UNITED NATIONS

ECONOMIC
AND
SOCIAL COUNCIL

GENERAL

E/CN.12/562
30 March 1961

ENGLISH
ORIGINAL: SPANISH

ECONOMIC COMMISSION FOR LATIN AMERICA
Ninth Session
Caracas, May 1961

WATER RESOURCES IN VENEZUELA*

* The present paper is a summary of a study bearing the same title of which the complete text (in Spanish only) is to be published shortly.

CONTENTS

/PRELIMINARY NOTE

PRELIMINARY NOTE

At the request of the Venezuelan Development Corporation, the ECLA/BTAO/WMO Water Resources Survey Group made an analysis of water problems in Venezuela, at the end of 1959 and during 1960. ECLA collated the observations and findings of the members of the Group and prepared a preliminary report, which has been summarized in the present document for ease of reference.[1/]

1/ The separate reports of the individual experts may also be consulted: hydrometeorology, by R. Schroeder; legal and institutional aspects, by G.J. Gano; and hydrology, irrigation, multi-purpose development and conservation, by N. van den Heuvel.

I

MAIN CONCLUSIONS

Certain main conclusions can be drawn from the survey of Venezuela's water resources. Although these conclusions will be further developed and documented in later sections of the present paper, it may be useful to outline them briefly here.

1. The organization and utilization of water resources is becoming increasingly important for Venezuela's development, since it can to a considerable extent counterbalance the effects of the weakness of the petroleum market, while making the economy more balanced and reducing its external vulnerability. These resources are a decisive factor in the expansion of the agricultural sector and, through the resulting increase in the purchasing power of that sector, of the industrial markets. Furthermore, industry can benefit considerably from improvement in the supply of drinking water and the greater supply of cheap power provided by hydroelectricity. Consequently, the Four-Year Plan has taken this into account by including provision for a rise of over 70 per cent in the level of annual investment in water projects compared with the previous five-year period. These projects previously accounted for 6 per cent of public investment, and this figure is now increased under the plan to 15 per cent. At a later date this sector will probably require a further rise of 30 per cent in the level of annual investment, compared with the level provided for in the plan.

2. The control of water flows is not only desirable but often necessary, since the climate prevailing in the most populated areas of greatest agricultural potential is the tropical savannah climate with high constant temperatures and heavy seasonal rainfall. The rainfall distribution produces heavy and often damaging runoff in the Venezuelan winter (May to October) and to prolonged droughts in the summer (November to April), which are a serious threat to the vital elements of the soil and greatly hamper the supply of water to the population.

/3. This

3. This situation calls for an administrative, legal and institutional organization; this was initiated and improved under the Land Reform Act, but there are still major gaps to be bridged. The most serious drawback is the lack of a central water authority with full power to control the use and protection of water resources in accordance with a water policy formulated by and carried out under the supervision of a high-level and widely representative planning body.

4. The hydrological and hydrometeorological measurement services are moderately well developed and fairly widespread, but should be further extended and co-ordinated.

5. The public services supplying drinking water reach barely more than half the urban population, which is low for a country with Venezuela's level of income. Even more important than the extension of these services is the question of their continuity, which is endangered by the reduced supply of the water sources in summer. The Four-Year Plan has started a substantial improvement in this situation by doubling the rate of investment attained in recent years. The new rate needs to be maintained for twenty years in order to supply water to the whole population.

6. At present there are some 1.4 million hectares under cultivation with a very low average level of productivity. This is evidenced by the fact that, although irrigation is essential for a stable high-yield agriculture in most of the area now under cultivation, only about one-fifth of that area is irrigated, and of the irrigated area, only ten per cent is irrigated by means of large-scale schemes built by the Government. An analysis of these schemes suggests that some improvement in planning is called for, from the standpoint both of agronomy and of water utilization, on the one hand, and of encouraging more widespread and effective use by consumers, on the other. The areas holding out the greatest promise for the future are those in the neigbourhood of the Andean States, especially in the Western Upper Llanos, between the river Cojedes and the Santo Domingo and Motatán. The first step should be to construct works based on river tapping; subsequently, as interest grows, more expensive operations involving flow regulation can be introduced. With the first method, nearly 100,000 hectares of the areas referred to could be irrigated, and with the

/second, very

second, very much more. The Four-Year Plan advocates an increase of 300,000 hectares in the area under cultivation; of these, 125,000 hectares would be brought under cultivation through irrigation, mainly through river tapping in the areas referred to and extension of projects where there is existing storage, and another 30,000 by drainage and flood control in the humid areas to the south west of Lake Maracaibo, a method which would probably be as economical as irrigation. At a later stage, the new acreage will all have to be brought under irrigation and flow control, which will require an expansion of 70 per cent in the annual volume of investment in hydraulic works compared with the level visualized in the plan.

7. Water power, which at present is scarcely used, could be the basis of the electricity supply within 20 years; consequently the development of the great potential of the Lower Caroní and the surveying of the Andean resources should be continued.

8. The progressive depletion of summer water sources in the populated areas and in the areas bordering on the northern part of the country calls for an active programme of water conservation, in co-ordination with the programmes of soil and forest conservation. Essential elements of such a programme are protection of the vegetation covering the higher areas of the basins against harmful usage, fire, neglect, etc.; regulation of flood waters, as far as possible, by infiltration, storage and lakes; limitation of the establishment of industry in areas where there is a shortage of water; and prevention of the contamination of water courses. The programme could concentrate at first on the more developed areas and be extended, on a small experimental scale, to other areas as required.

9. Protection of water resources should be combined with encouragement of multi-purpose use, with the hydrographic basin as the basic unit. The basins where action is most needed at present are those of the Tuy and Lake Valencia.

II

GEOGRAPHICAL, DEMOGRAPHIC AND ECONOMIC CHARATERISTICS

In the mountainous regions in the north and west of Venezuela, which comprise 19 per cent of the total area of the country, and which include the areas that were first colonized and that still have the highest population density because of their more temperate climate and their proximity to the sea, water problems of every kind are encountered. These include water shortages in the north and in the neighbourhood of the large cities such as Caracas, Maracaibo and Barquisimeto; erosion on high ground, especially in the Andes; and floods in the vicinity of the river mouths.

The flat lowlands of the interior, on the left bank of the Orinoco, take up 35 per cent of Venezuela's total area, and possess the biggest tracts of land which, on account of its uniform topography and the quality of the soil, is suitable for intensive farming, although as a rule only on the basis of irrigation. Owing to the lack of gradients, swamps are found and severe seasonal floods occur.

The rest of the country is constituted by the Guiana Shield, to the south of the Orinoco. Owing to its inaccessibility it is the least known and least densely-populated area, although it has substantial hydroelectric and mineral resources now on the way to utilization.

The population, which at the end of 1959 was estimated at 6.9 million, has been growing during the last decade at an annual rate of 3.2 per cent, one of the highest in Latin America. This expansion is a consequence of the boom in the extractive industries, which has been reflected in immigration, improvement of sanitary conditions, and so forth. The degree of urbanization has also considerably increased, and with it the resultant problems, outstanding among which is that of the drinking-water supply in cities affected on the one hand by the pressure of industrial development and the expansion of services, and on the other by rural population shifts prompted by the possibility of obtaining higher wages in the towns. Since 1958 the incidence of this last factor has abruptly increased, with the result that shanty towns devoid of basic services have sprung up on the outskirts of almost all the larger cities, which are found as a rule in semi-arid parts of the mountainous districts.

/The immature

The impetus acquired by the development of the petroleum industry in the last few years has generated other maladjustments in the Venezuelan economy, the remedying of which is largely dependent upon water resources.

In recent years, the extractive industries - especially petroleum - have maintained their preponderance, accounting for 30 per cent of the gross product, 96 per cent of the value of exports and a high proportion of tax revenue. This implies a considerable degree of external vulnerability which is now becoming apparent as a result of over-production of petroleum in countries which, like Venezuela, are exporters.

As this state of affairs may persist in the near future, the Four-Year Plan assigns to the petroleum sector only a 4-per-cent expansion as against the 7 per cent registered in the past decade. Lest the situation should last even longer, it is essential to seek ways and means of strenghthening other lines of production, by virtue of which a rate of growth high enough to provide work for Venezuela's rapidly-increasing population can be maintained, and at the same time the wide disparities in income levels can be smoothed out as far as possible.

Manufacturing industry has been undergoing vigoruos development, and, although its high degree of mechanization has resulted in its absorbing a relatively small proportion of the labour force - 12 per cent in 1959 -, it may employ more manpower if the balance of payments weakens slightly and, with it, import possibilities.

Agriculture will also be called upon to play an important part. Its development would considerably reinforce that of industry by broadening the latter's market and thus enabling it to achieve economies of scale which might bring down the present high costs. Moreover, if agricultural production were expanded, a considerable proportion of the foreign exchange currently spent on consumer goods could be saved. In contrast with the course of events in many Latin American countries, agricultural development in Venezuela would afford a means of absorbing manpower if it were based mainly on the extension of the area under cultivation and the introduction of new and intensive crops. In any event, the per capita productivity of Venezuelan agriculture, which is exceptionally low (23 per cent of the average productivity figure for the whole economy), will

/have to

have to be substantially improved if average income levels are to differ less widely from one economic sector to another. Hence emerges one of the most significant possibilities for the utilization of water resources in the Venezuelan economy.

The proper management of these resources is among the factors which can make the biggest contribution to the expansion of agricultural production. As this entails large-scale projects which only public capital can undertake, the responsibility for programming action in this sector is incumbent upon the Government, which has, moreover, already assumed the important role of a promoter of industry through the development of the production of low-cost electricity, thanks to the availability of such hydroelectric resources as those of the Lower Caroní. Lastly, the Government, in fulfilment of its functions as the guardian of public health, handles the drinking-water supply, another aspect of which activity is that it yields immediate economic returns by placing this other basic element at the disposal of small-and medium-scale industry.

In recent years, the central Government has allocated 1.8 per cent of its investment to irrigation, 2.6 per cent to drinking-water and sewage and 1.3 per cent to hydroelectricity. Under the Four-Year Plan for 1961-64, these percentages rise to 4.6, 7.0 and 3.2 respectively. Over the longer term, up to 1980, it has not been possible to estimate the corresponding proportions, since projections of Venezuela's total capital formation are outside the scope of the present study. It may be assumed, however, that annual investment, in absolute terms, will probably need, in the case of irrigation, to increase by at least 70 per cent in relation to the Four-Year Plan figures already indicated; in that of drinking water and sewage, at least to maintain the same level as under the Plan; and in that of hydroelectricity to rise by 20 per cent. In the aggregate, annual investment in hydraulic projects under the Plan, which will represent 15 per cent of total public investment, raises the average amounts registered in the last five years by 70 per cent. At a later stage it would be desirable for this average investment under the Plan to be increased by at least 30 per cent.

Some idea can thus be formed of the considerable importance which will attach to a water policy that satisfactorily organizes the utilization of water resources.

III

THE METEOROLOGICAL AND HYDROLOGICAL BACKGROUND

1. General climatic conditions

Venezuela's geographical situation in the tropical zone determines stable temperatures throughout the year, and this is the predominant characteristic of its climate. Altitude influences temperatures, which decrease as the height above sea level increases.

Mean annual temperatures reach their highest levels in the Gulf of Venezuela and parts of Lake Maracaibo, where they attain almost 28°C. (Maracaibo). In 65 per cent of the country's total area the mean annual temperature is approximately 26°C., as is the case along the seaboard from the Paraguaná peninsula to the frontier of British Guiana. The annual average is a little lower in some parts of the interior, especially in the Guiana Shield and the mountainous area, falling to 21.5°C. in Santa Elena and Caracas. Where the altitude is greater, as in Mérida, mean temperatures are still lower (18.5°C.), and on the highest peaks they drop to zero or below it.

Humidity varies not only with altitude but also in parts of the vast lowlands; consequently, there are large areas with a tropical rainy climate and others with a tropical steppe climate. Nebulosity is high in the Guiana Shield, in Barlovento and in the Lower Yaracuy and Tocuyo valleys. In the Cordillera de Mérida and throughout the mountainous region constituted by the Andean system the amount of cloud is considerable, while in the Central and Eastern Llanos it is smaller, and the areas freest of cloud are found along the coast of the Gulf of Venezuela in Nueva Esparta and in the Paria Peninsula.

Evaporation, which is related to humidity, is high in the dry zones of Lara and Falcón, the Eastern Massif and the Unare Basin. The large amount of cloud in the mountainous districts reduced evaporation to lower figures than might be expected from the altitude.

The above-mentioned climatic factors are affected or determined by the movements of the big air-masses which form centres of high pressure exerting a decisive influence on rainfall and on typical atmospheric conditions or synoptic situations. Of these, five predominant movements

/have been

have been singled out as objects of research. Air-masses from the northern and southern hemispheres form a high-pressure area above Venezuelan territory almost throughout the year, and by their northward fluctuations determine the beginning of the rainy season. During the astronomical winter, cold air from the north and north-east may bring about an interruption of the dry season (the Venezuelan summer) on the Caribbean littoral. Also from the north, but from the eastern Atlantic, come cold air-masses whose presence initiates the rainy period in the east of Venezuela. In the east of the Caribbean too, anticyclonic conditions occur which generate centres of high pressure and cause fine weather in Venezuela; this may happen at any time of year.

2. The rainfall régime

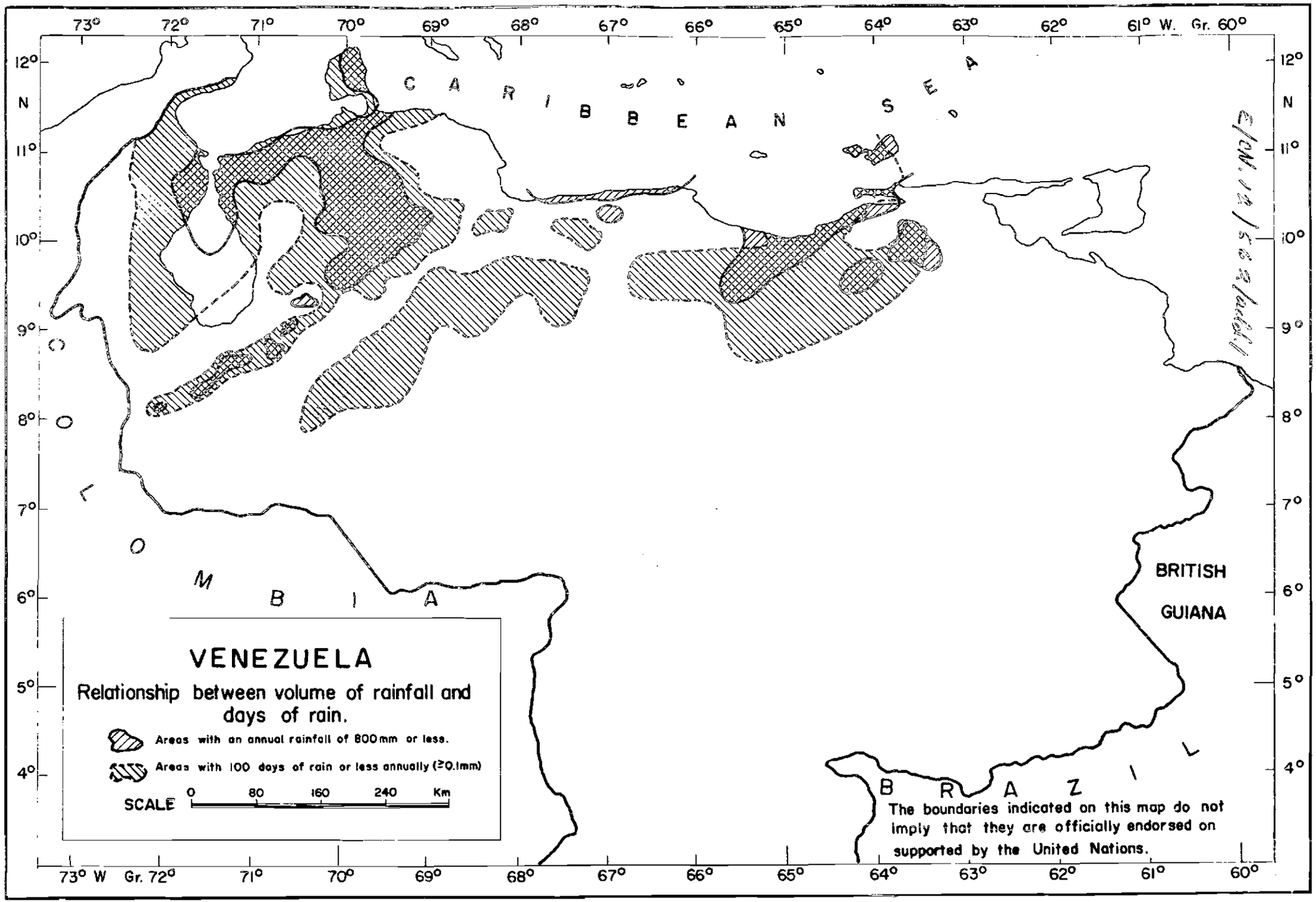
Venezuela possesses 1,016 precipatation stations belonging to the following bodies:

Ministry of Public Works (Ministerio de Obras Públicas - MOP)	532
National Institute of Sanitary Works (Instituto Nacional de Obras Sanitarias - INOS)	180
Private firms	138
Ministry of Agriculture and Animal Husbandry (Ministerio de Agricultura y Cría - MAC)	122
Meteorological Service of the Venezuelan Air Force	38
Venezuelan Development Corporation (Corporación Venezolana de Fomento - CVF)	6

The average density of stations is 1.1 per square kilometre, which is not a low figure in comparison with those registered in Argentina (1.3) and Chile (0.7), and higher than those found in Ecuador (0.3) and Bolivia (0.2). As this service has been expanded in recent years, the average length of records (12 years) is on the short side, but this is to some extent offset by the high proportion of automatic recording gauges.

Thanks to this coverage of measurements, overall knowledge of the rainfall régime has been obtained and it has been possible to prepare a climatological atlas whose degree of accuracy is satisfactory in the case of the more densely-populated areas, although deficient in that of

/the remoter


VENEZUELA
Relationship between volume of rainfall and days of rain.
Areas with an annual rainfall of 800mm or less.
Areas with 100 days of rain or less annually (≥0.1mm)
SCALE 0 80 160 240 Km
CARIBBEAN SEA
COLOMBIA
BRITISH GUIANA
BRAZIL
The boundaries indicated on this map do not imply that they are officially endorsed on supported by the United Nations.
73° 72° 71° 70° 69° 68° 67° 66° 65° 64° 63° 62° 61° W. Gr. 60°
12° N 11° 10° 9° 8° 7° 6° 5° 4°

the remoter parts of the country, where the relevant data are often of greater interest from the standpoint of water resources.

The areas where precipitation figures are very high (showing an annual average of 2,000 mm or over) are to be found in or near the mountains, and include the following: Barlovento, Rancho Grande and the central Upper Llanos in the Cordillera Caribe; the eastern slopes of the Andean massif and the Chama, Zulia and Upper Catatumbo valleys; and the Sierra de los Motilones. Heavy rainfall is also registered in somewhat lower-lying areas, such as the Western Llanos, the State of Bolívar and the Federal Territory of Amazonas. Since Venezuela is a tropical country, it is not surprising that fairly dry tracts of land are also found, with under 800 and even as little as 300 mm of rainfall yearly. The largest of these lies to the north of the Andean massif, and comprises part of the States of Lara and Falcón and the neighbourhood of the town of Maracaibo.

The problems created by an excess or a lack of water, measured in terms of annual precipitation, are aggravated when rainfall is concentrated in a relatively short period of the year, usually in April-May and September-October. The former signifies torrential rains with great destructive power, such as characterize the eastern slopes and some of the higher regions of the Andes, in the Yaracuy basin, etc. In contrast, a high degree of concentration and little rainfall produce really arid areas, like that mentioned above in the States of Lara and Falcón, Nueva Esparta, the Gulf of Cariaco, part of the Unare basin, etc. The appended map shows how these areas with low and intensively concetrated precipitation are distributed.

The foregoing remarks relate to the average behaviour of rainfall, and do not exclude the possibility of considerable variations - of over 100 per cent in some cases - from one year to the next, so that it is advisable to take as many observations as possible and correlate short series with others that are longer but have similar characteristics.

/3. Climate

3. Climate and agriculture

The variations in temperature determined by altitude demarcate "Thermal zones" where the following typical crops are grown:

Tropical (up to 800 metres): sugar-cane and staple export crops such as cacao, rice, palms, bananas;

Sub-tropical (from 800 to 1,500 metres): coffee and fruit for domestic consumption;

Temperate (from 1,500 to 2,200 metres): cereals, potatoes, vegetables;

Cold (from 2,200 to 3,000 metres): potatoes, and some cereals.

The extent of the sub-tropical and temperate zones, which are the most favourable for agriculture, is nor great (8 per cent of the total area of the country), and they are densely populated.

The influence of rainfall on agricultural possibilities is naturally decisive. These are extremely limited in the above-mentioned dry areas where mean annual precipitation is below 800 mm. Short and intermittent bouts of rain in some parts of the areas in question enable a little crop farming to be carried on. In the rest of the tropical zones, where more abundant precipitation is registered, the distribution of rainfall over the course of the year becomes important. Broadly speaking, during the dry season there is not enough water to meet crop requirements, with the result that productivity is considerably reduced, while in some instances the drought even affects vital soil factors and renders the rehabilitation of the soil in the rainy period progressively more difficult. On the other hand, the excess of rainfall in the wet season often produces very harmful erosive effects, especially on steeply-sloping ground and where the surface vegetation has been depleted by clearing, fires, over-population, over-grazing or prolonged droughts.

In order to remedy these drawbacks, irrigation is needed almost throughout the country during the Venezuelan summer (November/April), as well as measures to control flows and run-off in the winter (May/October), if agriculture is to be productive and stable.

If areas which are more or less homogeneous from the standpoint of climate and agricultural possibilities are grouped together, they form the climatic-economic zones of which a brief description is given below.

/(a) Tropical

(a) Tropical steppe climate

Precipitation is scanty (less than 600 mm yearly) and takes place mainly from April to October (astronomical spring and summer). Irrigation is necessary usually during nine months of the year (from September to May) but often throughout the whole twelve. In Venezuela such areas are found only in the parts of the country subject to the influence of the Caribbean Sea, including the State of Lara.

(b) Tropical savannah climate

Precipitation amounts to over 600 mm per annum, and may reach very high figures, but it is concentrated in the six astronomical summer months. The zone where this climate prevails is the largest in Venezuela, covering almost the whole of the Llanos and a considerable part of the State of Zulia. On an average, irrigation is required during 5-6 months of the year. There are, however, some parts of the country (such as Turén) where dry-soil farming is possible, but yields are low because two harvests are unobtainable, and conditions are highly precarious, as even in the rainy period the actual precipitation is occasionally just as low as in the dry season.

(c) Tropical rainy climate

In this zone precipitation is sufficient throughout the year, so that as a general rule irrigation is unnecessary, although there are excessively rainy periods which create flood problems. It comprises the part of Venezuela which stretches east from the Gulf of Paria, including the Amacuro Delta (except for land at more than 1,500 metres above sea level) the Barinas area and Apure - which is an exception within the tropical-savannah zone -, the south of Lake Maracaibo and the slopes of the Sierra de los Motilones.

Other climatic zones of less significance are those determined by altitude, although they cannot be clearly demarcated on the basis of the observations recorded. Above 1,500 metres, mesothermal areas are found, some of them of the savannah type - here and there along the coast and in the Cordillera de Mérida - and occasionally requiring irrigation, and others of the humid type at the higher altitudes of the Guiana Shield.

/4. Hydrographical

4. Hydrographical features of Venezuela

As in most countries, hydrological measurements are of more recent date and generally less complete than meteorological observations.

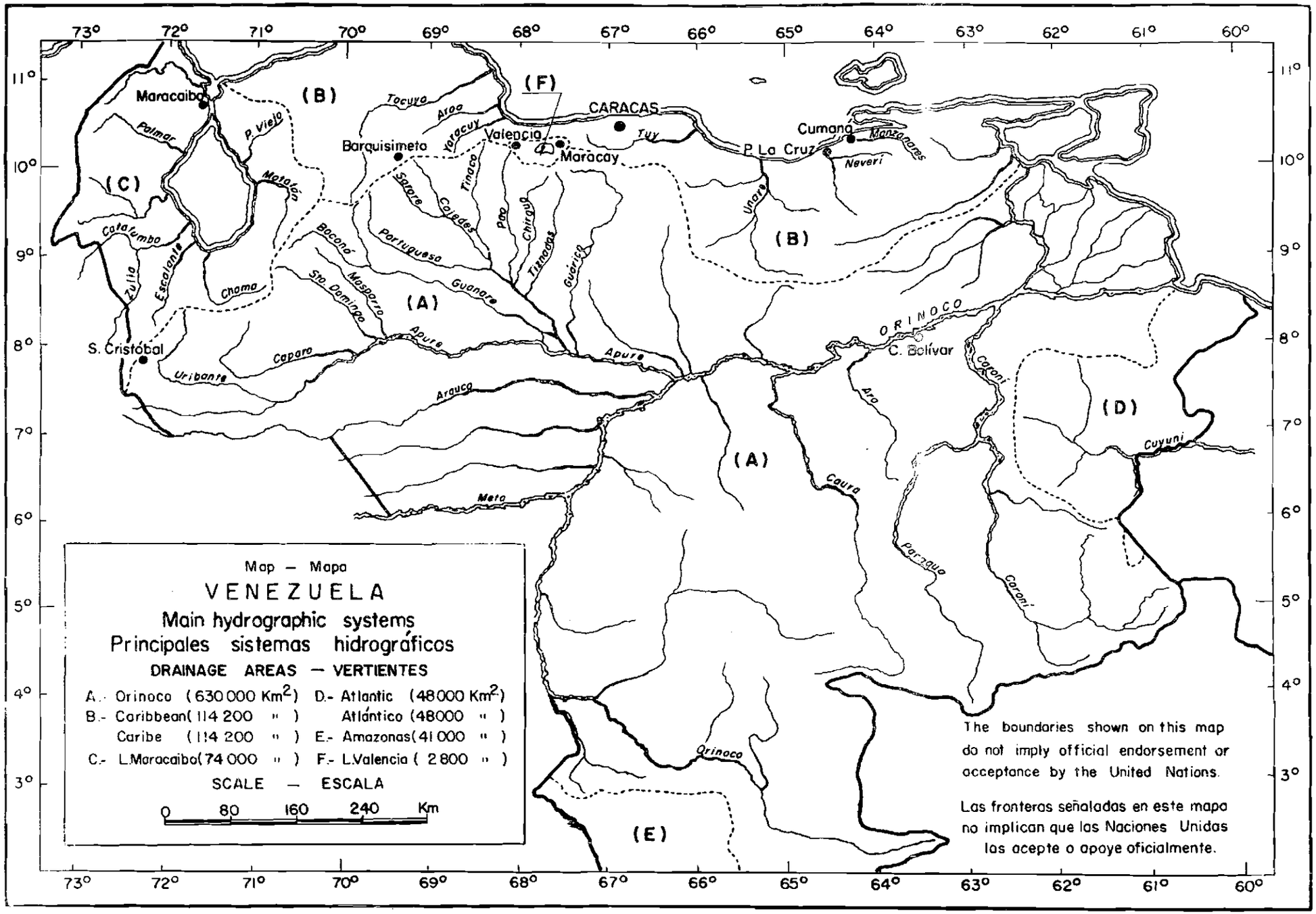
They are in the hands of the following three services: the Hydrology Division of the Department of Hydraulic Projects of the Ministry of Public Works (MOP), the National Institute of Sanitary Works (INOS) and the Venezuelan Development Corporation(CVF). While the stations attached to the Ministry are widely distributed throughout the territory, especially where possibilities of utilizing river flows appear to exist, those of INOS are concentrated around some few centres in the more densely-populated part of the country, and those of the CVF are found only in the Caroní basin.

The resulting average density of 0.3 stations per 1,000 km^2 is, in practice, too low for the river régime to be properly studied, although it is not less than the corresponding figure in the Latin American countries best endowed in this respect or in some comparable Asiatic countries. The average length of series - 6 years - is also low for the purposes of hydraulic projects, which require data for about 15 years at least. This figure is attained only in very few places. The situation as regards density of stations can be improved by increasing their number, but the short series can be compensated only on the basis of correlations with the few long series that do exist or with rain-gauge readings. Since this is not always possible, existing series should be continued with the greatest care so that the project economies which result from thorough knowledge of the river régime may ultimately be obtained.

The rivers of Venezuela can be grouped under three main systems - that of the river Orinoco, thatof the Carribean Sea and that of Lake Maracaibo. There are also the enclosed catchment area of the Lake of Valencia, and the remote and sparsely-populated basins whose waters flow into the Amazon and the Atlantic.

Along the western shore of Lake Maracaibo are the outlets of the Rivers Limón or Guasare, Palmar and Apón (with its tributary the Cogollo), which flow through the flat region that is characterized by

/a tropical


Map — Mapa
VENEZUELA
Main hydrographic systems
Principales sistemas hidrográficos
DRAINAGE AREAS — VERTIENTES
A.- Orinoco (630 000 Km2)
B.- Caribbean (114 200 ")
Caribe (114 200 ")
C.- L.Maracaibo (74 000 ")
D.- Atlantic (48 000 Km2)
Atlántico (48 000 ")
E.- Amazonas (41 000 ")
F.- L.Valencia (2 800 ")
SCALE — ESCALA
0 80 160 240 Km
The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.
Las fronteras señaladas en este mapa no implican que las Naciones Unidas las acepte o apoye oficialmente.
Maracaibo
Palmar
P. Viejo
Motatán
Catatumbo
Tulio
Escalante
Chama
S. Cristóbal
Uribante
Caparo
Tocuyo
Aroa
Yaracuy
Barquisimeto
Valencia
Maracay
CARACAS
Tuy
Cumaná
Manzanares
P. La Cruz
Neverí
Unare
Sarare
Tinaco
Cojedes
Portuguesa
Bocono
Sto. Domingo
Masparro
Guanare
Pao
Chirgua
Tiznados
Guárico
Apure
Arauca
Meta
Orinoco
C. Bolívar
Caroni
Cuyuni
Aro
Caura
Paragua
(A)
(B)
(C)
(D)
(E)
(F)

a tropical steppe climate. The Limón was formerly, and sporadically still is, a navigation route for canoes. On the Palmar, which is used partly for irrigation, the construction of an important drinking-water supply system for the town of Maracaibo is projected.

South of the River Sanàa Ana the climate is more humid, the quantity of surface streams increases and the ground becomes swampy. Outstanding among the rivers which have their outlets in this part of the country are the Catatumbo and its tributary the Zulia, both of which rise in Colombian territory. These rivers too are navigable for canoes, and in the past a relatively significant trade flow from the Santander area (Colombia) used the route they provided.

The River Escalante debouches into the southern part of the lake, as does also the Chama farther to the east. Both cross tracts of country subject to flooding, where large-scale stock farming is carried on. They rise in the Cordillera de Mérida and the Chama flows through mountainous districts during much of its course.

Farther to the north are the mouths of the last rivers rising in the Cordillera de Mérida, including the Motatán, which, after passing through a narrow gorge (Quebrada de Agua Viva), crosses a flat delta region - the so-called Llanos del Cenizo - where the prevailing climate is determined by the transition from the humid and swampy southern zone to the steppes in the north.

North of the Motatán runs the River Pueblo Viejo, whence drinking-water supplies for the Cabimas area are obtained by means of the recently-constructed Burro Viejo dam.

As regards the Caribbean seaboard, the rivers in the States of Falcón and Lara are in general short and of little importance, except for the Tocuyo, which is over 370 kilometres long, and crosses a relatively wide plateau or high valley before debouching in the plains, and the Aroa, which is a good deal shorter, measuring about 110 kilometres, but whose flow is relatively abundant and whose course runs through wooded valleys. Farther to the east is the river Yaracuy, in the depression of the same name, which forms a link with the low-lying districts in the interior and flows through one of Venezuela's most important farming areas.

/The rivers

The rivers rising in the Cordillera del Litoral and flowing northwards are all short and insignificant. Nevertheless, special mention must be made of the Tuy, which rises on the southern slope of the Cordillera del Litoral and runs eastward. In its basin lies Caracas. The flow of the Tuy increases considerably when, in Santa Teresa, it leaves the mountains behind, debouching in a plain whose swampy eastern extreme is known as Barlovento, an area of some agricultural and historical importance.

Among the rivers of the Caribbean seaboard, reference may also be made to the Unare, which crosses an area of the steppe type, the Neverí, and the Manzanares, which has its outlet in the Gulf of Cariaco.

The rivers in the enclosed basin of the Lake of Valencia are small, but flow through one of the most densely populated parts of the country, where the development of agriculture and industry is thriving. Hence their importance.

The course of the left-bank tributaries of the Orinoco lies in a flat region with very gentle gradients, and this, as was pointed out above, causes severe floods in their lower basins. These are not clearly defined, and temporary flows or caños, often make an appearance and link them up. The rivers referred to run through semi-desert or purely stock farming areas where the population density is very low. As will be seen later, some of them are destined to play an exceedingly important part in the development of farming on an irrigation basis.

The Orinoco's right-bank tributaries and the rivers of the Amazon basin are for the most part little-known. Outstanding among them is the Caroní, an affluent of the Orinoco where important hydroelectric projects have been constructed.

Table 1 sums up the hydrological characteristics of the rivers in the four principal basins on which sufficient data are available. Those of the Caribbean seaboard, Lake Maracaibo and the left bank of the Orinoco are extremely irregular, except for some in the south of Lake Maracaibo. They are fed by highly seasonal rains, infiltration in the upper basins is low and surface run-off is fostered by erosion.

/Table 1

Table 1

VENEZUELA: HYDROLOGICAL CHARACTERISTICS OF SELECTED RIVERS

River	Initial year of observations	Mean annual flow (cubic metres)	Flow per second (cubic metres) Maximun	Minimun
I. Lake Maracaibo drainage area				
Motatán (at Agua Viva)	1941	36.3	710	4.19
Palmar	1942	17.9	455	0.04
II. Caribbean sea board				
Tocuyo (at Pte. Torres)	1943	13.1	1 375	0.00
Morere (affluent of the Tocuyo)	1944	7.64	(208)	(0.00)
Bucares (affluent of the Tocuyo)	1941	2.14	900	0.12
Yaracuy a/	1942	9.83	215	1.35
Urama a/	1944	4.48	(720)	(0.14)
Tuy (at Hacienda Barrios)	1941	1.66	(180)	(0.09)
Tuy (at Cúa)	1941	7.67	598	0.45
Tuy (at El Vigía)	1946	23.2	688	1.20
Grande (affluent of the Tuy)	1943	8.11	374	0.00
Neverí	1945	37.1	(448)	(1.30)
Querecual (affluent of the Neverí)	1948	3.16	493	0.10
Manzanares	1941	17.2	410	1.60
III. Lake Valencia drainage area				
Aragua (at La Victoria)	1940	1.07	168	0.00
Turmero (at Turmero)	1942	0.85	220	0.00
IV. River Orinoco drainage area				
Uribante	1949	215	(5 500)	(27.0)
Paguey	1950	46.6	1 450	3.07
Santo Domingo	1952	31.9	1 267	5.35
La Yuca (affluent of the Masparro)	1952	11.0	(810)	(0.01)
Masparro	1951	28.5	3 000	1.64
Boconó	1952	73.9	2 150	9.50
Guache (affluent of the Portuguesa)	1950	14.0	604	0.30
Acarigua	1950	30.8	1 100	0.25
Agua Blanca	1942	6.35	375	0.10
Cojedes	1942	20.4	1 650	1.35
Turbio (affluent of the Cojedes)	1945	3.52	(158)	(0.45)
Tirgua	1941	16.1	886	2.20
Tinaco	1951	7.38	1 000	0.10
Pao	1951	26.8	820	0.07
Guárico b/	1952	25.2	(277)	0.0

Source: Ministry of Public Works. Department of Hydraulic Projects, Resumen de datos hidrométricos 1940-59.

Note: The figures in brackets represent estimates based on data from stations equipped only with staff gauges. The other flows per second correspond to recording stations, and may be considered accurate (with the same margin of error as the discharge curve). Basic data are available up to the year 1958 inclusive.

Measurements for the rivers of the Lake Maracaibo and Orinoco basins are taken near the foot of the mountains, where the streams are crossed by the Pan American, Barinas-San Carlos-El Sombrero and other highways. The rivers of the Caribbean seaboard, with the exception of the Tocuyo, The Yaracuy and the Tuy, are observed close to their debouchment.

a/ On the highway from San Felipe to Morón.

b/ According to the records for 1952-56, the mean annual flow at Calabozo was 55.7 cubic metres.

/For the

For the large-scale agricultural development of the Upper Llanos, this irregularity would necessitate major regulation works, which the topography would render relatively costly, at any rate on the dam sites recognized to date.

The northern part of Lake Maracaibo and the Caribbean seaboard, where most of the population is concentrated, are relatively poorer in water, whence serious shortage problems arise, especially as a result of the severe droughts.

5. Organization for hydrometeorological and hydrological measurements

Mention has been made of the institutions which record precipitation and stream gauging observations and of the extent of these services. Emphasis must be laid on the need to expand and improve them, in respect both of measurement of rainfall and flows and of all the related factors (evaporation, amount of cloud, radiation, agro-meteorological measurements, etc.). Awareness of this need is now evidenced, and many ideas have been put forward in relation to the co-ordination and remodelling of the services concerned. A National Institute of Meteorology and Hydrology (Instituto Nacional de Meteorología e Hidrología) was suggested, but this desirable project has not come to anything as yet. Until it materializes, it would be useful if a Co-ordinating Committee were set up to prepare the ground and carry out the necessary work of co-ordination and dissemination within the framework of more comprehensive programming of the utilization of water resources.

IV

JURIDICAL AND INSTITUTIONAL ASPECTS

1. The juridical system

The Venezuelan juridical system relating to water resources was conceived at a time when resources exceeded demand very considerably, and consequently the system rested on a basic standard of free availability of water for agricultural purposes; agriculture was, in fact, the largest single consumer. With the increased demand and the frequent decline in available water supply as a result of bad management, disputes arose which have been resolved by isolated measures - some local, others national - which frequently overlapped or failed to synchronise. There is thus no organic code or body of law dealing with water resources providing greater security and censuring dispatch in execution.

The ownership of water resources is regulated according to volume: rivers are public property and streams are private property. As it is not always easy to determine where a stream ends and a river begins, disputes may arise over ownership. Underground waters at all events belong to the owner of the land in which they come to the surface.

No special concession is required for the use of publicly owned waters. Respect of preferential rights is sufficient. This is a source of insecurity for users, as they can only take legal action a posteriori when they have suffered injury. Certain legislation authorises the Executive to regulate the use of publicly owned waters, and the new Agrarian Reform Act (Ley de Reforma Agraria) gives rights even over privately owned waters when this is in the interests of reform. There is, however, no general broad standard governing the matter. An adequate solution to the problem of stable rights to water use could be found by establishing compulsory concessions for the use of publicly owned waters and by regulating the use of privately owned waters by virtue of the police power vested in the Executive, thereby giving it adequate means for the regulation of water resources.

At the same time a water resources survey should be carried out as has been laid down in legislation of various kinds, without effect

/having so

having so far been given to it. The Agrarian Reform Act provides for the organization of a National Lands and Waters Survey Office (Oficina Nacional de Catastro de Tierras y Agua). To give the Office permanent and effective status the registration with it of water rights should be a preliminary and compulsory condition for inclusion of such rights in the Public Register of Immovable Property (Registro Público de la Propiedad Inmueble).

One of the important responsibilities of legislators is to establish priorities as between different uses. Under Venezuelan law, first priority is given to the provisioning of populated areas and to navigation. Once supply for these purposes has been assured, the next use in order of preference is for supply to mining and petroleum concerns, and this is understandable given the importance of those activities. After that, consideration is given to other uses, such as agriculture. The granting of water concessions to mining and petroleum concerns is the responsibility of the Ministry of Mines and Fuels (Ministerio de Minas e Hidrocarburos), while the Ministry of Agriculture and Stockbreeding (Ministerio de Agricultura y Cría) is responsible for granting certain other concessions for the public benefit as laid down in the Forests Act (Ley Forestal). There would be good reason to establish general norms for priorities and to entrust a single authority with responsibility for granting concessions.

Such unification of authority and standards also seems necessary for matters connected with the limitation of property rights for water use and conservation; legislation of various kinds is already operative in this connexion and includes the Expropriations, Mines, Fuels, Forests, Agrarian Reform Acts, etc. Such limitations cover for example the prohibition to cut down woods in the head waters of rivers, and the obligation to agree to defence or catchment works by virtue of servitudes allowing for the construction of aqueducts, or the provision of drainage, cattle watering and other facilities.

2. Specific legal standards for different water uses and water conservation

Very various and entirely separate norms regulate the use of water for different purposes and protect the enjoyment of water uses to a

/greater or

greater or lesser extent on the basis of long-standing and importance. Accordingly provision has, for example, been made for ensuring that water supply to populated areas should be given priority and that springs and water sources should be protected; the National Institute of Sanitary Works (INOS), an autonomous body established in 1943, is responsible for this service on behalf of the municipalities to which it gives service under the Constitution.

The Agrarian Reform Act has introduced profound changes in the system of water use for agricultural purposes and has in general improved the body of law pertaining thereto. The Act authorizes the Executive to regulate the rational use of water; this is a great step forward although effective only for the purposes of agrarian reform.

The use of water in mining is, as a result of its economic significance, explicitly and broadly regulated. Other newer or less developed uses such as for industry or power supply are not given sufficient consideration in existing legislation and there are thus large gaps in this respect.

Water conservation, like land conservation and conservation of forests, has been a subject of growing concern from the legal point of view.

Standards have been laid down for the protection of water sources and springs against the felling of protective trees, against fire, contamination, etc., and it is proposed to regulate the use of water sources and springs to avoid waste, even if the water is only to be used for purposes connected with agrarian reform.

The establishment of these conservation standards has not, however, progressed sufficiently, as it has run into serious obstacles of an economic and social kind.

Lastly, it is interesting to note that Venezuelan legislation contains no specific norms regarding international rivers. Attention should be given to this matter in view of the importance that is being assumed by the use of the river basins which Venezuela shares with Colombia.

/3. Institutional

3. Institutional structure

In all countries, at least in Latin America, water which was a free and abundant item, has become scarce so fast that there has been no time for the simultaneous adaptation of the institutional system in order to face new needs, particularly as regards administrative organization for the management of water resources. Venezuela is not an exception to the rule in this respect. The attached organizational chart which gives the names of the various agencies responsible directly or indirectly for the management of water resources, classifies such agencies in relation to the specific water use for which each is responsible. The chart also shows the relationship and hierarchy existing between them.[2/]

It will be noted that in Venezuela central government agencies are predominant despite the federal form of government of the country, and this a reflection of the true nature of the political administration of the country. For each separate water use there are usually a number of agencies responsible to different ministries, or if they are responsible to a single ministry the chain of responsibility usually flows through different departments within that ministry. Accordingly, the multiplicity of agencies complicates administrative procedure and usually leads to the same overall results as were seen in the case of legislation: overlapping in some areas of responsibility and the leaving of a vacuum in others. The cause of this complicated administrative procedure is the same as in the case of legislation: haphazard development to meet needs as they arose, no attempt ever having been made to bring about overall centrally planned revision.

An attempt to deal with the problem of achieving a standard of organization adequate to ensure the improved use of water resources has been tried in one case with concentration of responsibility in a

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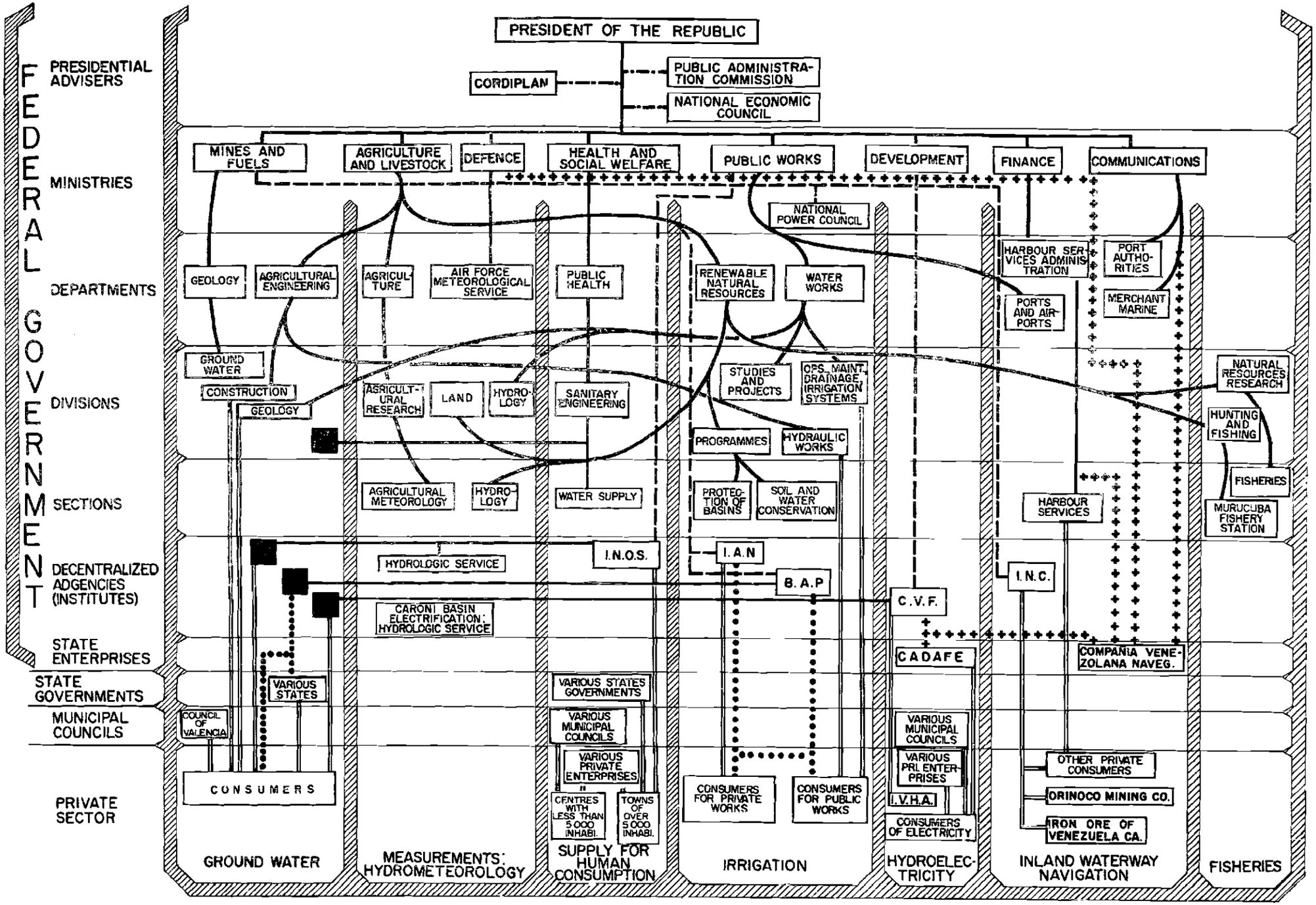
2/ ——— hierarchical dependence; •—•—•—•—•—• advisory functions; — — — semi-autonomy; ++++++ contributions; ..... provision of credit; ═══ provision of services; ▒ carrying out of activities under headings in the corresponding column.

/single ministry.

ADMINISTRATION OF WATER RESOURCES IN VENEZUELA



single ministry. That was, however, in Mexico. In Venezuela, it would hardly seem that the moment has arrived to attempt such a step. On the contrary the first step required would be to separate normative and juridically based functions from development functions for the establishment of works and services or their operation or both.

The first type of function should be the sole responsibility of a single waters authority which would grant water use concessions, authorize servitudes, impose restrictions on the enjoyment of property rights - without prejudice to the normal process of the law for the determination of the amount of compensation or indemnity to be paid in the event of disagreement - and ensure fulfilment of the law, by issuing regulations and maintaining the necessary inspection services.

As this function is closely linked to conservation problems - it in fact depends in the last resort on the terms under which the competent authority may grant or refuse permission for water use - it would seem that the aforementioned authority should be the Division of Renewable Natural Resources of the Ministry of Agriculture. Functions vested by virtue of some legislation, as for instance the Mines and Fuels Acts, in other Ministries, should be transferred to the Ministry of Agriculture making provision in certain cases for such other Ministries to act in an advisory capacity when the use of the water has a bearing upon the attributions of that Ministry, as might be the case with a water concession granted for mining purposes.

The exercise of authority over water resources implies participation in the management of registers and surveys of water resources and in the determining of priorities. This in its turn means that the waters authority must work within the framework of a policy whose formulation is beyond the authority's attributions, that being the responsibility of another body the establishment of which will be discussed at a later stage.

As to promotion functions, it is advisable to concentrate all matters concerned with a particular water use in a single agency. If it proves difficult to attribute responsibility for a specific use to

/a single

a single Ministry, recourse could be had to the expedient of the State institution or concern, whichever seems the more suitable in the circumstances, with the various interested Ministries, however, being represented on the board of management, so as to ensure representation of all sectors concerned. Such a system would have the advantage of placing no strain on the present administrative structure, and would at the same time bring about decentralization which might well give promotion functions greater flexibility and resilience.

As in the case of the waters authority, however, these various agencies - administrative departments institutes or State concerns - would have to bring their activities into line with overall water resources policy. In accordance with this policy and as an essential instrument for the proper management of water resources, encouragement should be given to consumer participation through legally constituted groups. The Venezuelan Civil Code has made provision for such participation and the Agrarian Reform Act gives it further application, although only for the purposes of the Act.

(a) Planning and co-ordination

The formulation of a waters policy is not at present the responsibility of any particular agency and in reality there is no water resources policy. The Central Co-ordination and Planning Office (Oficina Central de Coordinación y Planificación - CORDIPLAN) has since 1958 been made responsible for the preparation and periodic revision of a development plan for the whole economy. In 1960, CORDIPLAN submitted its first four-year plan fixing general objectives in all fields of activity including water resources, although in the latter no specific approach to the problem as a whole was adopted. The importance of the subject would seem to justify the establishment of a planning body for the use and protection of water resources. Such a planning body would logically be CORDIPLAN within which a small permanent nucleus should be established which would give its attention to problems connected with water resources and act as secretariat to some body such as a national waters council. The council would be a consultative body responsible for formulating waters policy, and membership would consist of the highest ranking

/government officials

government officials of all related public and private bodies interested in water utilization. Similar bodies operate successfully in other countries.

For specific problems such as those connected with hydrometeorology and hydrology or for large river basins such as the Tuy basin, special committees would be formed within the council, subject to supervision by it.

(b) Administrative organization of the various water uses

Of the bodies shown in the organizational chart responsible for the provision of water to populated areas, the largest is INOS which has confined its activities to towns of over 5,000 inhabitants. The Ministry of Health and Social Assistance (Ministerio de Sanidad y Asistencia Social) is responsible for other areas through its Division of Sanitary Engineering (División de Ingeniería Sanitaria). INOS has the organization required for working broadly at the national level. It is limited only by its lack of financial resources. If these were increased, INOS could well meet all the needs of the consumers for which it is responsible, and could extend its services even to small towns.

The most important of the agencies dealing with irrigation is the Water Works Division (Dirección of Obras Hidráulicas) of the Ministry of Public Works and the National Agrarian Institute (Instituto Agrario Nacional - IAN). The former builds and operates irrigation works and the second, through its land settlement activities, takes part in the development of irrigated land. Co-ordination between the two could be improved and for this purpose it is proposed to establish an irrigation institute (Instituto del Riego) which would be made responsible for building and operating irrigation works and also for undertaking land settlement. The idea of concentrating all matters pertaining to irrigation within a centralized authority seems to be purposeful, but especial care will have to be taken to ensure co-ordination between land settlement schemes carried out by the proposed institute and those which will continue to be the responsibility of the agrarian reform body which will concentrate its efforts mainly on dry-soil farmland. The Ministry of Agriculture and Stockbreeding also

/takes part

takes part in irrigation works as part of its normal functions. These include: experimental and extension work (Dirección de Agricultura), underground waters and small dams (Dirección de Ingeniería Agrícola) and planning (Dirección de Planificación Agrícola).

The use of water for hydroelectric power has so far not been made the responsibility of any particular agency and concessions for such purposes are granted by municipalities. Electricity policies are the responsibility of the Electricity Management and Development Company (Compañía Anónima de Administración y Fomento Eléctrico - CADAFE) and of the Caroní Electrification Survey Commission (Comisión de Estudios de Electrificación del Caroní), both of which are Government bodies active in the field of electricity generation. The first is financed by the Venezuelan Development Corporation and the second is directly dependent upon that Corporation.

As to navigation, apart from the ports and customs authorities etc., which have been assuming a share of responsibility in the matter since 1952, the National Canals Institute (Instituto Nacional de Canalizaciones) is now in existence; its main responsibility at present is the maintainance and improvement of access to Lake Maracaibo and navigation on the lower Orinoco.

Lastly, it is interesting to note that in December 1960 a round table conference of Government officials connected with underground waters was held. The meeting agreed that a request should be put forward for the establishment of a standing inter-ministerial committee for the study of underground waters. This committee with advisory functions, would co-ordinate its work with the official responsible for overall water resources policies referred to above.

/V

V

USES OF WATER

1. The overall picture

To judge from the available data, it would seem that the uses of water in Venezuela can be broken down approximately as shown in table 2.

Of the 3,550 million cubic metres used annually, 30 per cent is constituted mainly by the salt water utilized for refrigeration purposes in the petroleum refineries and thermoelectric power stations built along the coast in areas where there is a shortage of fresh water, such as the littoral adjacent to Caracas, the Paraguaná Peninsula and Lake Maracaibo. The volume of fresh water used is 2,480 million cubic metres per annum, some 60 per cent of which apparently falls to the share of agriculture. Hence the importance of agricultural problems in the development of water resources. Only a small proportion of this water comes from sub-soil sources, which are drawn upon to a greater extent for other uses, such as public services, which absorb rather more than 35 per cent.

The problems and possibilities arising in connexion with the most important uses of water will be briefly reviewed below.

2. Drinking-water

In 1959, water was laid on to the homes of 51 per cent of the 4.2 million urban inhabitants of Venezuela;[3/] this relatively small proportion falls below the average for Latin America, which is approximately 60 per cent. In the larger cities of Venezuela (those of over 50,000 inhabitants), such services are extended to about 60 per cent of the population, whereas in towns of under 10,000 inhabitants the corresponding figure is not as much as 30 per cent. In the Central and Andean areas it is above the average, and low in the Lake Maracaibo basin and in the Llanos.

3/ This account relates only to towns with over 5,000 inhabitants, to which the action of INOS is confined.

/Table 2

Table 2

VENEZUELA: POSSIBLE BREAKDOWN OF USES OF WATER, 1959

(Millions of cubic metres)

Use of water	Total	Salt water	Fresh water		
			Total	Surface	Underground
Irrigation	1 500	-	1 500	...	...
Public services	300	-	300	200	100
Household, commercial and public	255	-	255	170	85
Industry in general	45	-	45	30	15
Self-sufficient producers	1 750	1 070	680	500	180
Industry in general	30	-	30	-	30
Petroleum refineries	800	570	230	180	50
Extraction of petroleum	300	100	200	100	100
Thermoelectric power stations	480	400	80	80	-
Household uses in rural areas	140	-	140	140	-
Total	3 550	1 070	2 480	...	...

Source: ECLA estimates.

/The quality

The quality of the service in uneven. Only half the population served enjoys a continuous and fully-treated supply. The sanitary aspect is satisfactory, since practically all the networks at least disinfect their water with chlorine. The low proportion of continuous services is due to the inadequacy of the sources drawn upon, a situation which is aggravated in the larger cities, where requirements are relatively greater. Thus, while the average figure for the daily supply available may be about 200 litres per urban inhabitant, that registered in 1959 in towns of over 50,000 inhabitants, where the level of demand is considerably higher, did not exceed 220 litres. Among the bigger cities, Caracas, Maracaibo and Barquisimeto are faced with serious problems, while Maracay, Valencia and San Cristobal are better endowed.

The critical situation in Caracas is perhaps the most significant because of the importance of the capital in national life. In 1959, during the rainy months (September-October), when the sources utilized afford an unrestricted supply, this city received an average of 4 m^3 per second. On the other hand, during the dry season (April-May) when demand should be at least 25 per cent higher, it obtained only 3 m^3 per second. This implies per capita availabilities of only 200 litres daily, just at the time when the city needs double this quantity.

From these round figures some idea can be formed of the serious nature of the water crisis currently affecting the Venezuelan capital. This shortage necessitates rationing during five to six months of the year, and in the season when the situation is at its worst means that the majority of the townspeople are supplied with water for only two or three hours daily, and that intensive and costly activities in connexion with the control and economizing of water have to be maintained. The chief factors responsible for such a state of affairs are the exceptional rate of growth of the city (7.2 per cent annually in 1950-59) and the lack of a satisfactory and integrated programme

/in respect

in respect of this problem, considering all the possible demand alternatives in relation to the supply potential within the broad scope of the Tuy basin, which supplies the area with water.

Programming of this kind has now been embarked upon, apart from the new water storage projects currently under way. The Lagartijo dyke (80 million m^3), which might enter into operation as from 1962, would solve the problem for the time being. For a lasting improvement, a second pipeline from the river Tuy would have to be constructed, as well as additional reservoirs on this river and supplementary reservoirs near the city.

With an eye to the future, and from the standpoint of the country as a whole, the Four-Year Plan advocates that special priority be assigned to developing such services as that of drinking water and raising the proportion of the urban population served from 50 to 75 per cent, which would constitute a substantial advance. The INOS budget (which covers sewage) would then represent 8 per cent of public investment, i.e., almost 3 times as much as in 1954-58, when it accounted for 3 per cent. In order to extend the service to the whole of the urban population this intensive rate of investment would have to be kept up for about 20 years, and at the same time the organization of INOS and its programming and hydrological prospecting services would have to be strengthened, since 90 per cent of the urban population served is dependent upon this body, and by it the main burden of the future work in this field will have to be borne.

3. In industry

The water supply is one of the most important factors in the installation of industries, and, owing to the existing shortage, is among those which are at present causing the most serious difficulties in this connexion. Yet it has not been subjected to a

/systematic evaluation

systematic evaluation on which a conclusive enalyais can be based.

Industries which do not consume large quantities of water, and others on a small or medium scale which are situated in the cities themselves, may absorb about 15 per cent of the public supply. Possibly the industries which are the heaviest consumers may be self-sufficient in respect of an almost equal quantity; they generally obtain their supplies from wells. Cases in point are the sugar refineries, distilleries, breweries and plants manufacturing carbonated beverages, rayon thread and fabrics, paper, cement, etc. Much larger amounts are used by the thermoelectric power stations and petroleum refineries (see table 2). Paper-making is one of the manufacturing activities which have generated the greatest concentrated demand for water, both for the process itself and for the elimination of waste matter. The site chosen for the first big paper mill, installed in 1958, was in the neighbourhood of the industrial centre of Puerto Cabello-Morón, precisely on account of the debouchment of the River Yaracuy, which ensured it a plentiful supply. Of the nine large-scale thermoelectric steam plants in the area where consumption is heaviest, only one - that of La Mariposa, on the banks of the reservoir of the same name - is in a position to use open-circuit fresh water refrigeration. The remainder have to resort to sea water or recirculate their fresh water, both of which procedures raise production costs.

Among the leading industrial centres, Caracas is outstanding in respect of both the volume absorbed and the acuteness of the water shortage. Apart from the solutions to the public system problem which have already been referred to, steps are now being taken to promote the decentralization of industry in satellite towns - Guarenas, Guatire, Charallave, Santa Teresa, Cúa, etc. -, which is indubitably a laudable measure. The public system of Maracaibo is old-fashioned and restricted, but the new project to

/bring water

bring water from the River Palmar, 70 kilometres away, opens up possibilities of ample supplies for a long time to come. The trend towards reducing congestion in Caracas has given new importance to the cities of Maracay and Valencia, which are linked with the capital by good freeways. Maracay's only source of supply is its underground water table, which is sufficient at present but seems unlikely to be so in the future. Valencia is amply provided for, thanks to a neighbouring river and an irrigation reservoir (Guatapano) which makes a contribution in periods of shortage; to meet future requirements it will also be able to draw upon the near-by River Pao. Barquisimeto, third in importance among the cities of Venezuela, and situated in a somewhat arid region, will have to devote careful attention to the programming of its water supply if it plans to develop its industry. The large petroleum centre of Barcelona-Puerto La Cruz also has a few industries, besides big refineries, as a result of which the pressure exerted on the River Neverí is so severe that an integrated study is advisable.

If 20 per cent of the future expansion estimated as recommendable for the public service were allocated to industry - a larger proportion than at present -, the amount of water received by the latter would increase at an annual rate of about 8 per cent, which seems reasonable in view of the share absorbed by the public networks. A parallel development in respect of self-sufficient consumption will be necessary, and this calls for energetic official promotion and guidance.

4. Irrigation

(a) Present situation

As the prevailing climate in the more densely-populated parts of Venezuela is of the tropical savannah type, with a dry season, irrigation is advisable and sometimes essential. Nevertheless, it is not very widespread. At the present time, there may be about 260,000 hectares which enjoy the benefit of some irrigation, in most cases during 2 or 3 months of the year. The area irrigated represents approximately one fifth of that under cultivation (1.4 million hectares). Only in recent years has the Government concerned itself with the question. It is directly responsible

/for not

for not more than 10 per cent of the area currently irrigated, but its investment has been much greater. The big Guárico and El Genizo projects are not yet ready to enter operation. Owing to the considerable importance attached by the authorities to irrigation, today the Department of Hydraulic Projects of the Ministry of Public Works has 27 works projected and 19 at the investigation stage, apart from the 9 already in operation and 1 in course of construction.

A study of the irrigation systems already constructed reveals the existence of a wide margin for improvement, which can be turned to account in the future. In general terms, what is wanting is the sort of careful economico-agricultural programming which, taking into consideration all facets of the question, including the correlative social problems, would have determined the degree of priority and expediency of projects, and by virtue of which the measures required for the uninterrupted development and operation of the projects selected would have been forthcoming. In projecting irrigation systems, great emphasis has been laid on the aspects relating to construction, and not enough on the programming of agricultural activity and on prior research in respect of such matters as suitability of soils, topography, etc. Even in the engineering works themselves, more attention has been paid to their stability than to their efficiency from the hydraulic standpoint. Lastly, irrigation and land settlement have not been adequately co-ordinated in the development of the farms benefited; and within these same farms, water management and works maintenance techniques leave much to be desired. The most important requisite of all is that satisfactory rates of irrigation be experimentally studied and their adoption by farmers subsequently encouraged and supervised, with the help of the operators of the systems and agricultural extension services personnel.

(b) Irrigation requirements and possibilities

It has already been pointed out that in the future the Venezuelan economy will be more than ever in need of developing agricultural productivity in order to level up income distribution and expand the market for industry. Such a policy would help to reduce dependence on petroleum, at a time when the oil market situation is unfavourable. This truth is universally

/recognized, and

recognized, and is postulated in the statement of the agricultural objectives of the Four-Year Plan. The slight increase in productivity per hectare observable in recent years is largely attributable to a switch-over to the higher-yielding types of crops. But the process cannot go on much longer, and a rechannelling of agricultural investment in more productive directions is essential.

While it would be a mistake to overlook the importance of other factors, such as the application of technical "know-how" - reflected in satisfactory crop rotation, efficient sanitary practices and selection of seed -, the influence of climate must be reckoned with, because of the scantiness and irregularity of precipitation. If irrigation enables this strong element of uncertainty to be eliminated, and intensive crops are developed, on the basis of proper rotation systems and more than one harvest yearly, all these advances, in combination with the other technological improvements which have been pointed out as needful, may possibly determine an increase in agricultural productivity as significant as that registered by industry. It is worth noting that the reclamation of swampy ground in humid areas where irrigation is unnecessary may produce the same results as irrigation itself. The areas in which such reclamation could be effected however, except for the south of Lake Maracaibo, are much less extensive or are remote from population centres and means of communication.

An estimate of the product-capital ratio of investment in irrigation tends to support the foregoing assertions.

The gross product-capital ratio in agriculture is in the neighbourhood of 0.2, one of the lowest in Latin America. The agricultural gross product may be about 600 bolívares per hectare in dry-soil farming and 2,000 per irrigated hectare so that to irrigation a product of 1,400 bolívares per hectare should be attributed. If this figure is compared with the average cost of the irrigation system - approximately 2,500 bolívares per hectare - the resulting product-capital ratio is 0.6, which doubles the productivity of capital in relation to that invested in dry-soil farming, and may thus help to raise the current average in the agricultural sector.

/In the

In the programming of irrigation all the factors which come into play must be taken into account. In the first place, information on the soil and water resources available is indispensable. As regards soil, it is worth remarking that, while many studies have been carried out, methods of classification have not been brought into line either with one another or with international standards which enable advantage to be taken of the experience of other countries. Considerable stress has already been laid on the need for hydrological measurements. Studies on the geographical situation of markets, manpower, etc. are also required.

Given this state of affairs, the parts of Venezuela adjacent to the Andean States offer the best prospects for the large-scale development of irrigation. The land at the foot of the mountains has a semi-tropical climate, suitable gradients and, thanks to the water which flows down in abundance from the hills, a rich alluvial soil, as well as a good supply of manpower from the over-populated Andean States. Particularly favourable are the basins of the Portuguesa (to the east of the Cojedes), of the Masparro and the Santo Domingo on the eastern slopes, and of the Motatán on the western side.

Obviously, priority should be given to irrigation on the basis of tapping alone, without storage works. From the rivers of the Western Upper Llanos water could be obtained in this way for some 80,000 hectares, of which 53,000 lie in the basins of the rivers Guanare, Boconó and Santo Domingo. In the Chama basin, too, about 10,000 hectares could be irrigated by this method.

As regards reservoirs in these areas, the most suitable sites - because of the high reservoir volume - embankment volume ratio, among other reasons - would seem to be those on the river Motatán (at Agua Viva) and on the Boconó-Tucupido system, which would also allow hydroelectric energy to be generated.

(c) Investment required

The order of priority followed by the Four-Year Plan is more or less that outlined above. It is proposed to invest about 400 million bolívares in hydraulic works. Of this sum, 264 million would be spent on the installation of new irrigation systems and the expansion of those already in existence, and 50 million on drainage works. Irrigation by tapping is

/projected for

projected for the Rivers Guanare, Boconó, Santo Domingo and others which have been given priority for special reasons, as in the case of the river Palmar, where development will be promoted in order to supply Maracaibo with drinking water.

Investment in existing works includes that required for the irrigation of 50,000 hectares by means of the big Guárico dam, which would absorb 40 per cent of the total amount to be invested. In this connexion it should be noted that in addition to the 10,000 hectares for which irrigation works have already been constructed, it would be easy to equip another 10,000 where the network of irrigation channels is already partly prepared. How these 20,000 hectares would be utilized, however, does not seem altogether clear, since rice is the only intensive crop that could perhaps be successfully grown in these soils and the Four-Year Plan itself contemplates an expansion of only 12,000 hectares for this line of production. On the other 8,000, the process of enriching and improving the soil might be initiated in combination with stock farming. As regards the remaining 30,000 of the 50,000 hectares referred to above, it would be worth while to consider whether the intensive capitalization of this area by the installation of irrigation channels, etc., would not be more advantageous if irrigation were based merely on tapping in the basins of the Portuguesa or the Motatán.

The additional 125,000 hectares under irrigation, together with 31,000 that are being reclaimed by means of drainage in humid areas (mainly to the south of Lake Maracaibo), represent 50 per cent of the increase in the area under cultivation for which the Plan provides.

An estimate for the more distant future (1979) must take into account a certain increase in per capita consumption levels and in productivity per hectare; the fact that the possibilities of irrigation by means of tapping will be exhausted and that it will be necessary to resort to storage; the existence of about 150,000 hectares to the south of Lake Maracaibo that could be reclaimed by drainage; and the need for stock farming to be developed on the basis of irrigated pasturelands. All this leads to the conclusion that approximately 670,000 hectares under irrigation would be required, and investment in the neighbourhood of 170 million bolívares yearly, i.e., a good deal more than the 100 million contemplated in the

/Four-Year Plan.

Four-Year Plan. Hence the need to intensify the relevant programming activities and preliminary studies to ensure that the future development of irrigation follows the right lines.

In order to facilitate financing operations, stress must be laid on the importance of the payment which the farmer is supposed to make for the use of irrigation water, and which hitherto has been actually collected only on a very small scale. The Land Reform Act establishes that consumers will be responsible for the amortization of the works constructed, a principle which marks a striking advance in Venezuelan legislation.

5. Energy

For its energy supply, Venezuela is almost entirely dependent upon hydrocarbons. In 1959 it produced the equivalent of 166.6 million tons of petroleum, of which it exported 137.6 million. Out of the remaining 29 million tons, 16.5 million tons were wasted, in the form of natural gas burnt in the air and not susceptible of utilization or reinjection on the oilfield, and 12.5 million tons, representing 90 per cent of the country's gross demand for energy, were turned to account.

As regards coal, there are only old mines which are being reconditioned, mainly in order to provide fuel for the steel industry. The small contribution made by vegetable fuels will tend to decrease in the future.

The almost insignificant proportion of demand for energy which was covered by hydroelectricity was satisfied by several small plants whose aggregate capacity is not as much as 35 megawatts. The contribution of thermoelectric power stations, on the other hand, totalled 1,132 megawatts. This situation arose partly as a result of the plentifulness of Venezuela's fuel supply during the previous 15 years, when electricity development really began to forge ahead at an annual rate of almost 20 per cent, and partly because of the existing hydroelectric resources were relatively remote from the major consumer centres. Although, therefore, the National Electrification Programme launched by the Venezuelan Development Corporation several years ago had to concentrate on thermal plants in the first place, it did at the same time study the possibility of developing the the country's hydroelectric potential.

/Venezuela is

Venezuela is one of the richest of the Latin American countries as regards hydroelectric resources. As a result of its topography and rainfall régime, these resources are concentrated in the Cordón Andino and on the right bank of the Orinoco. In the former case, they consist in rivers with a moderate flow, highly seasonal and with abrupt stream gradients. According to preliminary studies, their installable capacity is in the neighbourhood of 4 million kW. The resources on the right bank of the Orinoco derive from major flows which, despite their less steep gradients, give rise to substantial concentrations of energy, of which the best-known is on the Lower Caroní, where about 14 million kW would be installed. In this latter basin there are very favourable plant sites whose exploitation was initiated some years ago, and in 1961 the installation of the Macagua I plant, of 300,000 kW, will be completed. An advanced stage has also been reached in the studies preliminary to the construction of a large dam at what would be the first possible upstream site for a reservoir as part of the integrated development of the Lower Caroní. The installations at the foot of this dam, in conjunction with the expansion of the Macagua plant, that the regulation of the stream will render possible, may yield about 4,000 kW. Its construction will be begun as part of the Four-Year Plan, and by 1975 about half the capacity indicated might be installed. This concentration of energy, which is equivalent to four times Venezuela's current installed capacity, and the economic utilization of which - already initiated - could be embarked upon only on the basis of large units, will constitute a source of supply that will obviate the need to exploit many of the smaller-scale resources scattered throughout the mountainous parts of the country.

Obviously, however, in the Andes it would be wise to make use of the best rivers, especially those which hold out prospects for multiple water uses, in order to reap the benefit of the consequent reciprocal economies whether in respect of irrigation or of any other possibility. In the first place, mention may be made of those where hydroelectricity projects could be combined with irrigation, and which, with this latter end in view, will be given priority in the near future. Cases in point are afforded by the River Boconó at Peña Larga, which might yeild about 70 megawatts, and the Motatán at Agua Viva, with 30 megawatts. The operation of these plants

/to supply

to supply urban centres might be very advantageously combined with pumping for irrigation purposes. Attention has also been called to potentials of about 15 megawatts on the river Mucujún (State of Mérida), 60 megawatts on the Capazón (State of Táchira) and 140 megawatts on the Santo Domingo, near Barinas. The river Uribante, too, would seem to offer interesting hydroelectric possibilities. The greatest obstacle to the development of these rivers lies in the lack of adequate hydrological statistics. For this reason, estimates both of the potential itself and of the extent to which it can really be exploited have been vague up to now, and will need to be carefully appraised in the light of additional studies and topographical surveys.

In the course of time, the importance of hydroelectricity will gradually increase, as the development of the Lower Caroní progresses. Thus, for example, it was pointed out above that the plant at the large dam on which work is to begin shortly, together with the units that are under construction and may be added at the Macagua site, might give an aggregate yield of a little over 2 million kW by 1975. If this possibility were to materialize it would probably represent at least 50 per cent of Venezuela's total capacity, and would account for a still greater proportion of the kWh produced.

The development of electricity in Venezuela will have to allow for some of the country's special features. Thus, the exploitation of huge potentials such as those of the Caroní, which must be based on large units if it is to be an economically sound proposition, should be accompanied by careful and energetic measures to promote demand, in order to prevent dephasing which would keep investment idle, with the consequent economic losses. Much of the consumption forecast will also be on a vast scale, linked to the exploitation of mineral resources in the Guiana Shield, and time-lags may seriously affect development programmes.

The abundance of natural gas and the large amounts at present wasted in the air make it essential that this product - or at least the part of it that is thus wasted - should be turned to account. As the generation of electricity may perhaps absorb a major share, it will compete with hydraulic energy. Consequently, careful study must be devoted to the economic merits

/of stopping

of stopping the waste of gas and even using larger quantities of this consumable resource, as compared with the desirability of developing water resources, a durable form of capital which is of the greatest importance and whose repercussions on national life are manifold.

Lastly, it should be stressed that before the systems serving the consumer centres in the central area of Venezuela can be interconnected with the generating resources of the Caroní and the Andes - which will be the basis of the long-term development of Venezuela's electricity supply - the problem of the different frequencies prevalent in the country (50 and 60 cycles per second) must be solved. To this end, public and private enterprise should join forces, especially the companies serving the capital.

VI

THE CONSERVATION OF WATER AND PROTECTION AGAINST ITS HARMFUL EFFECTS

Water has become a commodity in short supply in many parts of Venezuela, especially in the more densely-populated regions in the northern belt and in certain areas high up in the Andes. Hence the need for a serious attempt to tackle the problem of water conservation, either by protecting the upper basins against denudation (through grazing, fires, abandonment, etc.) - which, by destroying the surface vegetation, impedes the detention and infiltration of the winter rains and burdens the streams with the products of erosion -; or by storage of rainwater (in big artificial reservoirs, or small ones of a seasonal type, or at the level of the underground water table); or, lastly, by recourse to measures of a semi-experimental nature which may give satisfactory results, such as the so-called artificial rain, protection against reservoir evaporation, etc. Steps must also be taken to protect streams and bodies of water against contamination by sewage water or other effluents of human or industrial origin.

The application of a wise combination of all these measures in the various basins, according to the requirements of the particular case concerned, would be a supremely important undertaking. As the task is herculean, and the financial resources which can be allocated to it certainly inadequate, priorities must be established, first and foremost on the basis of development possibilities and water requirements in those parts of the basins which are populated and exploited. It would be best to begin by experimenting - as is being done in many countries - in small tracts of land or typical tributary basins, with the two-fold aim of trying out methods and spreading knowledge of them so that they can be more widely applied. Without detriment to this research work, which must be extended to all the important basins, for a more general study preference should be given to those basins where major irrigation works are projected or under construction. Cases in point are the Majaguas dam, in the catchment area of the Rivers Cojeres and Sarare, and the basins of the Motatán and Boconó.

/It would

It would also be worth while to study the hydroelectric possibilities of the Santo Domingo and the Uribante, with a view to the adoption of preliminary measures.

Among the protective measures suggested, it is important to stress those relating to supervision of the quality of the water. Contamination by sewage is causing health problems in the neighbourhood of many of the large cities. When, in addition, a water shortage supervenes, a serious economic problem is created by the rendering of large bodies of water unfit for human and agricultural use. This applies to the Guaire, which receives waste from Caracas and is contaminating the river Tuy at points which might constitute sources for a future reinforcement of the capital's water supply. In this instance, as in several others, INOS, which is responsible for the sewage systems of Venezuela's urban centres, is projecting plants for the treatment of sewage water.

The sewage system serves approximately the same proportion of the population as the drinking water supply, i.e., a little over 50 per cent of the urban inhabitants of Venezuela. The cost of the requisite investment in these systems, per inhabitant served, represents about 60 per cent of that of the aqueduct. Funds for its future improvement should be set up in this proportion.

Among the harmful effects of water, the most serious in Venezuela is constituted by the floods that occur in Barlovento, to the south of Lake Maracaibo and in almost all the river beds of the Llanos.

The first of these areas is the most highly developed, although the smallest. Under the Four-Year Plan, it has been assigned investment amounting to 14 million bolívares (4.2 million dollars) for embankments and drainage channels.

To the south east of Lake Maracaibo there are huge swampy areas where flood control combined with drainage works would permit the reclamation of about 200,000 hectares of first-class land. At the present time this area is used for large-scale stock farming. Its reclamation for which preliminary studies exist, would be a project of far-reaching scope, which should be given a priority comparable with that of irrigation in the Upper

/Llanos. Until

Llanos. Until more precise evaluation is feasible, the execution of part of the works - the right embankment of the Zulia-Catatumbo, for which the Four-Year Plan allocates 3.5 million bolívares (1 million dollars) - seems a wise move.

In the Upper Llanos, the areas subject to flooding are under-populated and, technically speaking, little-known. For the purposes of the relevant irrigation projects, it would be useful to obtain more pluviometric, topographical, edaphological and other data in relation to these areas.

VII

MULTIPLE USES OF WATER

Closely linked with the conservation of springs and watercourses is the promotion of their rational use. Alongside the introduction of practices designed to save water in its various applications, attention must be devoted to the possibility of combining these uses in order to derive the greatest benefit from water resources. In other words, policy should be focused on the multiple uses of water.

There are some instances in which water is not recoverable, as in the case of its agricultural uses and certain industrial applications. Approximately half the water consumed in Venezuela may be of this type (see again table 2). In others, again, the water used is not greatly affected or can be recovered by means of economic recuperation processes. When water is in short supply, demand for non-recoverable uses may give rise to serious conflicts. When, on the other hand, its uses are compatible, their development may be highly advantageous, inasmuch as they contribute to the more efficient financing of the works.

A typical instance of co-operation between uses is afforded by irrigation and the generation of hydroelectricity. In Venezuela, except on a small scale in populated areas, water is seldom in demand for both purposes simultaneously. Irrigation in the Motatán basin might be a useful development, since it is near oilfields where the hydroelectricity generated could be put to good use. The Boconó, on the other hand, is a very long way from urban or industrial centres, although consideration might be given to the possibility of mechanical irrigation on the basis of electricity.

The analysis of the multiple uses of water - as, in general, all problems connected with water resources - should be approached, as far as possible, in terms of the drainage area considered as a unit. There are three large basins where the shortage of water makes the study of available supplies and possible uses a matter of the greatest urgency; these are the Tuy basin, Lake Valencia and Lake Maracaibo. The problem arising in connexion with the Tuy basin is that of supplies for Caracas

/and its

and its zone of influence. In about twenty years' time, dependence on the sources at present drawn upon, even after regulation, would result in a deficit of about $5m^3$ per second. There would be two alternative ways of covering this deficit - tappings in the basin of the Tuy, downstream from the confluence of that river with the Guaire, or transfer from the basin of the Upper Guárico. In the first instance, recourse could be had to relatively distant tributaries, such as the Taguaza or the Cuira, which would mean more than doubling the length of the adduction works currently existing - with the consequent increase in costs -, or to pumping from the Tuy itself a short way downstream from the Guaire, that is, below the point at which it receives the sewage water from Caracas. This would be a case of re-utilization after proper treatment and dilution - a practice current in many industrialized countries - which would make a substantial contribution to the supply. Although the problem is complex and delicate, its projections are so far-reaching that it is worth thorough study, together with the alternative of pumping from the Upper Guárico after the requirements of this latter basin had been met, a measure which would signify only a partial contribution.

The Lake Valencia catchment area is of great importance because it too lies in the agricultural and industrial heart of Venezuela. The waterbalance in this basin shows that even after the requirements of the population have been satisfied, there is considerably more land suitable for farming than the area of about 30,000 hectares that can be irrigated with surface water. To exploit this land and provide water supplies for expanded industrial development, the underground water table (which is the basic source of supply for cities like Maracay), or transfer from other basins like that of the Pao, would have to be resorted to in greater measure. The problem should be studied in the light of an integrated analysis which would begin by establishing an order of priorities for the uses of water.