necessary to reassess benefit-cost ratios and environmental impact matrices as a basis for decision. How does one identify the key ecological, social and economic questions from the vast array of variables which impinge on decisions affecting long range resource management?

Apart from institutional, technical and information issues the question of how to generate a demand in water management agencies for professionals capable of formulating and analysing environmental issues, and how to meet such a demand, needs further exploration. What is the current capacity of the region's universities or training institutes to offer specialized and interdisciplinary courses whether short-term in-service, undergraduate or post-graduate? Should there be division and specialization among such institutions? What should be the course content and priority areas for specialization and type of course offered? In addressing these various interrelated issues there appear to be sound reasons for giving serious consideration to an approach which would link interdisciplinary research, training and evaluation to specific water development projects or water management situations where action is already under way in various countries. This would provide an opportunity to test hypotheses about new approaches, refine methodology and better assess the nature of the training required.