GOVERNMENT OF JAMAICA

FEASIBILITY REPORT
ON
THE MODERNIZATION AND EXPANSION
OF
THE RIO COBRE IRRIGATION SCHEME

VOLUME I
MAIN REPORT

JUNE 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of Jamaica, the Japanese Government decided to conduct a survey on the Feasibility Study on the Modernization and Expansion of the Rio Cobre Irrigation Scheme and entrusted the survey to the Japan International Cooperation Agency. The J.I.C.A. sent to Jamaica a survey team headed by Mr. Shinichi Yano, Nippon Koei Ltd. from February to November, 1986.

The team exchanged views 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.

June, 1987

Keisuke Arita
President
Japan International Cooperation Agency

June, 1987

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 Report on the Modernization and Expansion of the Rio Cobre Irrigation Scheme for the consideration of the Government of Jamaica.

The report submitted consists of:

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

The Main Report contains an agricultural development plan and recommendations for successful development of the project. The plan and its evaluation indicate high economic and technical viability, and that implementation would provide subject area but in Jamaica as a whole. The Annex Report contains detailed analyses and discussions in fourteen sectors to support the development plan presented in the Main Report.

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

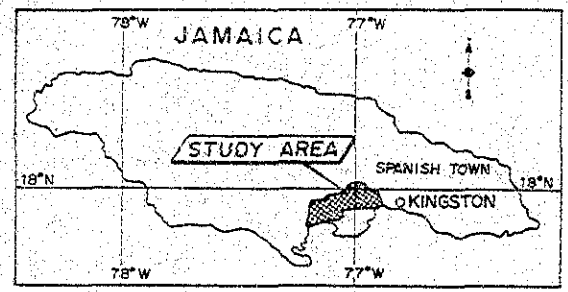
In conclusion, the Study Team sincerely hope that the results of this study will contribute to the socio-economic development, future agricultural development, and well-being of Jamaica.

Yours sincerely,

S. Yano

Shinichi Yano
Team Leader

LOCATION MAP



LEGEND

- BOUNDARY OF STUDY AREA
- CANAL
- ROAD
- RAILWAY
- RIVER / GULLY
- RIO COBRE EAST
- RIO COBRE WEST
- ST. DOROTHY
- SMALL FARMER

TO BOG WALK
DAM
MAIN CHASE
RIO COBRE RIVER
SPANISH TOWN
CATHARINE
TO KINGSTON
TO KINGSTON
OLD HARBOUR BRANCH
DUNBELL LINE BRANCH
BERNARD LODGE
PORTMORE
PORT HENDERSON BRANCH
PORT HENDERSON HILL
COLBECK
FLEMMING RIVER
FRASERS GULLY
SPRING VILLAGE
OLD HARBOUR
FREE TOWN CANAL
TO MAYPEN
TOWN
BOWERS RIVER
OLD HARBOUR BAY
SALT ISLAND CREEK
SALT ISLAND LAGOON
HELLSHIRE HILL
GREAT SALT POND
CARIBBEAN SEA
CARIBBEAN SEA
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SCALE
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SUMMARY AND RECOMMENDATION

INTRODUCTION

1. The Government of Jamaica requested the Government of Japan to carry out a feasibility study on the Modernization and Expansion of the Rio Cobre Irrigation Scheme (the project) in July 1985. In response to this, 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. The Scope of Work for the feasibility study was agreed upon between the Government of Jamaica and Japan International Cooperation Agency (JICA) in December 1985.

2. This Report presents the results of the field survey and feasibility study on the Modernization and Expansion of the Rio Cobre Irrigation Scheme in accordance with the national policy and plan, which aims to attain self-sufficiency in food production, to diversify agriculture and to increase production of exportable crops through irrigation and drainage development of approximately 14,620 ha.

3. The Government of Jamaica has laid great emphasis on the need for a substantial increase in food production. A comprehensive development study on the Rio Cobre area was performed in 1974 with the cooperation of UNDP/FAO. The study results indicated that there was a great potential for agricultural development. As a result, the Government of Jamaica has given high priority to the development of this area.

4. In accordance with the Scope of Work for the feasibility study, JICA sent a study team to the site from February to March, 1986. Collection and processing of the basic data as well as review of irrigation and drainage infrastructures, agriculture, sociology and agricultural institutions were initiated as a First Phase of the field survey. Subsequently, JICA sent a Second Phase field survey team in July 1986. The field survey and feasibility study of the overall development plan were carried out in this Second Phase of the field survey. An Interim Report presenting preliminary conclusions on the comprehensive development plan was prepared in November 1986. A Draft Final Report was presented to the Government of Jamaica at the end of February 1987. Then the Final Report is prepared and submitted in June 1987.

5. Meanwhile, a project loan and grant agreement was signed in September 1985 between the Government of Jamaica and the United States of America. The purpose of this project is to reinforce the institutional capacity of Agro 21 to promote and develop private commercial agricultural investment in Jamaica. To accomplish this, the project will assist Agro 21 in the initial phase of its recently initiated crop diversification programme, focusing on two underutilized sugar estates in the St. Catherine Plain area.

NATIONAL ECONOMIC AND AGRICULTURAL BACKGROUND

6. The island of Jamaica covers approximately 10,947 km^2 (4,231 square miles) of which the parish of St. Catherine occupies approximately 1,195 km^2 (461 square miles). The population of Jamaica was approximately 2.3 million with a density of 212 persons/km^2 (550 persons/square mile) in 1985. The annual growth rate of the population during the period from 1970 to 1982 was 1.4%. The population in the parish of St. Catherine was approximately 332,700 in 1982, or 280 persons/km^2.

7. After almost a decade of decline, the Jamaican economy began to recover in 1981 to 1983. However, a further downturn in the economy of Jamaica began to be evident in 1984. The GDP at 1974 constant prices was approximately J$ 1,853 million in 1985 with an annual growth rate of –3.7%. The GDP at current prices in 1985 was approximately J$ 11,025 million with an annual growth rate of 20.6%. This growth rate is low when compared with the 32.5% in 1984.

8. The new national approach to agriculture combines the application of modern technology with proper planning and targeted marketing to deal with agriculture on a business-like basis. Agro 21 has given top priority treatment to (i) reversing the decline in agricultural exports, (ii) development of other non-traditional crops for export, (iii) development of new agricultural opportunities, and (iv) import substitution of foodstuffs.

THE STUDY AREA

9. The study area is situated in the eastern part of Jamaica near the southern coast in the parish of St. Catherine. The study area covers approximately 27,400 ha (67,700 acres). The study area is bounded by mountains on the north, by the seashore and Hellshire on the south, by the parish of St. Andrew and the seashore on the east and by the boundary of the parish of Clarendon on the west, Spanish Town, the capital of the parish, lies in the centre of the area, and approximately 22 km (14 miles) west of Kingston.

10. The population in the study area in 1982 was 129,690 with a density of 473 persons/km^2 (1,223 persons/square mile), which is much higher than the national average. The average annual growth rate in the study area was estimated at 5.6% during the period from 1970 to 1982 which was considered to have been due to urbanization in the eastern area, migration from rural areas and new industrial development.

11. A tropical oceanic climate prevails in the study area. The mean annual temperature from 1931 to 1980 was 25.2°C (77.4°F) at Bernard Lodge and 24.9°C (96.8°F) at Bodles. The three months from January through March are relatively cool, while the period from July through September is warm in the study area. Average annual rainfalls are 721 mm (28.4 in.) at Smallwoods and 1,183 mm (46.5 in) at Old Harbour, of which about 70% occurs during the period from May to October. Pan

evaporation at Bernard Lodge averages 5.14 mm (0.20 in.)/day, and at Bodles 5.50 mm (0,22 in.)/day.

12. There are eight rivers and gullies in the study area, among which the Rio Cobre and the Spring Garden rivers are perennial, but river flow in the Spring Garden is negligible in the dry season. Average annual runoff of the Rio Cobre is about 10.0 m^3/sec (353 cfs) at the Rio Cobre dam site which varies from 5.5 m^3/sec (194 cfs) in March to 18.3 m^3/sec (647 cfs) in October. From probability analysis the annual low flow in 1:5 year chance of occurrence is calculated to be 6.5 m^3/sec (230 cfs).

13. Three main geomorphological features, dissected highlands, karstlands and alluvial plains, are found in and around the study area. The dissected highlands, which include impermeable Cretaceous deposits, have been denuded to form steep sided valleys. The karstlands comprise the Tertiary carbonate formations. The alluvial plains forms a gently sloping area between the limestone foothills in the north and the shore in the south excluding the Hellshire and Port Henderson hills. The stratigraphic sequence in and around the study area consists of Cretaceous volcaniclastics, the Yellow Limestone Group of the early Tertiary, the White Limestone Group of the mid-late Tertiary and the alluvium of the late Quaternary. The Cretaceous volcaniclastics and the Yellow Limestone Group are found in the northwest highlands of the study area and form an impermeable basal complex. The White Limestone Group outcrops in the karstlands, the inland hills, and in the Hellshire and Port Henderson hills. The alluvium overlies the White Limestone Group in the coastal flat areas, and varies in thickness from a few meters at the foothills to about 180 m. The basic structure in and around the study area is of a basement of folded Cretaceous volcaniclastics overlain by the Tertiary limestones. The Rio Cobre basin is dissected by several faults of northwest-southeast set and east-west set.

14. There are about 140 production wells in the study area, from which groundwater is pumped up from both the limestone aquifer and the alluvial aquifer. The annual total production averages 85.9 million m^3 (112.3 million cy) from 1970 to 1980. Most of the limestone aquifer wells are located on the northern part of the study area. Some parts of the limestone aquifer have been contaminated by saline water intrusion, which is caused by over-pumping and high draw-downs. The alluvial aquifer overlies the limestone aquifer in the alluvial plain over most of the study area. Annual production from the alluvial aquifer wells was 40 million m^3 (52.3 million cy) in 1972.

15. The main water resources available in the study area are surface water and groundwater. The Rio Cobre is the only river of which water is available for irrigation throughout the year. Other rivers such as the Plantain river, Coleburns gully and Black river have negligibly small discharges especially in the dry season. The annual mean discharge of the Rio Cobre at the dam site is approximately 315 million m^3 (10.0 m^3/sec on average) and annual discharge of the drought year with 1:5 year chance of occurrence is estimated at 202 million m^3 (6.5 m^3/sec on average).

Annual optimal yield of extraction from the limestone and alluvial aquifers in the study area were assessed at 104 and 36 million m^3 respectively under the drought year conditions.

The table below shows availability of both water resources in the study area under the drought year conditions.

(Unit: million m^3/year)

Source		Volume
Surface water	(Rio Cobre)	202
Groundwater	(Limestone basin)	104
	(Alluvial basin)	36
Total		342

16. Soils in the study area are derived from the three (3) parent materials, limestone, old alluvium and recent alluvium. Except for shallow soils with limestone outcrops and strong salinity land along the coastal zone, most of the land are generally suitable for upland crops and rice if irrigation water is fully available.

17. Conspicuous land uses in the study area are sugarcane, pasture and ruinate. Sugarcane occupies about 8,900 ha (22,000 acres), 42% of arable land at present. Pasture covers approximately 2,700 ha (6,670 acres), about 13% and ruinate, woodland and swamp approximately 7,560 ha (18,700 acres), about 36%. Vegetable/crop with about 920 ha (1,700 acres), about 3% is cultivated on the recent alluvial soils. Tobacco is only grown in St. Dorothy North, accounting for about 190 ha (470 acres), about 1%. Orchards occupy about 320 ha (790 acres), about 2% mostly grown in the west part of the study area. Recently paddy cultivation of 390 ha (960 acres), about 2%, was introduced at Amity Hall. Aquaculture of about 210 ha (500 acres), about 1% is practiced on the clayey land.

18. The yield of sugarcane in four (4) estates averages 61 ton/ha, and their annual production in 1986 was about 250,000 ton of cane. Vegetables are of calaloo, pumpkin, tomato, cucumber, okra, onion, sweet pepper, watermelon, etc. The average yields range from 6.3 ton/ha for okra to 13.8 ton/ha for cucumber. The average yield of the first crop of paddy in 1986 was about 5 ton/ha (4,500 lb/acre) which was quite a high yield for a first crop. The yield of dried leaves of tobacco at Colbeck in St. Dorothy North is 1.3 to 1.7 ton/ha.

19. Sugarcane is generally harvested once a year both in replants and 4 to 5 ratoons. Farming is semi-mechanized. With the expansion of overseas markets, farmers are encouraged to lengthen the planting seasons of some vegetables for year-round export trade. The planting season of these vegetables is September to January for the first season and April to July for the secondary season. The cropping pattern of paddy is rice-rice-rice throughout the year, averaging 2.5 crops per year. Field operations are all mechanized using farm machinery and aircraft. Improved pastures are found on large farm holdings which rear dairy cattle in St. Dorothy South, while

unimproved pastures are predominant on most beef cattle farms owing to lack of water.

20. The People's Cooperative Banks (PC Banks) of St. Dorothy, St. Thomas-Ye-Vale, Northwest St. Catherine and Stony Hill provide agricultural credits in the study area. Commercial banks also provide agricultural credit in the study area. PC Banks provide farmers with loans: short term (2 years); medium term (up to 7 years); and long term (up to 12 years) with an interest rate of 12% per annum. While, commercial banks supply only medium term (up to 7 years) and long term loan (up to 12 years) with an interest rate of 15% per annum.

21. There are two irrigation schemes in the study area, the Rio Cobre irrigation system implemented in 1874 and operated directly by the Rio Cobre Irrigation Works, and St. Dorothy irrigation system initiated in 1963 and operated by the St. Dorothy Plain Irrigation Authority, both under the Ministry of Agriculture. These two systems presently irrigate approximately 11,370 ha (28,100 acres) gross with water from the Rio Cobre and water supplemented by pumping from wells. However, much of the irrigable land does not receive adequate water for farming every year, particularly in the dry season, due to deteriorated irrigation facilities and poor water management.

22. Water diverted from the Rio Cobre at the headworks is delivered to the irrigable land through about 54 km (34 miles) of unlined main and branch canals. The main canal was designed for a conveyance capacity of 8.8 m^3/sec (310 cusecs) at its head, but the present capacity has been substantially reduced to about 3.2 m^3/sec (113 cusecs) due to deterioration, siltation and weeding of canal. This scheme covers approximately 9,500 ha (23,500 acres) gross.

23. There are seven (7) deep wells under the St. Dorothy irrigation system. Free Town station, with the largest capacity, diverts water of 0.55 m^3/sec (2,600 cy/hr) to the sugarcane land through about 2.8 km (1.7 miles) of woodstave pipeline and about 25 km (7 miles) long of canals. The wooden stave pipeline has been severely deteriorated, resulting in substantial loss of water pumped up. The others are properly operated.

24. Agro 21 is currently engaged in a crop diversification and irrigation programme in two estates, Caymanas and Bernard Lodge, covering approximately 6,150 ha (15,000 acres) under grant and loan aid provided by the Government of United States of America. The purpose of the project is (1) to rehabilitate the existing irrigation infrastructures of the Rio Cobre Irrigation Works, (2) to reinforce the institutional capacity of Agro 21 to promote and develop private commercial agricultural investment, (3) to upgrade the Government's ability to efficiently operate and maintain the rehabilitated system and (4) to establish a small farmer 'linkage' programme at Agro 21 to help upgrade the small producers.

THE PROJECT

25. The project has been formulated to maximize potential agricultural benefits through efficient use of land and water resources. The main concepts of the project are:

- to modernize and expand the present irrigation system by reconstructing and improving existing infrastructures,
- to introduce diversified cropping patterns including non-traditional crops into the annual rotation of cropping,
- to increase and stabilize yields and production of crops by means of sound management of irrigation and drainage,
- to achieve successful small scale farmer enhancement through appropriate training and agricultural support services, and
- to promote the levelling up of living standards and more equitable distribution of income to the people.

26. In order to select the potential development area from the study area of about 27,400 ha, the following factors were taken into consideration:

(i) Land capability classification,
(ii) Present land use,
(iii) Irrigability, and
(iv) Drainability.

The potential development area thus selected is 15,330 ha.

27. Several alternative studies were made based on irrigation system for the potential development area of 15,330 ha. As a result, approximately 14,620 ha was selected for the project area. The area is bounded by Caymanas branch, Old Harbour branch and Free Town canals on the north, by the marshy land along the seashore and Hellshire on the south, by the Portmore residential area on the east and by the Bowers river on the west. The area is divided into three in terms of irrigation water sources as shown below:

Area	Ha	Acres
Rio Cobre East	7,100	(17,540)
Rio Cobre West	6,030	(14,900)
St. Dorothy	1,490	(3,680)
Total	14,620	(36,120)

28. Proposed land use within the project area under new irrigation system was based on government policy, present land use and agricultural conditions, soil condition and crop suitability, agro-economic and social conditions including farmers intentions. The Rio Cobre East area where the crop diversification programme is underway by Agro 21, will be developed for diversified winter vegetables with grains, ornamental

crops, orchards and aquaculture. The Government policy on national land use in the Rio Cobre West area is to continue production of sugarcane for sugar in Innswood, and to expand paddy fields and increase rice production in Amity Hall and Hartlands. Since paddy is an important crop in the self sufficiency programme, paddy is proposed to be introduced on saline clay soils both on national and some privately-owned lands of the area. On the other privately-owned land of the area, vegetable/crop and pasture are proposed to be expanded. In the St. Dorothy area, land use is formulated to expand the present land use pattern, mainly sugarcane, pasture and vegetables, through improvement of cultural practices and expansion of the area under increased irrigation water. In the small farmers areas included in the irrigation area of Rio Cobre East, proposed land use is formulated as vegetable/crop with some orchards in Lawrencefield and paddy and aquaculture in Hartlands and Town gully areas.

29. In vegetable/crop category, the cropping pattern is divided into vegetables-grains in Agro 21 area and vegetables-vegetables in the other areas of privately-owned lands. Cropping pattern in paddy category includes rice-rice and rice-grains due to water supply and soil conditions. The grains subsequent to rice or vegetables include maize and soybean.

30. After implementation of the entire project, the following yields are expected:

Sugarcane	:	79 ton/ha
Vegetables	:	10 ton to 30 ton/ha
Paddy	:	5 ton/ha
Maize	:	6 ton/ha
Soybeans	:	2.5 ton/ha
Fruits (mango)	:	9.4 ton/ha (matured tree)
Milk	:	16 ton/ha
Beef	:	3.8 ton/ha
Fish	:	7.0 ton/ha

31. In order to examine the optimum scale of reservoir, a water balance study between the demand (water requirement) and supply (surface water and groundwater) was made for a period of 29 years from 1955 to 1983 based on the benefited areas stated above. The maximum deficit was estimated to be approximately 110 million m^3 in 1976 whereas the minimum is nil. An economic comparative study was made between cost and benefit in terms of B/C and B-C during the said period. As a result, the optimum scale of reservoir was estimated to be approximately 15 million m^3. It was noted that the optimum scale thus determined on the basis of the average of 29 years fulfills the requirements of a once in five years dry year.

32. The main civil works proposed in the Rio Cobre irrigation system are rehabilitation of headworks, improvement of irrigation main, branch and minor branch canals as well as their related structures, and construction of reservoirs. In the St. Dorothy irrigation system replacement of the existing woodstave pipeline by ductile iron pipe and improvement of irrigation canals are proposed. All irrigation canals are proposed

to be lined with concrete with a view to raising irrigation efficiency and minimizing operation and maintenance costs.

33. In view of the rather limited surface water available and cost of irrigation water from wells, on-farm development works with introduction of improved irrigation systems are essential. The following four types of irrigation method will be applied for upland crops and paddy, taking into account the varieties of crops to be introduced, topographic conditions, and characteristics of irrigation method.

Furrow irrigation	:	Sugarcane
Sprinkler irrigation	:	Vegetables, pasture
Drip irrigation	:	Orchard crop
Basin irrigation	:	Paddy

34. The construction time required will be about four (4) years for detailed design, contract documents, tendering and construction works. The total construction cost was estimated to be about US$ 64.3 million equivalent at the exchange rate of J$ 5.5 per US$ 1.0, including a physical contingency of about 10% of the direct cost and a price contingency for four (4) years.

PROJECT EVALUATION

35. With proper water management of the irrigation system, and improved irrigation farming after implementation, the economic benefits should reach US$ 21.6 million. According to the proposed construction plan, the economic irrigation benefits will begin to accrue in 1991 with completion of the rehabilitation of dam and canals, and will gradually increase as more land became irrigable. The project will reach its anticipated maximum agricultural production seven (7) years after completion of the construction works. The benefits of curtailed operation costs of irrigation wells will begin to accrue in 1992 with completion of the reservoirs. The negative benefit will commence in 1989 when construction of the first reservoir will start. The negative benefit will increase to the full amount in 1991 when the second reservoir will construct.

36. The total economic construction cost of the project is estimated at US$ 52.3 million including on-farm development, O&M equipments, engineering services and physical contingency, but excluding price contingency. Major civil works will be undertaken by contractors using heavy equipment. The time required for construction of the project would be about four (4) years including detailed design, tendering and award of contracts.

37. The project evaluation was made based on economic project costs and benefits so far estimated in order to ascertain its feasibility from the economic viewpoint. The economic feasibility of the project was evaluated in terms of the economic internal rate of return (EIRR). The result shows 24.0% of EIRR. Therefore, the project is economically feasible.

RECOMMENDATION

38. The Modernization and Expansion of the Rio Cobre Irrigation system with approximately 14,620 ha is technically and economically feasible. Furthermore, the project would provide substantial and sustainable socio-economic benefits not only to the project area but also to Jamaica as a whole. Thus, it is recommended that the project be implemented as early as possible.

FUTURE RESEARCH AND DEVELOPMENT PLAN

39. To achieve successful implementation of this project, it will be indispensable to develop agricultural technology for the proposed cropping patterns through research and extension. Due to the importance of salinization and alkalinization in problems of land conservation and crop production, recommendations on technical measures toward salinity and alkalinity are subjected to be established by the execution of following investigation and research:

    - Investigations on causes of salinization and alkalinization.
    - Research on remedial measures toward salinity and alkalinity.

    Research on vegetables, ornamentals and tree crops is already undertaken with an adequate budget under the Export Crop Project with support funding through the World Bank. However, the rice research programme in Jamaica had terminated since BRUMDEC was turned over to Jamculture in 1985. There is also no research or technologist on on-farm irrigation technology in the island. Both technologies will be essential for the project. The followings are therefore recommended:

    - Establishment of a main Rice Research Station at Bodles Research Station for fundamental research.
    - Establishment of a test and pilot farm especially on saline clay soils.
    - Training of research and extension staff for on-farm irrigation technology.

40. It is possible that there is still room for further development of surface water resources in future. It is possible to create reservoirs by constructing dams on the Coleburns gully and the Plantain river which are through-flowing streams and flood discharge channels with fairly large catchment areas of 87.3 km^2 and 31.5 km^2 at the respective dam sites, and originating in the hills to the north. It is expected that approximately 1,000 ha of additional land would be irrigated by these two reservoirs. In addition, it is also anticipated that groundwater conditions downstream would be improved to certain extent owing to the stored water in the upper reaches. In this regard, it is recommended that basic data on hydrology, geology, hydrogeology, etc. be collected for later review of irrigation and drainage infrastructures, agriculture and sociology in and around the benefited area.

THE MODERNIZATION AND EXPANSION

OF

THE RIO COBRE IRRIGATION SCHEME

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GLOSSARIES

ACB	Agricultural Credit Bank of Jamaica Ltd.
ADC	Agricultural Development Corporation
AEO	Agricultural Extension Officer(s)
APJ	Agricultural Products of Jamaica
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
IAW	International Agro-management Workyard
IBRD	International Bank for Reconstruction and Development
IRCJ	International Rice Corporation of Jamaica
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
JTC	Jamaica Telephone Company Ltd.
MAFF	Ministry of Agriculture, Forestry and Fisheries, Japan
MOA	Ministry of Agriculture, Jamaica
NIC	National Irrigation Commission Ltd.
NWC	National Water Commission
O&M	Operation and Maintenance
PAHO	Pan American Health Organization
PCB	Peoples' Cooperative Bank (PC Bank)
PCJ	Petroleum Corporation of Jamaica
PIOJ	Planning Institute of Jamaica
PMO	Producers Marketing Organization
RCIW	Rio Cobre Irrigation Works
RPPD	Rural Physical Planning Division, MOA
SCVPA	St. Catherine Vegetable Producers Association
SDPIA	St. Dorothy Plain Irrigation Authority
SIA	Sugar Industry Authority
SIRI	Sugar Industry Research Institute
TIDCO	Tobacco Industry Development Company Limited
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
UWA	Underground Water Authority
UWI	University of the West Indies

ABBREVIATIONS

mm	:	milimetre
cm	:	centimetre
m	:	metre
km	:	kilometre
in.	:	inch
ft.	:	foot
yd.	:	yard
cm^2	:	square centimetre
m^2	:	square metre
km^2	:	square kilometre
ha	:	hectare
cc	:	cubic centimetre
cm^3	:	cubic centimetre
m^3	:	cubic metre
lit	:	litre
klit	:	kilolitre
ci	:	cubic inch
cf	:	cubic feet
cy	:	cubic yard
IG	:	imperial gallon
USG	:	US gallon
cusec	:	cubic feet per second
EC	:	electrical conductivity
m mho	:	micro mho
mS	:	milli Siemens

g	:	gramme
kg	:	kilogramme
ton	:	metric ton = 1,000 kg
lb	:	pound = 0.45 kg
sec	:	second
min	:	minute
hr	:	hour
%	:	per cent
ppm	:	parts per million
°C	:	degree Centigrade
°F	:	degree Fahrenheit
HP	:	Horse Power
kw	:	kilowatt
MW	:	megawatt
kv	:	kilovolt
PS	:	0.9865 HP = 0.7355 kw
J$	:	Jamaican dollar
US$	:	US dollar
¥	:	Japanese yen
CEC	:	cation exchange capacity
meq	:	milliequivalent

1. INTRODUCTION

1.1 Authority

This report is prepared in accordance with Article IV (2) in the Scope of Work for the Feasibility Study on the Modernization and Expansion of the Rio Cobre Irrigation Scheme in Jamaica as agreed between the Planning Institute of Jamaica (PIOJ) and the Japan International Cooperation Agency (JICA) on 16th December, 1985.

This Final Report presents findings on present conditions in and around the study 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 the counterparts provided by the Government of Jamaica during the period from mid-February 1986 to June 1987.

1.2 Project History

After 1973, real per capita Gross Domestic Products (GDP) declined every year mainly as a result of external shocks, the increase in energy costs, the impact of the recession in the industrial countries on sugar and aluminium and the increase of interest rates in international capital markets. The Gross Domestic Product increased from J$ 9,145 million in 1984 to J$ 11,025 million at 1985 at current prices, an increase of 20.6% per annum. However, the real GDP is estimated to have decreased by 3.7% per annum.

The scope of agriculture in generating economic growth in the recent years was not fully realized with the result of a decline in production, particularly of the traditional export crops; banana and sugarcane. With the decline in the earnings of the bauxite/alumina industry, agriculture is being seen as one of the most promising sectors for generating economic growth given its capacity to provide foreign exchange earnings as well as to reduce Jamaica's dependence on imported foodstuffs. For this reason, Agro 21 was launched in 1983 with emphasis on non-traditional export crops, fishery and livestock, crop-zoning, optimal land use, efficient management and implementation of discrete commercially viable projects employing advanced technology.

In 1983, the Government of Jamaica also introduced a Five Year Food and Agricultural Policy and Production Plan 1983/84 to 1987/88, to ensure sustained social and economic progress in Jamaica through modernization and transformation of agriculture. The major objectives of the Plan are to attain self-sufficiency in food production, to diversify agriculture, and to increase production of exportable crops. Within the framework of the Plan, the development, rehabilitation and improvement of several irrigation projects were assigned highest priority. The Modernization and Expansion of the Rio Cobre Irrigation Scheme is one of these priority projects.

The Rio Cobre irrigation system, started in 1870 was the first major endeavour by the Government to develop irrigated agriculture. Construction of a diversion dam across the Rio Cobre river was completed in 1874. It is a gravity flow system deriving the bulk of its water from the Rio Cobre dam. The St. Dorothy irrigation system, also within the

study area, was started in 1962. This (Free Town irrigation system) is a lift irrigation system depending on two (2) deep wells drilled into the limestone aquifer. The water is delivered through a woodstave pipeline and concrete flume.

For the modernization and expansion of the above, the Government of Jamaica has carried out various studies with technical and financial assistance from foreign countries and international agencies. A comprehensive study on the Rio Cobre and St. Dorothy irrigation system was performed in 1974 with the Cooperation of UNDP/FAO. The study results indicated that there is a great potential for agricultural development. It was suggested in the technical report that the irrigation efficiency can be raised through improved operation and maintenance in supply and conveyance to the field, together with improved land and water management on the farm. The Government has given high priority to the development of these systems.

In July 1985, the Government of Jamaica made a request to the Government of Japan for technical assistance in a feasibility study on the development of the Rio Cobre basin. In response to this request, JICA which is entrusted by the Government of Japan with the execution of the above study agreed to undertake the Feasibility Study on the Modernization and Expansion of the Rio Cobre Irrigation Scheme, and dispatched a Preliminary Survey Team headed by Mr. Y. Dokyu to Jamaica from 5th December to 19th December, 1985 to conduct a preliminary survey of the proposed study area as well as to work out the Scope of Work for the feasibility study.

Meanwhile, a project loan and grant agreement had been signed on 25th September, 1985 between the Government of Jamaica and the United States of America. The purpose of this project is to reinforce the institutional capacity of Agro 21 to promote and develop private commercial agricultural investment in Jamaica. To accomplish above, this project will assist Agro 21 in the initial phase of its recently initiated crop diversification programme, focusing on two underutilized sugar estates in the St. Catherine Plain area.

1.3 Objectives of the Study

The objectives of the study are:

(1) to formulate the project and verify its technical and economic feasibility, and
(2) to undertake on-the-job training and transfer of technology to the Jamaican counterparts in the course of the study.

1.4 Outline of the Study

In order to achieve the objectives mentioned above, the study will cover the following items:

(1) Study area

The study area will be about 27,400 ha located around Spanish Town, capital of St. Catherine parish to the west of Kingston.

(2) Scope of work

The activities to be undertaken by the Study Team will be divided into field works in Jamaica and home office works in Japan.

(a) Work I (Field Work)

The field works will cover the following items:

(i) To collect and review the relevant existing data and information including:

- Topography,
- Meteorology and hydrology,
- Domestic water supply,
- Geology and hydrogeology,
- Soil and land use,
- Soil mechanics and construction materials,
- Irrigation and drainage,
- Agriculture and agro-economy,
- Sociology and socio-economy,
- Agricultural institutions,
- Existing agricultural development plans, and
- Others

(ii) To carry out supplemental data collection and field investigations in the study area, including the following items:

- Topographical survey in and around the major structures,
- Meteorological survey and hydrological survey,
- Geological survey,
- Groundwater survey,
- Land use and soil classification survey,
- Cropping pattern survey,
- Agro/socio economic survey including agricultural institutions, and
- Data collection and analysis to secure construction materials and to estimate project cost.

(b) Work II (Home Office Works)

The following home office works will be conducted in accordance with findings of the field survey:

- To formulate the agricultural development plan in the study area,
- To formulate the irrigation and drainage plan and the land use plan for the project,

- To prepare the rehabilitation plan for the existing major structures and their preliminary design for the project,
- To formulate the plan of operation and maintenance for water control and major structures,
- To formulate a plan for organization and operation for the project,
- To prepare the implementation schedule of the project,
- To estimate the costs and benefits of the project, and
- To make economic and financial analysis for the project.

1.5 Plan of Operation for the Study

The study area covers approximately 27,400 ha (67,650 acres). Spanish Town, the capital of the parish of St. Catherine is located in the centre of the study area, which is bounded by the mountains to the north, by seashore and Hellshire Hills to the south, by the parish of St. Andrew and Green Bay to the east and by the boundary of the parish of Clarendon to the west.

The study was scheduled over about 16 months from February 1986 to June 1987, and was divided into two stages, the first from February to June 1986, and the second stage from July 1986 to June 1987.

(1) First stage (February to June 1986)

The study during this stage was aimed mainly at grasping general conditions in the study area in the dry season, and collecting and processing the basic data on meteorology and hydrology, geology and hydrogeology, soils and land use as well as checking of topographic maps at a scale of 1 to 5,000. A review of irrigation and drainage infrastructures, agriculture, sociology and agricultural institutions as well as existing agricultural development plans was also be made. A Progress Report providing the results of analyses of data and information obtained during the first stage surveys was submitted to the Government of Jamaica on 15th July, 1986.

(2) Second stage (July 1986 to June 1987)

The field work was planned to clarify constraints encountered in the study area, and to formulate a preliminary comprehensive development plan based on the results of study in the field. The field survey lasted from July to November 1986, and an Interim Report presenting preliminary conclusions on the comprehensive development plan was prepared at the end of the field work. The above comprehensive development plan has been reviewed in Japan based on the data obtained and the results of the survey. The definitive agricultural development plan for the selected area has been formulated and its technical soundness and economic viability checked. The results of this work were presented in a Draft Final Report which was discussed in Jamaica at the middle of March 1987. The Final Report is submitted in June 1987.

1.6 Activities of the Study Team

The activities of the Study Team have been broadly divided into two parts; the field surveys in Jamaica and home office works in Japan.

(1) Field surveys

(a) Overall field reconnaissance,
(b) Collection and review of the relevant data and information,
(c) Meteorological and hydrological investigations,
(d) Geological and hydro-geological investigations,
(e) Soil and land use surveys,
(f) Irrigation and drainage surveys,
(g) Agricultural, agro-economic and socio-economic surveys,
(h) Formulation of the development plan including preliminary agricultural development and irrigation development plans as well as tentative economic viability and justification, and
(i) On-the-job training of Jamaican counterparts in the course of field works.

(2) Home office works

(a) Preparation of Final Reports based on analysis of field data and information and the results of discussion with the Jamaican Authorities concerned,
(b) Preliminary design, cost estimates and construction time schedule, and
(c) Evaluation and justification.

JICA Study Team carried out the field surveys and investigations of the First Stage in Jamaica commencing from 9th February, 1986 for about one and half months. The Plan of Operation for the Study prepared by the JICA Study Team was agreed on 14th February between the Planning Institute of Jamaica and the JICA Study Team with the attendance of the JICA Advisory Team, Mr. Y. Dokyu, the leader of the Advisory team. The Field Report was prepared on the basis of the findings and data collected during the field survey and in collaboration with the counterparts. It was submitted to the Ministry of Agriculture on 17th March, 1986.

Home office work of the First Stage was done in Japan from the middle of May to the middle of June based on the findings and data collected in the field survey. The Progress Report set out the results of analyses of data collected and the second stage investigation programme and was submitted to the Ministry of Agriculture on 15th July, 1986.

JICA Study Team resumed the field survey and investigation of the Second Stage in Jamaica from 15th July, 1986 for about four and half months. The Progress Report prepared by the JICA Study Team was explained in the presence of the representatives of the Jamaican Agencies concerned. The members of the Advisory Committee of the Government of Japan and the JICA Study Team had meeting with PIOJ, MOA, Agro 21 and USAID to exchange views on agricultural development in the St. Catherine Plains. The Interim Report presenting preliminary conclusions on the comprehensive

development plan was prepared at the end of the field work in Jamaica. The above comprehensive development plan has been reviewed in Japan based on the data obtained and the results of the survey. The definitive agricultural development plan for the selected area has been formulated and its technical soundness and economic viability checked. The results of this work were presented in a Draft Final Report which was discussed in Jamaica at the middle of March 1987. The Final Report was prepared taking into account the comments made by the Government of Jamaica on the Draft Final Report and is submitted in June 1987.

The members of the Scope of Work Mission (the Preliminary Survey Team), the Advisory Team and the Feasibility Study Team dispatched, and the counterpart personnel provided by the Government of Jamaica are listed in Table 1 and Minutes of Understanding for the project are given in ATTACHMENT.

2. NATIONAL ECONOMIC AND AGRICULTURAL BACKGROUND

2.1 Land and Human Resources

2.1.1 Land resources

The island of Jamaica lies between 76°11' to 78°22' west longitudes and 17°42' to 18°31' north latitudes having a total land area of 10,947 km^2 (4,231 square miles). A central mountain range runs east to west with the highest summit in the Blue Mountains at an elevation of 2,258 m (7,402 ft.). Almost half of Jamaica's land area is over 305 m (1,000 ft.) above mean sea level.

Jamaica has a maritime tropical climate characterized by warm trade winds generally known as the north east trade winds. The annual average rainfall ranges from nearly 7,600 mm (300 in.) in the Blue Mountain to less than 760 mm (30 in.) in some part of the south coast. The average annual rainfall for the island is 1,970 mm (78 in.). The annual mean temperature near sea level is 25.6°C (78°F).

2.1.2 Human resources

The population in 1985 stood at an estimated 2.3 million with a density of 212 persons/km^2 (550 persons/square mile), representing an increase of 1.3% above the 1984 figure. This growth rate is low when compared with the last four (4) years. Emigration has been an important determinant of population changes in Jamaica acting as a brake on the rate of growth. From a study of past trends in the components of growth a set of projections for the period 1985 to 2015 has been prepared by the Statistical Institute of Jamaica. According to this projection, the total population of Jamaica will be 3.2 million by the year 2015.

In 1975, the productive sectors accounted for 53% of the total employed labour force, moving to 54% in 1985. The level of employment in the productive sectors has shown steady growth since 1983, with a 6.5% growth in 1985. The greater part of this increase was Agriculture, Forestry and Fisheries, which make up two thirds of the employed labour force in the productive sectors and approximately one third of the total employed labour force, which was considered to be attributable to introduction of new agricultural programmes. In 1985, the number of unemployed persons was estimated to be 0.27 million or 25.6% of the total labour force. Such high unemployment has been relatively unchanged over the last four (4) years with unemployment rates ranging from 25.6% to 28.2%.

2.2 National Economic Background

2.2 1 National economy

The economy of Jamaica is slowly emerging from almost a decade of decline in the 1970's. The economy began to recover in 1981 to 1983 but another downturn began to be evident in 1984 and has continued into 1985. The Gross Domestic Product (GDP) at 1974 constant prices was about J$ 1,853 million in 1985 with an annual growth rate of -3.7%. In 1985, the decline has been most significant in the productive sectors of the economy. Mining and Quarrying recorded the greatest decline of 19.5%.

GDP at current prices in 1985 was approximately J$ 11,025 million with an annual growth rate of 20.6%. This growth rate is low when compared with 32.5% in 1984. The slower rate of growth can be attributed mainly to declines in real growth in most sectors, although there was a fall in the prices of bauxite and alumina.

Current per capita income has continued to grow and the value for 1985 was estimated at J$ 4,770. With the increasing devaluation of the Jamaican dollar over most of that period, however, the current per capita income has in effect fallen from US$ 1,369 in 1981 to US$ 867 in 1985. Real per capita income of J$ 1,070 in 1975 fell to J$ 867 in 1981 and continued into 1985 when the real per capita income had fallen to J$ 802.

In 1985, the contribution of the productive sectors to GDP was estimated at about 35%. Agriculture, Forestry and Fisheries taken together was the only sector to have increased its share and this only marginally from 8.0% in 1984 to 8.8% in 1985. In the services sectors, Distribution is the only area which has increased its share from 14.6% in 1984 to 15.0% in 1985.

The real constraint to economic development in Jamaica since the mid 1970's and continuing into the 1980's has been the shortage of foreign exchange to meet the increasing needs of industry for raw materials and capital goods, and for consumption not satisfied by local production. Both imports and exports as a proportion of GDP have increased, with exports moving from 35.3% in 1975 to 55.1% in 1985 while imports grew from 45.6% to 66.5% in the same period.

2.2.2 Social services and infrastructures

The formal education system in Jamaica consists of pre-primary, primary, secondary, and tertiary level education. In parallel with the formal education system, education of illiterates has been of major concern to the Government of Jamaica since 1972. The Communication Skills (Literacy) Survey in 1981 revealed that there was a noticeable decline in both the number and the rate of functionally illiterates in Jamaica since 1975. The rate of illiteracy in 1981, however, was still high, being 24.3% of the total population 15 years and over. About 51% of the farmers were illiterate based on this survey, the highest rate being among the mixed farming community.

The Ministry of Health provides health care services through 23 government operated hospitals, the university hospital and 372 primary health care centres. In 1984, the ratio

of doctors and dentists in Jamaica was estimated to be 1:2,808 and 1:36,506 respectively. It is indicated that the ratios of both doctors and dentists to population are still considerably low when compared with the ratios 1:910 for doctors and 1:2,857 for dentists as recommended by the Pan American Health Organization.

Between 1972 and 1981, a total of approximately 40,250 new building units were constructed representing an average annual rate of production of just over 4,000 units. It is generally accepted that adequate housing in Jamaica will be achieved when an average of 4.0 persons per dwelling is realized. According to the population census of 1982, the total number of dwellings in Jamaica was 508,710 and the average family size per dwelling was 4.3. This indicated a demand for approximately 38,150 new housing spaces existed in 1982.

The total length of roads in Jamaica is about 16,640 km (10,340 miles) excluding private and forestry roads and approximately 11,650 km or 70% of the total are presently paved. The Jamaica Railway Corporation is entirely responsible for operation of the railway and for its finances, and is free from Government control except in matters of public importance. In 1985, the total route length was about 235 km (147 miles).

The Postal and Telegraph Department is the national body responsible for the administration of postal and telecommunication activities in the island of Jamaica. Some 336 post offices, 474 postal agencies and 20 postal sub-agencies currently exist in Jamaica. Telephone services in Jamaica are provided by the Jamaica Telephone Company Ltd. which provides basic local telephone services, island-wide long distance services, and overseas services to most countries of the world.

Since October 1981, the National Water Commission (NWC) has been responsible for investigation of the water supply needs of Jamaica, the planning design and construction of water supply systems capable of meeting these needs, the production of portable water for sale in bulk to Parish Councils, and the design, construction, maintenance and operation of sewerage systems. In September 1985, NWC took full responsibility from the Parish Councils for production and distribution of water to the entire island. The added responsibility has increased supplied customers to 199,953. The average consumption by traditional customers excluding rural areas was 682 m^3 per year per connection. In recent years, consumption has been steadily declining.

In 1985, Jamaica Public Service Company Limited (JPS) had an average of 226,123 residential customers, 23,849 commercial and small industrial customers, 22 large industrial customers, and 2,069 miscellaneous customers. This indicates that more than 50% of the dwellings do not yet have connections with electric power lines. The existing generating system consists of about 482 MW of installed capacity, of which 373 MW is thermal, 88 MW is gas turbine and 20 MW is hydroelectric. In addition to electric power supplied by JPS, electricity is also generated for private use by the bauxite and alumina companies, cement company, etc. but has been declining in recent years due to downturn of the bauxite and alumina industries.

2.3 Agricultural Background

2.3.1 Economic situation of agriculture

Agriculture, Forestry and Fisheries continued to be one of the most important areas towards which government policy for development was geared. The development policy has been centered on the expansion of the non-traditional export sector as well as certain areas of the traditional export sector namely the expansion of banana and coffee production, in an attempt to earn badly needed foreign exchange. Emphasis has also been placed on selfsufficiency in the production of certain crops in order to reduce foreign exchange expenditure.

GDP at 1974 constant prices for traditional export agriculture declined by 3.4% between 1984 and 1985. This was due mainly to a fall of 6.3% in the production of sugarcane, the major contributor to GDP of the export sector. Sugarcane production fell from 2.5 million ton in 1984 to 2.3 million ton in 1985. This was as a result of the closure of some estates and the change over to the growing of other crops as a part of the Crop Diversification Programme. Other areas in which production declined were cocoa and coffee production which fell by 14.6% and 27.0% respectively when compared to 1984. The lower coffee output was due to the lowland areas experiencing an unusually long ripening period which resulted in unharvested coffee berries during this crop year. The production of bananas, ginger and pimento increased by 7.8, 11.2 and 2.1% respectively. The quantity of the above crops exported also increased by 15.4, 16.8 and 11.5%.

Since the establishment of the Agro 21 Programme in late 1983 a total of 16,000 ha (39,700 acres) of unutilized land has been put into production. The main products concentrated under this programme were winter vegetables and ornamental horticulture. In addition the expansion of production of ethnic crops for the export market was being encouraged, its promotion being carried out mainly by the Jamaica National Export Corporation. Non-traditional crops increased by 2.8%. This was due mainly to the increase in the production of yam, a non-traditional export crop provided for under the Agro 21 programme, which grew by 10.0%. Horticulture, another non-traditional export crop reflected a significant increase of 25.0% in its GDP at 1974 constant prices. Export earnings from horticulture were US$ 1.81 million in 1985, an increase of 15.7% over 1984.

The Food Self-sufficiency Programme was another area of development under Agro 21 Programme which is being implemented by Agro 21 Corporation Ltd. The project was aimed at expanding domestic production to include agricultural commodities presently imported and thus reduce the import bill. The main thrust under this programme was the production of corn and rice. Rice production fell from 5,370 ton in 1984 to 4,260 ton in 1985. This decline is attributed to the fact that one of the major rice producing areas went over to inland fishery. Rice production, however, will show significant increases in 1986, as approximately 810 ha (2,000 acres) was planted to rice on the Amity Hall Estate under this Programme.

In 1985 despite the initiatives taken by the Government to enhance the production of domestic agriculture sector there was an overall decline in its GDP at constant prices of

1.3%. The major contributors to the decline were pulses, vegetables, and tobacco. This group was severely affected by the drought which had occurred in late 1984 to 1985.

Livestock production also showed an overall decline in production in 1985. Poultry production declined significantly by 23.3%. Egg and livestock production also registered declines of 2.6 and 4.5% respectively. Milk production remained fairly stable going from 49,440 ton (41.7 million quarts) in 1984 to 49,800 ton (42 million quarts) in 1985, an increase of 0.7%. This was in spite of stiff competition from imported skimmed milk powder. During the year, the Government took measures to protect milk products, measures such as not allowing processors to sell reconstituted milk, the carrying out of quality control tests on milk being sold to consumers, stopping the sale of skimmed milk powder in bulk, and adjusting the price of milk powder upwards.

Production of pond fish increased to 730 ton in 1985 compared to 320 ton in 1984, an increase of 128%. This increase was due mainly to the fact that more ponds were put into operation during the year as pond fish became more popular with consumers as a cheaper source of protein than sea water fish. The overall decline of 0.2% in the fishing industry was due to declines in ocean and coastal water production.

2.3.2 Land tenure system

Today most agricultural land in Jamaica is free-hold, although since 1972 the lease-hold system of tenure has increased considerably. A significant feature of Jamaican agriculture is, however, the great diversity in farm holdings. 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 practical operation of farm lands the following types of tenure are found:

Family Land	Paying Tenants	Tenants at Will	Crop Sharing Tenants
Land passed down to members of family by inheritance.	Tenants on written contract between tenant and lord.	Tenants given rent free permission wherein tenancy will terminate at the will of the landlord.	Tenants must give a percentage of the returns usually 33% as consideration to the landlord.

2.3.3 Agricultural support services

The agricultural research programmes are mainly controlled by the Research and Development Division of the Ministry of Agriculture (MOA). There are four (4) research stations in Jamaica as listed below:

Bodles	Grove Place	Montpelier	Orange River
This is the main research station and is situated in the Central Region. It conducts research mainly in dairy cattle, pasture, animal nutrition, small stock and food crops mostly under irrigated conditions.	Located in the Central Region and concentrates its activities on rainfed pastures, beef cattle, as well as crops under rainfed conditions.	Located in the Western Region with emphasis on crops and dairy cattle breeding.	This is located in the Northern Region and carries out research on crops like cocoa, bananas, ackees, etc. This will be transfered to the Cocoa Industry Board.

Research programmes and budgets of the research stations have to be approved by the Standing Ministerial Committee. Some research is also being carried out by the Caribbean Agricultural Research and Development Institute of the University of the West Indies and by some of the Commodity Boards, such as the Sugar Industry Research Institute for sugarcane and the Coconut Industry Board, etc.

Extension services to farmers are implemented through four (4) regional offices, 13 Land Authorities, and the Fishery Division under the Production and Extension Division of MOA. Each Land Authority is administered by an Executive Agricultural Officer and his Deputy. The Deputy Executive Officer controls Division Officers who supervise Agricultural Extension Officers (AEO). Each AEO supervises field assistants and agricultural aides. 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 such matters as marketing and credit.

There are four (4) regional training centers in Jamaica. These training centres are residential with accommodation as follows:

North Region	:	Eltham 60 trainees
South region	:	Twickenham Park 30 trainees
Central Region	:	Brooklyn 48 trainees
Western Region	:	Canaan 36 trainees

Each centre is staffed by a Manager and auxiliary staff. The Unit, in addition to executive staff, has eight (8) trainers: four (4) assigned to each of the Regions, two (2) to special projects, one (1) to planning, monitoring and evaluation, and one (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.

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

(1) making funds available at a time and place suited to farmers' needs,
(2) encouraging greater participation by commercial banks in the agricultural sector, and
(3) 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 People's Cooperative Banks (PCBs) and commercial banks. Short term loans with a maximum two (2) years repayment period are provided working-capital support for condiments, pulses, tobacco, tubers and root crops, pasture upgrading, and vegetables. Medium term loans with a maximum seven (7) years repayment period and long term loans with a maximum of twelve (12) years repayment period provide support for projects in sheep and goats, horticulture, sugarcane, bananas and plantains, agro-industry, dairy and farm buildings. There are 40 PCBs funded by ACB in Jamaica.

There are the following Farmers' Organizations in Jamaica:

(1) The Commodity Boards/Associations, (CBA)

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.

(2) The Jamaica Livestock Association Ltd., (JLA)

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.

(3) The Jamaica Agricultural Society, (JAS)

JAS is a statutory body of great significance to small farmers. It has been the parent organization of most of the Commodity Boards and of the co-operatives now in operation.

(4) Farmers Cooperative Groups (FCG)

FCG fall under the Ministry of Youth and Community Development. Their main functions are to promote agricultural credits and marketing.

(5) Producers Marketing Organization (PMO)

PMO was established as a legal entity by a group of farmers to undertake the marketing of member's products and to supply farm inputs to its members under the Small Farmer Production and Marketing Project, which is funded by the Government of Jamaica and USAID.

3. THE STUDY AREA

3.1 Location

The study area, 27,400 ha, is situated in the central part of Jamaica near the southern coast of the parish of St. Catherine. The study area is located between 17°55' and 18°02' north latitude and 76°50' and 77°08' west longitude. The study area is bounded by mountains on the north, by the seashore and Hellshire on the south, by the parish of St. Andrew and the seashore on the east and by the boundary of the parish of Clarendon on the west, Spanish Town, the capital of the parish, lies in the centre of the area, and approximately 22 km (14 miles) west of Kingston.

3.2 Regional Economy

The parish of St. Catherine consists of two (2) regions; coastal plain and part of the central mountain range, and economic activities of these regions may be characterized as follows:

(1) Coastal plain (the study area is situated in this region)

This region is one of the main agricultural regions in Jamaica. Its agriculture is characterized by estate type of farming with intensive to semi-intensive farming of sugarcane and pasture as the main crops. Other crops of economic importance include vegetables, rice, tobacco, etc. Industries in this region include sugar, alcohol, and other mainly light industries. Industrial estates in this region are to be found at Portmore, Central Village, Twickenham Park, Old Harbour, Old Harbour Bay, etc.

(2) Central mountain range

This region is important agriculturally by virtue of two (2) interior basins. The crops of economic importance are sugarcane, citrus, banana and pasture. The limestone hills are used for subsistence farming by small farmers who grow root crops as well as some tree crops. In this region most of the industries are agriculturally based, e.g. citrus processing, sugar mills, condensed milk, etc., while in the Ewarton area bauxite and alumina processing.

3.3 Human Resources

According to the population census of 1982, the populations of the parish of St. Catherine and the study area were about 332,670 and 129,690 respectively. In 1982, the population density of the study area was estimated to be 473 persons/km^2 (1,223 persons/square mile). This figure is much higher than that for the parish, 278 persons/km^2 (722 persons/square mile) and Jamaica, 203 persons/km^2 (527 persons/square mile) in 1982. Such a high density is due to the urban areas within the boundary of the study area. The average annual growth rates in the parish and the study area during the period from 1970 to 1982 were estimated at 5.3% and 5.6% respectively. These growth rates are very high when compared with 1.4% for Jamaica as

a whole. It is considered that these high population growth rates are mainly due to new housing development, new industrial development, migration from rural area, and population moving from Kingston.

According to the population census of 1982, the total labour force in the parish and the study area was estimated at 107,550 and 43,420 respectively. Of the total population, these numbers represent 32.3% for the parish and 33.5% for the study area. The proportion of the employed labour force in the productive sectors within the parish was estimated to be 40.4% on the basis of population census of 1982 and mostly in Agriculture, Forestry and Fisheries which make up about half of the employed labour force in these sectors. The unemployment rate was estimated to be 30.1% for the parish and 33.0% for the study area in 1982. These rates are much higher than that for Jamaica as a whole where in 1982 it was 28.2%.

3.4 Natural Resources

3.4.1 Topography

The study area covers approximately 27,400 ha and is composed of alluvial plains. The alluvial plains form an almost featureless and gently sloping area lying between the limestone foothills in the north and the also limestone Hellshire Hills in the south. They are found along to the coast through Old Harbour Bay, the Kingston harbour area and the gap between Port Henderson and the Hellshire hills. In some areas, two distinct terraces are visible, one marking the present course of the river and confined to a strip usually not more than a few hundred meters wide, the other a higher one, which constitutes the major part of the plains. In terms of gradient, the study area slopes from north to south with micro-relief, ranging elevation from 3 m to 35 m. The gradient is approximately 1/150 in the upper part of the area and 1/300 to 1/500 in the lower part of the area adjacent to the seashore.

3.4.2 Climate

The study area lies in the North East Trade Belt and has a tropical oceanic climate. The monthly mean rainfall from 1937 to 1985 at Bernard Lodge indicates bimodal peaks in May and October. (see Fig. 1) About 70% of annual rainfall occur during the period from May to October. A large portion of the rainfall occurs in heavy squalls. The dry season usually lasts from December to March with less than 40 mm (1.6 in.) of monthly rainfall. Eighteen rainfall stations are located within the study area. The average annual rainfall at Old Harbour located at the western end of the study area is as high as 1,183 mm (46.5 in.), while it is only 721 mm (28.4 in.) at Smallwoods located at the centre of the study area.

The monthly mean temperature in the study area varies from 23.6°C (74.5°F) to 26.7°C (80.1°F) at Bernard Lodge. The three-month period from January to March is cool, with a mean temperature of 23.7°C (74.7°F), while the period from July to September is warm with a mean temperature of 26.5oC (79.5°F). The absolute maximum temperature of 37.2°C (99.0°F) was recorded in July and the absolute minimum of 11.7°C (50.0°F) in February. The average relative humidity at Bernard Lodge is about 74% with minor

seasonal variations. The average daily sunshine hours is 8.0 hr/day. Evaporation from class A pan averages 5.14 mm/day (1,877 mm/annum) at Bernard Lodge and 5.5 mm/day (2,007 mm/annum) at Bodles. The daily wind velocity averages 15 km/hr (8.1 knots) with directions frequently from East-South-East.

3.4.3 Hydrology

In the study area, there are eight rivers and gullies among which the largest is the Rio Cobre. The Spring Garden river also has a perennial flow. The six rivers are seasonal. The Rio Cobre has a surface water catchment area of approximately 578 km^2 at the existing headworks of Rio Cobre Irrigation system where the stream gauging stations, Rio Cobre main canal and Rio Cobre near Spanish Town, are located. The daily discharge as well as rating curves at both gauging stations mentioned above were obtained from UWA and verified by the Study Team. The maximum and the minimum of monthly mean discharges have been observed in October and in March, respectively. The average monthly discharge of the Rio Cobre at the dam site from 1954 to 1984 and the probable discharge of non-exceedance in a 5–year return period were found to be as follows:

(1) Average monthly discharge

(Unit: m^3/sec)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
7.8	6.1	5.5	5.9	8.1	12.9	8.3	8.4	12.7	18.3	15.3	10.5	10.0

(2) Probable monthly discharge

(Unit: m^3/sec)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
5.1	4.0	3.6	3.9	5.3	8.4	5.4	5.5	8.1	11.9	10.0	6.8	6.5

The annual average discharge, the minimum daily discharge and the 360–day dependable daily discharge in a year were estimated to be 6.5 m^3/sec, 2.7 m^3/sec and 3.0 m^3/sec respectively by the frequency analysis in a 5–year return period.

The design flood discharge on the Rio Cobre at the headworks was estimated at 1,640 m^3/sec based on a frequency analysis of observed peak discharges.

The annual basin rainfall in the Rio Cobre was estimated to be about 1,670 mm, and the average runoff coefficient about 32% on the Rio Cobre at the Dam Site.

From chemical analyses of water samples it appears that water in the Rio Cobre is of excellent quality for irrigation from salinity and alkalinity view points.

3.4.4 Geology

The three major geomorphological features identified in and around the study area include dissected highlands, (volcaniclastic areas), karstland (limestone outcrops), and flat areas (alluvial plains). The dissected highlands is found to the northwest of the study area include impermeable Cretaceous deposits. Surface runoff has denuded the area to form steep sided 'V' shaped valleys. The karstlands comprise Tertiary carbonate formations and include all the area north of the plains and also the Hellshire and Port Henderson Hills, which have very rugged topography, formed by numerous deep dolines, collapse structures, sinkholes and solution cavities. Considerable surface flow is therefore percolated into the ground.

The stratigraphic sequence in and around the study area consists of the Cretaceous volcaniclastics, the Yellow Limestone Group of the early Tertiary, the White Limestone Group of the mid-late Tertiary and the alluvium of the late Quaternary. The Cretaceous volcaniclastics and the Yellow Limestone Group found around Bartous, Water Mountain and Giblatore form an impermeable basal complex. The White Limestone Group crops out in the inland hills and the Hellshire and Port Henderson Hills. Alluvium overlies the White Limestone Group in the coastal flat areas, and varies in thickness from a few meters at the border of the plain to 180 m.

The basic structure in and around the study area comprises a basement of folded Cretaceous volcaniclastics overlain by the Tertiary limestones. The Rio Cobre basin is dissected by several faults. There are two major sets; a dominant northwest-southeast set including the Caymanas fault; and the east-west set including the Bog Walk fault.

Drilling investigations at the existing Headworks Dam site indicate that the left side of the dam is sitting on the alluvium. Most of the dam is founded on alluvial gravel, a sand bed, or Tertiary sheared limestone. The bedrock is Tertiary limestone which is well fractured with many cavities filled with clay. Some parts of the limestone and alluvium for the dam foundation are so permeable (permeability $k = 1 \times 10^{-4}$ to 5×10^{-2} cm/sec) that there must be some leakage through the foundation.

3.4.5 Hydrogeology

A hydrogeologic map of the Lower Rio Cobre basin is shown in Fig. 2. There are about 140 production wells (about 80 in limestone and about 60 in alluvium) in the study area, most of which were drilled for abstraction of groundwater for use in irrigation.

The limestone aquifer is more productive than the alluvial one. The limestone aquifer consists exclusively of rocks of the White Limestone formation which is a complex of rubbly or chalky rocks and hard, recrystalized and dolomitized rocks, which seem likely to have developed secondary permeability through solution and fracturing. Water level fluctuation of the aquifer varies seasonally from about 1 m in the southern part of the area, to as much as 10 m in the northern limestone hills. According to FAO (1974) transmissibility values of the limestone aquifer vary from 20 m^2/day to 15,000 m^2/day and the storage coefficients between 1.1×10^{-6} and 3.8×10^{-4}. According to Botbol

Report (1982), the total annual well discharge was 91.5 million m^3 in 1980 and averaged 1.19 million m^3 per well. The average total annual production for the years between 1970 and 1980 was calculated to be 85.9 million m^3. Almost all the limestone aquifer wells are located on the boundary between hills and flat areas. Around Old Harbour, Innswood and Caymanas areas abstraction from the limestone aquifer is greatest. Some regressions of the groundwater table are found on this region.

The alluvial aquifer overlies the limestone aquifer in the central part of the study area. The aquifer is comprised of unconsolidated deposits consisting of sands and gravels with intercalated clays. The water table of the aquifer varies from ground level in the coastal area to approximately 10m from the surface in the elevated area. According to FAO (1974) and Versley (1962), the transmissibility values of the alluvial aquifer vary from 160 m^2/day to 8,200 m^2/day and the storage coefficients vary from 3.3×10^{-1} to 1.8×10^{-2}. Annual production of wells from alluvial aquifer in 1972 was 40 million m^3. The alluvial aquifer wells are concentrated mainly in the Bernard Lodge and south Caymanas areas. Regression of the groundwater table is localized in these areas.

According to Botbol (1982) and White (1980) Reports, the limestone aquifer has been contaminated by saline inflow in response to development of the groundwater resources of the aquifer since 1930. Uncontrolled development has resulted in deteriorating groundwater quality, particularly in the south coastal area. Water quality analyses made by the Study Team indicate that the chloride content of wells and springs of the limestone aquifer ranges between 10 and 1,200 ppm, whilst the chloride content of samples from the alluvial aquifer ranges between 38 ppm an 421 ppm. At Innswood artificial recharge of surplus surface water into the limestone aquifer through sinkholes had been investigated by Water Resources Division (1980 to 1982). During the year May 1981 to March 1982, 9,700 m^3/day (3.2 million m^3) of surface water was recharged by gravity through 2 sinkholes. As a result of the recharge a 0.5 to 1 m groundwater mound had been created near the recharge area and apparently as a consequence some regression of the saline front has started.

3.4.6 Water resources

The main water resources available in the study area are surface water and groundwater. The volume that can be obtained from these water resources has been assessed as follows:

(1) Surface water

Though several rivers and gullys are found in the study area, the Rio Cobre is only a river which has water available for irrigation throughout the year. Other rivers such as the Plantain river, Coleburns gully and Black river have negligibly small discharges especially in the dry season.

The annual mean discharge of the Rio Cobre at the dam site is approximately 315 million m^3 (10.0 m^3/sec on average) and the annual discharge of the drought year with a return period of 5-years is estimated at 202 million m^3 (6.5 m^3/sec on average).

(2) Groundwater

In order to evaluate the groundwater potential in the Lower Rio Cobre basin, the analysis was made of a simulation model on the basis of the hydrogeological investigations. For calibration of the model the observed groundwater data in 1972 were used. Optimal yield was analysed as annual abstraction such that the groundwater level after one year's discharge would be almost the same as the primary water level, and that the groundwater level during discharge would always be above sea level in the limestone aquifer. After several trials using the probable rainfall data in 1975, the optimal annual abstraction was estimated as shown in Fig. 3 and Fig. 4. The annual permissible volumes of extraction in the Lower Rio Cobre were estimated as follows:

(Unit: million m^3/year)

Source	Agriculture	Industrial	Domestic*	Total
Limestone basin	60.7	5.9	37.2	103.8
Alluvial basin	31.0	2.6	2.5	36.1
Total	91.7	8.5	39.7	139.9

*; includes requirement for supply outside the study area

The table below shows the water resources available in the study area under drought year conditions.

(Unit: million m^3/year)

Source		Volume
Surface water	(Rio Cobre)	202
Groundwater	(Limestone aquifer)	104
	(Alluvial aquifer)	36
Total		342

3.4.7 Soils and land capability

Characteristic features of the soils and land capability in the study area may be summarised as follows:

(1) The soils in the study area may be classified into five (5) orders, seven (7) sub-orders, nine (9) great groups and ten (10) sub-groups in the higher categories of Soil Taxonomy. Soils formed on recent river alluvium were classified as Mollisolls with weak profile differentiation and/or stratification. Soils formed on old marine alluvium mainly consist of Vertisols with moderate profile differentiation. Soils formed on limestone consist of Inseptisols with various degrees of profile differentiation. Soils formed on recent marine alluvium consist of Entisols with very weak or weak profile differentiation. A total of 27 mapping units were employed in the study area. They consist of 16 consociations, one (1) association, two (2) undifferentiated soils and six (6) miscellaneous areas. Soil map of the study area is illustrated on Fig. 5.

(2) The soils formed on recent alluvium have kaolinite as the dominant clay mineral. The soils formed on old alluvium have montmorillonite as the dominant clay mineral and relatively high values of cation exchange capacity varying between 30 to 45 meq/100g of soil. The recent alluvial soils have Mollic epipedon and are calcareous throughout. They are non-saline and non-sodic and their natural fertility is relatively high. The old alluvial soils are moderately to strongly saline in their subsoils and are sodic in some soils. Their natural fertility is low in comparison with recent alluvial soils, especially in available phosphate content.

(3) The solid volume of the hard subsoils ranges from 50 to 60% near to close packed status. It is necessary to improve their hard subsoil in order to increase crop production. The voids ratio of surface soils ranges between 50 to 55%. The water retention of recent alluvial soils is higher than that of old alluvial soils because of their large number of capillary pore spaces. Wilting point (pF 4.2) of old alluvial soils is extremely high due to the hydration of montmorillonite clay. Therefore, recent alluvial soils are more suitable for upland crops from the viewpoint of the water retention.

(4) According to the results of a salinity survey by the Soil Survey Unit, salinity in the study area can be classified into four (4) categories. Class I land and Class II land can be used for crop production without land reclamation and total 14,900 ha or 54% of the study area. Class III land can be consolidated for higher crop production with some land reclamation and amounts to roughly 6,700 ha or 24% of the total area. Class IV land occurs along the coast seems likely to have been formed by sea water intrusion, can be changed to low salinity by reaching of logged water under the paddy field. This category roughly covers 1,100 ha or 4% of the total area. The remainders occupy the area of 4,700 ha (17%). Soil reaction of the study area shows an alkalinity which ranges from weak (pH7 to 8) to moderate (pH8 to 8.5) values. Exchange sodium percentage of soils except for Salt Island soils are less than 15%, and electric conductivity of top soils shows 4 mS/cm or less. Therefore, most soils can be classified into a category of saline alkaline soils.

(5) Drainage of soils must be studied in order to increase the crop productivity and to decide on proper land use. Intake rates of recent alluvial soils range from moderate to very rapid, and in old alluvial soils from very slow to moderate. Caymanas soils series in particular show a very rapid intake-rate so that these are not suitable for rice paddy. Since the Salt Island soil series show a very slow intake-rate such soils are most suitable for rice paddy and fish ponds.

(6) Land capability classification in the study area was carried out by the Soil Survey Unit using the criteria of USDA. Land capability for upland crops was divided into six (6) classes based on the degree of limitations. Each class is divided into sub-class based on the dominant limitations. Arable land suitable for agriculture consists of Classes I to IV. This area covers approximately 18,900 ha and corresponds to 69% of the total area. Therefore, most land in the study area is suitable for upland crop production. Limited arable land categories consist of lands having limitations such as strong salinity or very shallow soil, and occupying only 2,200 ha (8%). Non arable land consisting of rock land and tidal swamps, occupies roughly

6,400 ha (23%). Land capability classification in the study area is shown in Table 2. Land capability map for upland crops is given in Fig. 6.

(7) When land capability classification is made for rice culture taking into account limitations of leakage of logged water, workability of soils, plowing and soil salinity. Potential arable land for rice culture is approximately 13,500 ha or 50% of the total area. Soils formed on the recent alluvium are ranked into limited arable land of Class V due to leakage and infiltration losses occupy 7,500 ha (27%). None arable land of Class VI covers approximately 6,400 ha (23%). Most soils formed on old marine alluvium are suitable for rice paddy due to their fine clayey texture. Soils formed on limestone and tidal swamps are not used for rice paddy. Thus potential lands for rice culture should be selected mainly on the plains of old marine alluvium. Land capability map for rice is given in Fig. 7.

3.5 Social Services and Infrastructures

In 1984 the parish of St. Catherine had four (4) pre-primary level schools, 87 primary level schools, 17 secondary level schools and one (1) tertiary level school, with about 1,980, 63,020, 20,510 and 80 enrollments, respectively. According to the Communications Skills (Literacy) Survey of 1981, 23.3% of the population 15 years age and over was illiterate. In 1984 in the study area, there were four (4) pre-primary level schools, 24 primary level schools, eight (8) secondary level schools and one (1) tertiary level school, with about 1,980, 32,870, 13,100 and 80 enrollments respectively. In addition to the above schools, there were 15 JAMAL training classes for illiterates with 748 trainees and 23 volunteer teachers in 1985.

The parish has two (2) hospitals; Linstead hospital, and Spanish Town hospital which is located in the study area. The study area also has one (1) of the nine (9) Type I health centres, three (3) of the nine (9) Type, health centres, one (1) of the six (6) Type III health centres and one (1) of the one (1) Type IV health centre of the parish. The ratio to population for each type of health centre both for the parish and the study area was estimated to be about 1:37,000 and 1:130,000 for Type I; 1:37,000 and 1:43,000 for Type II, and 1:55,000 and 1:130,000 for Type III respectively. The ratios for each type of health centre are remarkably low when compared with the ratios that are recommended by the Ministry of Health.

The population census of 1982 reported that there were about 74,220 dwellings in the parish with the average number of persons per dwelling being 4.5. From the viewpoint of adequate dwelling (4.0 persons/dwelling), it is considered that a further approximately 8,950 housing spaces were needed in the parish. In the study area, the total dwellings were estimated to be about 28,940 with the average number of persons per dwelling being 4.5 in 1982. The shortage of housing space in the study area was estimated at about 3,480 from the viewpoint of adequacy of accommodation. Construction of the Start-a-Homes for low income groups and Complete Homes is in progress by the Ministry of Construction (Housing) in the study area. In addition to the above on-going programme, construction of Complete Homes and improvement of low income houses are planned. However, the planned new housing development still does not meet the needs of the study area.

Transportation in the parish and the study area is mainly by road. The total length of roads in the parish is estimated to be 1,500 km (940 miles). About 1,050 km (660 miles) are presently paved. Two (2) main roads pass through the parish, of which one connects Kingston to Savanna-la-Mar, running through the coastal plain and, the second connects Spanish Town to St. Ann's Bay crossing the central mountain range. The main roads in the study area are about 33 km (20 miles) long having a well maintained dual carriageways. There are about 56 km (35 miles) of secondary roads, paved with asphalt and relatively well maintained, which link the principal points. There are also many roads used mainly for transportation of commodities in the study area. Most of these roads are paved but maintenance is generally poor.

The railway in the parish consist of two (2) lines, i.e., Main line from Kingston to Montego Bay, and Bauxite line used for transport of bauxite and alumina between Ewarton and Port Esquivel. The total length of railways in the parish is estimated at about 68 km (43 miles) of which 38 km (24 miles) are Main line and 30 km (19 miles) for Bauxite line. The rehabilitation programme, involving the changing of the rails, for both Main and Bauxite lines is in progress. Approximately 33 km (20 miles) of the Main line runs along the main road and across the study area. This line mainly carries passengers and consumer goods between Kingston and Montego Bay. There is also the Bauxite line from Bodles to Port Esquivel. This line belongs to the bauxite industry, however, maintenance and locomotive supply are provided by the Jamaica Railway Corporation.

In the parish of St. Catherine there are 29 post offices, 51 postal agencies and seven (7) postal sub-agencies. There are nine (9) post offices in the study area. A further, eleven (11) postal agencies and three (3) sub-agencies operate in the study area. It seems that the postal facilities and services are satisfactory. The telephone services in the parish are serviced by the Linstead exchange, Old Harbour exchange and Spanish Town exchange. In the study area, the Jamaica Telephone Company services 1,381 telephones through the Spanish Town and Old Harbour exchanges. In addition, 21 call boxes are located in the study area. The capacities for two exchanges are now being increased and installation of usable cable pairs will be completed in 1990. Commencing in 1987, the existing set of call boxes will be replaced with modern automatic units.

According to the population census of 1982, the public authorities supplied domestic water to about 69% of the total dwellings in the parish. The UNDP/Underground Water Authority (Draft Water Development Master Plan Jamaica 1985) reported that about 31 million m^3 of water is consumed annually for domestic uses in the parish with an average per capita consumption of 143 m^3/year in urban areas and 15 m^3/year in rural area respectively. The water supplied within the study area is obtained from ten (10) limestone wells and the Rio Cobre river. Domestic water from the Rio Cobre river is supplied to Spanish Town through a full treatment plant. In the study area, the public authorities supply the domestic water to approximately 77% of the total dwellings in 1982. This figure is high when compared with that of the parish.

About 38,490 dwellings received electricity in 1982 based on the population census. This is equivalent to about 52% of the total households in the parish. This percentage is high when compared with the figure for Jamaica as a whole. However, electric power supply services are limited to major towns and their vicinities. The Old Harbour Bay thermal

generating station with approximately 230 MW capacity is located in the south western part of the study area. Dwellings receiving electricity in the study area were estimated to number about 16,080 or 56% of the total in 1982. 138 kv transmission lines link Old Harbour Bay power station to Spanish Town and Kingston through the northern and southern part of the study area. A 69 kv transmission line links Old Harbour Bay power station to Spanish Town along the main road.

3.6 Present Land Use and Agriculture

3.6.1 Present land use

The present land use of arable land (including potentially arable land) in the study area is shown in the following categorized table and on Fig. 8.

Land Use Category	Area (ha)	Proportion (%)
Sugarcane (cultivated sugarcane land)	8,900	42.4
Vegetable/crop (includes tobacco and ornamental crops)	920	4.4
Orchard (mainly mango, papaya, banana)	320	1.5
Paddy	390	1.8
pasture (improved and unimproved)	2,700	12.9
Ruinate (grassland, bush/grass and bush)	6,690	31.9
Woodland (forest with grass)	530	2.5
Aquaculture	210	1.0
Swamp (shallow peat layer and no sulphuric acidity)	340	1.6
Total	21,000	100.0

Noteworthy land use in the study area includes sugarcane, pasture and vegetable/crop. The sugarcane category include four (4) large estates and some smaller farms scattered in the study area. These account for 42% of the total arable land. The vegetable/crop category includes vegetables and several traditional field crops which dominate in the central part of the study area and tobacco in St. Dorothy North area. The pasture category includes improved and unimproved pasture and occupies 13% of the total arable lands. Ruinate area including grassland, bush/grass and bush land which accounts for about 31% of total arable land mainly owing to lack of water.

3.6.2 Land tenure and holdings

According to the land holding survey conducted by the Data Bank and Evaluation Division of MOA in 1982, the total number of farm households in the study area is 2,140 of which farms of more than 40 ha (100 acres) account for only 17 (0.8%) of the total number of farmers and about 87% of the acreage in farm land. On the other hand, farmers holding farms of less than 2 ha (5 acres) number 1,950 (91%) but with a total acreage of only 650 ha (1,600 acres) or only 4.9% of the total farm land. Three (3) large