THE IMPACT OF DRAINAGE, IRRIGATION AND FLOOD CONTROL ON AGRICULTURE IN GUYANA*

S.S. Naraine
Technical Specialist,
Ministry of Economic Development, Guyana

Introduction

In Guyana considerable sums of money have been spent over the years on drainage, irrigation and flood control works. It is difficult to assess the economic impact of this expenditure because of the lack of statistical data. Drainage, irrigation and flood control expenditure figure prominently in coastal development. The greatest impact of these works no doubt has been the transformation of coastal swamp into dry land for settlement and arable lands for cultivation.

Some attempts have been made, based on experience and research, to relate drainage and irrigation to various crop requirements, with best results in sugar cane. However, technical difficulties in the design of systems have been magnified by the lack of a coordinated approach to drainage, irrigation and agriculture, resulting in low productivity in many areas.

It is felt that this paper can serve its purpose by describing what has been done so far in drainage and irrigation as a contribution towards agricultural development. In doing this, it might be useful to examine a few of the more recent projects, and to make suggestions for the future planning of drainage, irrigation and flood control projects with the objective of making a greater impact on agricultural development.

Description of the Coastal Plain

General Description and Topography

The coastal plain of Guyana is about 260 miles long and varies in width from 2 to 20 miles. It is divided into 5 distinct parts by major rivers flowing into the Atlantic Ocean. Between these 5 rivers there are smaller ones flowing through the plain. The smaller rivers are the main source of the flooding of the coastland during the rainy season. The average level of the coastal plain is about 50.00 G.D.[1] that is, about mean sea level; mean high tide springs being 54.04 G.D. and mean low tide springs 46.24 G.D. The plain is generally very flat with a slope of only about 1 foot in 10 miles in places (that is, 0.0002); the watersheds between the rivers are only 2 to 3 feet high. The catchment of the upper reaches of the smaller rivers is relatively steep having a slope of about 0.3.

Population

The population of the coastal plain is approximately 652,000 out of a total population of 730,000.[2] Of this number approximately 459,000 people live in the

*This paper is concerned with the subject as it relates to the Coastland. Approximately 90 per cent of the population of Guyana live on the Coastland where an even greater percentage of the country's agricultural activities is carried on.

[1] The units of measure are in feet and expressed in relation to the Georgetown Datum (G.D.).

[2] Figures were calculated from the 1960 Guyana Census for the year 1970.

rural areas and more than half depend directly on agriculture for a livelihood.

Climate and Hydrology

The climate of the coast is pleasant and healthy for the greater part of the year. The mean temperature is 80°F. with extremes of 68°F. and 98°F., but usually temperature will range between 70°F. and 90°F. There are two wet seasons, one occurring from mid-April to mid-August and the other between late November to the end of January. The mean annual rainfall is about 90 inches, but annual rainfall figures of 52.2 inches and 148 inches have been recorded. The daily average sunshine is six to seven hours, and daylight hours range between 11½ to 12½ hours.

Data collection on climate and hydrology has been reasonably satisfactory in some respects, but inadequate for the proper planning and development of land use. Based on population densities and appraisal of the aerial variability of the elements, the present adequacies (in percentage terms) of the data gathering programme with reference to the elements are considered to be approximately those shown in Table 1.[1]

Adequacy of data for any given study is normally a function not only of spatial distribution, but also of length of records available. Based on work done by Langbein[2] and Alvarez and Henry[3] the degrees of accuracy shown in Table 1 were based on recommended recording station densities relative to the population density of the coastlands of Guyana. The result of this analysis shows clearly that it would be risky to use existing data to plan any large scale irrigation schemes utilising stream-flow or ground water. Such development would require further data collection and analysis.

Soils and Land Use

The soils of the Coastal Plan are compact clays, pegasse and riverain silts with sand reefs and levees occurring in places. The pegasse (young pest) soils are usually found in land behind the coastal clays and have not been extensively used for agricultural purposes. The reef sands are usually used for the cultivation of coconuts and food crops. The clays and riverain silts are fertile and here the major agricultural crops, rice and sugar cane, are cultivated. Reconnaissance and semi-detailed soil surveys[4] are available for most of the coastal area.

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1 Potter, K.E.D., 'An Appraisal of the Hydrology and Climate of Guyana', Ministry of Works, Hydraulics and Supply, Guyana, 1970.

2 Langbein, W.B., 'Hydrologic Data Net Works and Methods of Extrapolating or Extending Available Hydrologic Data', Flood Control Series No.15, W.M.O.

3 Alvarez, F. and Henry, W.K., 'Rain Guage Spacing and Reported Rainfall', Bulletin of the Association of Scientific Hydrology, No. XV, Jan.-Mar., 1970.

4 F.A.O., Report on the Soil Survey Project, British Guiana, Vol. I-V, Rome, 1966.

There are about 2 3/4 million acres of cultivable lands on the coastal plain. However, less than 1 million acres are at present under crops and pasture; and of this less than 450,000 acres fall under controlled drainage and irrigation. Possibly another 150,000 acres of land are cultivated without any organised drainage and irrigation facilities, while large areas are utilised as wet pastures. The relatively small area of cultivated land, not under controlled drainage and irrigation, is for the most part owned by relatively large operators. There is a growing dependence on public drainage, irrigation and flood control projects for any large scale agricultural development on the coastal region.

Assuming that the net cultivable area on the coastlands is about 2.1 million acres and that for a reasonably good agricultural economy 3 acres of land are required per head of rural population, then the coastlands when drained and irrigated could give a reasonably good living to a rural population of about 700,000 and also an urban population of over 500,000, if the existing relation does not change. However, to realise this goal major water control projects involving hundreds of millions of dollars would be required.

Water Control Problems

The coastlands in their natural state are swamps. The sources of the water are overflowing rivers and flooding from the sea. It must have been these uninviting conditions which caused the first Dutch settlement of the country in the seventeenth century to take place well inland along the banks of the major rivers. However, by the eighteenth century, soil exhaustion made these lands useless for agriculture and plantation owners started to move onto the more fertile coastal plain, despite the higher cost of land reclamation.

From the earliest days of settlement, the pattern of development followed a system of piece-meal polders as individual proprietors sought to protect their lands from flood waters from the sea as well as from the creeks and rivers which overflowed their banks whenever there was heavy rainfall. These polders extended about 2-4 miles inland and were drained by a system of channels discharging through sluices into the sea or river. Behind the distant empolder dam known as a "backdam" lay large areas of flood waters used as sources of irrigation for the empoldered front lands. This system provided drainage, irrigation and flood control for lands used for agricultural purposes. However, this system limits the utilisation of cultivable land, and the individual efforts were not an adequate solution to the many problems. Thus steps were taken to deal with water control problems in a more rational and methodical manner.

At first there were joint efforts of sugar plantation owners in carrying out larger projects; later various ordinances were enacted and management organisations were set up to plan, develop and operate various drainage, irrigation and flood control systems. Today, these systems are controlled and operated either by Water Commissioners or the Drainage and Irrigation Board, while sea defences are controlled by a Sea Defence Board. The scope of activities and extent of responsibilities of the Water Commissioners have grown very little over the years and they serve areas mainly dominated by sugar estates. On the other hand the services of the Drainage and Irrigation Board and the Sea Defence Board -- paid for out of public expenditure-- have expanded enormously within recent years.

The expenditure on these services has not always been associated with a high degree of planning. Furthermore, technical, administrative, and financial difficulties have also been encountered.[1] As a consequence the potential impact of drainage and irrigation as a catalyst of agricultural development in the coastal region has not been fully realised.

Public Expenditure on Drainage, Irrigation and Sea Defences

Drainage and Irrigation

Many drainage and irrigation projects were not subjected to detailed cost/benefit economic analyses. Land and agriculture were seen as the solution for employment of the excess population in the rural areas. Drainage and irrigation schemes were seen, therefore, more as social necessities; the economic aspects of projects were given second place. Thus no real production goals were set for these projects. The result was poor management arrangements, inadequate agricultural planning, lack of extension service and credit facilities, and little or no coordination of these services with the goal of improving productivity. Over the past few years expenditure on drainage and irrigation has decreased considerably and steps are being taken to review existing projects and plan new ones that are more in keeping with economic considerations (Table 2).

Sea Defences

Expenditure on Sea Defences is shown in Table 3. The present sea defence programme planned for the period 1969-1973 involves an expenditure of over $30 million. However, unlike previous programmes, which involved no economic study, the present programme was authorised after a technical and economic feasibility study was done[2] and it was possible to obtain loans for the works from both the World Bank and the U.K. Government. The impact of this expenditure on agricultural activities is well established since the project showed a benefit/cost ratio of not less than 2 in all areas to be protected.[3]

Some Recent Drainage and Irrigation Projects

Boerasirie Extension Project

This project was done at a cost of approximately $9 million. It is basically an irrigation storage project, but main drainage and irrigation were provided to lands falling within the commanded area where these facilities did not exist before the project was undertaken. The total commanded area was 130,000 acres; the cultivable area was 90,000 acres and 40,000 acres of new lands, not previously provided with facilities, were brought into the project. The project was completed in 1959, and for many years benefit went mainly to the sugar estates comprising about 42,000 acres. The full benefit of the project is not yet realised, for large areas of land still lie idle awaiting land clearing, internal drainage and irrigation works, and cultivation.

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1 Naraine, S.S., 'Planning and Development of Drainage and Irrigation Projects on the Coastal Plain of Guyana', Paper presented to the I.C.I.D. Seventh Congress on Irrigation and Drainage, 1969; as well as Naraine, S.S. and Potter, K.E.D., 'Water Development Situation in Guyana', Paper presented to the Water For Peace Conference, Washington, 1967.

2 Naraine et al, 'Feasibility Study for a Four Year Sea Defence Programme', Ministry of Works and Hydraulics, Guyana, 1968.

3 Ibid.

Black Bush Polder

The Black Bush Polder consists of 31,000 acres and provides drainage and irrigation to 23,645 acres of rice lands and 3,955 acres of new farmsteads. It provides for 4 new settlement areas, housing a total of 1,500 families in what was formerly an uninhabited marsh. "Gathered" type of settlement is used, thus creating longer "agro-distance"; this pattern is considered more favourable because of social, organisational and security considerations. The maximum work activities distance is not more than 3 miles. Fair-weather roads give access to the settlement areas. Each family is allotted in the main 15 acres of rice lands, plus an additional 2½ acres for a farmstead on which the farmer can build a house and do intensive food crop cultivation.

Irrigation distribution and drainage is by gravity. Each plot of land is provided with an intake box for irrigation and an outlet box for drainage. Irrigation is provided on a time-run basis to blocks of land; and the system is designed for a supply of 1,000 cubic feet per acre per day. The design drainage capacity is a uniform coefficient of 1½ inches in 24 hours.

The project[1] which was constructed at a cost of $13 million provides an opportunity to group together sociological, agricultural, economic, administrative and engineering activities. Experience has shown that success of such a project, inhabited by persons drawn from all parts of the country with a minimum of financial and other resources in most cases, depends heavily on coordination of all these efforts directed towards an efficient system of management. Unfortunately, this coordination and the supporting financial, technological and other services needed by the project are not adequately provided. The return from the project, therefore, has been relatively low; and further studies are being undertaken to remedy defects in the project.

Tapakuma Project

The Tapakuma Project[2] was completed in 1963 at a cost of approximately $12 million. It provides irrigation for 27,000 acres of rice lands within a commanded area of 36,500 acres. Prior to the project, irrigation was available for about 8,000 acres only. Since the completion of the project, except for certain areas of high lands and others owned by a few large proprietors, most of the cultivable lands are now productive.

The project area is still deficient in adequate drainage and a study has been authorised to improve this and to extend the project by another 8,000 acres.

Agricultural Production and Growth

It has been pointed out that project investigation in the past has not been very thorough. Also, many projects have not been complete in every respect; and

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1 Scott, P.A. et al, 'The Reclamation and Irrigation of the Black Bush Polder in British Guiana', Paper presented to the Conference of Civil Engineering Problems Overseas, London, I.C.E., 1960.

2 Naraine, S.S. and Fairbain, D.S., Report on the Drainage and Irrigation Department for years 1960 and 1961, British Guiana, Ministry of Works and Hydraulics, 1963.

from time to time as problems are identified works may be implemented to remedy them. Further, even projects which have been planned on a more comprehensive basis were invariably designed with inadequate data. There has been no review of projects, and their operation is not directed as a part of any planned productive process. Additional requirements for agricultural development were either non-existent or slow in coming, and general management and coordination were well below the level needed for efficiency. The true benefits from drainage and irrigation expenditure and facilities are, therefore, rarely realised, except in the possible case of sugar.

Sugar cane is operated on a plantation system, and sugar production and its by-products are planned on a commercial basis. High emphasis is given to management, economics and research, and therefore technological and economical factors go hand in hand. It is not unusual to see land which could not produce rice profitably for a private operator being put under sugar cane with the assistance of the sugar estates and becoming productive with good economic returns.

With proper management, with carefully selected varieties of crops and with good cultural practices, the benefits of drainage and irrigation become more noticeable. An example is seen in the La Bonne Intention sugar area where the improvement of internal drainage alone resulted in an increase of yield of 6 tons of cane per acre, or an approximate increase of 20 per cent. Also, studies carried out by Bookers Sugar Estates show that there can be a reduction of yield by as much as 10 per cent in a drought year when adequate irrigation is not available.[1]

Planning Future Drainage and Irrigation Projects

The entire coastal region between the Pomeroon and Corentyne rivers has been studied either on a preliminary or more detailed basis, and drainage, irrigation and flood control projects[2] have been suggested for the various areas. Based on past experience and in an effort to remove some of the constraints on the effectiveness of water control projects, it has been suggested that all future drainage and irrigation projects should be planned and designed with certain objectives and that they should be production oriented. It would seem that the methodology of drainage and irrigation system design[3] for future use should involve the following related steps:

(a) identifying and evaluating objectives;
(b) translating these objectives into Design Criteria;
(c) using the criteria to devise plans for development of specific water control systems that fulfill the criteria in the highest degree;
(d) evaluating the consequences of the plans that have been developed.

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1 Wilkins, R.A. and Atesbian, K.H., 'Estimating Yield from Relationship Between Sugar Cane Performance and Critical Months Rainfall for Period 1957-1965', Proceedings of the 13th Congress of the International Society of Sugar Technologists, British West Indies Sugar Technologists Association, November 1966.

2 Government of Guyana, The Mahaica-Mahaicony-Abary Water Control Project, 1961; also MacDonald, Sir M. and Partners, Report on the Survey of the Canje Reservoir Scheme, F.A.O., Rome, 1965.

3 Maas, A., *et al*. Design of Water Resource Systems, Macmillan, London, 1967.

It is further suggested that, if any given system is to function optimally, it is necessary to pursue certain basic requirements.[1] These are seen to be:

1. The capability of the system should be identified, that is, the capacity to drain and irrigate in terms of time and volume of water should be determined.

2. Drainage and irrigation should be regulated in order to meet the needs of particular crops.

3. Continuous research into the systems should be conducted in order to determine the requirements for optimum performance.

4. The systems should be required to achieve and sustain certain production targets which would justify the expenditure incurred in the construction and maintenance of the systems involved. This means in effect that the Drainage and Irrigation authorities must share with the Agricultural, Community Development, Economic Development and other public agencies, the responsibility for attaining and sustaining certain production targets in the area.

Unless the above-mentioned measures are taken drainage and irrigation would not necessarily fulfill the desired objectives. These services would continue to improve land conditions and agricultural production, but would tend to operate in isolation and out of context with the needs of their environment; full benefits from this development are not likely to be realised.

However, the suggested new approach to the planning, design and operation of drainage and irrigation systems will not only satisfy the need of greater agricultural productivity, but can be utilised as an effective factor in bringing about social and economic reforms. However, it requires as a basic consideration closer relationships between engineers, agriculturists, economists, community developers and the farming community, whereby they will work together as a team throughout all stages of the proposed development, setting their targets always to the prosperity of the community and the national welfare.

Table 1 Guyana: Percentage Adequacy of Data Gathering Programme of the Coastlands of Guyana

Element	Adequacy (per cent)
Rainfall	90
Streamflow	25
Ground Water	5
Evaporation	40
Temperature	90
Humidity	90
Wind	40
Sunshine	90

Source: Potter, K.E.D., Ibid.

[1] Naraine, S.S. et al, Land Use Study in Guyana, Government of Guyana, 1970.

Table 2 Guyana: Capital and Maintenance Expenditure on Drainage and Irrigation, 1955-1969

Year	Capital	Maintenance of Works	
		Total	Gov't. Subsidy
	(............ $'000 ....)		
1955-1959	23,920.0	n.a.	n.a.
1960	5,079.0	394.0	189.0
1961	5,079.0	480.6	187.3
1962	6,233.0	456.7	298.0
1963	4,759.0	584.2	386.6
1964	2,298.0	959.0	394.4
1965	2,224.0	1,057.9	428.6
1966	204.0	1,017.4	467.3
1967	287.0	1,110.7	467.0
1968	180.0	1,063.0	483.1
1969	475.0	1,149.2	483.1

Table 3 Guyana: Capital and Maintenance Expenditure on Sea Defences, 1959-1969

Year	Capital Expenditure	Maintenance
	(................ $'000 ....)	
1959	1,543.6	416.2
1960	1,817.4	420.2
1961	2,333.3	405.0
1962	1,234.0	341.6
1963	879.1	249.2
1964	1,307.0	308.2
1965	3,182.2	305.2
1966	4,047.4	237.1
1967	2,435.9	234.7
1968	2,883.8	221.3
1969	2,608.6	294.3

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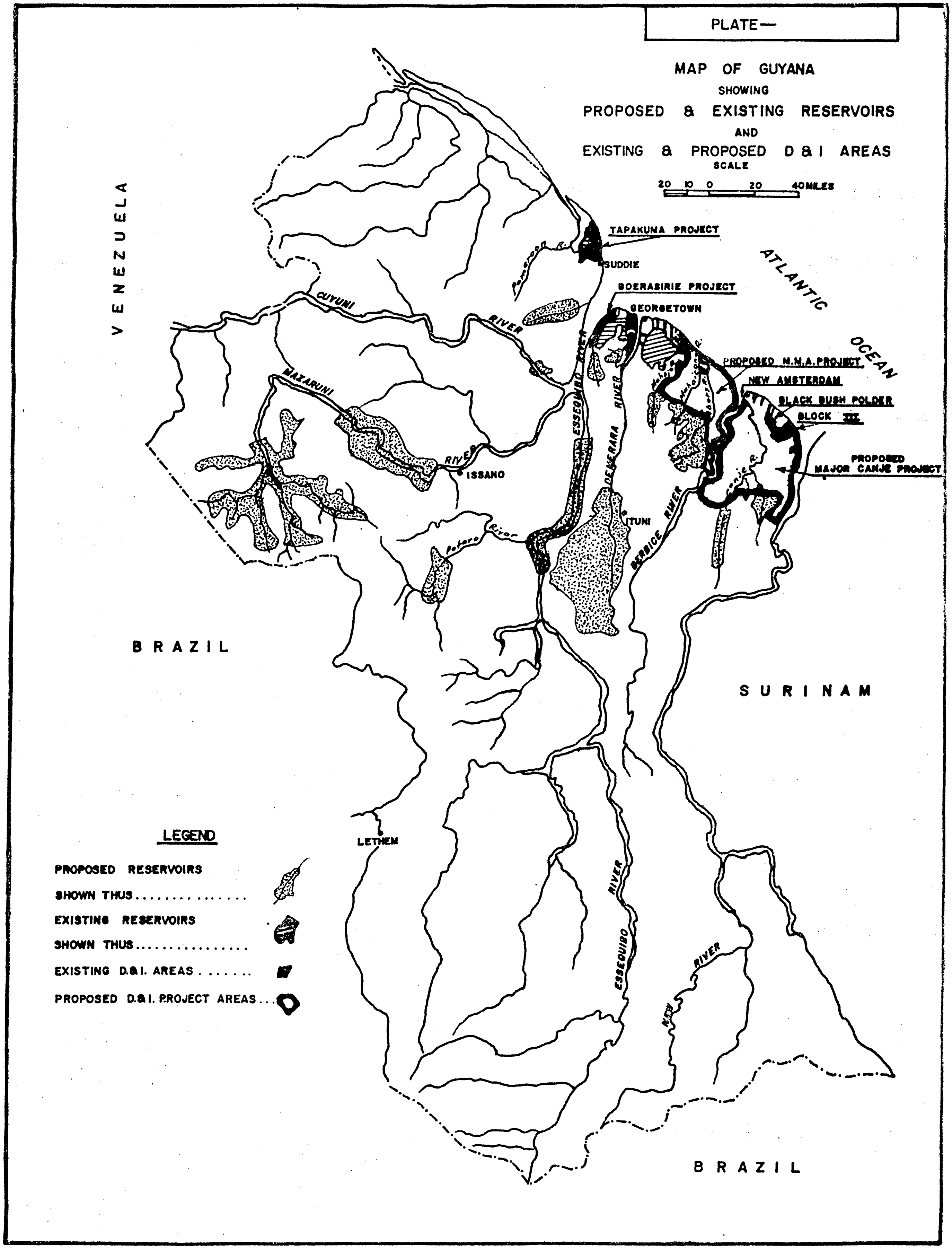
PLATE—
MAP OF GUYANA
SHOWING
PROPOSED & EXISTING RESERVOIRS
AND
EXISTING & PROPOSED D & I AREAS
SCALE
20 10 0 20 40 MILES
VENEZUELA
TAPAKUNA PROJECT
SUDDIE
ATLANTIC OCEAN
BOERASIRIE PROJECT
GEORGETOWN
PROPOSED M.M.A. PROJECT
NEW AMSTERDAM
BLACK BUSH POLDER
BLOCK III
PROPOSED MAJOR CANJE PROJECT
CUYUNI RIVER
MAZARUNI RIVER
ISSANO
ESSEQUIBO RIVER
DEMERARA RIVER
BERBICE RIVER
ITUNI
Potaro River
BRAZIL
SURINAM
LETHEM
NEW RIVER
LEGEND
PROPOSED RESERVOIRS SHOWN THUS
EXISTING RESERVOIRS SHOWN THUS
EXISTING D.&I. AREAS
PROPOSED D.&I. PROJECT AREAS