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WATER, DEVELOPMENT AND THE ENVIRONMENT IN LATIN AMERICA

(Summary)

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*/ This document is a summary of the study entitled "Water, Development and the Environment in Latin America" (E/CEPAL/L.148).

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CONTENTS

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 (i) a synthesis of the principal findings of a Latin American regional enquiry designed to contribute to the improvement of the planning and management of water resources, with specific recognition of the need for reconciliation between the requirements for accelerated economic development and environmental protection; and (ii) some suggestions for future action. The project was commissioned by the United Nations Environment Programme (UNEP) with the 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 consultants and United Nations specialized agencies.1/

The study examines the changing relationships between water use, accelerated economic development and accompanying alterations in the environment in the Latin American scene. Within this historical perspective there appeared to be a clear need to focus the analysis on representative situations from the point of view of: the nature of intervention in aquatic ecosystems; the demands placed on water by development activities; the importance of human resources and capital in meeting these demands; the relative complexity of the planning and administrative systems applied, and the magnitude and permanence of the alterations to the environment.

1/ For a complete listing of reports see Annex A.

On the basis of these criteria nine cases of intensified water use were selected for study in the principal ecological zones of Latin America (see table 1). These cases had all been subject to previous study and reflect the thinking of research and water management institutions in the region concerned with environmental dimensions. The cases illustrate aquatic ecosystem changes stemming from incorporation of new land and water resources, intensification of resources already exploited, hydroelectricity development, and expansion of large urban-industrial complexes. This analysis focussed on the technologies used in changing aquatic ecosystems in urban and rural situations, the direct and indirect environmental consequences associated with these changes, and the systems applied in planning and management of water resources.

On the basis of the findings of the case studies and available information on other experience in the region, certain common themes were identified suggestive of general propositions applicable in the region regarding: analytical approaches, design and evaluation of projects, professional training and organization for water management. Rather than being solutions, these propositions constitute guidelines which may facilitate the identification and evaluation of alternative courses of action designed to allow society to utilize water efficiently in an environment which is transformed but not unnecessarily degraded.

Selected elements of the enquiry are presented in section 1 which gives a general picture of water, development and the environment in Latin America.

Section 2 covers the principal conclusions on environmental issues, obstacles and the possibilities for improving the planning and management of water through incorporation of environmental dimensions, and section 3 deals with some future avenues for further improvement of water management through the introduction of environmental dimensions.

/Table 1

Table 1

CHARACTERISTICS OF WATER MANAGEMENT CASES a/

	Water systems dominated by urban complexes				Water systems dominated by regulation structure				
	Bahía de Guanabara (Brazil)	Río Bogotá (Colombia)	Río Maipo (Chile)	Sao Paulo (Brazil)	La Chontalpa (Mexico)	San Lorenzo (Peru)	Guri (Venezuela)	Río Aconcagua (Chile)	Caño Mánamo (Venezuela)
Water system									
River/canal		x	x	x	x	x	x	x	x
Lake/reservoir				x					
Bay/estuary	x								
River type									
Estuarine	x		x			x		x	
Deltaic					x		x		x
Tributary		x		x					
Climate									
Arid temperate			x					x	
Arid tropical						x			
Humid temperate		x							
Humid tropical	x			x	x		x		x
Principal water use									
Waste transport	x	x	x	x				x	
Irrigation			x			x		x	
Hydroelectricity		x		x	x		x		
Flood control and drainage					x				x
Recreation	x			x					
Principal area of environmental concern									
Upstream - erosion							x		
Downstream and local									
- contamination	x	x	x	x				x	
- ecosystem change					x	x		x	x

a/ See Annex A for information sources. Location is shown on map 1.

/1. Water,

1. Water, Development and Environmental Relationships in Latin America

In general, Latin America is a humid region. Mean precipitation, at 1,500 mm, is some sixty per cent above the world average, and the annual run-off, at 370,000 m^3/second represents thirty per cent of the world total. These averages cloak the existence of some very significant differences. For example there are enormous variations in precipitation in the region as a whole, ranging from a long-term average of 1 mm in Arica, Chile, to almost 8,000 mm in Quibdó, Colombia. Rainfall is the most important climatic element and 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. The seasonal and inter-annual variations in rainfall result in wide variations in stream flows and complex behaviour in the larger basins.

The river systems in Latin America can be subdivided into three major groups: 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.

Runoff reflects significant geographic concentration. The three largest river systems are the Amazon, Orinoco and La Plata and their combined flow represents more than two-thirds of the total runoff. However this concentration does not reflect either the actual or potential use of water to satisfy human needs. For example, quite apart from the flow, the slope and the availability of fertile flat areas adjacent to rivers influence the degree to which water can be utilized for hydro-electricity or irrigation respectively. Of the three large river systems, it is only in the La Plata basin that suitable conditions here existed in the past for extensive water use. On the contrary, in the other two basins the large flows and their variations have tended to constitute a barrier rather than a vehicle for development.

/Population and

Population and economic activity in Latin America is concentrated in areas with less than 1,600 mm of rainfall. Only one city with over 1 million population in 1975 lay outside these areas. Thus, the greatest pressure on water resources exists in the basins of the medium and small rivers of the lower rainfall areas which, as a rule, are subject to the greatest seasonal and inter-annual variations in flow. A reflection of this pressure is the marked increase in inter-basin water transfer projects which have been initiated in the past 20 years. 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 tapping ever more distant sources, to the drawing down of ground water levels and to 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 supply of drinking water in the home.

A corollary of the expansion of domestic and industrial demands for more water has been the increase in waterborne waste discharges in terms of both volume and concentration of contaminants affecting water quality. This increase in waste discharges has not been accompanied by an expansion of treatment facilities. The obvious consequence of this situation is the 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 the case of urban centres of more than 100,000 population. Water supply and waste discharge, although perhaps dominant, are not the only means by which metropolitan centres have an impact on the water resources. Such large concentrations of population and industrial activity generate demands for drainage of wet land, protection of built-up areas from flooding, and water-based recreation. Further, the increased rate of runoff from urbanized land changes hydrologic régimes.

/Despite the

Despite the demands which have been placed on aquatic and related ecosystems in Latin America, the latter appear to have shown considerable resilience in absorbing the impact of man's intervention.

The use of water in the region is spatially sporadic and is heavily concentrated in restricted areas (see map 1). While there is little information on the use of water in the region, two indicators can be used as proxys - the volume of water in impoundments as an indication of interference in flow régimes, and urban population as an indicator of use of water for transport of domestic and industrial residuals. Using reservoir volume as an indicator, accelerated intensification of water use is illustrated in figure 1. A sharp up-turn started in the fifties and was largely a consequence of dynamic urban and industrial expansion. Between 1903 and 1973 reservoir capacity increased one thousand fold, and two-thirds was built in the last 15 years of this period. Dams in construction in 1972 will double the capacity of that year. The biggest thrust, reflecting the huge energy demands of development, is in hydro-electricity - projects under construction in 1972 will almost quadruple the capacity of reservoirs used for this purpose (see table 2). This change in water requirements, coupled with the evolution of technology in construction, electric power transmission, etc., has resulted in progressively larger structures. Prior to 1970 average reservoir capacity was less than 100 million m^3, whereas the average capacity of reservoirs constructed in the decade 1963/1972 was 460 million m^3 and those under construction in 1972 were five times that size. This increase is due mainly to the enormous hydro-electric projects under way (see table 3). The scale of these activities is suggestive of the force of interventions in aquatic and related ecosystems.

The La Plata basin represents 25 per cent of total regional storage capacity; other important areas are the Orinoco, 9 per cent, the Rio Negro (Argentina), 8 per cent, the San Francisco (Brazil), 8 per cent, and the rivers of the Gulf coast of Mexico, 8 per cent.

/Map 1

Mapa I

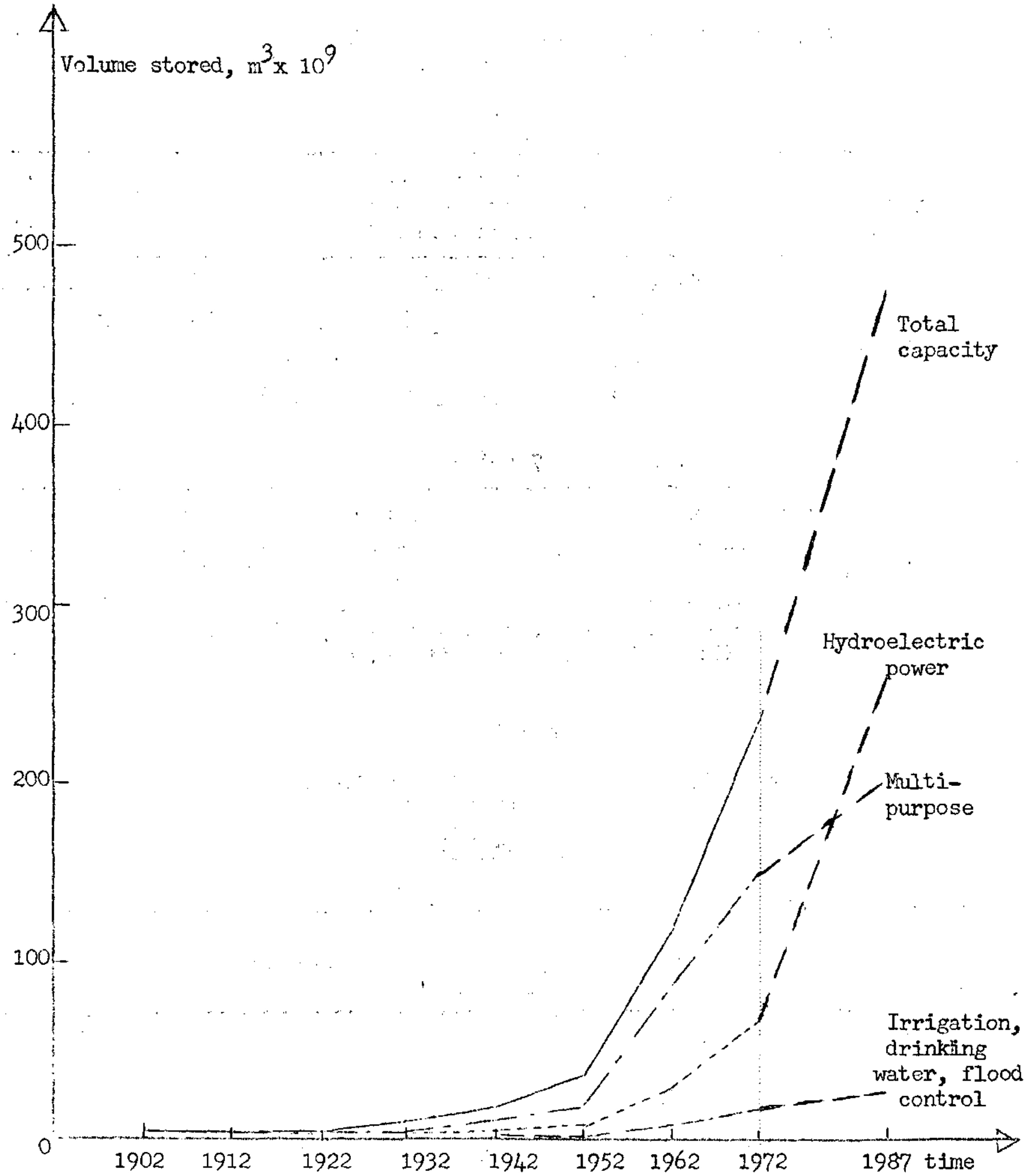
LATIN AMERICA AND THE CARIBBEAN

LEVELS OF USE OF RIVERS
AND LOCATION OF CASE STUDIES

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

Figure 1

TOTAL VOLUME OF WATER STORED IN LATIN AMERICAN DAMS, BY PURPOSE



The broken line indicates the capacity of dams at present under construction and expected to be brought into service around 1987

Source: Based on information from the International Commission on Large Dams, World Register of Dams, 1973.

/Table 2

Table 2

LATIN AMERICA: RESERVOIR CAPACITY BY PERIOD OF ENTRY INTO OPERATION

(million m^3)

Period of entry into operation	Single purpose hydro-electricity	Irrigation potable water flood control	Multi-purpose	Total for Period
Before 1942	2 254 (41)a/	3 386 (111)	9 531 (39)	15 171 (191)
1943-1952	8 420 (30)	2 958 (56)	9 746 (23)	21 124 (103)
1953-1962	15 376 (56)	3 531 (108)	64 679 (49)	83 586 (213)
1963-1972	46 890 (42)	9 714 (183)	70 176 (52)	126 780 (277)
Under construction	191 626 (24)	7 428 (48)	37 159 (23)	236 213 (95)

a/ The numbers in parentheses show the number of reservoirs.

Source: International Commission on Large Dams, World Register of Dams, Paris, France, 1973. Dams registered include all those over 15 m in height, plus those dams between 10 and 15 m which either are over 500 m in length, have a capacity of 1 million m3 or more or a flood discharge capacity in excess of 2,000 m3/second.

Table 3

LATIN AMERICA: AVERAGE RESERVOIR CAPACITY BY PERIOD OF ENTRY INTO OPERATION

(million m^3)

Period of entry into operation	Single purpose hydro-electricity	Irrigation potable water flood control	Multipurpose	Total
Before 1942	55	31	244	79
1943-1952	281	59	424	205
1953-1962	275	33	1 320	392
1963-1972	1 116	53	1 350	458
Under construction	7 984	155	1 616	2 486

Source: Ibid.

/The water

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 expanding 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. As indicated above, the question of treatment of residuals has barely been touched. In general, extensions of urban water supply and sewage are planned rather than actually in construction, thus reflecting relative priorities vis-á-vis hydro-electricity, for example. The more extended time horizon may be gauged from the fact that in 1972 the projected increase in reservoir capacity for urban water supply was five times the capacity under construction; in other water uses capacity under construction was double the projected level.

The scene in Latin America is one of rising demand and intensification in all aspects of water use, thus influencing both quantity and quality. Aside from the fact that the amount of water to be regulated or diverted and the volume of residuals discharged into water bodies will at least double in the next 20 to 30 years, the unit costs of structures are also expected to increase. The best-located dam sites have already been used; there will be an increasing need to resort to elaborate inter-basin transfers and there is reason to believe that unit costs will rise due to the increasing conflicts over multiple use and the complex technical and administrative arrangements needed for their resolution. Total investment in water projects over the period 1975-2000 (water supply, sewage, waste treatment, irrigation, flood control and hydro-electricity - excluding transmission) is estimated at around 150 billion dollars (1975). The increasing water use and the scale of the projects may be expected to have major ecological implications. The change is essentially permanent and negative environmental effects frequently manifest themselves in the short run while the positive effects often are not realized without extensive delays.

/Table 4

Table 4

SELECTED FEATURES OF WATER USE IN NINE CITIES OF LATIN AMERICA, 1975

City	1 Population (thousands) 1975	1 Population (thousands) 2000	2 Drinking water Coverage (percentage)	3 Sewerage Coverage (percentage)	4 Recipient water body	5 Flow m3/sec (annual average)	6 Estimated outflow of sewage (m3/sec)
México City	10 942	31 616	79	64	Tula and Lerma/Panuco	3 350	54
São Paulo	9 965	26 045	55	33	Tiete and Billings Reservoir	87	22
Buenos Aires	9 332	13 978	88	52	La Plata	20 425	96
Santiago	3 063	5 119	78	47	Mapocho, Sanjón de la Aguada	16	14
Caracas	2 673	5 963	85	56	Guaire y Tuy	28	11
Medellín	1 477	3 743	84	79	Medellín	30	6
Córdoba	891	1 338	65	-	Primero	9	4
Barranquilla	795	1 808	68	55	Magdalena	6 871	1
San José	471	1 143	95	-	Grande de Tarcoles	101	3

Source: United Nations Population Division, New York: Trends and Prospects in the populations of agglomerations; 1950-2000 as assessed in 1973-1975; Centro Panamericano de Ingeniería Sanitaria y Ciencias Ambientales; CEPAL estimates based on official statistics of the countries for various recent years.

/Why has

Why has water become critical in Latin American development? In general it may be said that there is need for systematic planning in the use of water resources because: the resources are very extensive (particularly those which are currently little utilized); demand projections are impressive, to say the least; the combination of increased regulation, provision of urban water services and rising unit costs will place formidable demands on national budgets, and potential negative environmental consequences may be expected as the slack in underutilization (absorptive capacity for residuals, recreation, irrigation efficiency, etc.) is taken up. In addition, when one considers the new scale of intervention proposed, which represent a sharp departure from historical and projected trends, the region is at a critical point with respect to decisions on current and future intervention.

The magnitude of the water regulation structures under construction or proposed suggests an immediate need to address the long-run environmental issues. Since such a large volume of construction is underway it appears opportune and feasible to move as rapidly as possible to consider action oriented towards environmental protection. In the area of residuals there appears to be somewhat more margin. Only in certain cities is there a high priority for early action. However, the accelerating concentration of population and industrial activity yield exponential rates of growth in waste discharge. Considering the requirements to meet urban water supply and sewage goals there is a potential for an explosive widening of the gap between waste discharge and the capacity of water bodies to handle such discharge within some acceptable standard of water quality consistent with human health and other uses. This situation would appear to demand systematic evaluation in the near future if the region is to develop water management and technologies which can enable the region to avoid some of the massive investments which seem to be required in the more highly industrialized countries. For example, projections in the United States

/over the

over the period 1960-2000 indicate that the investment associated with water treatment will exceed water regulation investment by a factor of seven. Total investment in maintaining water quality is estimated in the range of 50-100 billion dollars.1/

Latin America has not yet recognized that it is gradually becoming a dam-based society and that water management is no longer a specific issue which can be treated in isolation by individual agencies or specialized irrigation and electricity commissions, etc. The scale of investments, potential conflicts in use and environmental impacts of the interventions expected from now on call for a system which can maintain permanent vigilance and regulation over the broad array of activities which impinge on water use and water quality.

2. Environmental Issues in Water Management

The changing relationships, outlined in section 1, between water resource use, development and the environment call for a change in concepts and approaches in the planning and management of water. The fundamental question is how to intensify water use and at the same time handle the increasing impact of such use on the environment while also coping with seemingly limitless demands of expanding urban-industrial complexes.

Evidence from the case studies on the intensified use of water systems in the region is drawn upon to elucidate these questions. In presenting the material the issues are arbitrarily divided into: (i) those related to management of water systems where virtually all decisions are subordinate to the water requirements of a large urban-industrial complex for domestic and industrial use or for transport of residuals, and (ii) those arising from increased regulation of river systems, primarily in rural areas, for the production and development of related resources.

1/ See: N. Wollman and G.W. Bonen, The Outlook for Water: Quality, Quantity and National Growth, Johns Hopkins Press, Baltimore, 1971, p. 25.

/(a) Systems

(a) Systems dominated by urban centres

In general, the metropolitan centres face a situation where the provision of public water supply, sewerage and drainage are deficient, the discharge of domestic and industrial wastes has degraded the quality of the water resource in the vicinity of the urban area, and the increasing urbanized area has had a generally adverse impact on the hydrologic régime. In the four urban case studies - Bogotá, Rio de Janeiro, São Paulo and Santiago - deterioration in water quality, fundamentally due to biological pollution, has resulted in conflicts in water use of increasing severity.

The outstanding characteristic of the conflict between waste disposal and other uses is not its existence but the limitation in the spatial extension of its 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 surround them.1/ 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. For instance, gastroenteric disease in Santiago is linked to the consumption of fruit and vegetables from downstream areas irrigated by polluted water. The beaches in Rio de Janeiro, Santos, Buenos Aires and Montevideo and lakes in the vicinity of São Paulo and Xochimilco in Mexico City are contaminated by the same urban population which uses them for recreation. Hydro-electricity generated downstream from Bogotá and São Paulo is destined largely for the same cities. The upstream-downstream conflict, traditionally the central problem in water management, is barely reflected in these cases. As a general phenomenon the clash between upstream and downstream interests has not yet arrived, although incipient signs are visible, particularly in the case of water supply to downstream urban centres. Although in physical

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1/ See: Ruben D. Utria, Hacia un enfoque más integrado de los problem y las políticas de desarrollo regional en América Latina, Siglo XXI, Mexico, 1974, pp. 301-320.

/terms the

terms the external effects are closely associated with the metropolitan regions, in most cases they are not taken into account in the decision-making process. The case studies all show that a single city complex takes to itself all the benefits and costs or consequences of urban water management decisions. This situation is not, however, reflected in the managerial understanding of the issues or in the managerial response to these same issues. Urban demand for water is no longer one among many in the vicinity of large metropolitan centres in 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 of water management actions taken by the large urban agglomerations of the region. It has often been claimed that the most important environmental quality problems of the region do not lie in the relation of man to the physical environment but in the social environment created by human settlements. About one-fifth of the urban population of Latin America is not provided with water, and sixty per cent lack sewage connexions. It is the poorer sections of the population that do not enjoy such services, and this deficit forms part of the total poverty syndrome. There is at least an implicit conflict between the assignment of resources to the 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.

Massive investments are required to rectify these deficiencies. It has been estimated that to provide 70-80 per cent of the urban population with water and sewage services would require an investment of 7-10 billion dollars between 1974 and 1980.1/ In contrast evidence from São Paulo and Bogotá suggests that traditional investment required for sewage treatment would amount to only about 5 per cent of that figure, and therefore constitutes minimal competition for public funds.

1/ Ten Year Health Plan for the Americas, PAHO, Washington, D.C., 1973, p. 50.

Resource assignment conflicts are more likely to arise between the priorities given to the water services and those allotted to other social facilities. There are no grounds, in reality, for the commonly expressed fears of the high cost of environmental quality protection. The decline in the quality of the water resource tends to reinforce the burden of the lack of urban services, thus affecting the poor more than the better-off. The equity aspects of the conflict are not, however, between the assignment of resources to treatment or to extension of basic services but rather lie in the need for a complete adjustment of the social system to spread equally the costs of the diseconomies brought by urban expansion and industrial growth. This would suggest that some reconsideration is necessary of the thesis that environmental quality is a concern of the wealthy.

Perception 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 intensity of urban water use in step with development and the consequent effects on the environment is one aspect of the more general question of the effect of changes in the scale of problems on institutional effectiveness. Managerial failure is manifeste by the physical deficiencies and inadequate social services.1/ In urban water management, even where the system contains all the basic administrative machinery, as in the four cases considered here, there arises a problem of adjusting jurisdictional to physical boundaries. The superimposition of institutional boundaries in the management of the Upper Maipo valley seems to reflect a lack of understanding of the nature and scale of the change that has occurred in the water management problem, rather than inefficiency on the part of individual agencies. This is different from the situation in Bogotá, where the lack of coincidence between institutional and physical boundaries, and particularly the relative autonomy of the city versus the regional agency,2/ hampers the decision-making process. In Brazil considerable

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1/ Ligia Herrera and Waldomiro Pecht, Crecimiento Urbano de América Latina, BID-CELADE, Santiago, 1976, p. 79.

2/ Corporación Autónoma Regional de la Sabana de Bogotá y los Valles de Ubatá y Chiquinquirá (CAR).

/progress has

progress has been made towards understanding the nature of the urban water management issues and the need to adjust institutional to physical boundaries through the national sanitation plan.1/ This has helped the consideration of environmental aspects of water use in both São Paulo and Rio de Janeiro.

(b) Systems dominated by regulation structures in recent areas for production and development of related resources

In rural areas environmental concern derives mainly from uncertainties inherent in the disturbance of water régimes for development purposes, which are subsequently reflected 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 perhaps the most readily identified - salinization of soil and water; oxidation, acidification, concretionary layering and the build-up of toxicity 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 water control and the 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.

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. A

1/ José Roberto de A.P. do Rego Monteiro, Water Supply at the National Level: a Permanent Solution, Information Office, Banco Naçional Hipotecario, Rio de Janeiro, 1972.

/fundamental question

fundamental question is that of national and institutional goals with respect to production, equity, time horizons and risk.

In the five cases of water regulation, some broad national goals are discernible: employment, equity (agrarian reform) and an 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 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 Cuidad 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 the 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 relatively narrow vision of objectives and processes whereby the regulation and use of water may promote economic and social development. Agricultural production and power generation have been regarded as overriding objectives.

A critical element in the setting of objectives, which centres around the issue of resource conservation and development, is the inter-temporal flow of benefits expected to result from diversion or regulation of water systems and management of associated resources. This is a question of the extent to which objectives are oriented

/towards maximum

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 development of forestry and agriculture in the upstream catchment area. 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.

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.

On the issue of equity, while the general framework is set by national policy, 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 around the failure of redistribution benefits to materialize for the intended beneficiary groups when these groups come from the poorer strata of society, e.g., declining yields and abandonment of marginal lands in San Lorenzo. The second category is probably more important, and in large measure the problems are a consequence of unforeseen events in the social or institutional system which restrict or negate equity objectives. Examples are the delays in implementing the agrarian reform goals and difficulties in obtaining necessary complementary services and inputs for agriculture in San Lorenzo and the restriction placed on the individual peasant's margin of decision over use of his land in La Chontalpa.

/Apart from

Apart from engineering safety standards, risk and uncertainty do not appear to have been explicitly included among the considerations of agencies responsible for water regulation and development in the five cases. With the benefit of hindsight, it seems 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 should they arise.

(c) Management Response: Incorporation of Environmental Dimensions

In considering man's impact on his environment one can generalize only to the point of stating that with increasing total consumption and rising productivity associated with higher per capita consumption, there is greater environmental alteration and the level of potential adverse environmental impact increases. Thus, all alternatives require toleration of environmental damage. If not, 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. There are two objectives - higher consumption and environmental preservation - which in the short run tend to be competitive. In addressing these issues water managers have frequently neglected to take account of the combination of damage and positive effects resulting from alteration of the environment or have overlooked the uncontrolled aspects which delay or reduce realization of benefits.

The response of management may broadly be characterized by: (i) administrative adjustment to permit improved perception of the nature of the issues and to provide a basis for more integrated management; (ii) initiation of investigation into the nature of the physical impact of urban expansion and wastes on the aquatic ecosystem, and into the range of impacts associated with disturbance of flows and water-soil-plant relationships; and (iii) introduction, on the basis of the above, of alternative project designs, operating procedures, regulation, monitoring, etc., which may be applied to somewhat broader systems.

/(i) Latitude

(i) Latitude and constraints. The adoption of new directions in the planning and management of water resources will depend on the interest of the institutions providing finance and on the organizational and professional capability of the executing agencies to address the complex dynamic interrelationships between physical, social and institutional systems. In this connexion it is important to distinguish between water management and water user institutions. For example, in the case of the Río Bogotá and the Maipo and Aconcagua, the CAR and the Dirección Nacional de Aguas are management agencies and the utility companies, municipalities and irrigation associations are users. There is a tendency towards domination by user agencies. Even where nominally projects have been undertaken with social objectives a similar situation may prevail, e.g., La Chontalpa and Caño Mánamo. Only in São Paulo and Rio de Janeiro and in the upper Bogotá basin is there evidence of management agencies dominating the decision processes.

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 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 impinge on the water manager's latitude for decision.

(ii) 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

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. National and regional institutions are only starting to come to grips with the environmental quality issues involved. The Fundação Estadual de Engenharia Sanitaria do Meio Ambiente (FEEMA) in Rio de Janeiro and the Centro Estadual de Tecnología en Saneamiento Basico (CETESB) in São Paulo are examples of water management institutions which have developed considerable research and planning capacity to tackle these issues on a regional scale. With the exception of Guri the water regulation case studies show 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.

Virtually all water 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 and/or interbasin transfers in all cases except Guri, plus treatment of sewage, as being the simplest way of gaining control of the situation. In spite of their evident administrative and technical capacity, however, many institutions are not well equipped to consider a wider range of management alternatives involving non-engineering components. Such alternatives would require 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 pattern of La Chontalpa or Caño Mánamo in place of increasingly complex systems of drainage, irrigation and water table

/management. On

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 alternatives.

The knowledge gaps on behaviour of natural and social systems revealed by the case studies indicate a need for a more systematic accumulation of information within a carefully structured framework designed to identify key questions. Given the complexity of the questions posed with respect to the functioning 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 requiring 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 remain on file 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 the environmental management questions arising in connexion with water use, there appears to be little alternative to the adoption of a broad "system view". This requires that planners and managers 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.

(iii) Towards better integration. The experience of the cases suggests that: 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 construction and management of engineering works to incorporate natural ecosystems and socio-economic factors; and thirdly, greater control should be gained over the use of the ecosystem in order to restrict unnecessary environmental damage. The underlying conditions for effective operation appear to 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.

A number of the cases reflect a limited view of objectives and of the water "system" being managed, with the result that they fail to consider potential environmental consequences. 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 the intensification of water use, or activities which are unrelated to water use but nevertheless affect its quality or quantity, may be a source of strength. 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 may not add up to a coherent whole. 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 among their own staff all the required talents 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 order to acquire a larger common vision of the whole, integration machinery must be created to demonstrate the disadvantages of individual action and the mutual benefits of closer collaboration.

Agencies with responsibility for water regulation structures - hydro-electricity, irrigation and flood control - tend to enjoy considerable autonomy. Their objectives in terms of physical output are clear, the economic and financial viability of projects is relatively easy to establish, and service charges provide an independent source of funds. Accordingly, they tend to be immune from pressures to place

/their activities

their activities within a wider decision-making framework. A similar situation applies to urban water-using institutions - water supply, sewage and drainage. The concern for integration frequently derives from Ministries of Health or environmental protection agencies, where the primary focus is on water pollution by industrial and urban domestic waste discharge, but the financing of the majority of these agencies and their authority to regulate environmental degradation has been limited.

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 of the cases studied. 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, however. 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.

(d) Decentralization and beneficiary participation

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 bureaucracies 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.

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. For example the Grijalva Commission has wide powers with respect to water development and land use and has been actively involved with local interest groups as well as state and federal institutions concerned with development and the provision of social services. The situation with respect to water systems dominated by a large urban complex is similar, where the management issue primarily hinges on causes and consequences of change in water quality. In such cases responsibility generally rests with municipal or state authorities (e.g., FEEMA) and central government agencies which work through such authorities.

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. It may be argued that if users or beneficiaries 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 the necessary adjustments will be made more rapidly. The question is complex, and from society's viewpoint it will vary according to the characteristics of the user, e.g., a large corporation or a peasant. For example, decentralization need not involve the beneficiaries at all, and where income distribution is a concern it may even worsen the situation by reinforcing local structures whose objectives are not necessarily consistent with social equity.

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, which might have avoided some of the environmental damage which later occurred. 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 agricultural and 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 urgency of the 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 limited 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. For example, La Chontalpa represents a specific investment project with a plan of action and deadline. In this case the Grijalva Commission found itself obliged to take virtually all the initiative for organization. The Guanabara Bay case illustrates a situation where gradual unrestrained intensification in the use of the waters of the Bay gave rise to political pressures for the systematic settlement of conflicts between competing uses which led to the creation of FEEMA in 1974.

The concept of "beneficiary" in the case of water management needs to be broadened to "participant" which includes 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 and those damaged 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 interest law. The new environmental protection law in Colombia appears to offer a forum for such an activity.

/3. Future

3. Future Steps

The fundamental conclusion of this study is that if relationships between the intensification of water use, development and environmental alteration are to be given priority, approaches to water resource management in Latin America must be changed. This calls for a rethinking of ways of dealing with the natural systems and the organization of social action 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. 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 that what is needed 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. However, progress is being made, and organizational structures staffing patterns and capacity for interagency co-ordination are being adapted in some instances. Management needs to be convinced of the practical value of changes. Legal, institutional and political aspects of adding an environmental dimension to the planning and management of water in the region are complex and sensitive issues, and many unanswered questions need to be addressed. 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 mechanisms 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?

/Related to

Related to these institutional aspects are questions of analytical techniques and the availability of reliable data which can yield convincing projections on the probabilities of various outcomes from alternative courses of action. 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? What limits should be placed on the system to be managed, and how can account be taken of potential uncontrolled events such as chain effects and irreversibilities which have disrupted water management programmes in economic, social and ecological terms?

(a) Analytical approaches and limitations

A wide range of analytical approaches have been employed in the assessment of environmental impact: e.g., impact matrices, physical mapping overlay procedures, simulation models of ecosystems, water quality and energy flows and combinations of simulation and programming models for addressing management questions.

Two issues must be tackled in coming to grips with the design of water management programmes or projects: the specification of multiple objectives, and information on benefits and on the dynamic behaviour of physical and social systems.

Since there is rarely a 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? Standards which apply to the effect on the environment of the discharge of residuals or water diversion and regulation are not always readily quantifiable, and even when they are quantified, monitoring and control frequently present formidable difficulties particularly where a margin of flexibility is necessary. Many countries have laws governing conservation and the depletion of natural resources, but it will probably be some time before such laws have 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 minimum water quality levels, land-use zoning and restrictions on use of water, must be decided largely on a case-by-case basis.

The quantification of benefits is an information problem which appears to be virtually insurmountable, especially in the case of the environmental dimensions, and it is doubtful if the effort to attempt rigorous quantification is warranted: nevertheless, much has been written about the problems of monetization and shadow pricing of the various types of inputs and outputs. It is in the second class of information problems - the functioning of physical and social systems - where the opportunity for improving the bases for decisions appears greatest. The use of cost-effectiveness or constrained optimization techniques, where minimum standards of environmental protection or social welfare are imposed as restrictions, would enable regulatory requirements to be assessed. Greater knowledge of the behaviour of the natural and social components will clearly lead to better assessment of the original objectives, environmental standards, the need for regulation and monitoring, alternative project designs and resource management measures.

The essence of the above discussion is that 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 for resource managers. Experience suggests that decisions on water regulation have been dominated largely by engineering considerations. There is probably agreement on the range of other disciplines which should be brought to bear in greater degree, such as ecology or law; but there is little evidence that other disciplines have played a significant role in project design, monitoring or management. This is taken as *prima facie* evidence of the need for a different approach. It may be unnecessary, or even misleading, to design large models of complex natural and social systems. However, if long-range, interdisciplinary integrative analysis is to be made of the objectives, cost, effectiveness and risk

/and uncertainty

and uncertainty associated with alternative water management strategies, there appears little alternative to the application of modelling techniques, where communication between disciplines is obligatory.

To what extent may the various analytical approaches discussed above be applied in a meaningful way to water management issues in Latin America? Clearly, the techniques could all be applied to the range of water management questions found in the region, limited by the same shortcomings as elsewhere. It is evident that the selection of techniques will be conditioned by the specific nature of the management issues to be addressed. Here the formulation of the issues is fundamental, and the selection is determined by the cultural, political, socio-economic and ecological conditions which prevail in each specific case. There can be no blanket rule on when and how to apply any set of techniques. In many instances lack of information or trained personnel may preclude consideration of sophisticated mathematical models. It is questionable whether it would be realistic even to attempt to structure many of the water management problems encountered in the region within such a framework. This does not, however, gainsay the use of models. The essence of incorporating environmental dimensions into water management is the adoption of a systematic approach which takes a broader view than that traditionally taken of the manner in which systems interact as the consequences of any decision on water use work themselves out.

Information will inevitably be a constraint in the application of any analysis designed to help water managers. One of the principal conclusions which may be drawn from the case studies is that water regulation structures and associated developments were designed with insufficient information, or with insufficient 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, and 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 with this dilemma, most countries opt for immediate action in the expectation that corrective actions will be evolved before all options are foreclosed. There is no easy answer to the questions of how much information to collect prior to a decision on regulation or investment; whether uncertainty means that there should be a delay, thereby foregoing expected benefits from early development while collecting more information; or whether it is desirable to undertake pilot projects.

A further constraint will be the availability in public agencies for the planning, management and use of water of staff who are able and motivated to test some of the techniques in order to explore a wider range of management alternatives in the search for greater flexibility. There can be little doubt that such constraints on the application and applicability of these techniques could be removed by successive approximation. The critical question, however, is the institutional framework for determination of objectives for water management, data collection, personnel training and incentives, and the actual use of the results of analysis in decisions. While there are some notable exceptions, the general picture is not encouraging. Many countries have, or are in the process of enacting, legislation for environmental protection, and have created new agencies, inter-ministerial councils or <u>ad hoc</u> commissions to deal with the issues. But in a number of instances difficulties have been encountered in the co-ordination and implementation of efforts to get to grips with the real issues of environmental quality and water management.1/ If an institutional structure cannot be developed which will be responsive to analytical approaches calling for a broad integrated vision of the management of natural systems, it follows that such approaches will have little effect.

1/ See: Hugo A. Mattiello, Víctor H. Pérez and Miguel R. Solanes, <u>Administración Hídrica en América Latina</u>, INELA, Mendoza, December 1976, pp. 31-34. Report prepared for CEPAL/UNEP as part of the ADEMA enquiry.

/(b) International

(b) International collaboration and training

In considering international exchanges related to resource management, the question rises 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 application 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 the incorporation of environmental dimensions from countries within the region and elsewhere, is relevant.

Many Latin American institutions have considerable experience and expertise which would be invaluable to other countries in the region for broadening and strengthening their approaches to water management. To draw only on the cases examined in this enquiry, FEEMA and CETESB have developed noteworthy capacity in the analysis of water quality issues. They offer interesting examples of the transfer and adoption of techniques developed elsewhere in such a way as to build a qualified staff 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, 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.

In addition, there are a large number of international agencies active in the field, and a significant number of studies of resources, river basin development, water quality, etc., have been undertaken by national institutions with the collaboration of such agencies. However, there has been little progress in assuring that studies are cumulative in their impact on research, planning, project evaluation, and in-service and university training. Furthermore, this fund of knowledge has not been used systematically to develop 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 water development and use.

There is a clear need to institutionalize the assembly and dissemination of the knowledge available. Multilateral and bilateral organizations are in a unique position to undertake useful activities on a transnational basis, which individual countries cannot readily do on their own. These activities could 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.

The axis of any programme of international co-operation must be the development in the respective countries of human resources 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. Related to any activity of this sort is the question of how to generate a demand in national and regional planning and water management agencies for professionals capable of formulating and analysing water-development-environmental relationships. Since the water management systems in most countries are not currently in a position to think about or cope with this issue, 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 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 existence of some minimal core staff in the relevant agencies who can deal with the approach proposed.

/In coming

In coming to grips with the operational dimensions of the training issue, it is necessary to consider: (i) the type of university training most appropriate for preparing 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; (ii) the course content and priority areas of specialization in preparing analysts and administrators to work in interdisciplinary activities; and (iii) the advantages of building up international training institutions capable of providing specialized training in management of water resources and environmental quality, versus building up a similar capacity in a limited number of national institutions.

In addressing these various interrelated questions 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 and management situations where action is already under way. In the expectation that a forum could be generated for the exchange of ideas and experience among those engaged in such activities in Latin America, a strong case may be advanced for a set of pilot projects as one of the more promising areas for international collaboration. Such projects might enable the development, testing and monitoring of alternative approaches to management incorporating environmental dimensions, and at the same time provide an opportunity to better assess the nature of the training required.

/Annex A

Annex

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