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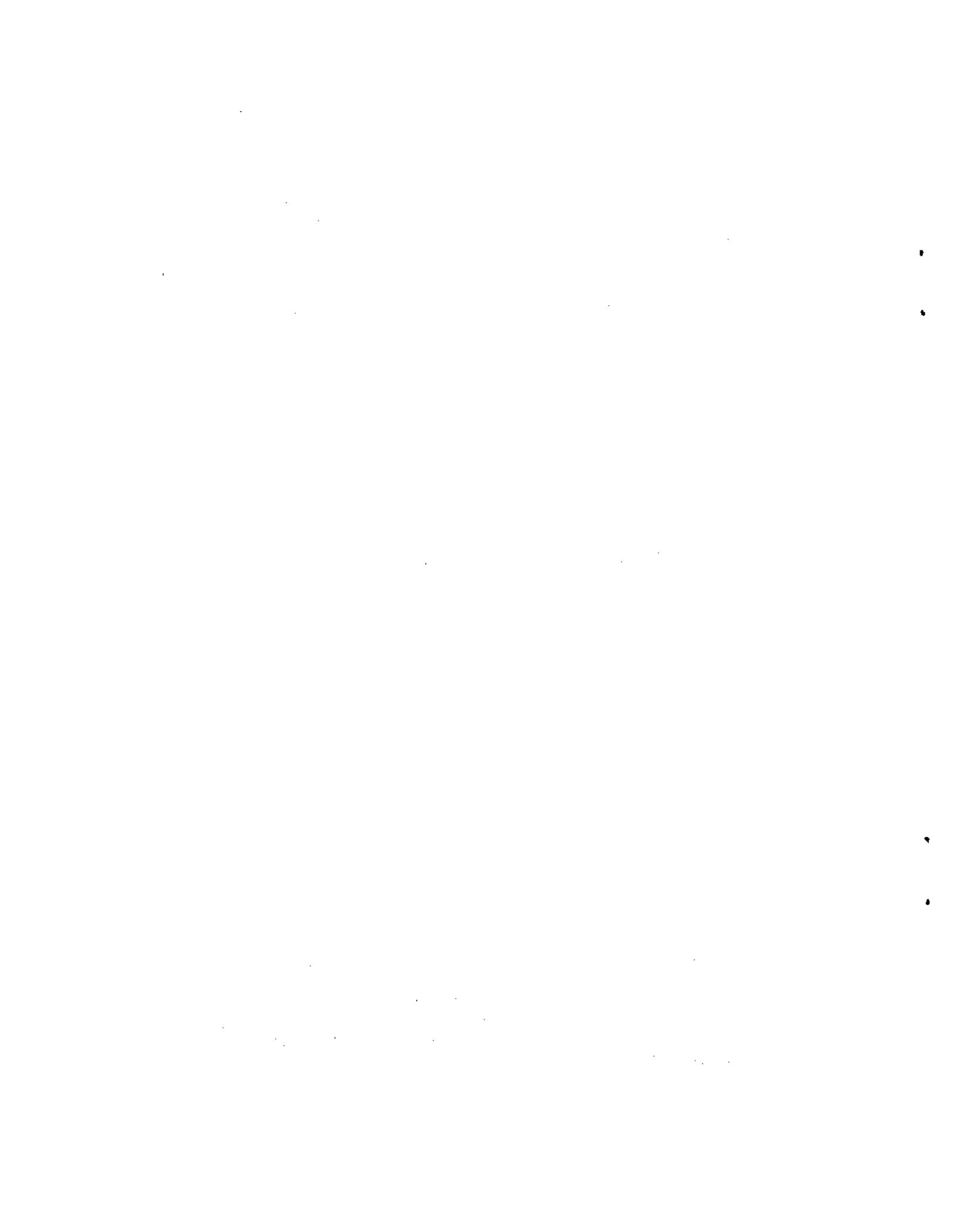
Economic Commission for Latin America and the Caribbean



CASE STUDY: THE BOGOTA RIVER BASIN */

Summary

*/ This report was prepared by Mr. Jaime Saldarriaga, Consultant of the project "Horizontal co-operation in water resources management in Latin America and the Caribbean", financed by the Government of the Federal Republic of Germany. The author alone is responsible for the views expressed in this paper, which may not be those of the Organization.



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INTRODUCTION

This report was prepared under a contract between the Division of Natural Resources and Energy of the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) and the Consultant. The task assigned was to conduct a case study on the management of the Bogotá River Basin, as part of ECLAC's project "Horizontal co-operation in water resources management in Latin America and the Caribbean", between 1 April and 31 December 1986, according to the terms of reference set out by ECLAC.

The Consultant is thankful to ECLAC for having chosen him to conduct this case study. He is also grateful for the collaboration provided by official agencies such as the National Planning Department and the Regional Autonomous Corporation for the Bogotá, Ubaté and Suárez Rivers (CAR), in providing information and exchanging ideas, all of which was of fundamental importance in the preparation of the paper.

The ideas expressed in this paper, however, are solely the responsibility of the author and should in no way be taken to reflect the official views of the institution.

I. RESOURCES WITHIN THE WATER SYSTEM

A. PHYSICAL FEATURES

1. General characteristics of the basin

The basin has two distinct sections, divided according to topography and climate: the upper basin is made up of cold highlands and the lower basin is mountainous, with a medium to hot climate, sloping down from the savannah to the confluence of the Bogotá and the Magdalena Rivers.

The Bogotá River has its source at an altitude of 3 400 meters in the eastern mountain range and flows southwest into the Magdalena River, at an altitude of 280 meters. Over its 270 km course, it drains the waters of a land area of approximately 5 996 km².

The upper basin has a drainage area of 4 305 km² and is made up mainly of a quaternary river-lake deposit forming the high plateau La Sabana de Bogotá, on which there occur outcrops of sedimentary rock

The lower basin has a drainage area of 1 691 km² and begins where the river enters into a canyon, forming the Tequendama Falls (a 150-meter fall). In the lower part, the valley widens out to form a small alluvial plain surrounded by mountain folds which merge into the Magdalena River valley.

The plains in the upper basin, including the urbanized areas, cover approximately 36% of the area, or 154 340 hectares, while in the lower basin, they cover only 12%, equivalent to 20 300 hectares, with the remainder consisting of hills, slopes and páramos (high terraces).

Average annual precipitation in the basin ranges from a minimum of 600 mm in some parts of La Sabana de Bogotá to a maximum of 1 700 mm in the middle section of the lower basin. The average annual air temperature in the upper basin ranges from a minimum of 8.1° C to a maximum of 13.8° C, while in the lower basin the temperature goes up to 27° C. The temperature gradient is between 0.5 and 0.6° C per meter of altitude. The seasonal variation in temperature is very slight.

The average annual relative humidity of the air varies between 68.8% and 81.9% in the upper basin and between 67.7% and 79.8% in the lower basin.

Average annual potential evapotranspiration ranges between a minimum of 870 mm and a maximum of 1 064 mm in the upper basin and between 1 310 and 1 765 mm in the lower basin.

In the upper basin freezing occurs in some areas of La Sabana de Bogotá in the most critical area, freezing temperatures occur on an average of 13 days.

As regards life zones, approximately half the area of the upper basin is made up of very humid mountain rain forest and the other consists of low mountain dry forest. In the lower basin, 43.6% of the area consists of tropical dry forest, 43% of pre-mountain forest, 12.6% of very humid forest or low mountain humid forest, and less than 1% of the low mountain dry forest.

The area actually used for agriculture is considerable less than the total area suitable for that purpose; in the case of stockraising, the opposite is true, as a much greater area is used for this purpose than should be.

2. Physical boundaries of the water system

The water system is made up, essentially, of the watershed of the Bogotá River up to its confluence with the Magdalena River; it also includes the watershed of the Blanco River, which is a tributary of a group of wells connected to the underground section of the conduit joining the Chuza reservoir (on the Chuza River, on the eastern slopes of the Andes) with the Francisco Wiesner treatment plant, located in the Bogotá River basin. Nevertheless, from the standpoint of planning, the water system also includes the Sumapaz mountain grouping, located in the southeastern part of the Bogotá River basin, inasmuch as a project similar to Chingaza is envisaged for the Sumapaz area (figure 1).

B. TECHNICAL FEATURES OF THE WATER SYSTEM

1. History

The first aqueduct in Bogotá was built in 1886 as a private enterprise; it operated as such until 1914, when it was purchased by the city government. In 1924, the Municipal Enterprises Division (División de las Empresas Municipales) was established to administrate the water service, as well as the trolley system. In 1955, the Bogotá Water and Sewer Corporation (Empresa de Acueducto y Alcantarillado) was established as an autonomous agency having its own legal standing and capital.

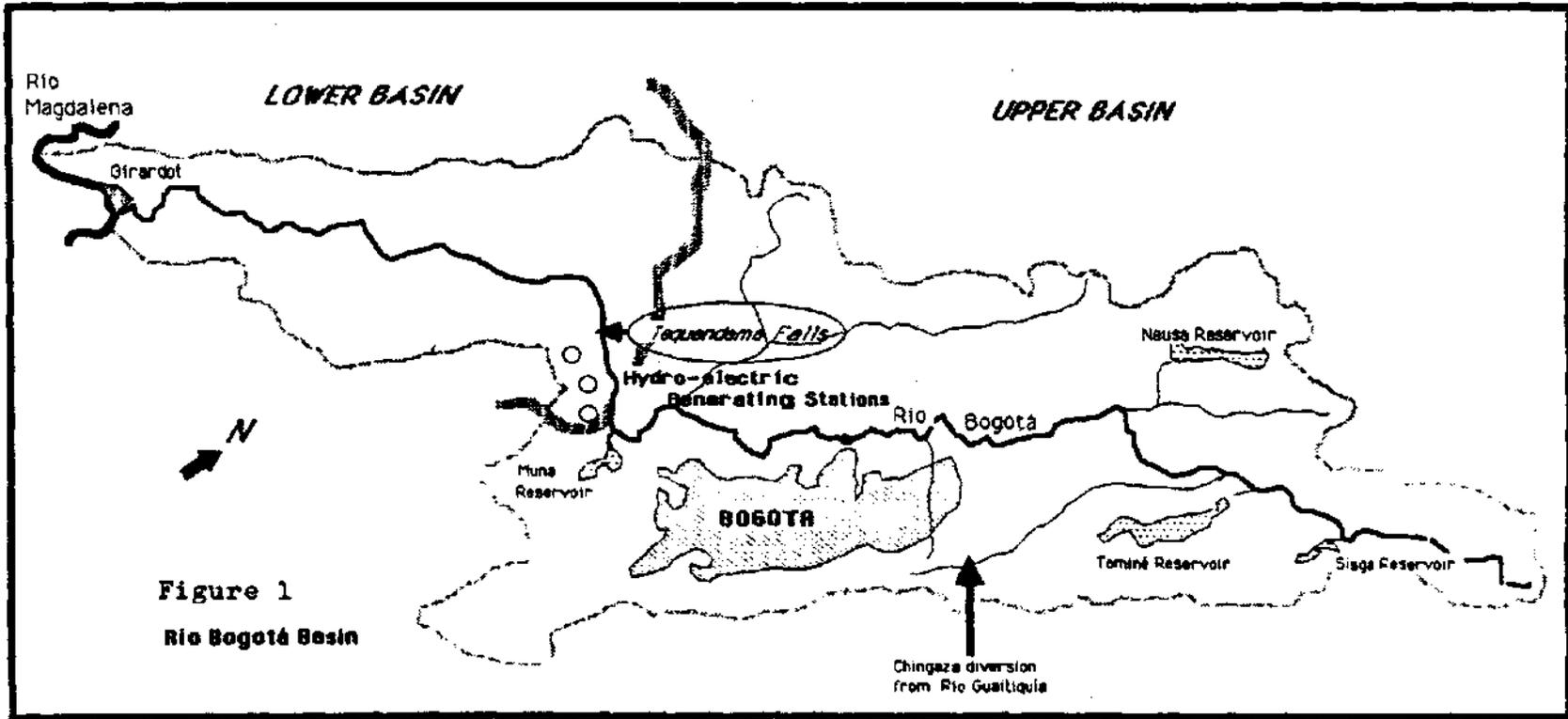


Figure 1
Rio Bogotá Basin

The Bogotá Electric Power Corporation (Empresa de Energía Eléctrica de Bogotá) was established in 1895 as a collective company which requested a concession to install the first hydroelectric power plant over the Bogotá River, making use of the Charquito waterfall. This company was liquidated in 1904 and became the Electric Power Company S.A. (Compañía de Energía Eléctrica S.A.). In 1920, the National Electric Power Company (Compañía Nacional de Electricidad), a competitor, was founded; in 1926, the Bogotá city government purchased all the shares of the National Electric Power Company. In 1927, the two companies were merged and became the United Electric Power Corporations S.A. (Empresas Unidas de Energía Eléctrica S.A.). In 1946, the Bogotá city government reserved the right to purchase the shares of this corporation, which was in private hands. In 1951, the city government purchased all the shares and created the United Electric Power Corporations of Bogotá (Empresas Unidas de Energía Eléctrica de Bogotá) to replace it. In 1959, the present company, the Bogotá Electric Power Corporation (Empresa de Energía Eléctrica de Bogotá- EEEB) was set up as a decentralized public corporation belonging to the district but having its own capital and enjoying administrative autonomy.

The La Ramada irrigation and drainage system was built initially in 1939; additions have been built in 1956, 1963, 1964 and 1982. A new expansion project is currently in progress.

2. Reservoirs

The Bogotá River system has a total storage capacity of 1 681 billion m^3/sec ; of this, 941.9 million come from the Bogotá River basin and 226.2 million from the Chuza reservoir, located outside the Bogotá River basin on the eastern watershed of the eastern Andes range and connected to the Bogotá River basin through the Chingaza project. The main reservoirs of the Bogotá River basin are the Tominé, Neusa and Sisga reservoirs, which have capacities of 690, 102 and 96.3 million m^3/sec respectively, and are located on tributaries of the Bogotá River in the highest part of the basin. In addition, there is the Muña reservoir, with a capacity of 41.4 million m^3/sec , which is located on the Muña River, an affluent of the Bogotá River slightly upstream from the Tequendama Falls. There are also the small reservoirs of Chisaca, La Regadera and Los Tunjos, with capacities of 5.1, 4.7 and 2.4 million m^3/sec , in that order.

3. Control structures

The main control structures on the Bogotá River are the gates installed at the main water intake locations. These structures are the Achury gates, located at the pumping station where water is pumped from the Bogotá River to the Tomine reservoir; the Espino gates, located at the Tibito pumping station, and the Alicachin gates, located near the Muña pumping station.

4. Pumping station

The plant where water is pumped from the Bogotá River to the Tibito purification plant has a capacity of $12 \text{ m}^3/\text{sec}$; from here, water is pumped through a distribution system with a capacity of $12 \text{ m}^3/\text{sec}$, to Bogotá. There is also a pumping plant to pump water from the Teusaca River to the Tibito plant; with a capacity of $7 \text{ m}^3/\text{sec}$.

The hydroelectric power subsystem includes a plant located in Sesquile, where water is pumped from the Bogotá River to the Tomine reservoir. This plant consists of a reversible pumping unit having a capacity of $8 \text{ m}^3/\text{sec}$ and a non-reversible pumping unit having a capacity of $8 \text{ m}^3/\text{sec}$. On the Muña, there is a 5-unit pumping plant with a total capacity of $64 \text{ m}^3/\text{sec}$, where water is pumped from the Bogotá River to the Muña reservoir.

5. Water supply systems

The Bogotá water supply system consists of the Tibito purification plant, with a capacity of $12 \text{ m}^3/\text{sec}$; the Vitelma plant, with a capacity of $1.5 \text{ m}^3/\text{sec}$; the Francisco Wiesner plant, $14 \text{ m}^3/\text{sec}$, and the La Laguna plant, $0.16 \text{ m}^3/\text{sec}$. Thus, the treatment system has a total capacity of $27.66 \text{ m}^3/\text{sec}$, although only the amount needed to meet current demand is used. It is estimated that the Bogotá water service has a coverage of 96%.

In the main towns of the remaining municipalities in the basin, coverage varies considerably, ranging from 56% to 100%.

6. Sewer systems

The central sector of Bogotá has combined sewer systems which cover an area of 73 km^2 . The system is equipped with spillways or structures for separating dry-season and rain-water flows, each with the necessary sewage traps.

The areas outside the combined sewer system have separate networks for rain water and sewage. In this sector, some previously low quality and underdeveloped areas only have sanitary sewers, which sometimes have been illegally connected with rain-water drainage systems, thus overloading the system and causing the operational and functional problems one might expect.

The boundaries of the sanitary district corresponds with the urbanized area and covers approximately 240 km². The Bogotá Water and Sewerage Corporation (Empresa de Acueducto y Alcantarillado de Bogotá -EAAB) has been incorporating into the system certain outside areas which had not been planned for, mainly low quality developments and squatter or clandestine settlements. New areas were built up outside the sanitary district before it became saturated, so that only 79% of the area within the sanitary district is developed. The present sanitary district is 25% larger than envisaged in the master plan, which explains the deficit in services. Only 25% of the developed area has sewerage. Only 84% of the population is covered; the unserved population occupies an area of 50 km² and includes approximately half a million people.

Sewer service coverage ranges from 30% to 100% in the principal towns of the remaining municipalities in the basin.

A system for the separation, treatment and disposal of sewage for Bogotá is still in the process of being designed. It will consist essentially of a main separation canal, a pumping system to feed it, and a treatment plant at the Canoas site. There are only two oxidation lakes in the remaining population centers of La Sabana; these are located in the municipalities of Cota and Tabío, and are operated by CAR. In addition, work had been completed on the design of 20 treatment plants for municipal sewage. A water-quality master plan is being drawn up under a technical assistance agreement with the Government of The Netherlands.

7. Irrigation and drainage systems

The only hydroagricultural system in the basin that is actually organized as such is the La Ramada Irrigation and Drainage District (Distrito de Riego y Drenaje La Ramada), which covers an area of 6 300 hectares. It comprises a pumping system which discharges into an adduction canal which in turn drains the water into a marshy area used for water storage before distribution to the irrigation canal network. There is a pumping plant in the lower part of the district which drains the water from the district to the Bogotá River.

It is estimated that 30 600 hectares of land in the upper basin of the Bogotá River and 6 069 hectares in the lower basin, in the Girardot-Tocaima sector, are currently under irrigation.

8. Hydroelectric power plants

The installed capacity for hydroelectric power production currently in operation is 559.7 MW. The new Mesitas project, with a capacity for 600 MW, will be put onstream soon. The entire capacity has been installed by EEEB.

C. ECONOMIC AND SOCIAL STRUCTURE OF THE WATER SYSTEM

1. Boundaries

The region served is the Bogotá River basin. The main user is the Special District of Bogotá, which is served through EAAB and EEEB; in addition, the farmers of the area are users of the irrigation system.

2. Economic structure of the region

Agricultural sector. In 1983, the basin included 413 720 hectares of farmlands, 76% of which was sown in pastures and the remainder in other crops.

Approximately 300 000 head of cattle are raised in the basin. Milk production amounts to 379 million litres per year, which represents 15.5% of national production. In the middle subregion in the lower basin, the main crops are coffee, fruit trees, maize and sugar cane; in the Girardot-Bajo Bogotá subregion, stockraising, particularly of breeding cattle, is important, in addition to sorghum, cotton and maize.

Industry. The industrial value added of the basin is accounted for mainly by consumer and intermediate goods and, to a lesser extent, capital goods. In 1981, there were 3 596 industrial establishments in the basin, most of them pertaining to the manufacturing and mining industries, with a smaller percentage devoted to flower growing and tanning.

Electric power. Electric power sales by EEEB amounted to \$37 627 billion in 1985. The corporation's area of influence is the Special District of Bogotá and the Departments of Cundinamarca and Meta. The total population of this area is estimated at 4.6 million, and it is estimated that 95% of that population has electricity. In 1985, the gross demand for power from the aggregate system was 6 685 billion kWh. In 1985, the system had 763 752 customers.

Water Supply and Sewage. In December 1985, EAAB had 574 819 customers. Its revenues from water and sewer services totalled \$9 973 billion.

Role of the region in the national economy. The market for the industrial production generated in the basin extends beyond its boundaries into the rest of the national territory and to other countries; the manufacturing industry

is particularly important. Agricultural production also plays an important role in the nation's economy, particularly flowers, milk and dairy products, and coffee.

Role of the water system in the regional economy. The hydroelectric power subsystem supplies energy to a region larger than the basin itself, although EEEB's electric power system is not self-sufficient. The municipal water subsector also plays an important part in the rest of the economy.

These utilities have a considerable impact on the regional economy, not only through the sale of their services but also because of the demand for resources which they generate in providing these services. Irrigation, agriculture also plays an important role in the economy of the region, particularly flower growing.

Population of the basin. The basin has a total population of 4.7 million, 94.1% of which is located in the municipal capitals and 5.9% in rural areas. The overall population growth rate is 2.33%; in the urban areas, the growth rate is 2.94% and in the rural areas, 0.26%.

D. ADMINISTRATION OF THE WATER SYSTEM

1. Administrative agency

The Regional Autonomous Corporation (CAR) was created in 1961 to promote development in the area under its jurisdiction; in 1968, the National Institute for Renewable Natural Resources and the Environment (Instituto Nacional de los Recursos Naturales Renovables y del Ambiente - INDERENA) was created to manage all renewable natural resources throughout the national territory. INDERENA delegated to CAR the management of the water resources and the organization of hydrographic basins in the area under its jurisdiction. In 1978, a law was enacted which returned to the regional autonomous corporations the authority to manage the natural resources in their particular areas of jurisdiction.

CAR's initial area of jurisdiction included the catchment area of the Bogotá River from its source up to the Tequendama Falls, and all the catchment area of the Ubaté and Suárez Rivers located in the departments of Cundinamarca and Boyacá. Act 62 of 1983 modified CAR's jurisdiction, extending it to the entire watershed of the Bogotá River, from its source to its outlet in the Magdalena River, including the entire municipality of Girardot. CAR, however, is authorized to conduct studies and/or execute works outside its

jurisdiction, for which purpose it may enter into arrangements with institutions or individuals for the carrying out of studies and the construction and administration of works.

2. User agencies

The main user agencies are EAAB and EEEB, which are enterprises of the Special District of Bogotá. Other users are the agencies responsible for supplying water and sewer services in the head towns of the municipalities located in the basin.

3. Organizational structure of CAR

Under decision No. 34 of 1981, the Board of Directors of CAR modified its organizational structure; the current organization is shown in figure 2. The Board of Directors of CAR is made up of six members, as follows: the Head of the National Planning Department (Departamento Nacional de Planeación - DNP), who presides over it or who sends a delegate to take his place; a member and an alternate member appointed by the President of the Republic; the Mayor of Bogotá or his delegate; the Governor of Boyacá or his delegate; the Governor of Cundinamarca or his delegate, and the Manager of INDERENA or his delegate. The Executive Director has a voice but no vote in the deliberations of the Board.

4. Co-ordination mechanisms

Co-ordination is carried out through the Water Committee, made up of the Managers of CAR, EAAB and EEEB; through the Mayor of Bogotá, who presides over the Boards of Directors of EAAB and EEEB and is a member of the Board of Directors of CAR, and through the National Planning Department, through its Special Division on Regional Corporations and its Infrastructure Unit.

E. FINANCIAL RESOURCES OF THE WATER SYSTEM

1. Sources of financing for the system

The main traditional sources of funding for the system have been CAR, EAAB and EEEB. CAR's main source of income is the national tax on real estate located within its jurisdiction, established by law on 1 January 1984 at 2.5 per mill on the official appraisal value. Works constructed by CAR, such as those pertaining to the Bogotá River, are partially financed from the national budget, although this source represents a minor share of its revenues. However, it may also resort to such means as special taxes and charges for its services, as well as fines.

2. Income

CAR's income in 1985 amounted to \$2.18 billion, in current terms. The share of CAR's income provided by each source in 1985 was as follows: from its own resources, 90%; contributions from other institutions, 5%; credit resources, 4%; and the national budget, 1%. Revenues from the 2.5 per mill tax totalled \$1.278 billion, in current pesos, in 1985. Resolutions have recently been issued to distribute contributions from special taxes for specific works.

3. Investment and expenditures

During the period between 1962 and 1984, CAR's annual expenditures have ranged between 11.2% and 10.45% of its annual income. Investment has represented between 58% and 83% of total expenditures, with the remainder representing operating expenditures. In terms of income, investment has ranged between 41% and 87% per year.

Investments have been allocated as follows: 46%, for infrastructure works; 33%, for water management and pollution control; 12%, for soil and wildlife management; 8%, for other programmes, and 1%, for territorial organization. Infrastructure works have been partially financed by contributions from the benefitting communities or municipalities.

CAR's objective, in regard to financial management, is to make optimum use of the region's financial resources in order to ensure that there are enough sources of financing to enable it to operate. Some of the strategies envisaged are the strengthening of municipal autonomy in accordance with the level of development of each municipality and the promotion of activities carried out jointly with the Departments, with a view to training municipal officials in budget management.

The corporation's outlays in 1985 totalled \$2.243 billion in current terms; of this amount, 81% represented investment expenditures; 15%, operating expenditures, and 4%, debt service.

II. EVALUATION OF THE MANAGEMENT SYSTEM

A. EXTERNAL FACTORS

1. Biophysical aspects

Droughts are frequent in the basin, particularly during the dry season --between December and March-- and especially in the upper basin, where precipitation is lower and water use more intensive. In addition, during the dry season, the available flow of water in Alicachin is too low, even with the

regulating reservoirs, to allow for the full utilization of the installed capacity of EEEB's hydroelectric power generation subsystem, located downstream. During this season, irrigation users and EEEB compete for use of the resource, with EEEB taking the leftovers; thus, the underutilization of EEEB's installed capacity seriously affects its economic results. This situation is caused by shortcomings in planning the use of the basin's water resources with a multiple-use approach. The hydroelectric power use has been planned without a careful forecast being made of the demand for water for irrigation in La Sabana; hence, a rising demand for water for this purpose may mean that the installed capacity for electric power generation is excessive for the residual flows actually reaching Alicachín. This conflict between irrigation and hydroelectric power generation in the Bogotá River basin is of crucial importance in considering the economic utilization of water in the basin, currently being studied under the second phase of the National Water Study.

Floods also have a significant impact on the water system. This problem has been partially solved through an emergency programme designed to reduce the risk of the river overflowing, over the short term. Studies are in progress with a view to finding a final, long-term solution to the problem.

Frost also seriously affects agriculture in La Sabana de Bogotá, particularly during the period from December to December, when there is a 12% probability of freezing.

2. Political aspects

Although the country may not enjoy complete political stability, because of the presence of subversive forces in some regions, the situation is under control, and a political process is underway which is aimed at achieving a peaceful settlement that would eventually put an end to subversion. It is believed that subversion will continue to be kept under control. The Bogotá River basin itself has not been the scene of significant subversive activity, and is not expected to have this problem in future.

3. National economic policy

The country has followed a relatively orthodox economic policy, within the framework of an essentially capitalistic mixed economy. The goal in recent years has been to achieve an acceptable growth rate within the limitations imposed by the international economic environment, so as to keep employment at an acceptable level. The Government has sought to generate the foreign

exchange required to pay the external debt and provide the flow of foreign exchange necessary to ensure the adequate operation of the economy. In the last few years, economy policy has been mainly directed towards managing the external debt; to this end, an adjustment programme has been designed which is also aimed at reducing the fiscal deficit.

The gross domestic product grew at a rate of 2% in 1985, a year when primary activities, particularly coal and oil, experienced greater growth. Economic growth was weak in urban activities, and this caused unemployment in the four main cities to rise to 14.7% of the economically active population.

This went hand in hand with a fall in real wages in all sectors of the economy; while adjustment rates for nominal wages were reduced, the inflation rate rose as a result of the insufficient production of foods. The 1985 inflation rate was 22.5%.

As far as prices are concerned, the general policy is to allow freedom, except in the case of products of vital social significance, such as fuels, cement, utility rates, transport and milk.

4. Technical limitations

The main technical limitation of the system has to do with the discharge capacity of the Chingaza tunnel, which was designed for a maximum discharge of 30 m³/sec, without reinforced coating on a considerable portion of the tunnel. After it was put into operation, however, geotechnical problems arose which caused landslides, thus making it necessary to add reinforced coating. The tunnel's maximum capacity is now only 20m³/sec.

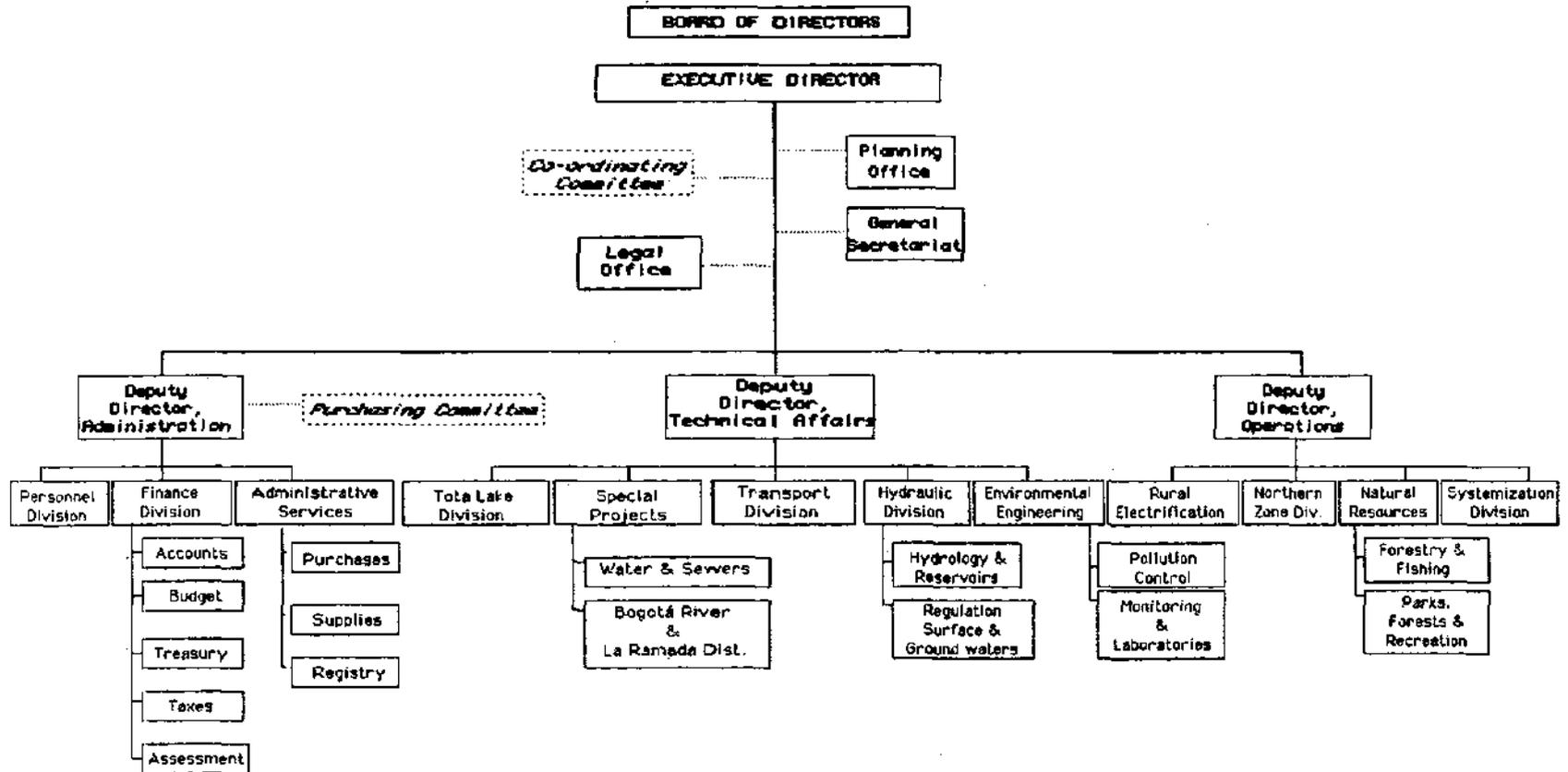
B. ORGANIZATIONAL STRUCTURE FOR WATER SYSTEM MANAGEMENT

1. Functional units (see figure 2)

The main structure of the organization consists of a Board of Directors, under which is the Office of the Executive Director, assisted by a Legal Office, a Planning Office and a General Secretariat. The Executive Directorate oversees three offices headed by the Deputy Directors for Technical Affairs, for Operations and for Administrative Affairs. The office of the Deputy Director for Technical Affairs has five divisions: hydraulics; environmental engineering; transport, road and pavements; special projects, and Tota Lake (outside the basin).

The Office of the Deputy Director for Operations has four divisions: natural resources, rural electrification, northern zone (outside the basin)

Figure 2
 ORGANIZATIONAL STRUCTURE OF CAR
 Decree No. 2021, September, 1981



and systematization. There are also three advisory and co-ordinating bodies, as follows: the Co-ordinating Committee, the Board of Tenders and the Personnel Commission.

The highest body of CAR is the Board of Directors, whose decisions are classified as follows: class-A decisions must be approved by the national Government, and include adoption of the by-laws and all amendments thereto; decisions regarding recruitment of staff; participation in corporations or purchase of shares in same; adoption of regulations for establishing and collecting taxes and appraisals or similar contributions, and approval of the creation of reserve zones and setting aside of areas within these zones. Class-B powers include the delegation to other decentralized --territorially or by services-- agencies of duties entrusted to the corporation, as well as the resumption of such duties when necessary, and the approval of contracts or agreements. Class-C duties include all other activities, such as decisions regarding the internal structure of the corporation, for which purpose it may create, eliminate or merge its subdivisions and assign duties to them; formulation of the general policies of the corporation and of plans and programmes, in accordance with the rules set forth by the National Planning Department; delegation, as deemed necessary, of some of its duties to the Executive Director, and so forth.

The Executive Director is an agent of the President of the Republic, who freely appoints and removes him; he is the legal representative and the highest executive authority responsible for the operation of the corporation. He must be an expert of widely recognized competence and experience in organizational techniques and management of corporations. His main duties are to direct the staff in the performance of their duties; to sign contracts; to appoint and remove employees; to propose to the Board of Directors the creation and elimination of posts; to establish administrative regulations and standards; to present to the Board of Directors the proposed budget, and to report to the President of the Republic, through the National Planning Department, on the implementation of programmes.

The duties of the Planning Office are, among others, to advise the Executive Director on technical, economic and administrative matters, submitting plans pertaining thereto, and on the co-ordination of programmes with similar agencies or institutions carrying out activities related to those of the corporation; to maintain a data system for purposes of evaluating planning activities; to collaborate with the Regional Planning Board; to draw up the master plan for the area under CAR's jurisdiction, and to propose terms of reference for studies required by the corporation in the area of urban and regional planning.

The Legal Office has the following duties among others, to study legal issues of concern to the corporation and draw up proposals or recommendations pertaining thereto; to codify legal norms; to supply the necessary documentation to the Public Ministry in lawsuits to which the corporation is a party, and to report to the National Planning Department and the Legal Secretariat of the Office of the President of the Republic on the progress of such lawsuits, and to draw up the necessary legal documents for acts and contracts of the corporation.

The duties of the General Secretariat are to oversee compliance with the rules of the institution and the efficient performance of its technical and administrative duties; to sign the administrative acts of the Executive Director and the Board of Directors; to carry out functions delegated to it by the Executive Director and to represent him upon his request.

The main duties of the Deputy Director for Technical Affairs are to draw up plans and programmes of work for submission to the Executive Director; to direct, co-ordinate and supervise programmes pertaining to projects and design, opening and maintenance of roads, water works, environmental engineering, water regulations, hydrology and reservoirs, surveying and design, opening of wells, and other activities pertaining to this office; to collaborate with the Planning Office in drawing up the preliminary budget proposal of the corporation, and to advise the Executive Director on technical matters.

The duties of the Deputy Director for Administrative and Financial Affairs include the drawing up of plans and programmes of work to be submitted for approval; to direct and supervise the preparation of studies, regulations, standards, and administrative systems and procedures; to supervise preparation of the budget proposal; to advise the Executive Director and the Deputy

Directors for Technical Affairs and for Operations on administrative and financial matters, and to evaluate the development and execution of his own programmes and activities.

The duties of the Deputy Director for Operations are to direct, co-ordinate and supervise programmes pertaining to electrification, natural resources, irrigation and drainage districts and systematization; to collaborate with the Planning Office in the preparation of the corporation's budget proposal; to direct and supervise the reforestation programme for the eastern hills of Bogotá; to approve specific programmes pertaining to the operation and maintenance of works administered by the corporation; to submit his programme of work to the Executive Director, and to evaluate the development and execution of programmes.

Advisory and co-ordinating bodies:

- Co-ordinating Committee. This committee is made up of the Executive Director, who presides over it; the General Secretary, who serves as Secretary of the Committee, and the Deputy Directors for Administrative Affairs, for Technical Affairs and for Operations.

- Board of Tenders and Purchasing. This board is made up of the General Secretary, who presides over it; the Deputy Directors for Administrative Affairs, for Technical Affairs and for Operations; the Chief of the Finance Division and the Chief of the Administrative Services Division, who acts as Secretary of the Board, with voice but without vote. The auditor assigned to CAR by the Office of the Comptroller General of the Republic also attends the Board's meetings, with voice but without vote. The Board analyses, studies and recommends the awarding or rejection of proposals and tenders.

- Personnel Commission. Decision 34, of 1981, provides for the appointment of the Personnel Commission, which is to perform the duties established by the legal provisions in force on the matter.

2. Appraisal of the organizational structure

A central aspect of the structure is its division into deputy directorates. There is not a clear need for the office of Deputy Director for Operations, which has been assigned work in connection with natural resources and management of the upper sub-basin of the Suárez River. This office might be replaced by that of a deputy director for planning, thus upgrading and strengthening the current Planning Office. The main purpose of this change would be to pursue and update CAR's regional master plan. This new office

would have a section devoted to water planning, an area in which the corporation seems to be weak.

A full-scale administrative reorganization would call for a much more thorough study than can be done in the context of this report.

3. Location of staff

Most of the staff is located in Bogotá, at the head office. A second office, for the upper sub-basin of the Suárez River, is located in the municipality of Ubaté.

Consideration should be given to the possibility of setting up another office in the lower basin of the Bogotá River, inasmuch as the middle and lower sections of this zone are quite a distance from Bogotá; moreover, especially careful management is needed for the middle region, because of its particular geotechnical and geomorphological conditions. This office might be located in Girardot.

Because of the nature of their work, some staff work outside the main offices, as in the case of personnel working in nurseries and parks and the operators of the water system.

4. Participation of users in management decision-making

Users take part in the management of water resources mainly through the Water Committee, which includes representatives of EAAB, EEEB and CAR. It should be noted, however, that users of water for agricultural irrigation are not directly represented on this committee. This has meant that CAR has tended to act as a spokesman on the Committee for irrigation users, thus downplaying its fundamental role as a vehicle for ensuring that optimum use is made of the water in the basin for all purposes.

EEEB has played a major role in managing the system because of the fact it owns the Tominé reservoir, the largest in the system. It is in charge of the physical operation of this reservoir, in order to ensure a maximum volume of water for the generating system, thus entering into competition with the irrigation users upstream from the hydroelectric power plant.

EAAB has played a minor role in the management of the system, as its main concern has been to have enough water to meet the demand for the water supply subsystems, and this is usually guaranteed through the normal operation of the hydroelectric power system. When the water level rises excessively—an infrequent occurrence—, thus creating drainage problems in the lower areas of Bogotá or creating a high risk of flooding in the urban area, EAAB is

concerned with operating the system in such a way as to reduce the level of the river. At such times, this company may significantly influence operating decisions.

The main constraint on the participation of irrigation water users is the lack of direct representation on the Water Committee; hence, the structure of this committee should be reviewed in order to include a direct representative of the irrigation water users. A highly qualified full-time professional specialized in this area should be appointed --and provided with a secretary-- to act as Technical Secretary of the Water Committee, so as to enhance its effectiveness. This official would be employed by CAR and would be classified as an advisor.

5. Organizational structure of institutions responsible for water resource management

In addition to EAAB, EEEB and CAR, there are other institutions in the basin that are water users, especially those which provide the water supply systems for the municipal capitals and return the water to the system as sewage. There is virtually no co-ordination between the former and the latter institutions, despite the fact that they are all water users. Institutionally, the proper tool for ensuring such co-ordination, as far as planning is concerned, is CAR's regional master plan; however, because the master plan is very new and has not yet been officially adopted, this co-ordination has not taken place.

C. EVALUATION OF THE SCOPE OF DUTIES OF THE BODY RESPONSIBLE FOR ADMINISTERING THE WATER SYSTEM

1. Degree of authority

As the body responsible for administering the water system, CAR is empowered to recruit personnel, provided it complies with the legal provisions currently in force, such as the decrees on public employees and official workers (Planeta de Personal de Empleados Públicos y de Trabajadores Oficiales). Salary scales for the different categories of personnel are also regulated by the (national) Administrative Department of the Civil Service, which sets salaries for CAR and for other similar regional corporations.

As regards the establishment of valorization contributions, the corporation is empowered to collect the valorization tax, with the prior approval of the national Government. In addition, it is authorized to receive

the revenues from the national real-estate tax on property located within its area of jurisdiction, which is equivalent to 2.5 per mill of the appraised value. It is also empowered to decide on rates for its services.

2. Limitations

CAR's main shortcoming is its personnel system, inasmuch as the salaries it pays are low by comparison with those paid by EEEB and EAAB, and its professional staff is small, considering the technical problems it has to deal with, the importance of its role and the great responsibility entrusted to it. District service corporations often have personnel who are more qualified than CAR's, which means that CAR may sometimes be viewed as having less technical authority. This puts CAR at a disadvantage, considering that it bears the greatest responsibility for the overall management of the water resource.

With regard to this particular limitation, it is worth mentioning the question of the staff's capacity to carry out planning duties. Presumably, this weakness has a great deal to do with the fact that the corporation's master plan has been relegated to a secondary position within the organization itself. It is particularly weak in the field of water planning.

A third limitation of the corporation which should be noted —one which is specifically related to the water system—, is that of the Water Committee, which is organized simply as a group of officials who meet periodically to consider issues and take decisions, but which has no permanent technical secretariat to work full-time on those matters which concern the Committee.

As regards the consistency of objectives pertaining to the exploitation of the water system, the stated objective of CAR is, essentially, to ensure that optimum use is made of the water resource; nonetheless, it sometimes appears to be interested in the use and control of water for those purposes which are not covered by EAAB and EEEB, i.e., irrigation and flood control, although it has also shown a definite concern for water quality control. Thus, its objectives are not entirely consistent; this shortcoming should be corrected, so that the corporation may indeed work to ensure optimum and comprehensive use of the water resource, rather than promoting a partial and less than optimum use.

As a result of the above, there is no evidence that all the staff concerned with the water system understand clearly what the objectives and priorities of the system are. Instead, the corporation projects an image of disparity and confusion.

The corporation operates with an annual budget for all its activities, including those associated with the water system. The budget is drawn up in consultation with the relevant units of the corporation's organizational structure and may be reviewed during the course of the year.

Job descriptions are set out in writing for the different units of the organization and for each and every post, at all levels; however, there is no guarantee that these are strictly observed. A great deal of authority is vested in the Executive Director, who acts under the restrictions stipulated in the corporation's by-laws, and he is required to consult periodically with the Board of Directors. Traditionally, the Head of the National Planning Department has carried the most weight on the Board, given his greater technical capability and the support he receives from the Special Division for Regional Corporations (División Especial de Corporaciones Regionales).

D. MANAGEMENT OF WATER SYSTEM OPERATIONS

1. Management planning

A Manual of Duties and Minimum Requirements (Manual de Funciones y Requisitos Mínimos) has been drawn up to facilitate the different operations and activities necessary for the normal operation of the corporation. This manual, which specifies the rank, duties and requirements for each individual post, was approved by the Administrative Department of the Civil Service by resolution 792 of 1985. In theory, the job description sets forth the staff member's responsibilities. In practice, however, the staff usually act on their own judgement and follow instructions from their immediate supervisor.

The methods used for compiling and analysing data on operations should be carefully reviewed.

Proposed plans regarding operations are studied jointly with EAAB and EEEB in the Water Committee, which recently created a small subcommittee charged with harmonizing the interests of these corporations. It is assumed that user interests are represented, to some extent, by CAR; it is recommended that a direct representative of the irrigation water users be included in the committee.

2. Implementation of management

Substantial improvements could be made in the design of methods and procedures for compiling and analysing data concerning the operations of the water system.

3. Monitoring

CAR has a regular environmental monitoring programme designed to control pollution of water by industries. It keeps a record on the industries concerned and tries to keep its data up to date by conducting occasional visits to the industries. This up-to-date record system enables it to monitor the industries by sending notices to those causing pollution, and requiring them, first of all, to carry out studies aimed at setting up pollution-monitoring projects at the plant level and adopting specific measures to control water pollution. This programme is supported by a subprogramme on sampling and laboratory analysis, which enables the corporation to follow-up on the water quality of discharges. In order to ensure the proper development of its master plan for the sewer system, EAAB, for its part, has deemed it necessary to carry out a discharge monitoring programme to regulate discharges which are harmful to the sewer system and future treatment plants, or which directly affect public health and the natural resources of the Bogotá River basin. The programme allows users within EAAB's jurisdiction to meet the requirements relating to water use and discharges into the sewer system, canals and surface sources established under existing regulations (National Sanitary Law: Decree 1594; CAR Agreement 09, and the EAAB Users Regulations). This programme has been carried out as a result of prior consultation and agreement among the Ministry of Health, CAR, the Bogotá Health Service and EAAB. The programme also has a co-ordinating committee, made up of the aforementioned institutions, as well as representatives of the industrial sector of the city. This committee is responsible for ensuring compliance with the programme and reporting on its progress to the governmental sector as well as to the users of the sewer system.

The objectives of the programme are to make a diagnosis, establish policies on regulations and discharges, and organize a long-term monitoring system. The programme is to be carried out by stages, as follows: a pilot plan to determine the characteristics of industrial groups; an inventory of users; identification of pollutants, through sampling and analysis of discharges; monitoring of discharges, and monitoring and enforcement of regulations.

4. Maintenance

The physical infrastructure of the system managed by CAR has not been kept up as well as it might have been. Thus, for example, the stations set up for measuring meteorological and hydraulic phenomena are not well maintained, nor are some of the infrastructure works, such as pumping stations, canals, and others. An equipment and works maintenance programme should be set up, as there seem to be no written procedures for planning, executing and monitoring infrastructure maintenance.

The EEEB maintenance programme leaves much to be desired, judging from the high rate of down time of plants over the last year, as well as the high percentage of losses.

The EAAB sewer maintenance programme could also be improved.

5. User relations

Traditional efforts to ensure that users get maximum benefit from the system's infrastructure and other opportunities provided by the administration of the water system are not effective enough. Users are not always kept informed about operating procedures or about changes in procedures; also, there is no formal assignment of responsibilities for user relations.

III. EVALUATION OF MANAGEMENT EFFICIENCY

A. PRODUCTIVITY

In 1985, EEEB generated 2 768 gWh of power, of which 2 389 gWh (86%) were generated by water power and the rest by thermal power.

The total value of energy purchased in 1985 was \$9 918 billion, and the average rate was \$2.86 per kWh. At the same price, the power generated by EEEB would be worth \$7 916 billion.

The hydroelectric power stations had a utilization factor of 50%, which is low, and average availability was only 69%, due to the weakness of the preventive maintenance programme for the generating plants. A total of 806 million m³ is used for hydroelectric power generation, giving a factor of 3 kWh per m³ of water going through the turbine.

With regard to the water system, in December 1985, EAAB had 549 819 customers in Bogotá and showed an annual growth rate of 5.2% with respect to the previous year. In 1985, EAAB sold 257 million m³ of water, i.e., 432 m³ per customer per year, or 1.18 m³ per customer per day. It received a total income of \$11.93 billion in 1985, for both water and sewer.

services. The income from the water system was \$6 661 billion, which amounts to \$26 per m³ of water delivered by the system.

The supply of irrigation water is regulated by a system of concessions for a maximum volume; so far, there is no charge for the amount used. Nevertheless, irrigation water has a high productivity in the agricultural sector, although this has not yet been carefully measured. At any rate, the economic value of irrigation in the Bogotá River basin varies greatly, depending on the use given to the water; it is very high --possibly higher than \$15 per m³-- when used for flower growing, and relatively low when used for less profitable crops, such as pastures.

Because no detailed in-depth study has yet been made, it is still not clear what the situation is with regard to the economic conflict between the use of water for irrigation upstream from the hydroelectric power generating plants, and power generation per se. It is possible that from this economic point of view, water may have a higher value, in the case of more profitable crops, such as flowers, than the opportunity cost of water for the generation of electric power; it is doubtful, however, that this would be the case with the less profitable crops, such as pastures. This is a problem of water economics that should be clarified in sufficient detail to allow for a more rational planning of water use.

B. ENVIRONMENTAL IMPACT OF WATER SYSTEM OPERATIONS

1. Geophysical system

In the lower basin, land use has been affected somewhat by water pollution. This zone, which has an excellent climate for recreational purposes, was very popular a few years ago for private recreational activities and tourism; however, because of the increasing pollution of the Bogotá River, it has gradually declined and lost its attractiveness. This has indirectly affected land use, preventing it from becoming more intensive.

Erosion has occurred in the basin in certain specific locations. In the upper basin, erosion in the Checua River area has been caused mainly by the irrational use of the soil, which is naturally inclined to this phenomenon anyway; erosion has also occurred, for the same reason, in some parts of the upper Bogotá River basin, as well as in the basin of the tributary to the Tominé reservoir. A reforestation programme has been carried out in the Tominé watershed, as well as around the other reservoirs. Nevertheless, siltation in

the system's reservoirs is still within tolerable limits and does not present a serious problem. This is not the case, however, with the Checua River basin, where the high content of sediment in suspension increases the cost of water treatment in the Tibitó purification plant.

In the lower basin, a complex phenomenon of erosion has occurred which has seriously jeopardized geotechnical stability, and hence the safety of the civil works pertaining to the installed capacity for hydroelectric power generation. The middle zone has a high precipitation and a high slope, and these factors, together with rather careless soil management practices and the building of infrastructure works (highways) without taking into account certain aspects relating to drainage and erosion control, have created a situation in which the utmost care must be taken to avoid damaging the stability of the hydroelectric works.

The pollution of the water, especially by chlorides and salts in solution from upstream industries, has significantly affected the soils in the La Ramada irrigation district. This has been verified through studies conducted by the Colombian Agricultural Institute (Instituto Colombiano Agropecuario - ICA).

Presumably, strict control over discharges from upstream industries would substantially attenuate this problem, which is causing a gradual salinization of the soil. A similar phenomenon may be taking place in the lower basin, where polluted water from the Bogotá River is being used for crop irrigation in the municipality of Tocaima; however, no study has yet been made of the extent to which this is occurring.

As regards flood control, the water system has had a significant impact on the geophysical system, as a direct result of the regulation of the volume of water flowing through the reservoirs and the earth-fill dams that have been built at the lower end of the upper basin.

2. Biological system

Pollution of the Bogotá River has almost entirely eliminated the fish and amphibious species that lived in it, has deteriorated the habitat for birds that fed in it, and has affected fishery production from the Magdalena River. This problem has not received the attention it deserves.

The pollution of water in the area covered by CAR includes the urban areas having sewer connections and the rural areas as well; in either case, the pollution may be of either domestic or industrial origin. It has been

estimated that domestic organic pollution in the Bogotá River basin produces a biochemical demand for oxygen on the order of 209 tons per day, 90% of which occurs in the area of Bogotá and Soacha; pollution by pathogenic organisms, measured as the most likely number of fecal coliforms $\times 10^{-10}$, is in the order of 4 686 092 per day. Industrial organic pollution, expressed in terms of biochemical demand for oxygen, amounts to 85.3 tons per day, 81% of which is in the area of Bogotá and Soacha.

The poor quality of the water has significantly affected the health and nutrition of the population living in the lower basin, part of which still uses the Bogotá River as a source of water (municipalities of Anapoima and Agua de Dios).

3. Human environment

Water supply and sewer systems. The potable water service for the Special District is estimated to have a coverage of 96%; this indicator seems high in percentage terms, but it means that the population having no potable water service totals 140 000. The sewerage service, for its part, covers 84% of the population, which leaves a deficit of 639 000 inhabitants in absolute terms; the bulk of this population is located in the outlying areas, especially towards the south, where EAAB is currently carrying out a plan to improve the situation over the next four years.

As regards the municipal capitals, some of them have water supply coverage levels as low as 65%; in addition, in some capitals, water is not available all the time, and water treatment is deficient. Only about half the capitals have type-A treatment facilities, i.e., guaranteed potability; in the other capital cities, mainly in the upper basin of the Bogotá River, treatment facilities are either deficient or non-existent. The quality of the water provided depends on the agency administering the service and the efficiency of its management. Water systems with adequate treatment facilities are usually those administered by Sanitary Works Enterprises (Empresas de Obras Sanitarias - EMPOS) or sponsored by public corporations or administrating boards. Systems administered directly by municipal governments generally do not provide suitable water treatment services, usually because of administrative inefficiency. It should be noted that even in those municipalities which apply type-A treatment, analyses show that the water is not entirely potable; this seems to be due to the high level of pollution at the source and inadequate administration of the service.

As regards sewer systems, the deficiencies are even greater, as it is estimated that they only cover about 70% of the population. The municipality of Tena has no sewer service at all, and many others in the Bogotá River basin have serious shortcomings in this regard.

As regards sewage treatment systems, there are only two oxidation lakes in the upper basin, the Cota lake and the Tabio lake.

In the rural areas, water supply coverage is extremely low --under 10% in the smaller population centres. In this regard, the information available is not entirely reliable. Given the high level of water pollution in the region, it may be said that the situation is critical.

The municipalities in the basin have high mortality rates among children under age 5, because of intestinal infections and diarrhea associated with the poor quality of the water. The mortality rate among children under 5 is in the order of 13 per thousand, while the morbidity rate is in the order of 19 per thousand. The rate of mortality from intestinal infections among children under 5 is in the order of 2.6 per thousand and the morbidity rate is 4.5 per thousand.

C. COSTS AND COST RECOVERY

The costs pertaining to the Bogotá River system as a whole are met by three agencies: EAAB, EEEB and CAR. EAAB and EEEB are typical public-service enterprises, i.e., they supply a service, and in so doing incur a cost, which they try to recover through the rates they charge their users, under a policy aimed essentially at ensuring that the enterprise is self-financing.

CAR, on the other hand, is a regional development corporation whose purpose is to promote the social and economic development of the region. Hence, it does not have the profile of a public-service enterprise.

CAR's total income during 1985 was \$2.18 billion, obtained as follows: 89.7%, from its own resources; 5%, contributions from other agencies; 4.4%, credit resources, and 0.9%, from the national budget. Revenues from the 2.5 per mill tax, in 1985, totalled \$1 277 billion, or 58.6% of total income.

The corporation's operating expenditures during 1985 totalled \$346 million, or 15.9% of total income for that year. Hence, 84.1% of the corporation's income goes back into the system, considering that operating expenditures do not.

It may be noted, then, that the corporation's income (excluding the contributions from the national budget, which amount to less than 1% of total income) is sufficient to finance its annual costs. Should a deficit occur, it would probably be financed through the national budget, although such a situation would not be considered desirable.

As for the rest, costs incurred in the river basin water system through the district enterprises, EAAB and EEEB, are essentially self-financed through the rates charged by these corporations for their services.

IV. CONCLUSIONS

1. The productivity of the management of the Bogotá River basin's water system is greatly influenced by the competition between users, i.e., between irrigation users, in the upper basin, and the hydroelectric-power-generation use, in the lower basin. In this competition, irrigation in the upper basin is considered a priority "user" under existing legislation; it is also a "primary" user in that it is located upstream from the hydroelectric generating plant. EEEB, on the other hand, is a "residual" user. Under these circumstances, if the net margin of return from the irrigation use is higher than that of the power-generation use, the irrigation use --especially for flower growing and in some other cases-- will be particularly efficient. However, this is not usually the case, and it is therefore not clear that the use of water for growing pastures is more efficient than its use for generating hydroelectric power, considering that the system has a potential for highly efficient generation, given its natural and physical conditions and the high investment put into it. When the Mesitas project is put onstream, the system will have a very high installed capacity for electric power generation, and any water used for irrigation will be needed to maximize power production, thus giving rise to an opportunity cost. In this regard, it is important to bear in mind the existence of the upper basin of the Suárez River, bordering on the Bogotá River basin; this catchment area, which is within the jurisdiction of CAR, has some physical similarities with La Sabana de Bogotá and is very close to it. In the upper Suárez basin, the use of water for irrigation does not entail an opportunity cost with regard to hydroelectric power generation, and the gross return on irrigation is potentially similar. Thus, if CAR were to follow a strategy aimed at promoting irrigation projects in the area within its jurisdiction in the upper basin of the Suárez River,

rather than in La Sabana de Bogotá, it would make a positive contribution towards improving the economic yield of the system over the long-term, and would help prevent any intensification of the current conflict between irrigation and hydroelectric power generation. In conclusion, how productive the management of the water system is over the medium and the long-term will depend on how the irrigation vs. hydroelectric power generation conflict is resolved. It may be that significant inefficiencies are being generated because of a failure to make optimum use, in economic terms, of the water in the system. It is also recommended that the hydroelectric power plant maintenance programme followed by EEEB be improved in order to increase its availability (percentage of time in service) and substantially reduce losses in the power distribution system.

2. Only in the La Ramada district is a charge made for the use of irrigation water; i.e., other users of irrigation water receive it free of charge. Actually, this water does have a cost, namely, that involved in the construction and maintenance of the reservoirs which have made it possible to improve substantially the availability of the water; consequently, the users who receive it free are being subsidized by the rest of the community. This situation, on the one hand, encourages the use of water for irrigation, accentuating competition with the hydroelectric-power-generation use, and, on the other, gives rise to a problem of inequity. It is recommended, therefore, that a price be established for irrigation water for all users scattered throughout the area. This is particularly important at present, inasmuch as EEEB is in a critical financial position.

3. As regards the management of water quality, for which CAR has overall responsibility in the basin, with EAAB being responsible locally for discharges of sewage, no scheme has been devised up to now for financing the works needed to achieve acceptable water quality. The solution to this problem is still under study; a greater effort must be made in this regard, with a view to significantly alleviating the situation.

4. As regards management of the water system, it is essential to define a clear and definite long-term strategy based on a water plan for the basin. It is hoped that the National Water Study, currently in progress, will establish the necessary guidelines with regard to the Bogotá River basin. It is suggested that this strategy should be aimed at increasing the transfer of water from neighbouring basins towards the Bogotá River basin, as this could

substantially alleviate the conflict between irrigation and power generation and allow for a more efficient utilization of installed electric power generating capacity in the basin.

5. The Water Committee (CAR-EAAB-EEEB) is an essential mechanism for co-ordinating water management in the basin; nevertheless, its present structure is weak, and it needs to be strengthened with the creation of a highly specialized technical secretariat.

6. CAR's present organizational structure is not the best suited to enable it to fulfill its objectives efficiently and should be revised. The personnel system should be reorganized and the salary scale revised in order to ensure that working conditions at CAR are not inferior to those at EAAB and EEEB.

7. Planning activities are quite weak; hence, as part of the internal administrative reforms, the planning function should be strengthened considerably; the planning office should be upgraded to the rank of a deputy directorate. CAR must be clearly aware of the great responsibility it has for managing the natural resources within a context of serious conflicts of interests and of complex interaction between different types of institutions. CAR's regional master plan is an essential tool for dealing with this situation.

8. The aforementioned shortcomings can be attenuated through better training of the staff, especially as regards administration in the area of water resources. Water management is a highly specialized field in itself, and has not been sufficiently recognized in Colombia. Consideration should be given to the possibility of conducting a training programme in co-operation with the National Planning Department.

9. The present administrative system was set up only recently, and must be evaluated before any medium-term guidelines are established. In principle, interest seems to be centered on the agricultural problem, particularly as regards flood control, and on improving the quality of water upstream from Juan Amarillo. There also seems to be an interest in constructing all the irrigation projects proposed for La Sabana de Bogotá. It appears to the author of this study that the economic facts do not substantiate this emphasis on building all the irrigation projects in La Sabana, particularly since the irrigation vs. power-generation conflict has not been clearly stated. The author of this study recommends waiting for the final conclusions of the National Water Study before taking a decision on the construction of the

projects located in the Bogotá River basin. On the other hand, priority should be given to irrigation projects located in the upper basin of the Suárez River.

10. The experience gained from the administration of this water system can greatly contribute to the overall process of water-system management in Latin America and the Caribbean, particularly as regards administrative and institutional aspects. Experience has shown that the institutional scheme set up for the Bogotá River basin is a viable one; nevertheless, in such a scheme, when the institution that is mainly responsible for the overall management of water resources finds itself at a disadvantage because of weaknesses in its technical and administrative staff, its efforts to meet its objectives will be greatly hampered. A tremendous effort must be made to co-ordinate and reconcile interests, as very difficult situations can be expected to arise, such as the present problem of pollution of the Bogotá River. It may be necessary, in order to solve a problem of this magnitude, to consider the possibility of a complete institutional change over the medium-term.

11. In light of the recent change in the national Government, circumstances seem to be favourable for influencing the perception which the leadership of the system has of its problems and for making administrative changes designed to allow for optimum management of the water system.

Bibliography

1. "Plan Maestro Regional de la CAR". CAR. Bogotá, 1985.
2. "Estudio Nacional de Aguas". Segunda Fase. Primer Informe de Progreso correspondiente a la cuenca del Río Bogotá. FONADE, DNP, CAR/Mejía, Millán y Perry Ltda., mayo, 1985.
3. "Estudio Regional Integrado del Altiplano Cundiboyacense". IGAC-ORSTOM. Bogotá, 1982.
4. "Principales normas legales vigentes". CAR, 1985.
5. "Informe de Gerencia 1985". Empresa de Acueducto y Alcantarillado de Bogotá, 1986.
6. "Informe 1984-1985. Empresa de Energía Eléctrica de Bogotá". 1986.
7. "Estudio y Diseño de la Ampliación de la Estación de Bombeo de La Ramada". CAR, Jaime Saldarriaga, 1981.
8. "Censo Nacional de Población y Vivienda, 1985". Departamento Administrativo Nacional de Estadística, DANE.
9. "Agua, Desarrollo y Medio Ambiente en América Latina". CEPAL. Julio, 1980.

10. "Informe Técnico N° 2 para los Diseños Definitivos de la Adecuación Hidráulica del río Bogotá, las Extensiones del Plan Maestro de Alcantarillado y los Estudios de Tratamiento de Aguas Negras de la Ciudad de Bogotá". EAAB/Hidroestudios-Black and Veatch, mayo, 1985.
11. "Plan Maestro de Calidad de Aguas Superficiales". Volumen Principal. CAR/Gobierno de Holanda/Haskoning. Septiembre, 1986.