GOVERNMENT OF JAMAICA

MINISTRY OF AGRICULTURE

THE AGRICULTURAL DEVELOPMENT PROJECT

ON

THE BLACK RIVER LOWER MORASS

FEASIBILITY REPORT

VOLUME I

MAIN REPORT

MAY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

THE AGRICULTURAL DEVELOPMENT PROJECT

ON

THE BLACK RIVER LOWER MORASS

FEASIBILITY STUDY REPORT

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PREFACE

In response to the requiest of the Government of Jamaica, the Japanese Government decided to conduct a feasibility study on the Black River Lower Morass Agricultural Development Project and entrusted the study to the Japan International Cooperation Agency. The J.I.C.A. sent to Jamaica a survey team headed by Mr. Shinichi Yano from February to October, 1984.

The team exchanged views on the project with the officials concerned of the Government of Jamaica and conducted a field survey in the project area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Jamaica for their close cooperation extended to the team.

May, 1985

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

May, 1985

Mr. Keisuke Arita
President
Japan International
Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit the Final Report of the Feasibility Study on the Agricultural Development Project on The Black River Lower Morass for the consideration of the Government of Jamaica.

The report submitted consists of:

Volume I - Main Report
Volume II - Annex Report
Volume III - Drawings

The Main Report contains an agricultural development plan which includes consideration of conservation of the environment as well as the post-project hydrogeological regime, and recommendations for successful development of the project. The plan and its evaluation indicate high economic and technical viability, and that implementation would provide substantial and sustainable socio-economic benefits not only in the project area but in Jamaica as a whole. The Annex Report contains preliminary analyses and discussions in fifteen sectors to support the development plan presented in the Main Report.

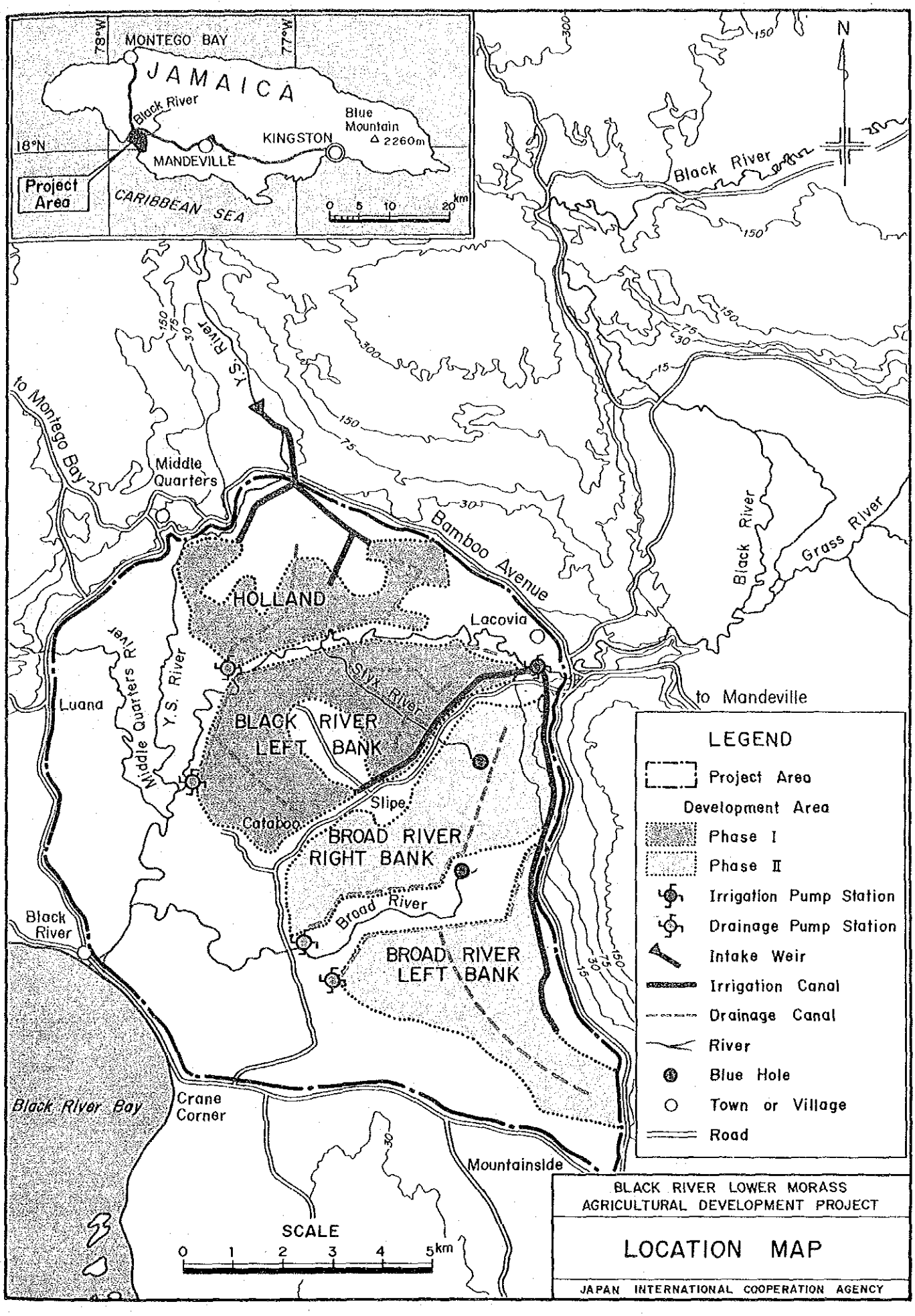
All members of the Study Team wish to express grateful acknowledgement to personnel of your Agency, the Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Agriculture, Forests and Fishery, the Embassy to Jamaica, as well as officials and individuals of Jamaica for the assistance extended to the Study Team.

In conclusion, the Study Team sincerely hope that the results of this study will contribute to the socio-economic development, future agricultural development, and well-being of Jamaica.

Yours sincerely,

S. [signature]

Shinichi Yano
Team Leader


JAMAICA
MONTEGO BAY
78°W
77°W
18°N
Black River
KINGSTON
Blue Mountain
△ 2260m
MANDEVILLE
Project Area
CARIBBEAN SEA
0 5 10 20 km
N
Black River
Y.S. River
to Montego Bay
Middle Quarters
Bamboo Avenue
HOLLAND
Lacovia
Grass River
Luana
Middle Quarters River
Y.S. River
Slyx River
BLACK RIVER LEFT BANK
to Mandeville
Slipe
Catabac
BROAD RIVER RIGHT BANK
Broad River
Black River
BROAD RIVER LEFT BANK
Black River Bay
Crane Corner
Mountainside
SCALE
0 1 2 3 4 5km
LEGEND
Project Area
Development Area
Phase I
Phase II
Irrigation Pump Station
Drainage Pump Station
Intake Weir
Irrigation Canal
Drainage Canal
River
Blue Hole
Town or Village
Road
BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
LOCATION MAP
JAPAN INTERNATIONAL COOPERATION AGENCY

SUMMARY AND RECOMENDATIONS

INTRODUCTION

1. In response to the request of the Government of Jamaica to carry out the feasibility study of the Black River Lower Morass Agricultural Development Project (the Project), the Government of Japan decided to provide technical services for the feasibility study of the project as a part of the technical cooperation programme of the Government of Japan.

2. This Report presents the results of the field survey and feasibility study of the Black River Lower Morass Agricultural Development Project with particular emphasis on rice cultivation through drainage and irrigation development of about 3,080 ha net.

3. The Government of Jamaica has laid great emphasis on the need for a substantial increase in food production, particularly rice production to minimize imports of foodstuff. A feasibility study of the Black River Morass Reclamation Project was carried out with the co-operation of the Netherlands in 1963/64. The first development priority was given to reclamation of the Upper Morass. Subsequently the Black River Upper Morass Feasibility Study was realized in 1976 and the project is now under construction by the Black River Upper Morass Development Company Ltd. (BRUMDEC). It is financed partly by a loan from the Inter-American Development Bank.

4. In accordance with the Scope of Works for the feasibility study agreed upon between the Government of Jamaica and the Government of Japan, Japan International Cooperation Agency (JICA) sent a study team to the site from February to March, 1984. Topographic survey, soil survey and meteo-hydrological investigation were initiated as Phase I of the field survey. Subsequently, JICA sent a Phase II field survey team to the site in June 1984. The team completed the field survey as well as a Pre-feasibility study by October 1984, in collaboration with the counterparts provided by the Government of Jamaica and a Pre-feasibility Report was submitted to the Government of Jamaica. Based on the comments and suggestions made by the Jamaican authorities concerned on the Pre-feasibility Report, a feasibility study was carried out from November 1984 to February 1985.

ECONOMIC AND AGRICULTURAL BACKGROUND

5. The island of Jamaica covers about 10,957 km^2 (4,231 sq. miles) of which the Parish of St. Elizabeth occupies about 1,207 km^2 (466 sq. miles). Total population of Jamaica was about 2.1 million with a density of about 191 persons/km^2 (495 persons/sq.mile) in 1982. The annual growth rate of the population in the 12 years from 1970 to 1982 was 1.1%. The population in the Parish of St. Elizabeth was about 132,000 in 1982, or about 110 persons/km^2 in density.

6. Since 1980, the economy of Jamaica has been slowly emerging from the recession suffered during the 1970s. The modest recovery in output, however, has not been sufficient to alleviate the chronic unemployment problem. The rate of unemployment has remained very high, at a level of 26% in 1983. The GDP rose from J$4,380 million in 1979 to J$6,750 million in 1983 at current prices, corresponding to an annual increase of about 11.4%. However, the average real rate of growth has been -0.2% per annum. The agricultural contribution to GDP was 6.4% in 1983, but the value of agricultural production is still significant, at J$447 million in 1983.

7. Agriculture in Jamaica has always played a significant role in its economy. The agricultural active labour force in Jamaica was about 29% of the national labour force in 1983. The characteristics of Jamaican agriculture are its orientation to export crops, particularly sugar and bananas, and the great disparities in size of land holdings.

8. Rice is one of the main staple foods of Jamaican people. Although Jamaica has a long experience in rice cultivation, rice production in the 1970s averaged only 700 tons per year. Because of the Government intense promotion in increasing domestic production, rice production has been increasing since 1981, and amounted to about 2,000 tons in 1983. This correspond to only about 3.4% out of the total consumption of about 60,000 tons. The balance was imported mainly from USA. In addition, Jamaica imported about 166,000 tons of maize, about 12,000 tons of dairy products and other foodstuff in 1983, which could have been produced domestically.

9. The Government of Jamaica put great emphasis on the rapid growth of agriculture as manifested by the launching of AGRO 21. The new national approach to agriculture combines the implementation of modern technology with proper planning and targeted market to deal with agriculture on a business-like basis. AGRO 21 is giving top priority treatment to (i) reversing the decline in agricultural export, (ii) development of other non-traditional crops, (iii) development of new agricultural opportunities, and (iv) import substitution of foodstuffs.

10. All the agricultural research programmes are controlled by the Research and Development Division, Ministry of Agriculture. Rice experiments on mineral soils were carried out in BRUMDEC for 4 years between 1977 and 1980. Trial cultivation of rice on peat soils is also being carried out by BRUMDEC. Extension services to the farmers are carried out by Agricultural Extension Officers (AEO) under the supervision of the Land Authority. Credits for farmers are provided by the Agricultural Credit Bank (ACB) of Jamaica.

THE PROJECT AREA

11. The Project area is situated in the western part of Jamaica near the southern coast in the Parish of St. Elizabeth. The Project area covers about 11,450 ha (28,600 acres) in gross area of which about 6,800 ha (17,000 acres) consists of marsh land covered primarily with sawgrasses and forest at elevations of less than 1 m above mean sea level. The population in the Project area was about 8,200 in 1982 with a density of 71 persons/km^2.

12. A tropical oceanic climate prevails in the Project area. The mean monthly rainfall indicates bimodal peaks in May and October. About 70% of annual rainfall occurs during a period from May to October. Average annual rainfall at Holland located at the northern end of the Project area is as much as 1,912 mm while it is 1,177 mm at Black River town located at the southwestern end. The mean monthly temperature fluctuates very little ranging from 24.2°C in January to 26.5°C in July. The absolute minimum of 12.7°C was recorded in December. The average relative humidity is about 76% with little seasonal variation. The daily sunshine hours average 7.6 hours/day. The annual pan evaporation amounts to 1,955 mm on average.

13. The Black River has a surface water catchment area of about 830 km^2 at Lacovia. The Y.S. River, a tributary of the Black River, debouches into the Lower Morass at Middle Quarters at which its surface water drainage is about 160 km^2. Average annual flows of both the Black River and the Y.S. River are 19.2 m^3/sec at Lacovia and 4.7 m^3/sec at Middle Quarters bridge respectively. The maximum monthly run-off of 31.1 m^3/sec in the Black River occurs in October and the minimum monthly run-off of 9.9 m^3/sec in March. Similarly the maximum and the minimum monthly run-offs in the Y.S. River are 9.7 m^3/sec in October and 0.9 m^3/sec in March respectively.

14. The limestone aquifer is the main hydrogeological unit extending throughout the entire Lower Morass. The alluvium aquiclude rests directly on the limestone and separates it from the overlying Peat Aquifer. The limestone and peat aquifers are in direct hydraulic continuity only in the eastern section of the Broad River. Groundwater discharged to the depressions is drained mainly by the Broad, Styx and Middle Quarters Rivers. Slightly saline groundwater occupies about one-half of the limestone aquifer, extending up to 10 km inland of the sea. The implementation of the Broad River basin development is likely to result in a maximum increase of 0.3 m^3/sec in groundwater flow into the depression from the present 1.6 - 1.9 m^3/sec. A drainage induced reduction in the water table up to 0.8 m within the limestone aquifer of the Broad River groundwater catchment is likely to produce, at worst, a marginal reduction in the yields of the Burnt Savannah and Holland Wells.

15. Soils in the Project area are derived from the three parent materials, limestone, old alluvium and recent alluvium. Peat layers cover most of the marsh land ranging from 1 m to more than 10 m in thickness. Except for shallow soil areas with limestone outcrops, most of the uplands are suitable for rice and upland crops. In the inundated land, peat soils in the Middle Quarters River basin are very deep and the lower reaches of the Black River are often affected by salt intrusion. These areas are classified as not suitable for either rice or upland crops. Except for the above soils, peat soils are suitable for rice cultivation but are not suitable for upland crops.

16. Noticeable crops in the Project area are sugar cane and pasture at present. Out of about 4,500 ha gross of upland, about 910 ha of sugar cane and about 2,800 ha of pasture are cultivated. In addition about 600 ha of mixed upland crops are cultivated on the elevated land. Most of the 6,800 ha of marsh land is covered with sawgrass and forest. Only trivial rice cultivation is practised in the very limited lowland.

17. Present crop yields in the Project area are rather low except for sugar cane in the Holland Estate. Average yields of crops in 1983 were 56 tons/ha of sugar cane, 1.1 tons/ha of peanuts, 9.0 tons/ha of root crops, 1.1 tons/ha of rice (paddy) and 1.0 tons/ha of maize. The average yield of pasture is approximately 40 tons/ha.

18. Sugar cane is generally reaped once a year. Farming is semi-mechanized. Cattle graze on the predominantly wild grasses which, in recent years, have been substantially improved by application of fertilizer and rotational grazing. In small scale subsistence farming, soil preparation for most of the crops is done by hand hoe. No draft animals are used for cultivation. Very limited amounts of fertilizer and chemicals are applied for upland crops at present. The average cattle grazing intensity in the Project area is about 2.5 heads per ha.

19. The Peoples' Cooperative Banks (PCBs) of Santa Cruz and New Market provide agricultural credits in the Project area. However, it will be necessary for ACB to upgrade the activities of PCB at Black River to serve the Project. Only 5 AEOs provide extension services to a limited number of farmers in the Project area. There are 5 branches of the Jamaica Agricultural Society which seem to be inactive in the Project area.

20. About 260 fishermen practise shrimp fishing particularly in the western part of the Project area. Their annual production is estimated to be about 90 tons, which is estimated to be worth more than J$ 1 million. The existing conditions of shrimp resources in the Project area are considered to be good. The surveys show that the catch volume is balanced with the natural breeding of the shrimp. Agricultural development in the Project area should not affect present shrimp fishing activities if the fishing grounds kept as they are.

21. The Lower Morass has a unique ecosystem, combining important herbaceous swamp and swamp forest plant associations, together with their precious wild-life inhabitants. The density of American crocodiles (alligators) was estimated to be about 0.22 individuals/km along the streams. The swamp forest along the Y.S. and the Black Rivers, the hummocky swamp along the Middle Quarters River and aquatic plant association in the upper reaches of the Broad River include various endemic species and still preserve the natural conditions and uniqueness of the ecosystem. These are known as "a noticeable Caribbean floral element".

THE PROJECT

22. The Project was formulated with its main concepts as:

(1) exploitation of potential arable land, particularly marsh land for producing foodcrops by means of irrigation and drainage,

(2) introduction of diversified cropping pattern particularly of rice and soya bean for annual rotation of crops.

(3) increased and stabilized yield and production of crops introduced, through supply of irrigation water, proper drainage management, and by introduction of improved irrigated agriculture,

(4) successful settlement of farmers through proper training and agricultural support services, and

(5) improving living standards and creating more equitable distribution of income.

23. From the viewpoints of land capability, present land use, physical soil characteristics, peat mining plan area, ecological impact and inland shrimp fishing practices, about 3,800 ha of potential agricultural development area were selected, consisting of 4 irrigation systems. Economic viabilities as well as social and environmental aspects were studied in the Pre-feasibility study in October 1984. As a result, an early development of 2 irrigation systems i.e., Y.S. and Lacovia were recommended since both systems showed the highest economic viabilities as well as a substantial contribution to the national economy. The total area of the above 2 systems which was estimated at about 3,050 ha in the Pre-feasibility study, was revised to 3,080 ha in the present study.

24. The following 3 alternative development plans were made by taking into acount the topography and irrigation water sources.

1) Full scale development plan for 3,080 ha composed of the Holland area (560 ha), Black River Left Bank area (920 ha), Broad River Right Bank area (800 ha) and Left Bank area (800 ha),
2) Medium scale development plan for 2,280 ha excluding the Broad River Left Bank area from the full scale development plan, and
3) Small scale development plan for 1,480 ha excluding the Broad River Right and Left Bank areas from the full scale development plan.

The results of comparative studies showed that the alternative plan 1) would be the more attractive than the other 2 alternatives in terms of net present value, production of paddy and foreign exchange saving as shown below:

Alternative development plan	EIRR (%)	Net present value (10%) 10^3US$	B/C (10%) 10^3US$	Annual production of paddy 10^3ton	Annual foreign exchange saving 10^3US$
(1)	13.4	11,010	1.3	29	3.0
(2)	14.1	9,840	1.4	21	2.3
(3)	15.6	8,660	1.5	14	1.5

25. For future agricultural development, the following 2 cropping patterns are proposed in the Project area taking into account the agro-climatic conditions, present land use, land suitability and marketability as well as the Government's agricultural development programme.

(1) Triple cropping in the mineral soils, viz., double crops of rice and one soya bean crop,
(2) Double crops of rice in the peat soils,

The following table shows the proposed net cultivation area under the proposed cropping pattern:

Unit: ha (acre)

Area	Cultivated Area	Spring Rice	Fall Rice	Soya Bean
Holland (Black River Right Bank)	560	500	560	560
Hatfield	220	220	220	220
Styx River Basin	300	300	300	-
Frenchman-Holiday Pen	400	400	400	-
Broad River Right Bank	800	800	800	-
Broad River Left Bank	800	800	800	-
Total	3,080 (7,800)	3,020 (7,550)	3,080 (7,700)	780 (1,950)

26. Land preparation and harvesting of rice and soya beans, which require considerable manpower in manual operation would be mechanized, while sowing, weeding and fertilizing etc., would be done manually. Small type tractors of the 30HP class with adequate implements are proposed for land preparation because of the low bearing capacity of the soil in paddy fields. A small type of conventional combine with rice specification is recommended. The required number of machinery and equipment are shown below:

Machinery & Equipment	Nos.
Disc harrow 16"x16	69
Land leveller 1.8m width	30
Cultivator 3 row	8
Cage wheel (pair)	58
Power sprayer 10-15 lit/min	122
Dump truck 2 ton	28

Machinery & Equipment	Nos.
Rotary harrow 2.2m width	42
Ridger 2 row	12
Tractor (4DW) 32HP	78
Combine harvester 2.5m width 75HP	45
Manual seeder 1 row	103

27. After implementation of the entire project, the following crop yields and production are expected:

Area / Yield:	Production (10^3 tons) Paddy in mineral 5.5 t/ha	Paddy in peat 4.5 t/ha	Soya beans 2.5 t/ha
Holland (Black River Right Bank)	5.9	-	1.4
Hatfield	2.4	-	0.6
Styx River	-	2.7	-
Frechman-Holiday Pen	-	3.6	-
Broad River Right Bank	-	7.2	-
Broad River Left Bank	-	7.2	-
Total	8.3	20.7	2.0

28. Irrigation requirements for the Project were estimated for the proposed cropping pattern based on the climatic data. Effective rainfall with 5-year return period was taken into account for the calculation. Overall irrigation efficiencies were estimated to be 70% for flood irrigation on the paddy fields and 50% for furrow irrigation on the upland crop fields. The peak diversion irrigation requirements estimated for each area range from 0.96 lit/sec/ha to 1.45 lit/sec/ha. Thus the diversion requirement for the Holland area (Black River right bank) of 560 ha was estimated at 0.45 m^3/sec from the Y.S. River by gravity and 3.42 m^3/sec for the Lacovia system with 2,520 ha from the Black River by pumping respectively. The main and secondary irrigation canals would be lined with concrete. The tertiary canal and farm ditches would be lined with soil cement.

29. The Land reclamation plan of marsh lands was carefully made based on the specific soil (peat) physical conditions, and trafficability of farming machinery after implementation. As a result, the typical field plot was determined to be 50 m by 100 m and rectangular in shape, which would be enlarged to 100m by 200m after the plot was properly settled after a few years.

30. Drainage of the peat layer in the marsh land is essential for agricultural development. Four drainage pump stations are proposed. Farm drains as well as drainage canals would be provided so as to drain rainfall within 3 days from the farm land. The design discharges of drainage canal was estimated range from 4.2 lit/sec/ha to 5.2 lit/sec/ha.

31. The proposed layout of irrigation and drainage facilities in each scheme is illustrated in PLATEs 5, 6 and 7. The following table shows the salient features of the proposed development plan:

		Y.S. System Holland	Lacovia Sytem Black R. Left	Broad R Right	Broad R. Left	Total
Net irrigation area	(ha)	560	920	800	800	3,080
Max. Div. req.	(m^3/sec)	0.45		3.42		3.87
Headworks		1		-		1
Irrigation Pump Ø700	(set)	-		4		4
Drainage Pump Ø 800	(set)	3	5	4	3	15
Main & secondary irri. canal	(km)	14.3	15.4	5.2	13.9	48.8
Main Drain	(km)	8.9	17.1	7.0	8.2	41.2
Main & Secondary Road	(km)	28.4	34.4	26.2	29.6	118.6
Dike	(km)	9.3	8.3	5.7	5.7	29.0

32. Rice mill and storage facilities are essential for such new development projects. The capacity of a mill was estimated on the assumption of a double shift or 16-hour operation a day and 150 working days for one crop season. The principal features of the post-harvest stream is as follows:

Total production of paddy/year		29,000 tons
Moisture content of paddy harvested		24% (max)
Moisture content of paddy stored		14%
Drying facilities		5 sets
Milling facilities	6 tons/hour	1 set
Storage facilities		11,400 tons

33. The organizational structure of the Project will be designed in three components as follows:

(1) a Holding Company,

(2) a Farm Development Company, and

(3) a Farmers' Association.

The actual organization would include:

(1) The Holding Company owned by the government with responsibility for:

- implementing the construction programme,
- developing a Pilot farm,
- procuring farm equipments,
- recruiting, training, selecting and settling farmers,
- operating the irrigation and drainage units, and
- land management including collection of irrigation fees.

(2) The private sector or joint venture Farm Development Company with responsibility for:

- leasing and developing a mother (nucleus) farm,
- providing farm supplies,
- managing and operating equipments,
- servicing farmers after they have been trained, selected and settled,
- purchasing, milling and marketing paddy, and
- producing seed rice for planting.

(3) The Farmers' Association

- organizing regular meetings with farmers,
- providing a cooperative negotiating body with the Farm Development Company, and
- promoting agricultural extension services and credits.

34. The construction time required would be about 6 years including preparatory works and construction works. Development of the project would be made in two phases. The both bank areas of the Black River (Holland area as well as Hatfield, Styx River and Frenchman-Holiday Pen) would be implemented first. The development of the right and left banks of the Broad River in phase two would await further studies on the effects of drainage on the hydrological regime of the area, particularly on the ground water of the Pedro Plains and salt water intrusion. The embankment works for the polder dike and drainage works would be carried out prior to construction of irrigation canals and land reclamation in the Lacovia Pump Up System.

35. The total construction cost was estimated to be about US$43.4 million equivalent, including a physical contingency of about 10% of the direct cost and a price contingency for 6 years. If irrigation water is provided to the Pedro Plain Irrigation Project of about 1,800 ha, an additional cost of about US$1.3 million equivalent would be required. In addition, there would be approximately US$7.9 million of costs incurred for procurement of farm machinery and US$11.7 million equivalent for rice processing facilities.

36. There will be little serious impacts on inland fisheries from the decrease of swamp area resulting from the implementation of the Project , because the Project excludes the western part of the Lower Morass from the development programme. The proposed agro-chemicals are classified into classes A and B under a standard for safe application in Japan under appropriate management to avoid any harm to the shrimp resources. The proposed peat mining area is located mostly in the Middle Quarters River Basin and the lower reaches of the Black River, where most of shrimp fishing is practised at present. However the implementation of the peat mining programme would decisively damage the present shrimp production in the Lower Morass. Even if cage and raft cultures were introduced into the lakes formed after peat mining, these cultures are considered to be uneconomic.

37. The hydrological regimes of the Black River and the Broad River will be affected by the changes in land use within the development area. Agricultural chemicals are proposed for use in accordance with standards for safe application. The Black River Lower Morass possesses necessary attributes of a national park in Jamaica. The following areas are recommended for conservation. (see Plate 4)
    (1) The area of the swamp forest and hummocky swamp along the Middle Quarters River, the Y.S. River and the Black River.
    (2) The area of the Cladium-Sagittaria association, including the aquatic vegetation in the upper reach of the Broad River and the Blue Holes, and
    (3) The area of mangrove forest in the southwestern part of the Lower Morass including the lower part of the Broad River.

38. The development plan of necessary social infrastructures required for the Project was made, which includes houses of settled farmers, schools, a health center, road system, water supply system and a community center. The total cost for their construction was estimated at about US$5.6 million equivalent.

39. The project benefit will primarily accrue from increased crop production. Annual incremental benefits will increase from year by year. The total annual incremental benefits will amount to about US$8.1 million equivalent at the full development stage (3,080 ha).

40. The project evaluations was made in order to ascertain its feasibility from the economic, financial and socio-economic aspects. The economic feasibility of the Project was evaluated in terms of the economic internal rate of return (EIRR). The results show that the Project is economically feasible with an EIRR of 13.3%.

41. In the evaluation of the project viability from the financial view point of the farmers settled in the Project, a farm budget analysis was made. The net reserve of a farmer would be about J$21,310 (US$5,300) on mineral soil and J$25,390 (US$6,300) on peat soil per annum. In the examination of repayment capability, a prospective water charge of J$2,000/ha/annum (US$500) is collectable, which is equivalent to the required operation, maintenance and replacement cost of the irrigation and drainage systems.

42. The financial evaluation of the Farm Development Company was made for recovery of the capital investment cost on farm machinery and workshop. The examination indicates that the direct revenue from the benefit of the mother (nucleus) farm and from hire of farm machinery can cover the necessary annual repayments.

43. The financial evaluation of the Project as a whole was made by examining the repayment capacity for the capital costs of the Project on the basis of the following conditions:

1) The foreign currency portion of the capital cost will be financed through a loan - to be arranged by the Government - at an assuming interest rate of 4.75% per annum for repayment period of 25 years including a grace period of 7 years.
2) The local currency portion of the capital cost will be invested by Government budget allocation with no repayment involved.

The examination indicates that the direct revenue from the Farm Development Company and farmers cannot cover the annual repayment of the loan, except for farm machinery cost, operation and maintenance cost, and replacement cost, consequently the repayment of the loan has to be made by the Government.

44. In addition to the benefits stipulated in the economic evaluation the following indirect benefits and favourable intangible socio-economic benefits are expected from the implementation of the Project.

1) Foreign exchange saving,
2) Increase of employment opportunities for local people,
3) Up-grading of human resources such as experience, technical know-how and skills of farmers,
4) Improvement of social infrastructures,
5) Improvement of living standards of the local people.

RECOMMENDATIONS

45. The development of the Black River Lower Morass for irrigated agriculture in about 3,080ha is technically and economically feasible. Furthermore, the Project would provide substantial and sustainable socio-economic benefits not only to the Project area but in Jamaica as a whole. Thus, it is recommended that the Project be implemented as early as possible.

46. The Project should be implemented through two phases. This is because a more reliable quantitative evaluation of the effects of the drainage on the hydrological regime of the area, particularly on the groundwater of Pedro Plain and salt water intrusion should be made prior to the development of the Broad River basin as phase two.

47. Because of the scientific interest in the Lower Morass, adequate protection and management of the ecology and environment is necessary.

1) Construction period

Some turbidity may be expected in drainage water due to disturbance of soils particularly peat soils. It is desirable that this should not be discharged directly into the stream. Therefore drainage water should be passed through some grass land some distance from the river to trap or settle out suspended matter in the interests of river water quality.

2) Post-construction period

Ecological studies should be encouraged, and carefully undertaken, in the remaining undisturbed natural environment. It is important to conduct a sound baseline survey followed by periodic monitoring to assess the general impact of agricultural devleopment on the ecology. The biological uniqueness for genetic resources in the Lower Morass is remarkably high. Comprehensive legislation will be required to facilitate integrated development of the Black River Lower Morass as well as a standard for Safety Application of Chemicals and National Park Act.

48. The people have to beware of the American Crocodile while engaged in the Project both during the construction period and after. Usual precaution should be taken by the Government in appropriate way.

49. In order to ensure success of the Project, it is recommended that the development of a commercial rice research programme, particularly on the peat lands at BRUMDEC, should be implemented by the Govenment in collaboration with competent experts experienced in rice cultivation.

50. The Project area possesses good natural conditions for shrimp and fish farming and provides suitable sites for aquaculture. It is recommended that a "National Aquaculture Research and Extension Center" be established in the Project area and that the following researches be initiated:

- Shrimp culture in rice fields,
- Shrimp/fish mixed culture,
- Research on the possibility of using rice bran as feed, and
- Research on the ecology of the several shrimp species and their aquaculture.

With careful implementation of the plan, the following socio-economic advantages are expected: shrimp resources in the Project area may be increased by stocking, and catch of shrimp be increased; fishermen will have opportunities to start shrimp culture; employment opportunities will increase; and economic activity in the Project area as well as in Jamaica will be improved.

THE AGRICULTURAL DEVELOPMENT PROJECT

ON

THE BLACK RIVER LOWER MORASS

FEASIBILITY STUDY REPORT

VOLUME I

MAIN REPORT

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GLOSSARIES

ACB	Agricultural Credit Bank of Jamaica Ltd.
AEO	Agricultural Extension Officer(s)
BRUMDEC	Black River Upper Morass Development Company Ltd.
CARDI	Caribbean Agricultural Research and Development Institute
CBA	Commodity Board/Associations
FAO	Food and Agriculture Organization
FCG	Farmers Cooperative Groups
GDP	Gross Domestic Product
IBRD	International Bank for Reconstruction and Development
IDB	Inter-American Development Bank
IUCN	International Union for Conservation of Nature and Natural Resources
JAMAL	Jamaica Movement for the Advancement of Literacy
JAS	Jamaica Agricultural Society
JICA	Japan International Cooperation Agency
JLA	Jamaica Livestock Associations Ltd.
JPS	Jamaica Public Service
MAFF	Ministry of Agriculture, Forestry and Fisheries (Japan)
MOA	Ministry of Agriculture (Jamaica)
NRCD	Natural Resources Conservation Department
NWC	National Water Commission
O&M	Operation and Maintenance
PCB	Peoples' Cooperative Bank (PC Bank)
PCJ	Petroleum Corporation of Jamaica
PIJ	Planning Institute of Jamaica (National Planning Agency)
RPPU	Rural Physical Planning Unit, MOA
SIRI	Sugar Industry Research Institute
TGI	Traverse Group Inc. (Jamaica)
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture

ABBREVIATIONS

mm	=	millimeter	in	=	inch
cm	=	centimeter	ft	=	feet
m	=	meter	yd	=	yard
km	=	kilometer	mil	=	mile
cm^2	=	square centimeter	sq. in	=	square inch
m^2	=	square meter	sq. mile	=	square mile
km^2	=	square kilometer	ac, acs. ac,	=	acres
ha	=	hectare	cu in	=	cubic inch
cc	=	cubic centimeter	cu ft	=	cubic feet
m^3	=	cubic meter	I.gal, Gal	=	imperial gallon
lit	=	liter	US gal	=	US gallon
kl	=	kiloliter	lb	=	pound = 0.45kg
kg	=	kilogram	lb/ac.	=	pound per acre
t, ton	=	metric ton = 1,000kg	cusec	=	cubic feet per second
sec	=	second	HP	=	Horse Power
min	=	minute	kw	=	kilowatt
hr	=	hour	MW	=	Megawatt
d	=	day	PS	=	0.9864 HP = 0.7355 kw
yr	=	year	J$	=	Jamaican dollar
%	=	per cent	US$	=	U.S. dollar
^oC	=	Degree Centigrade	¥	=	Japanese yen
^oF	=	Degree Fahrenheit			

1. INTRODUCTION

1.1 Authority

This Report is prepared by Japan International Cooperation Agency (JICA) in accordance with the "Revised Plan of Operation for Feasibility Study on the Black River Lower Morass Agricultural Development Project" (hereinafter referred to as "the Project") in Jamaica, as was agreed upon between the Government of Jamaica and the Government of Japan.

The report presents the results of field surveys and a feasibility study of the Project, and contains the findings on the present conditions in and around the Project area, the development concept and plan, proposed major project features, project benefits and costs and economic justification of the Project, as undertaken by the study team of JICA and their counterparts provided by the Government of Jamaica.

1.2 Project History

The economy of Jamaica was affected by a severe disturbances during the 1970s. After 1973, per capita GDP declined every year mainly as a result of external shocks, increases in energy costs, the impact of the recession in the industrial countries on sugar and aluminum and the increase of interest rates in international capital markets. Since 1980, the economy has been slowly recovering, so that the real GDP rose by 3.3% in 1981 and by 0.2% in 1982. The leading sectors have been construction, manufacturing, distribution and various private services, while two major reductive sectors, mining and agriculture, have suffered setbacks. Agricultural production particularly of sugar cane and bananas in 1979 and 1980 declined substantially due mainly to adverse weather, unsatisfactory cultivation practices, low returns and low farmgate prices, and to shortage of agricultural machinery as well as to insufficient agricultural credits. Agriculture in Jamaica has always played an important role in the national economy, though its contribution to GDP is now relatively small, 6.4% in 1983, but the value of agricultural production is still significant, J$447 million in 1983. Imports of agricultural products, particularly, food stuffs have been increasing significantly as a result of the increase in population as well as the rising living standards of the people. In particular, rice, soya beans, maize and dairy products were major staple import items.

Imports of rice have increased substantially in recent years, from about 28,000 tons in 1979 to about 57,000 tons in 1983, while rice production in 1983 was estimated to be about 2,000 tons according to the Data Bank, Ministry of Agriculture. In view of this situation the Government of Jamaica has laid great emphasis on agricultural development in its new agricultural policy. In paticular the government has proclaimed AGRO 21 as a new national approach to agriculture.

A feasibility study of the Black River Morass Reclamation Project was carried out in 1963/64 with the cooperation of the Netherlands. At that time the first priority for development was reclamation of the Upper Morass. The Black River Upper Morass Feasibility Study followed in 1976 and the project is now being undertaken by BRUMDEC financed in part by a loan from the Inter-American Development Bank (IDB).

In September 1982, the Government of Jamaica requested the Government of Japan to extend technical assistance for a feasibility study of the Black River Lower Morass Agricultural Development Project. In response to this, JICA sent a study team to Jamaica from end November to mid December to conduct a preliminary survey of the proposed Project area as well as to reach an agreement on the Scope of Works for the feasibility study of the Project (see ATTACHMENT 1). In accordance with the Scope of Works, JICA sent a feasibility study team to the site from 20th February to the end of March 1984, to carry out the field survey with paticulary emphasis on topographic survey, soil survey and meteo-hydrological investigations as a Phase I field survey. Subsequently, JICA prepared topographic maps at a scale of 1 to 5,000 covering about 5,000 ha of the northern part of the Project area and revised existing maps at a scale of 1 to 12,500 for about 11,450 ha in the Project area.

Toward the end of the Phase I field survey, the Government of Jamaica submitted a new request to the Government of Japan to include the study of possible shrimp rearing and fish farming in the Project area. With due consideration to the Jamaican request and taking into account the results of the field survey, the Japanese Government decided to modify their approach to the feasibility study and prepared the "Revised Plan of Operation for the Feasibility Study on the Black River Lower Morass Agricultural Development Project". A preliminary feasibility

study on shrimp rearing and fish farming in the Project area was included in the "Revised Plan", (see ATTACHMENT 3). In June 1984, JICA sent an Advisory Committee Mission and a Phase II field survey team to Jamaica, to discuss the Revised Plan of Operation and to carry out the Phase II field survey. The team completed the field survey as well as pre-feasibility study by the end of October 1984 in collaboration with the counterparts provided by the Government of Jamaica, and subsequently the Pre-feasibility Report was submitted to the Government of Jamaica (see ATTACHMENT 3).

ATTACHMENT - 2 lists the counterpart personnel provided by the Government of Jamaica, the Advisory Committee members and the study team members for the Project in both Phase I and Phase II field survey.

After receiving the comments and suggestions of the Jamaican authorities concerned on the Pre-feasibility report the study team carried out the feasibility study and prepared Draft Feasibility Report in Japan. The Draft Final Report was submitted in February 1985 for the review of the Government of Jamaica.

JICA dispatched a Draft Final Report Explanation Team consisting of members of JICA's supervisory committee and feasibility study team, headed by Mr. S. Takahashi to Jamaica in the end of March 1985. The Draft Final Report was discussed by the Jamaican Authorities concerned and the feasibility study team at the presence of the Supervisory Team. The Final Report was prepared taking into account the comments made by the Government of Jamaica on the Draft Final Report (see ATTACHMENT 3).

1.3 Objectives of the Study

The objectives of the study were (1) to study the overall agricultural development potential of the Black River Lower Morass covering about 11,450 ha, (2) to formulate a prospective agricultural development plan in the most promising areas and to verify the technical and economic feasibility of the plan, and (3) to undertake on the job training and transfer of knowledge to the Jamaican counterparts in the course of the study.

1.4 Activities of the Study Team

The activities of the study team were broadly divided into field survey and feasibility study of the project. The field survey included:

1) topographic surveys for aerial photo mapping and major structure sites proposed,
2) meteorological and hydrological investigations,
3) soils and land use surveys,
4) geological and hydrogeological investigations,
5) irrigation surveys,
6) drainage and land reclamation investigations,
7) physical soil investigations and construction materials surveys,
8) socio- and agro-economic surveys,
9) agricultural investigations,
10) inland fishery surveys, and
11) environmental investigations.

The office works feasibility study included:

1) processing and analysis of the collected data and information,
2) preparation of topographic maps of about 5,000 ha at a scale of 1 to 5,000 and revision of existing maps of about 11,450 ha at a scale of 1 to 12,500.
3) formulation of the agricultural development plan,
4) formulation of the irrigation, drainage and land reclamation plan,
5) preliminary design of project facilities,
6) study on the possibility of shrimp rearing and fish farming,
7) study of environmental impacts,
8) study of project organization and management,
9) estimation of project benefit and costs,
10) study of project implementation schedule, and
11) economic and financial evaluations.

2. ECONOMIC AND AGRICULTURAL BACKGROUND

2.1 Land and Population

The island of Jamaica amounts to about 10,957 km^2 (4,231 sq. mile) located in the south-east of the Caribbean sea between $76^{o}11'$ to $78^{o}22'$ west longitude and $17^{o}42'$ to $18^{o}31'$ north latitude. Jamaica is comparatively well endowed with natural resources and has a relatively well educated and skilled labour force in plentiful supply. About 526,000 ha (1.3 m.acre) including improved pasture were cultivated in 1980, corresponding to about 48% of the entire land area. Out of this about 68,000 ha (12.9%) are cultivated with sugar cane, about 34,000 ha (6.5%) with bananas, about 41,000 ha (7.8%) with coconuts and 101,000 ha (19.2%) with improved pasture. The Parish of St. Elizabeth covers about 1,207 km^2 (466 sq. mile) of which about 7,700 ha (19,200 acres) of crops including about 2,410 ha (about 5,950 acres) of legumes, about 900 ha (2,220 acres) of vegetables and about 770 ha (1,900 acres) of cereal and about 850 ha (2,100 acres) of tubers were cultivated in 1983.

The total population of Jamaica was about 2.1 million, with a density of about 191 persons/km^2 (495 persons/sq. mile) in 1982. The annual growth rate of the population in the 12 years from 1970 to 1982 was 1.05%. This rate, however, has shown a tendency to increase in recent years due to a slow down in emigration. The population in the Parish of St. Elizabeth was about 132,000 in 1982, about 110 persons/km^2, which is quite a low density compared with the national average.

2.2 National and Regional Economy

The economy of Jamaica was severly affected during the 1970s by various external shocks and the impact of domestic policies. In 1980, the real GDP stood 18% below the 1973 peak. The agricultural sector was one of the few sectors whose output did not decline. However, while agricultural production for the domestic market increased by 3.8% per annum, agricultural production for exports declined at a rate of 4%.

Since 1980, the economy of Jamaica has been slowly emerging from the decline suffered during the 1970s. The modest recovery in output,

however, has not been sufficient to alleviate the problem of chronic unemployment. The rate of unemployment has remained high (26% in 1983) despite the continued expansion in employment. The Gross Domestic Product (GDP) rose from J$4,380 million in 1979 to J$6,750 million in 1983 at current prices, corresponding to an annual increase of about 11.4%. However, the average real rate of growth has been -0.2% per annum. The following table shows GDP and equivalent per capita in Jamaica from 1979 to 1983.

	1979	1980	1981	1982	1983	Ave. Annual Growth Rate(%)
Current Prices ($J\$10^6$)	4,377	4,728	5,297	5,799	6,750	11.4
Per Capita (J$)	2,076	2,218	2,450	2,634	3,010	-
1974 Constant ($J\$10^6$)	1,941	1,828	1,888	1,889	1,923	-0.2
Per Capita (J$)	920	857	873	858	857	-

Source: Economic and Social Survey Jamaica, 1983

Because of the increasing economic diversification of Jamaica, agriculture, forestry and fisheries now contribute relatively less to the GDP than in the past. Table 1 shows the distribution of GDP in recent 5 years (1979-1983) in the economic structure. The agricultural contribution was 6.4% in 1983 compared to 7.1% in 1979, but the value of agricultural production is still significant, J$447 million in 1983.

The value of imports in 1979-1983 increased substantially while the export value in the same period decreased slightly as shown in the following table. The import value increased at an annual rate of about 13% in the same period, while the export value decreased at 1% per annum, and resulted in considerable deficits in the trade balance. Out of the total imports, though imports of mineral fuels, manufactured goods and machinery has shown a substantial increase, imports of foodstuffs particularly rice, dairy products and soya beans has increased remarkably, e.g., imports in 1983 were about 1.62 times as much as that in 1979.

Unit : $J\$10^6$

	1979	1980	1981	1982	1983
Export	1,445	1,718	1,735	1,367	1,392
Import	1,754	2,099	2,623	2,460	2,841
Balance	-309	-381	-888	-1,093	-1,449

Source: External Trade, 1979-1983

2.3 Agriculture

Agriculture in Jamaica has always played a significant role in its economy. The agricultural active labour force in Jamaica was 265,000 or about 29% of the national labour force in 1983. The average farm family size was 5.0 persons and farm size including estates was about 2.9 ha/household in 1978. The characteristics of agriculture in Jamaica are its orientation to export crops, particularly sugar and bananas, and the great disparities in size of land holdings, both being the results of the colonial history of the country. The following table shows the number and acreage of farms classified by major income earning agricultural activity in 1978.

Major Income Earning Agricultural Activity	No. of Farms	(%)	Acreage (ha)	(%)	Average Acreage (ha)
Export crops	56,723	30.8	229,642	42.7	4.0
Domestic Crops	86,803	47.2	107,813	20.1	1.2
Mixed Crops	15,703	8.5	43,092	8.0	2.7
Livestock and Poultry	10,699	5.8	124,396	23.2	11.7
Other (activities)	6,505	3.5	14,624	2.7	2.2
None (no activity/fallow)	7,585	4.1	17,887	3.3	2.4
TOTAL	183,988	100.0	537,454	100.0	2.9

Source: Census of Agriculture, 1978/1979

As shown above, 47.2% of farms (20.1% of total acreage) are farms where the major income source is derived from domestic crops. About 30.8% of farms (42.7% of the acreage) provided export crops as their principal source of income, while 5.8% (23.2% of total acreage) were farms in which livestock and poultry provided the main income.

Rice is one of the main staple foods of Jamaica. Although Jamaica has a long experience in rice cultivation, rice production in the 1970s was only about 700 tons a year, while about 37,000 tons of rice a year was imported during the same period. Because of the intense promotion for domestic rice production by the Government, production has rapidly increased since 1981, and amounted to about 2,000 tons in 1983. Even so this still corresponds to only about 3.4% of the total domestic consumption (about 60,000 tons). The following table shows the total production of rice and imports in Jamaica.

Unit: 10^3 tons

Years	1950's	1960's	1970's	1980	1981	1982	1983
Local Products	5.6	2.6	0.7	0.1	2.1	1.7	2.0
Imported	15.8	25.4	37.3	52.0	42.8	39.1	57.0

Source: AGRO 21 Self Sufficiency Programme

In 1983, in addition to rice, Jamaica imported about 166,000 tons of maize, and about 12,000 tons of dairy products and other food stuffs all of which could have been produced domestically.

2.4 AGRO 21 National Plan

Most of the export crops in Jamaica have seriously declined since 1970. Banana exports fell from 134,000 tons in 1970 to 27,000 tons in 1982, and sugar from 293,000 tons in 1970 to 134,000 tons in 1982. All other export crops have declined similarly with adverse effects on the country's foreign exchange earning capacity. The Government of Jamaica has therefore placed great emphasis on the rapid growth of agriculture through the launching of AGRO 21, which is a new national approach to agriculture that combines the implementation of modern technology with proper planning and targeted market to deal with agriculture on a business-like basis. AGRO 21 is giving top priority treatment to the following major aspects:

i) reversing the decline in agricultural exports,
ii) development of other non-traditional crops,
iii) development of new agricultural opportunities, and
iv) import substitution of foodstuffs.

In order to implement the above programme and to ensure the continued development of their export market, AGRO 21 will allocate to small farmers selected blocks of unutilized or under-utilized land, in the case of publicly-owned land, for the production of specific crops under an organized production plan. In case of private land holdings, AGRO 21 will provide a package programme to help farmers bringing their acreage into full production. Through AGRO 21, the Government intends to develop stronger linkages between the agricultural and industrial sectors through a deliberate process of exploring opportunities for converting agricultural raw materials into processed commodities and industrial goods.

2.5 Land Tenure System

Today most agricultural land in Jamaica is free-hold. Since 1972, the lease-hold system of tenure has, however, increased considerably. A significant feature of Jamaican agriculture is, however, the great diversity in farm holdings between the sizes of the farms. According to the census of agriculture 1978/79, the average farm size in Jamaica is 2.9 ha (7.2 acres). Farms of less than 2 ha (5 acres) however, accounted for about 82% of the total number of farmers but represented only about 16% of the total acreage. Farms of over 200 ha (500 acres) accounted for 0.2% of the total farmers but 44% of the total acreage.

In the practical operation of farm lands the following types of tenure are found:

(a) Family land : land passed down to members of family from ancestors

(b) Paying tenants : tenants on written contract between tenant and landlord

(c) Tenants at will : tenants given rent free permission wherein tenancy will terminate at the will of the landlord

(d) Crop sharing tenants: tenants must give a percentage of the returns usually 33% as consideration to the landlord.

2.6 Agricultural Support Services

2.6.1 Research

All the agricultural research programmes are controlled by the Research and Development Division, MOA. There are 4 research stations in Jamaica as listed below:

1) Bodles: This is the main research station and is situated in the Central Region. It conducts research mainly in dairy cattle, pastures, animal nutrition, small stock and food crops mostly under irrigated conditions.

2) Grove Place: Located in the Central Region and concentrates its activities on rainfed pastures, beef cattle, as well as crops under rainfed conditions.

3) Montpelier: Located in the Western Region with emphasis on crops and dairy cattle breeding.

4) Orange River: This is located in the Northern Region and carries out research on crops like cocoa, bananas, ackee, etc.

Research programmes and budgets drafted by the research station are to be approved by the Standing Ministerial Committee. Some research is also being carried out by the Caribbean Agricultural Research and Development Institute (CARDI) of the University of the West Indies and by some of the Commodity Boards, such as the Sugar Industry Research Institute (SIRI) for sugar cane and the Coconut Industry Board, etc.

Rice growing trials on mineral soils were carried out in BRUMDEC for 4 years from 1977 to 1980. The trial cultivation of rice on peat soils is being carried out by BRUMDEC at present. Their results will provide very useful guide-lines for rice farming in the Project. For successful development of rice farming, however, further scientific research including selection of suitable varieties and application of fertilizers and minor elements needed is strongly recommended, particularly on peat soils.

2.6.2 Extension

Extension services to farmers are provided by Field Assistants and Agricultural Aides under the supervision of Agricultural Extension Officers (AEO). The Production and Extension Division, MOA administers the Regional Office and Land Authorities. Nationally there are 65 Divisional and 448 Area Extension Officers each AEO servicing, on the average 400 - 500 farmers.

The activities of the extension staff are many and varied such as operating subsidy schemes, crop care activities, assistance in farmer training, development and settlements, livestock improvement, the revolving herd scheme, attending and participating in farmers' forums, preparing farm plans, and assisting in aspects of marketing and credit, among others.

Over the years, the service has been restructured many times. The last reorientation of the service occurred in 1980, when the TVM System (Training, Visiting and Monitoring) was introduced. However, this system has not met with the anticipated success, and presently another attempt at a re-organization is being contemplated.

2.6.3 Training

There are 4 regional training centers in Jamaica. Each residential training centre with accommodation is as follows:

a) North Region : Eltham 60 trainees
b) South Region : Twickenham Park 30 trainees
c) Central Region : Brooklyn 48 trainees
d) Western Region : Canaan 36 trainees

When necessary, other venues and facilities are used. Each centre is staffed with a Manager and auxiliary staff.

The Unit, in addition to the executive staff, has 8 trainers: 4 assigned to each of the Regions; 2 to special projects, 1 to planning, monitoring and evaluation, and 1 co-ordinates the Learning Resource Centre. This centre prepares documentation and information. Centres are used primarily for farmers' training. Staff are usually trained at the Administrative Staff College (Ministry of the Public Service) located in Kingston.

2.6.4 Credit

The Agricultural Credit Bank of Jamaica Ltd. (ACB) was established under the Companies Act in 1981 to rationalize all public sector agricultural credits. The objectives of ACB are to assist in the agricultural development of Jamaica by:

- making funds available at a time and place suited to farmers' needs.
- encouraging greater participation by commercial banks in the agricultural sector, and
- strengthening and upgrading the PC Banking system and encouraging greater farmer participation and involvement in its operation.

ACB provides short, medium and long term loans to farmers through commercial banks. Short term loans are provided working-capital support for condiments, pulses, tobacco, tubers and root crops, pasture upgrading, and vegetables. Medium term loans with a maximum 7 years repayment period and long term loans with a maximum 12 year repayment period provide support for projects in sheep and goats, horticulture, sugar cane, bananas and plantains, agro-industry, dairy and farm buildings. There are 40 PC Banks funded by ACB in Jamaica.

2.6.5 Farmers' organization

Farmers' Organizations include:

- The Commodity Board/Associations, (CBA)
- The Jamaica Livestock Associations. Ltd., (JLA)
- The Jamaica Agricultural Society, (JAS) and
- Farmers Cooperative Groups (FCG).

CBAs vary from a simple association of growers to a statutory board or the joint membership of the growers and the Government. Their function is to promote the development and marketing of the individual crop which they represent. JLA is an association of livestock farmers which not only represents the livestock industry but has a very efficient supply division with branches all over Jamaica. JAS is a statutory body of great significance to small farmers. It has some 1,017 branches all over Jamaica with branch membership, both direct and associate of totalling some 90,000 to 100,000 members. It has been the parent organization for most of the Commodity Boards and the co-operatives now in operation. FCG falls under the Ministry of Youth and Community Development. There are 269 Co-op Societies nationally, most of them in agriculture. The two major functions are to promote agricultural credits and marketing.

2.7 Social Infrastructures

In general, the formal education system in Jamaica consists of pre-primary, primary, all-age, secondary, tertiary and higher education. The period of pre-primary, primary and all-age education is 2 years, 6 years and 10 years respectively. The education at secondary level consists of new secondary, secondary high, comprehensive high, technical

high, agriculture high and vocational schools. The period of secondary education is 6 years. The tertiary and higher education consist of university and colleges. On the other hand, in spite of JAMAL (Jamaica Movement for the Advancement of Literacy) about 40% of the adult population of Jamaica is considered to be functionally illiterate.

The health service in Jamaica is rather adequate there are 28 hospitals (23 Public and 5 Private) which are administered by 9 Regional Hospital Boards. The primary health services are divided into 47 health districts which are served by 132 health centres and dispensaries, 10 rural national centres, 232 other government maternity homes and child health clinics, and 69 public dental health clinics.

The Post Office was established in 1671, and provides the postal and telegraph services of Jamaica. The services are managed by the Post Master General through 11 regions and 12 regional inspectors. In Jamaica, telephone service is provided by the Jamaica Telephone Co., Ltd., which operates under a licence granted by the Government. The telephone company operates through the main office in Kingston and 8 regional offices.

Formerly, the Kingston and St. Andrew Water Commission, the National Water Authority and the one Local Government Authorities (Parish Councils) were responsible for providing and distributing water for domestic use. The functions of investigation, designing, constructing and distributing domestic water supply for the country has now been made the responsibility of the National Water Commission since October 1981. The take-over is proceeding on a phased basis. For example, the total domestic water supply of some parishes has already been taken over by the NWC.

In Jamaica, the Jamaica Public Service Co., Ltd., under the franchise granted by the Government is the sole public supplier of electricity. In addition, electricity is also generated for private use by some industrial concerns: the bauxite and alumina companies, the sugar estates, etc. There are 9 power stations linked together in a national grid: 2 are thermal stations, oil fired; 5 hydroelectric generating and 2 diesel generating. The national demand is for approximately 240 MW and the total capacity is 385 MW.

3. THE PROJECT AREA

3.1 Location

The Black River Lower Morass is situated in the western part of Jamaica near the southern coast in the Parish of St. Elizabeth. The Project area is bounded by the Santa Cruz - Black River Highway to the north and west, by the Lacovia - Mountainside road to the east, and by the Mountainside - Black River road to the south. Black River, the capital of this Parish, lies in the southwest corner of the Project area, about 160 km (100 miles) west of Kingston.

The Black River, the second longest river in Jamaica with a total length of about 84 km (52 miles), originates in the central range of mountains in the Parish of Trelawny, where the river is called Hector's River. It runs westerly for about 14 km (9 miles) to end in several sink holes in the limestone formation of the Cockpit Country. Then the river re-appears near Oxford in the Parish of Manchester. Near Balaclava the river sinks again to pass underneath a ridge of the north of Bogue Hill and re-appears at Mexico in the Parish of St. Elizabeth. The river flows again westerly through the Nassau Valley and turns sharply to the south-east of Maggotty, and then it enters a flat area of the Upper Morass where the Black River is joined by several tributaries such as the Grass and New Rivers. Near Lacovia the river passes through a narrow and twisting gorge, before finally entering the Lower Morass. The Black River meanders westwards about 8 km (5 miles), turns to the south, and then debouches into the sea at Black River. In the Lower Morass, the Black River joins its main tributary, the Y.S. River, about 6 km (4 miles) upstream from its mouth and the Broad River near its mouth. The catchment area of the Black River at its mouth is about 1,200 km^2 (463 sq. mile).

3.2 Human Resources

St. Elizabeth Parish occupies about 1,207 km^2 (466 sq. mile) of land corresponding to about 11.0% of the entire territory of Jamaica. The following table shows the population in St. Elizabeth and the Project area as well as of the whole of Jamaica in 1970 and 1982.

Region	Area (km^2)	Population		Annual Growth Rate (%)	Population Density per km^2
		1970	1982		
Jamaica	10,957	1,848,500	2,095,878	1.05	191
St. Elizabeth	1,207	125,900	132,353	0.42	110
Project area	115	7,909	8,161	0.26	71

Source : Population Census 1970 and 1982, Department of Statistics

The population density of the Parish, 110 persons per km^2, shows only 57% of that in Jamaica as a whole, the density in the Project area in particular is only 37% which is mainly due to the large extent of swamp in the Project area. The growth rate of the population in the Project area is extremely low as compared with that of Jamaica, which is considered to be due to emigration of population from the rural area to the industrial and commercial centres.

3.3 Natural Resources

3.3.1 Topography

The Project area is surrounded by the Santa Cruz mountains on the east, by the Lacovia mountains to the north and by the Middle Quarters hills to the west, and faces the Black River Bay and the Pedro Plains to the south. The Project area covers approximately 11,450 ha of which about 6,800 ha are marsh land, covered primarily with sawgrass, at less than 1.0 m above mean sea level. The north-east part of the area is composed of old and recent alluvial soils sloping gently from north to south with micro-relief and elevation ranging from 0.3 m to 5 m. About 1,000 ha of the Slipe-Cataboo area, a so-called island, has an elevation ranging from 1 m to 15 m and is located in the centre of the Project area.

The Black River is the main stem by which surface runoff in the Project area is drained to the sea. It is joined by 4 major tributaries in the Project area, i.e. the Y.S., Broad, Middle Quarters and Styx Rivers. The Y.S. River originates outside the Project area and has also abundant water. The other tributaries - Broad, Middle Quarters and Styx Rivers - rise from within the Lower Morass, their flow being sustained mainly by groundwater. The Broad and Styx Rivers have their sources in "Blue-Holes" in the eastern area of the marsh land. The Middle Quarters River rises as a spring at the central edge of the marsh land in the area of Luana.

The marsh land is inundated throughout the year. Every year the above tributaries seasonally overtop their natural banks to flood the swamp area. The water in the swamp takes a long time to drain away because of the flat topography of the area, low water surface elevation and fairly gentle slope of the river bed. The water level on the rivers and the ground surface level are almost same through the year. The slope of the river bed ranges from 1/5,000 to 1/20,000 in the Project area. The river bed elevations of the rivers are about 3 m below mean sea level.

3.3.2 Climate

The Project area is located between $18^{o}00'$ and $18^{o}10'$ in north latitude and between $77^{o}45'$ and $77^{o}55'$ in west longitude. The area lies in the North East Trade Belt and has a tropical oceanic climate. The monthly mean rainfall from 1974 to 1982 at Black River indicates a bimodal peaks in May and October (see Fig. 1). About 70% of annual rainfalls occur during the period from May to October. A large portion of the rain falls in heavy squalls. The dry season usually lasts from November to March with less than 75 mm (3 inch) of monthly rainfall. Five rainfall stations are located within the Project area. The average annual rainfall at Holland located at the northern end of the Project area is as high as 1,912 mm (75.3 inch), while it is only 1,177 mm (46.3 inch) at Black River located at the southwestern end of the Project area.

The annual mean temperature at Crawford Meteorological station, about 6 km northwest of Black River is $25.8^{o}C$ ($78.4^{o}F$). Three months from January to March are cool, with a mean temperature of $24.2^{o}C$ ($75.6^{o}F$), while the period from June through August is warm with a mean temperature of $26.5^{o}C$ ($79.7^{o}F$). An absolute maximum of $35.0^{o}C$ ($95.0^{o}F$) was recorded between June and August and an absolute minimum of $12.7^{o}C$ ($54.9^{o}F$) was recorded in December. The average relative humidity is about 76% with little seasonal variation. The daily sunshine hours average 7.5 hours/day. Class-A pan evaporation varies from 4.3 mm/day to 6.4 mm/day and averages 5.3 mm/day in a year. The annual amount of evaporation is estimated at 1,955 mm/annum (80.0 inch). The daily wind run averages 94 km/day (59 miles/day).

3.3.3 Hydrology

1) Available discharge

Limestone formation and karst topography are predominant in the Black River basin. The varied permeability of this limestone, its fissures and the many subterranean passage dissolved by infiltrated water, preclude the establishment of an exact hydrological picture of the Black River. The general river morphology is described in the previous Section 3.1 (see Fig. 2).

The Black River has a surface water catchment area of about 830 km^2 at Lacovia where the stream gauging station is located. The Y.S. River, one of the largest tributaries of the Black River, debouches into the Lower Morass at the bridge of Bamboo Avenue near Middle Quarters, at which its surface water drainage basin is about 160 km^2. The daily discharges as well as rating curves at the both Lacovia and Middle Quarters were obtained from the Water Resources Division in the Ministry of Mining and Natural Resources, Kingston.

The maximum monthly mean discharge occurs in October and the minimum in February and March in the Black and Y.S. Rivers. The minimum flows in the Black and Y.S. Rivers recorded 5.2 m^3/sec and 0.16 m^3/sec respectively in April 1976. Total annual runoff in both rivers during the past 19 years has been estimated as follows:

Unit: 10^6 m^3

River	Average	Maximum	Year	Minimum	Year
Black	605	752	1970	416	1976
Y.S.	148	180	1970	99	1976

The rainfall in the Y.S. River catchment is the highest in all of the Black River's catchment area. The annual basin rainfall in both the Black River and the Y.S. River are estimated at 1,900 mm and 2,500 mm respectively. Consequently, the average runoff coefficient can be estimated at about 38% on both the Black River and the Y.S. River.

A 20-day dependable daily mean discharge in a month was studied for each year of data for the Black and Y.S. Rivers. For the Black River at Lacovia the data period extended from 1964 to 1982 and for the Y.S. River Near Middle Quarters from 1959 to 1982. These results were then

subjected to frequency analysis and probable low flow in 5-year return period determined as shown below:

Unit: m^3/sec

River	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Black	8.8	7.6	7.2	6.9	11.6	11.2	10.8	13.0	18.0	17.9	17.5	11.5
Y.S.	0.63	0.42	0.24	0.29	1.79	1.93	2.20	3.48	4.09	4.43	2.60	1.28

2) Peak flood discharge

The probable peak flood discharges for 10 and 50 year return period on the Black River at both Newton and Lacovia, and the Y.S. River at Near Middle Quarters were estimated by the unit hydrograph method. The data used in the analysis were available from 1964 to 1982 for the Black River and from 1955 through 1982 for the Y.S. River. Newton is located at the entrance of the Upper Morass. The storage effect in the Upper Morass has decreased significantly since the area was developed by BRUMDEC for agriculture, and thus the peak flood discharge on the Black River at Lacovia will be significantly greater now than pre-BRUMDEC. Taking the above condition into account the peak flood discharges of the Black River and Y.S. River were estimated as shown below:

Unit: m^3/sec (cusec)

Return period in year	Black River at Newton	Black River at Lacovia	Y.S. River at Near Middle Quarters
10	87 (3,100)	133 (4,700)	41 (1,500)
50	128 (4,500)	193 (6,800)	55 (1,900)

From chemical analyses of water samples it appears that water in both the Black River and the Y.S. River is of excellent quality for irrigation from salinity and alkalinity view points. The water can be classified as C2-S1 in the Standard of the USDA. The electric conductivity of 270 to 490 micro mho/cm is well below the tolerance level for paddy. High nutrient levels were observed in the water of the Black River, which will benefit agriculture, particularly paddy cultivation.

Because of tidal effects from the Black River estuary on the gauging station of the Broad River, the measurement data so far obtained are insufficient to allow an estimate of reliable flow in the Broad River. Similarly, the discharge of the Middle Quarters River is obscured by flooding into the Morass.

The reliable river runoff of both the Broad River and the Middle Quarters River was therefore calculated on the basis of the water balance between rainfall and estimated evapotranspiration as follows:

Unit: m^3/sec

River	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
M.Q.	-	-	-	-	1.0	0.05	1.0	1.1	0.5	0.7	0.01	-	0.4
Broad	-	-	0.1	0.4	2.4	0.2	3.9	4.9	2.6	3.1	1.8	-	1.6

A continuous tide record of the Black River at the bridge in the town of Black River is available since 1956. Examining the record, the difference in tide level is 0.45 m at spring tide but only 0.15 m at neap tide.

Salt water intrusion was studied on the basis of observations carried out by PCJ. As a result, the tip of the salt water wedge was found to extend about 9 km upstream from the Black River estuary. Accordingly, no serious problem is expected for irrigation water intake, since the pump station for the Project would be located about 19 km upstream from the Black River estuary.

3.3.4 Geology and hydrogeology

During this study geological and hydrogeological conditions within the Black River Lower Morass were established. The Limestone Aquifer is the main hydrogeological unit extending throughout the entire Lower Morass. The Alluvium Aquiclude rests directly on the Limestone and separates it from the overlying Peat Aquifer. The Limestone and Peat Aquifers are in direct hydraulic continuity only in the eastern section of the Broad River. Groundwater level contours in the Limestone Aquifer were drawn to a maximum water table elevation of 2.0 m, with groundwater depressions developed in the Broad River and Middle Quarters area (see Fig. 3). These depressions were separated by a groundwater ridge in the Lacovia - Frenchman - Cataboo area. Groundwater discharged to the depressions is drained mainly by the Broad, Styx and Middle Quarters Rivers. Slightly saline groundwaters, identified by the Electrical Conductivity Method, occupies about one half of the Limestone Aquifer, extending up to 10 km inland of the sea (see Fig. 4). Saline groundwater also occupies areas of the Peat Aquifer in the right bank of the Black

River downstream of the Middle Quarters River confluence and the left bank area of the Broad River, downstream of the Salt Spring bridge.

Changes in these hydrogeological conditions likely to result from an implementation of the proposed development project were also evaluated. The changes identified were confined to the groundwater catchment of the Broad River, upstream of the Salt Spring bridge.

It was determined that a drainage induced reduction in the base level within the Broad River groundwater depression, from an elevation of 0 metre (mean sea level) to a post-project elevation of -0.8 metre, is likely to result in a maximum 0.3 m^3/sec (20%) increase in groundwater flow into the depression from 1.6 to 1.9 m^3/sec. This increased inflow would be supported by an expansion of the catchment area mostly at the expense of the Pedro Plains. A corresponding reduction in the size of the groundwater resource in the Pedro Plain is implied. A more reliable quantitative evaluation of this impact should be carried out with the aid of computer simulation prior to the development of the Broad River Basin.

A drainage induced maximum 0.8 m reduction in the water table within the Limestone Aquifer of the Broad River groundwater catchment is likely to produce, at worst, a marginal reduction in the yields of the Burnt Savannah and Holland Wells. Shallow hand dug wells would have to be deepened in order to compensate for the expected fall in the water levels in these wells.

A post project -0.8 m base level can also be expected to reverse the groundwater gradient with respect to the sea and cause some salinisation of the Limestone Aquifer. A quantitative assessment of the extent of salinisation will have to await future definitive investigation of the fresh/salt groundwater interface associated with the Broad River basin.

No significant post-project changes in the groundwater quality of the Peat Aquifer is expected. Unchanged low flows in the Black and Broad Rivers should maintain the status quo with respect to sea water intrusion along the bed of the rivers. The sections of the Peat Aquifer within the Project area although no longer subject to flooding by the rivers, will continue to be flushed by infiltrated fresh irrigation water subsequently removed by drainage pumping.

3.3.5 Soils and land capability

1) Soil classification

The soil survey covered about 11,450 ha approximately and the soil classification was made according to the USDA Soil Taxonomy. In reference to the Soil Taxonomy, the parent material, lithological sequence, diagnostic profile features, physical and chemical properties and environment were taken into account for the classification and mapping. The soils in the Project area are classified into 7 orders, 11 sub-orders, 12 great groups and 12 sub-groups in the higher categories of classification. Soil properties of each sub-group are as follows :

i) Typic Eutrorthox (Chudleigh and Anglesey clay loam #73 and #83) mainly developed on the side slopes of limestone hills and lower slopes of the alluvial plain. These are well drained dark brown to dark yellowish soils with moderately fine (fine loamy) texture. These soils have low neutral fertility and moderately moisture supplying capacity. These soils occupy about 450 ha of the Project area.

ii) Udic Haplustalfs (Lucky Hill #74) are developed over a hard white limestone formation and occurs mainly on foot slopes of hills. These are well drained fine textured soils (clay to clay loam) and have low natural fertility. These soils occupy about 90 ha of the Project area.

iii) Lithic Ustorthents (Bonnygate #77) soils are erodible soils in the dissected limestone hills. These soils are shallow (0 - 25 cm deep) and are associated with typic Eutrorthox (Chudleigh). These soils have very low moisture supplying capacity and low natural fertility. These soils occupy about 185 ha of the Project area.

iv) Typic Quartzipsamments (Hodges #150) are the typical sandy alluvial soils developed in sandy parent material occupying very gently undulating area of the alluvial plain. These soils are generally associated with Typic Chromusterts (Four Paths sandy loam). These soils are neutral to slightly acid, have very low moisture supplying capacity and have low natural fertility. These soils occupy about 160 ha of the Project area.

v) Typic Chromusterts (Four Patsh #203/204, Cashew #151 and Holland #109) are mainly developed in old and recent alluvial materials and occur on both elevated and lower part of the alluvial plain. The surface texture of these soils show wide range in variation (i.e., clay, clayloam, sand clay loam, sandy loam etc.). These soils have high moisture supplying capacity and low to medium natural fertility. These soils occupy about 2,600 ha of the Project area.

vi) Typic Chromuderts (Carron Hall #94) are mainly developed over flat limestone hills. These soils are slightly alkaline at the surface and increase in alkalinity with depths. These soils have a bedrock at about 60 cm sometimes at about 20 - 30 cm in some places. These soils occupy about 590 ha of the Project area.

vii) Aquic Hapludolls (Wallens clay #9) are the predominant soils developed on the narrow river trails and extended over the alluvial depression in the low lying alluvial plain. These soils are rich in organic matter and exchangeable bases. These soils are associated with Hemic Troposaprists (Broad River peat) in some places. The soils occupy about 360 ha of the Project area.

viii) Aeric Tropaquepts (Black River clay, #12) are the predominant very fine textured soils developed on the low lying alluvial plain. These soils are generally in a wet condition throughout most of the year. These soils occupy about 460 ha of the Project area.

ix) Hemic Troposaprists (Broad River peat # H1a) consisting of almost completely decomposed plants remain in the subsurface tier which is wholly organic except for a thin mineral layer. The degree of peat decomposition of these soils are H8 or more. These soils are usually black in colour and occur in area where the groundwater table tends to fluctuate within the soil profile. These soils occupy about 2,060 ha of the Project area.

x) Hydric Tropohemists (Morass peat - high decomposition phase # H1b) are dominantly humid in the sub-surface tier which is

wholly organic except for a thin mineral layer. These soils are usually very dark brown in colour. The degree of peat decomposition is H6 or less. These soils occupy about 1,490 ha of the Project area.

xi) Hydric Tropofibrists (Morass peat - low decomposition phase # Hlc) are dominantly fabric in the sub-surface tier. These soils are usually brown to dark brown in colour. If the soil is drained and cultivated, subsidence due to decomposition could be rapid. These soils occupy about 900 ha of the Project area.

xii) Typic Sulfihemists (Morass peat - sulfidic phase # Hls) are potentially acid sulphate soils that are dominantly organic. These soils are generally dark brown to very dark brown in colour and have sulfidic materials within one meter of the surface. Sulfidic materials are water-logged organic soil materials that contain 0.75% or more sulfur. These soils occupy about 1,150 ha of the Project area.

In the Project area, 13 soil series were recognized out of which 10 are in upland and 3 in inundated area. The soil series as well as soil phases in the Project area are shown in Table 2 and PLATE 1.

The pH of soils in the Project area ranges from 4.0 to 8.0. The pH in the inundated area is higher than that of the upland area. Distribution of E.C. in the Project area ranges from 0.01 to 3.0 millimhos/cm. E.C. values in the inundated area are higher than those in the upland area. Sulfur contents in the area ranges from 0.001 to 1.2%. Potential sulfidic peat soils that contain sulfur of 0.75% or more, are recognized in the Black River estuary.

Soil fertility of upland mineral soils tends to decrease in following order; recent alluvial soils, old alluvial soils and limestone soils. The difference in such soil fertility might be controlled depending on the dominant clay minerals. The dominant clay minerals of the recent alluvial soils are montmorillonite and the dominant clay minerals of other soils are kaolinite.

On the other hand, chemical deficiencies of peat soils are expected especially in phosphates, copper and silicates. It would

therefore be necessary to apply fertilizer to maintain the fertility of these soils. The nitrogen contents of peat soils are relatively high which would increase the vegetative growth of rice plants rather than yields of grain. It is also therefore necessary to be careful on the excess nitrogen.

2) Land capability classification

In order to evaluate the land capability for rice culture in the low-lying area, special specifications were prepared on the basis of criteria for land classification as defined by MAFF, Japan. Land capability for upland crops employ a modified format of the present system being used in Jamaica (see Annex D).

Suitable land for rice culture in the upland amounts to about 3,700 ha of class II and III land.A further 4,000 ha of suitable land for rice cultivation is found in the inundated area which includes class II to IV. Because the class IV in the inundated area is flat in topography, its poor drainage conditions will have to be improved. On the other hand, suitable land for upland crops is defined as class I to III except for class IV of marginally suitable land. Proper irrigation and land reclamation will be limited, however, by undulating topography and limestone outcrops. The suitable lands in the upland are similar to those for rice culture. Peat soils in the inundated area will not be suitable for upland crops because of subsidence with excessive drainage, aerobic decomposition under upland conditions and excess moisture injury due to poor drainability. Tables 3 and 4 show the land capability for both paddy and upland crops. PLATE 2 and PLATE 3 show the distribution of land suitability of the soils in the Project area.

3.4 Social Infrastructures

3.4.1 Education

In St. Elizabeth, there are 74 primary level schools, 10 secondary level schools and 1 tertiary level school. The enrollment pupils of each level schools are 28,000 in primary, 16,000 in secondary and 1,300 in tertiary respectively. Besides, a recent survey in the Parish revealed that only 25% of the population was illiterate (29% male and 21% female). This figure is low for Jamaica.

In and around the Project area, there are 6 primary schools and 2 all-age schools and 2 new secondary schools with about 6,100 pupils. Also there are 7 centres for JAMAL training with 200 trainees in 24 classes and a team of 10 volunteer teachers. It is considered that the number of schools in and around the Project area are sufficient but staff and facilities need to be expanded.

3.4.2 Health

The medical and health services are well organised in the parish of St. Elizabeth. Well operational Government Hospital with 128 beds complement is located in Black River, Capital of the Parish. In the rural area in the Parish, 31 health centres including dispensaries have been set up in the major village centres. Only 5 health service centres are located in the Project area. The ratio of doctor and dentist to population in St. Elizabeth is low as compared with Jamaica as a whole.

3.4.3 Transportation

Transportation in the parish as well as in the Project area depends mainly on road traffic which is served by a Highway and a number of secondary or parochial roads. The Highway runs along the northern and western boundaries of the Project area. This road about 200 km (125 miles) long runs between Kingston and Savanna-la-mar and is well maintained. There are secondary roads linking Black River to Mountainside and Mountainside to Lacovia. These roads about 25 km (16 miles) long are asphalt paved and well maintained. However, 56 km (35 miles) of roads inside the Project area are generally in poor condition. Rivers are also used by small canoes for transportation inside the Project area. It seems that the poor condition of roads inside the Project area is one of the main limiting factors for the development.

3.4.4 Communication

Postal services are provided by 25 post offices and 41 postal agencies under supervision of the Black River Regional Office in St. Elizabeth Region of which three post offices, Middle Quarters, Lacovia and Mountainside in addition to the Black River Regional Office are

located in the Project area. A post office provides all the postal and telegraphic services. Their services are considered to be adequate.

Telephone services are provided by the Jamaica Telephone Co. Ltd. The regional office in Mandeville supervises the service in St. Elizabeth. The Parish is serviced by the Black River exchange (with 70 customers), the Santa Cruz exchange (with 135 customers) and 11 call boxes. Telephone services in Black River as well as in the Project area are considered to be extremely poor as compared with other existing facilities.

3.4.5 Domestic water supply

Some water supply systems (waterworks) have already been taken over by NWC, but in the Parish of St. Elizabeth, the Parish Council still provides all water distribution services and most of the supply. Water for customers in the Project area is provided from three wells, Luana and Dalintober under NWC and Burnt Savannah under the Parish Council. At present about 900 metered customers in the Project area benefit from water supply services. There is reserve capacity in these wells to meet the projected increase in water demand.

3.4.6 Power supply

The requirement of power supply for the Parish of St. Elizabeth is estimated to be 4.5 MW with 9,500 customers. The power supply services are limited in major towns and their vicinities with only 48% of households served in 1982. In and around the Project area, the power distribution system is adequate. The present power requirement is estimated to be 2 MW with 3,000 customers. The distribution line links Black River, Lacovia and Mountainside along the main road and extends inside the Project area.

3.5 Present Land Use and Agriculture

3.5.1 Present land use

The Holland Estate area located in the northern elevated land in the Project area has been developed as a sugar cane estate. It covers about 1,900 ha as a whole including about 1,700 ha of the Project area,

where the soils comprise mainly of old and recent alluvial soils, which are fairly fertile. Out of this 1,700 ha, about 910 ha are properly drained and were planted with sugar cane in 1984.

About 6,800 ha of inundated lands are mostly composed of peat soils, in which approximately 5,100 ha are swamp covered by saw grass and about 1,700 ha with forest and bush. The swamp land between the Black River and the Middle Quarters River is extensively fished for wild shrimps by local fishermen. Both banks of the Y.S. River extending in narrow strips are covered with swamp grasses, where some cattle grazing is practised.

The elevated uplands located in Slipe and Cataboo island, the narrow strip along the skirt of Santa Cruz Mountains, and the northern end of the Pedro Plain, are mainly composed of shallow residual clay soils with limestone outcrops, where farmers mostly grow wild grasses for pasture, some root crops and vegetables. Table 5 and Fig. 5 show the present land use approximated by the aerial photo interpretation and field survey.

Marshlands play an important role in the hydrological system of the coastal zone, acting as a natural flood control system and a buffer between the fresh and sea water regimes. The regulating effect of marshlands on flood water governs the influence of fresh water on the downstream marine ecosystem. The physical structure of these marshlands provides a habitat for fish, shrimps, edible frogs, waterfowl, and an endangered American crocodile (alligator).

3.5.2 Land distribution and tenure

In St. Elizabeth, 93% of the acreage in farms was held on free-hold basis in 1968/69. This figure is higher than average for Jamaica. The average farm size in the Parish was 3.7 ha in 1978/79, on the other hand, farms of less than 2 ha accounted for 82% of the total number of farmers but represented only for 13% of the total acreage in St. Elizabeth. However, farms of more than 200 ha accounted for 0.5% of total farmers but represented 65% of the total acreage of farms. The figures are extremely high compared with national figures.

In the Project area, according to the farm economic survey, about 92% of the acreage of farm land is held free-hold. This is a very similar figure to the Parish. Farms of more than 40 ha (100 acres) account for about 0.4% of the total number of farmers and 62% of the acreage in farmland. On the other hand, farms of less than 2 ha account for about 82% of the total number of farmers. But the average farm size in the Project area is 4.4 ha (11 acres). The average farm size, excluding the 0.4% of the farmers with more than 40 ha, is 1.7 ha (4.2 acres). As the crop incomes of these peasant farmers are insufficient to sustain their livelihood, most of these farmers are engaged in various sideline activities.

3.5.3 Agricultural setting, cropping pattern and practices

The dominant crops cultivated in the Parish of St. Elizabeth are peanuts, other legumes, rice and vegetables, tomatoes and onions. Peanuts produced in the area account for more than 60% of the total production of Jamaica. Tomatoes and onions produced in the Parish represent around 33% of Jamaica production and rice 27%. Carrots and pineapples are also important crops.

Agriculture in the Project area is practiced at present in the following three types of farming under rainfed condition.

- large scale estate farming of sugar cane
- small scale subsistence farming, and
- medium scale livestock farming

Sugar cane farming in the Holland area covering about 910 ha (2,270 acres) is managed by the National Sugar Co., and is semi-mechanized. Usually, about 13% of cane cultivated is replanted in a given year with 87% being ratooned. Ploughing and harrowing for soil preparation are done by tractors. Subsequently, seeding, weeding, fertilizer application and reaping are mainly done manually. Transportation of cane to the mill at Frome is done by tractors and trailers.

There is small scale subsistence farming for upland crops throughout the Project area except in the sugar cane and livestock farming areas. The main crops grown are peanuts, red pea, root crops and vegetables. Paddy is also grown in the very limited lowland mainly within the Holland Sugar Estate property. Farming practices are conventional but no draft animals are used for cultivation. The table below shows the percentages of cropped areas by location and crops within the land use category upland crops and grassland.

Location	Area of Crops (ha)
Hatfield	15
Frenchman/Slipe/Cataboo	16
West of Lacovia/Mountainside road	17
Lacovia	8
Total	56

Average % of Crops grown in all locations	
Crops	%
Cassava	30
Gungo pea	25
Peanut	20
Yam	15
Corn	10

Hatfield is the most densely cropped area and cassava is the most popular upland crop. Generally, no improved crop varieties are grown by small farmers. Planting dates for these main crops are dependent on the rainy seasons.

Livestock farming, particularly cattle grazing, is one of the main economic activities of the Project area. Generally cattle grazing is practised on the wild grass under rainfed conditions, but some improved pastures are introduced in some specific areas with irrigation. Goats and poultry are also raised by the farmers but their production is limited to the home consumption.

3.5.4 Crop yield and production

Except for sugar cane, the yields of crops are relatively low due to low standards of cultivation, insufficient agricultural extension services, inputs and credits. Yields and production of crops in the Project area were estimated based on the data collected by the Parish of St. Elizabeth as shown below:

Crop	Area (ha)	Yield (ton/ha)	Production (ton)
Sugar cane	910	56.2	51,142
Rice (Paddy)	22	1.1	24
Cassava	17	9.0	153
Yam	8	9.0	72
Corn	6	1.0	6
Gungo pea	14	0.8	11
Peanut	11	1.1	12

3.5.5 Livestock production

The productivity of grasses in the elevated land is rather low due to the very shallow surface soil. At present, about 2.5 heads per ha of cattle are grazed in the Project area, which suggest that the primary productivity of grass would be in the order of 40 tons per ha. The following table shows the livestock production in recent years in St. Elizabeth.

Year	1981		1982		1983	
Type	nos.	Production(ton)	nos.	Production(ton)	nos.	Production(ton)
Cattle	3,369	689.0	3,970	819.5	4,204	764.0
Pig	4,270	269.0	4,975	307.2	5,684	372.3
Goat	1,711	20.0	2,207	21.6	2,712	23.5

Production: Dressed weight

3.5.6 Farm economy

The socio-economic survey in the Project area was commissioned a) to clarify the prevailing general socio-economic situations of the Project area but more particularly the farmers socio-economic situation, in order to facilitate the evaluation of the socio-economic impact on the area after the Project is implemented, b) to determine the interest of the farmers in the proposed project activities, and c) to assess the various constraints and to identify ways the Project could overcome them.

The findings of the survey are summarized as follows:

1) The average household size in the Project area was 4.2 persons whereas the average farm household size was 5.6.

2) The average age of a farmer was 54 years. Ninety four percent of the farmers had not gone beyond primary school.

3) Farmers indicated that there was an adequate supply of labour but in general they could not afford to hire labour. Twenty one percent of the farmers were involved in labour exchange.

4) Eighty eight percent of the farmers had their own lands. Eighty one percent of the farm holdings were 2 ha (5 acres) or less and 40% were 0.4 ha (1 acre) or less. The average farm size was 0.8 ha (2 acres).

5) The main economic activities were crop cultivation, livestock rearing, fishery (mainly shrimp fishing), and the making of craft items from thatch. These economic activities yeild low earnings.

6) A typical farm household spent J$9,691 in the previous year and about one third of this was allocated to food. Seventy five percent of the farmers did not or could not depend on income derived from farming alone to meet their household expenses.

7) Within the content of the present credit system some farmers' level of poverty militates against them obtaining adequate credits. There was limited farmer - extension officer contact; only 38% of the farmers had been visited by an extension officer.

8) Only 6% of the farmers were presently growing rice; but 44% of those not growing rice indicated that non-availability of land accounts for this. Thirty eight percent of the farmers actually stated that they would want to grow rice if the Project is implemented.

3.5.7 Processing and storage facilities

A number of processing plants ranging from cottage to large scale industries have been set up across the parish mainly based on domestic food production. With the exception of the Appleton Sugar Factory which is a privately-owned sugar, alcoholic drink and liquid carbon dioxide producer, raw materials for the efficient operation of the other

factories are generally short. Reasons cited for this shortage of raw materials were most frequently; insufficient production at any given time, and seasonality of some inputs.

Although St. Elizabeth produces 61% of the island's peanuts, there are not sufficient quantities available to justify a medium-sized processing facility within the Parish. The rice mill at Middle Quarters has served small and large producers of rice for many years. It operates a small mill (capacity 1.8 ton/day) which is adequate for the milling needs of the small farmers who usually harvest piecemeal.

Overall, limited raw materials are available for the processing facilities and an increase in acreage and/or intensification of the present acreage is necessary. Storage facilities for products except for a sugar warehouse in Black River, are non-existent.

3.6 Inland Fisheries

Shrimp fishing in the Project area is an important economic activity. The total number of fishermen engaged is estimated to be 260 in the entire area. The chief fishing ground for shrimp is in the western part of the swamp between the Black River and the Middle Quarters River and along the Broad River. Commercial fin-fish fishery is scarcely practised at present in the Project area.

The annual production of shrimps was estimated to be about 90 tons (0.2 million lbs.) valued at about J$1.1 million as the result of interviews with fishermen. Shrimp fishing as well as the shrimp industry in the Project area is of importance not only for employment but also in assisting to meet the inhabitant's food requirements.

Of 7 shrimp species found in the Project area, Macrobrachium acanthurus is of the most commercial importance. The relationship between shrimp fishing and its resources is considered to be balanced at present as given in Annex K. About 40 species of fish are found in the Project area, but improvement of fin-fish fishing methods on a large scale, however, is hardly possible due to topography, particularly the presence of marshy peat land, and also to non-availability of natural nutrients.

The water supply in the Project area, which is provided by the Black River and aquifers, is enough to support the fisheries resources. The surroundings of the western marsh, the land between the Black River and the Middle Quarters River must be carefully preserved from disturbance, however, if the present shrimp production is to be maintained.

3.7 Agricultural Support Services

3.7.1 The credit system

Credits are often necessary to enable small farmer to adopt modern systems of production. Within the context of the present credit systems small farmers' levels of poverty militate against them obtaining adequate credits. Some of the farmers surveyed by the team have been refused loans because of lack of collateral.

There are ten Peoples' Cooperative Banks (PCBs) in St. Elizabeth at Southfield, Malvern, Palnyra-Nain, Siloah, Balaclava, Magotty, Santa Cruz, New Market, Black River, and Watchwell. Only three at Watchwell, Santa Cruz and New Market, are serviced by ACB. The other PCBs provide their own financing by re-cycling their collections and share capital.

PCBs which are likely to service the Project area are the Santa Cruz and New Market branches. According to the socio-economic survey, credit officers from the PCBs usually visit farmers for loan assessment and also for the supervision of credits. The 20% farmers/credit officer contact reported is therefore understandable in view of the fact that only 30% of the farmers had ever applied for loans. However, the level of development the Project is likely to bring to the area may necessitate upgrading the PCB at Black River to the one serviced by ACB.

3.7.2 Extension and related services

St. Elizabeth is divided into 36 extension areas in 8 extension divisions. Extension services are undertaken by only 26 AEOs, resulting in very inefficient services to the farmers. At present in the Project area only 5 AEOs provide extension services for farmers. Although

personal contacts are most effective for stimulating farmers to improve their farming, only a limited number of farmers benefit from the services at present due to shortage of trained extension workers. Four regional training centers in Jamaica primarily provide training for farmers. The Center at Brooklyn is nearest to the Project area and could be used for this purpose.

According to the socio-economic survey, 30% of the farmers belong to the "Farmers Group for Extension". 25% of them replied that they were involved in the Training, Visiting and Monitoring Programme (TVM Programme). Over thirty percent of those involved in the TVM Programme had never been actively involved but two farmers had been "contact farmers". Forty percent of the farmers that know the existence of the veterinary officer having been visited by him and this was usually for the purpose of treating sick animals. The Rural Farm Family Development Programme which is geared mainly towards improving general education and services to rural farm families appears to be non-operative in the Project area. None of the farmers or their wives has any knowledge of such programme.

3.7.3 Farmers' organization

1) The Jamaica Agricultural Society (JAS)

St. Elizabeth has one Organizer and one Project Officer, with offices in Santa Cruz, 96 branches and 2,600 members. There are 5 branches in the Project area located at Slipe, Vineyard, Burnt Savannah, Mountainside and Middle Quarters. However, the survey found that JAS seems to be inactive in the Project area. Fifteen percent of the farmers know about JAS with only 13% of them being members of this organization.

2) Farmers Co-operative Groups

The St. Elizabeth Group has 9 active Societies. They are:

- Credit Union: 3 ; Alpart, Appleton and St. Elizabeth Coop Credit Union Ltd.
- Agriculture : 4 ; St. Elizabeth Coffee Coop, Newell Irrigation Coop, St. Elizabeth/Manchester Coop Society, and Honslo- Farmers Coop.

- Fishery : 2 ; Calabash Bay Fisherman Coop, and Great Bay Fishermen Coop.

The St. Elizabeth/Manchester Coop Society located in Southfield has a business portfolio in excess of J$2 million and has been in business for the past 30 years. It markets peanuts and other crops on behalf of its members and supplies agricultural inputs to them.

3.8 Present Irrigation and Drainage

3.8.1 Irrigation

Although about 4,690 ha or 41% of the Project area is utilized as grass land, sugar cane fields, upland crop/grass land, trees/village/grass land and paddy/swamp, no irrigation facilities even for sugar cane exist. An intake structure and canal were constructed on the Y.S. River about 1.5 km upstream from the Bamboo Avenue in the late 1920s to supply cooling water to the Holland Estate Sugar Factory, but both the intake and the canal are now broken and have not been used since the factory was closed in 1981.

3.8.2 Drainage

Despite their limited flow capacity due to the fairly gentle slope of the river bed and tidal effect, the existing rivers such as the Black, the Y.S. and the Broad Rivers play an important role in draining water from the swamp to the sea. Since the ground surface elevation in the Project area and the water surface elevation of the rivers are almost same throughout the year, polder dikes and drainage pump stations will be indispensable to develop the swamp area.

There is one drainage pump station about 11 km upstream on the Black River right bank, in which 2 sets of pumps driven by electric motors drain the surface water from the Holland Estate. One of these pumps with a diameter of 700 mm is operable but the other one, 400 mm in diameter, is out of order. Another pump station is situated on the right bank of the Y.S. River at the western end of the Holland Estate, but its pump has been removed, and the surrounding area is presently inundated.

A chain of polder dikes were constructed on the right bank of the Black River in the late 1920s to protect the Holland Estate sugar cane fields from floods of the Black River. The dike of about 5 km in total length starts 4 km downstream from Lacovia and ends at the above pump station. The dike was rebuilt in 1982 to contain the expected 10 year peak flood discharge after implementation of the Upper Morass Development Project by which the peak flood discharge on the Black River was significantly increased.

Some works were implemented within the Lower Morass from 1964. These included the construction of about 2 km of embankment to divert the Y.S. River and the dredging of a by-pass channel from the Y.S. River to and along the Middle Quarters River. A bridge across the Styx River at the confluence with the Black River was also constructed at this stage, in April 1973. However, such construction was suspended in the mid 1970s when efforts were concentrated on implementation of the Upper Morass Development Project. Neither a road nor a dike along the Black River left bank was constructed.

3.9 Environment in the Black River Lower Morass

3.9.1 Environmental condition

The Black River Lower Morass is the largest wetland in Jamaica. It provides a unique ecosystem in which herbaceous swamp, mangrove forest and swamp forest are recognized, and inhabited by precious wild-life and commercial species.

The Black River carries with it the distillery slop from a sugar estate and a rum distillery in Appleton. This pollutant makes the Black River the most turbid and nutrient rich water way within the Lower Morass. The Y.S. River flows into the Lower Morass accompanied by high suspended solids. The Middle Quarters River and the Broad River have high transparencies of water estimated to be more than 3 meters.

3.9.2 Flora and fauna

1) Flora

One hundred and forty-four plant species including 25 rare species were identified in the Lower Morass (NRCD and TGI, 1981; Coke et al., 1983). These may be classified into 4 major formations, (1) Forest, (2) Herbaceous swamp, (3) Pasture and cultivated area and (4) Aquatic vegetation. The forest and herbaceous swamp are further sub-divided into 12 communities. A vegetation map was prepared in a scale of 1 to 25,000 based on aerial photographs (taken in 1979) interpretation and field survey for its confirmation. The vegetation map of the Project area is shown in PLATE 4.

Vegetation	Area in ha	% of Total area
(1) Forest	1,660	14.5
(1) Mangrove forest	500	4.4
(2) Swamp forest	180	1.6
(3) Secondary forest	980	8.6
(2) Herbaceous swamp	5,230	45.7
(1) Crinum/Sagittaria zone	170	1.5
(2) Scirpus olneyi zone	520	4.5
(3) Hummocky swamp	510	4.5
(4) Thick Cladium zone	340	3.0
(5) Typha zone	480	4.2
(6) Typha hummocky swamp	700	6.1
(7) Cladium/Sagittaria association	1,240	10.8
(8) Typha/Thalia zone	160	1.4
(9) Cladium/Conocarpus zone	470	4.1
(10) Others	640	5.6
(3) Pasture and cultivated area	4,560	39.8
TOTAL	11,450	100.0

The mangrove forest is distributed in patches in the southern part of the Lower Morass and along the both Black River and Broad River. The swamp forest comprising the particular type of forest growing on peat within the Morass is located between the Black River and the Y.S. River. Forty-seven plant species were identified in the swamp forest (NRCD and TGI, 1981; Coke, et al, 1983). This Amazonian type water forest has many endemic plant species such as Grias cauliflora (Anchovy pear), the only member of the Brazil nut family in the West Indies, and Roystonea princeps (Swamp cabbage palm).

The Cladium/Sagittaria association around the upper part of the Broad River provides the greatest number of plant species (41 spp.) in the herbaceous swamp. Next to this formation is the Typha zone (33 spp.), and Hummocky swamp (24 spp.), around the area of the confluence of the Middle Quarters River, Y.S. River and Black River.

In the upper part of the Broad River and in the vicinity of the Blue Holes, aquatic plants grow thickly, where 11 plant species were identified (NRCD and TGI, 1981). Water Hyacinths are dominant along the water ways. The unique aquatic plants growing in the Broad River are believed to be associated with the transparency of the water.

2) Fauna

In the Lower Morass, a total of 9 species of crustaceans (including 7 species of shrimps), 37 species of fish, 4 species of amphibians, 7 species of reptiles, 141 species birds and 3 species of mammals were recorded.

Although the species number of amphibians, reptiles and mammals are fewer than that of birds, the fauna includes 2 very important species, the American Crocodile Crocodylus acutus and the American Manatee, Trichechus manatus both of which are listed in Appendix I of the Convention on Trade in Endangered Species of Plants and Animals (IUCN, 1982), as endangered species and are protected species under the Wild Life Protection Act. As the result of field surveys, the population of the American crocodile was estimated to be about 0.22 individuals/km along the streams.

One hundred and forty-four species of birds found in the Lower Morass correspond to about 60% of their total number in Jamaica. The Lower Morass is ranked second rank as a bird habitat in Jamaica. The avifauna of the Lower Morass includes 8 endemic species. Internationally, the Black River Lower Morass is an important area for birds because of the variety and the high level of endemism.

4. THE PROJECT

4.1 Basic Concept of Development

The Government of Jamaica has laid great emphasis on a substantial increase in food production through the AGRO-21 national plan. The plan aims at promoting the opening of new agricultural land to a wide range of food crops to attain national self-sufficiency in food and to relieve unemployment. In line with the above objective, the Lower Morass Agricultural Development Project covering a total area of about 11,450 ha has been formulated to maximize the potential agricultural benefits through efficient use of land and water resources. The main concepts of the Project are:

- to exploit potential arable land, particularly marsh land for the cultivation of food crops by means of irrigation and drainage,
- to introduce diversified cropping patterns particularly of paddy and soya bean into the annual rotation of cropping,
- to increase and stabilize yields and production of crops through the supply of irrigation water, proper drainage management, and introduction of improved irrigation farming,
- to achieve the successful settlement of farmers through proper training and thorough agricultural support services, and
- to promote the levelling up of living standard and more equitable distribution of income to the people.

For lack of drainage and irrigation facilities in the marsh land (Morass area), most of the area is at present unutilized and wasted. The elevated uplands also suffer from drought (or water shortage) in the dry season and low-lying areas are hampered by poor drainage in the rainy season. In order to achieve successful agricultural development in the Project area, the following undertakings should be realized:

- construction of an irrigation network consisting of diversion headworks, a pump station, and main, branch and on-farm canals,

- construction of a drainage network consisting of drainage pumping stations, main, branch and minor drains,
- land reclamation and on-farm development,
- construction of a road network,
- operation and maintenance of the irrigation and drainage networks,
- improvement and strengthening of the agricultural support services, and
- improvement of socio-economic infrastructures.

4.2 Demarcation of Area to be Developed

4.2.1 Factors affecting demarcation

In the demarcation of the development area, the following factors were taken into consideration:

1) Land capability classification

Based on the evaluation of the land capability, lands classified as Grade II, III and IV are proposed for agricultural development. In this evaluation, the relevant factors in the demarcation were soil texture, topography, soil depth, fertility, drainability, soil salinity and acidity, and soil physical properties.

2) Present land use

The present land use and vegetation were also taken into account in the demarcation, viz., the western marsh land sandwiched between the Black River and the Middle Quarters River is extensively used as fishing area for shrimp by local fishermen. In addition the lower basin of the Black River is covered by mangrove forest. These areas were excluded from the proposed agricultural development area.

3) Soil physical characteristics

Peat soils in the Project area have an extremely low bearing capacity, resulting in high construction costs of infrastructures related to irrigation and drainage systems. In addition, the subsidence of soils in developed farm land is expected to be relatively large due to

desiccation and consolidation of soils as well as continued biological oxidation of peat. For the above reasons peat soils of more than 4m in depth were excluded from the agricultural development to be proposed.

4) Peat mining plan area

According to the Environmental Feasibility Study of the Jamaica Peat Resources Utilization Project prepared by NRCD in September 1981, potentially large volumes of peat are located in the Middle Quarters River basin, which is excluded from the agricultural development area.

5) Ecological considerations

In the Lower Morass notable unique herbaceous swamps and swamp forests and precious wild-life have been recognized. The Black River Morass system offers one of the few diverse and stable wetland habitats in the Caribbean for many forms of wild-life and plants. In order to minimize the environmental impacts on these species, the agricultural development area has been carefully demarcated particularly in regard to the swamp forest and surroundings of the Broad River.

4.2.2 Pre-feasibility study of potential agricultural development plans

The pre-feasibility study made in October 1984 identified four irrigation systems for study as follows:

System/Area	Irrigation area (ha)	Water resource	Crops
Y.S. system	500	Y.S. River	Rice-Rice-Soya beans
Black River Right Bank (Holland)	500		
Lacovia system	2,550	Black River (pump up)	Rice-Rice
Hatfield	220		
Styx River Basin	300		
Frenchman-Holiday Pen	400		
Broad River Right Bank	850		
Broad River Left Bank	780		
Farbas system	450	Black River (pump up)	Sugar cane
Holland Sugar Cane Land	450		
Luana system	250	Middle Quarters River (pump up)	Pasture & Legumes
Luana	250		

In the above areas, it was proposed to adopt sprinkler irrigation systems in the Farbas system which commands the Holland Estate, and in

the Luana system. Gravity irrigation was proposed in the Y.S. system and Lacovia system. Economic viabilities as well as social and environmental impacts were studied to assess the development priorities for the above plans. The results were shown in the Pre-feasibility Report in which earliest development of the Y.S. and Lacovia systems was recommended since both systems showed promise of high economic viability and a substantial contribution to the national economy.

4.2.3 Area to be developed

Based on the outcome and recommendation of the Pre-feasibility study, a feasibility study on agricultural development was made in the areas of the Y.S. and Lacovia systems. From the viewpoint of topography and irrigation water sources, the development area was divided into 3 main area and further to 6 sub-areas (see Fig. 6). Their boundaries have been carefully examined and measured by planimeter. Consequently, the physical areas were revised from those given in the Pre-feasibility Report. The gross and net irrigable areas selected are shown in the following table.

Unit: ha (acre)

Area	Gross	Net
Black River Right Bank		
Holland	680 (1,700)	560 (1,400)
Black River Left Bank		
Hatfield	300 (750)	220 (550)
Styx River Basin	400 (1,000)	300 (750)
Frenchman-Holiday Pen	500 (1,250)	400 (1,000)
Broad River Basin		
Broad River Right Bank	1,000 (2,500)	800 (2,000)
Broad River Left Bank	1,000 (2,500)	800 (2,000)
Total	3,880 (9,700)	3,080 (7,700)

As shown in Table 5 about 1,020 ha of the Holland Estate area, of which 600 ha were planted with sugar cane in 1984, was excluded from the proposed development area.

4.2.4 Study of alternative development plans

1) Basic Considerations

For the project formulation, the following basic considerations were incorporated in the study:

i) Water Resources

In the Black River basin, there are four major rivers, i.e. the Black River main stem, the Y.S. River, the Middle Quarters River and the Broad River. Among them, both the Black River main stem and the Y.S. River provide an ample perennial flow, while both the Middle Quarters River and the Broad River have quite a limited flow. The runoff of the Black and Y.S. Rivers would be sufficient to irrigate more than 8,000 ha (20,000 acres) except for the three months of February, March and April, if proper water management be made. The river flow of both the Middle Quarters and Broad Rivers is mainly the outflow of groundwater. Along both of these Rivers there are notable herbaceous swamps and precious wild-life, so the impact of changing the regime of above two rivers as irrigation water sources would be significant. Accordingly, the Middle Quarters and the Broad Rivers will not be utilized.

ii) Pedro Plain Agricultural Development Project

The Pedro Plain has quite a high potential for agricultural development with a net area of about 1,830 ha (4,520 acre) if irrigation water is available. Because of the severe shortage of irrigation water resources, the present area developed for agriculture is restricted to about 670 ha (1,670 acre). Consequently, diversion of water from the Black River to the Pedro Plain has been contemplated in the past, but implementation has been precluded by the considerable construction cost required for the head reach from the Black River to the Project area.

iii) Deep Peat Marsh Land

In the lowland of the Project area there are about 5,600 ha of marsh land composed of peat. The peat layer ranges from 1m to 10m in depth. From the viewpoint of physical soil properties, particularly of ground bearing capacity for mechanized farming, and soil subsidence due to consolidation as well as oxidation after its implementation, and

economical development, those areas with peat of more than 4m thick are excluded from the proposed development.

2) Alternative 1 (Full scale development plan)

As shown in Fig. 7, flood protection dikes of about 13 km in length will be required along both banks of the Black River, and of about 12 km along both banks of the Broad River. Four drainage pump stations would be needed. The total area to be developed would be about 3,080 ha (7,700 acre) net area of which 560 ha (1,400 acre) would be irrigated by gravity through about 1.6 km of head reach from the Y.S. River. Irrigation water for the left bank area of the Black River and areas located on both banks of the Broad River would be pumped up from the Black River and then diverted to the fields through irrigation canals.

In addition, 1.7 m^3/sec. of irrigation water required for the Pedro Plain would be pumped up from the Black River and be diverted through main canals for both banks of the Broad River. Of the 1.7 m^3/sec, 0.57 m^3/sec would be returned to the Broad River at Salt Spring bridge for possible use on the Pedro Plain. The remaining 1.13 m^3/sec would be supplied near to Mountainside. Although the enlargement of the canal capacity and additional secondary canal construction would be required, the construction cost for the Pedro Plain would be substantially reduced.

3) Alternative 2 (Medium scale development plan)

Both bank areas extending along the Black River main stem would be developed as in Alternative 1. For environmental reasons, the surroundings of the Broad River as well as the left bank area would be left as it is. Three drainage pump stations would to be constructed. Irrigation water for the Pedro Plain, if required, would be diverted to the Broad River through a diversion canal. The irrigable land would be about 800 ha (2,000 acres) less than in the Alternative 1, resulting in about 2,280 ha (5,700 acres) of irrigable land to be developed.

4) Alternative 3 (Small scale development plan)

In order to minimize the environmental impacts due to agricultural development in the basin, land along the banks of the Black River would be only developed. The construction of two drainage pump stations would be sufficient. No provision would be made for diverting water to the

Pedro Plain area. The total irrigable area would be about 1,480 ha (3,700 acres).

5) Alternative 4 (Black River diversion plan)

In order to maximise the development area along the banks of Black River, water from the Black River main stem would be diverted to the Broad River at about 1 km downstream from the Lacovia bridge by constructing a diversion dike and canal. The net irrigation area would be increased by about 20 ha. Although the height of the polder dikes along the banks of the Black River could be lowered by about 1m, considerable amounts of embankment would be required for a diversion dike in addition to rock excavation for the diversion channel to the Broad River basin, which would result in a substantial increase in construction costs. Moreover, because of flood flows containing sediment from the Black River, the notable uniqueness of the ecosystem in the Broad River basin, particularly the aquatic vegetation surrounding the Blue Holes, would be seriously damaged. On the other hand, the Pedro Plain would benefit by getting irrigation water from the Broad River through provision of an inlet channel.

6) Economic comparison

A comparative study of the development scale is made for above 4 alternative plans shown in Fig. 7. Table 7 shows the main features of each alternative. A general economic comparison was made in terms of EIRR, Net Present Value (NPV), B/C ratio and etc. for three alternatives, 1, 2 and 3. Alternative 4 was omitted from the economic evaluation due to extremely high construction cost required for diversion works from the Black River to the Broad River. The following table shows the result of the economic comparison (see Tables I-4 and I-5 in Annex I).

	Unit	Alternative Development Plan		
		1	2	3
Net irrigation area	ha	3,080	2,280	1,480
"	acre	7,700	5,700	3,700
Economic Construction cost	10^3US$	33,570	25,480	17,110
Annual benefit	10^3US$	8,130	6,120	4,380
EIRR	%	13.4	14.1	15.6
Net Present Value (at 10%)	10^3US$	11,010	9,840	8,660
B/C (at 10%)		1.3	1.4	1.5
Annual production of paddy	ton	28,950	21,750	14,550
Annual foreign exchange saving	10^3US$	3,000	2,300	1,500