government estates, Caymanas, Bernard Lodge and Innswood, occupy approximately 8,400 ha (20,700 acres) in total, or approximately 60% of the total farm land.

3.6.3 Crop production

Domestic crop production (except for tobacco and sugarcane) and the area harvested in the parish of St. Catherine increased by 9.7% and 7.9%, respectively in 1984, in comparison with 1983. The increase is attributed to availability of an export market for some crops. Within the study area, sugarcane and certain upland crops such as vegetables and tobacco are dominant. Paddy and mango plantations have started only within the last two (2) years.

Sugarcane is mainly grown by some large national and private estates on most of the fertile recent alluvial land and is the most important agro-industry for export and the domestic market. However, production on these estates has decreased mainly owing to lack of water and decrease of government subsidy. Present production of sugarcane in these estates is about 247,000 ton, the area harvested 4,000 ha and average yield 61 ton/ha in 1985/86 which is higher than average yield in the island or the Central America. The cropping pattern of sugarcane is 4 to 5 ratoons after harvesting of replants after one year of growing season for both replants and ratoons. Field operations are mechanized, except for planting, harvesting and application of fertilizer.

Concerning vegetable production, many small farmers and some medium farmers are the chief producers and are found mainly in Spring Garden and Bushy Park. Despite increased market outlets and assistance from the St. Catherine Vegetable Producers Association (SCVPA), production has decreased significantly over the past 5 years. The primary planting season is September to January with a secondary season in April to July. The period of highest production is December to March. Crop rotation is usually not practiced in the true sense. Production and yield of main crops in 1985 are given below:

	Calaloo	Pumpkin	Tomato	Cucumber	Okra	Sweet Pepper
Production (ton)	840	415	260	870	365	190
Yield (ton/ha)	12.5	12.5	11.3	13.8	6.3	12.8

Their yields are at a medium level in the Central and South America.

Paddy cultivation has been practiced at Amity Hall since 1985. The variety cultivated is CICA-8, the same as at Jamculture (formerly BRUMDEC) and Meylersfield, the main paddy producers in the island. The cropping pattern of paddy at Amity Hall farm is based on staggered planting all the year round. The average number of crops per year is 2.5. Field operations are all mechanized using farm machinery for land preparation and harvesting and aircraft for seeding, application of fertilizer and chemicals. The average yield of the first crop (1986) was about 5 ton/ha (4,500 lb/acre) but of the second crop decreased to 4.5 ton/ha owing to weed and other reasons.

Orchards in the study area are mainly mango. Others include papaya, coconut and banana. There are two (2) large farms, Brampton (73 ha) and Thetford (97 ha), planting mango orchards each with 1 to 2 year-old trees under drip irrigation. The main mango varieties are Tommy Atkins, St. Julian and East Indian which may all be exported. Small farm orchards are only small holdings (less than 1 ha) of papaya and mango.

Tobacco is cultivated by small farmers who lease the land from Agricultural Products of Jamaica (APJ) under contract. The tobacco area owned by APJ and farmers at Colbeck covers about 160 ha, but the actual cultivated area has decreased to 70 ha because of the decline in domestic demand. APJ supplies input materials for farming and leases drying barns. The planting season is September to March. The yield of dried leaves is 1,300 to 1,700 kg/ha which is at an average level in the Central and South America.

Within the study area, small amounts of condiments, ornamentals, tuber and root crops are found. Ornamental crops at Caymanas cover a gross area of 12 ha.

3.6.4 Livestock production

The parish of St. Catherine is the largest livestock producer in the island, and most of the livestock in the parish may be produced in the study area. Pasture is widespread in the study area. Most dairy cattle are raised by large scale farmers in the St. Dorothy area where irrigation water is comparatively sufficient and much more improved pastures are maintained than in other areas. Beef cattle are concentrated on medium and small scale farms at Bushy Park which suffers from water shortage.

Total milk production in the study area as estimated by MOA for 1985 is 3,880 ton including 3,230 ton produced in Old Harbour Agricultural Extension area which represents 85% of total. The gross area of these farms is 10 to 200 ha and the percentage area of improved pasture in terms of gross area changes from 40 to 100%, mainly depending on water supply. The number of cattle on each farm varies from 60 to 400.

Beef production in the study area is essentially practiced on small to medium-sized farms. The number of cattle ranges from 10 to 60 with the gross farm area varying from 2 to 60 ha. In most cases, farmers keep a small breeding herd to supply weaners for fattening, otherwise, they are purchased at 9 months averaging 200 kg as found often on small-sized farms.

Improved pastures are found mainly on large farm holdings which rear dairy cattle in St. Dorothy South. Nevertheless, in Bushy Park where most beef cattle farms are located, only unimproved pasture is found owing to lack of water. Improved pastures are those which receive regular irrigation, fertilization and stumping. Usually the grass type is African Stargrass which is vigorous, recovers quickly after grazing and high stocking rate. Other grass type of less importance are Pangola and Guinea grass.

3.6.5 Aquaculture

Aquaculture within the study area is found in St. Dorothy South and Rio Cobre West mainly scattered in pasture, upland fields and ruinate. The highest concentration is found

in the south of Old Harbour and Little Hartlands. The total net fish pond area is approximately 150 ha. The main type of fish produced is the *Tilapia nilotica* or silver perch but silver and red hybrids are also grown. Usually, large-scale fish farms (over 20 ha) produce fingerlings (silver perch) for their own production ponds while smaller farms purchase the surplus. Market weight per fish is usually 0.23 kg (0.5 lb). There is a shortage of silver perch fingerlings but, a newly established red hybrid farm (Hill Run) can supply sufficient quantities of these fingerlings.

3.6.6 Post harvest facilities

Post harvest facilities in the study area include milk processors, seed (planting material), rice, sugar, meat and vegetable producers. The Spanish Town Rice Mill and Century Farm Milk Processors are currently expanding facilities. However, Bernard Lodge Sugar Factory has now closed having given way to the Petroleum Corporation of Jamaica which still has tentative development plans for sugar and Ethanol production. The seed production facility at Thetford Seed Farm is operating far below capacity but an anticipated increase in production for future growing seasons is planned. The St. Catherine Vegetable Producers Association which currently markets up to 73,000 kg/month of vegetables from the study area is directly affected by the lack of water faced by contributing farmers. This quantity makes operating their new 400 m^2 packing facility uneconomical. The only meat facilities are a number of small slaughter houses for beef cattle in the study area. Storage facilities are limited despite operating for only 3 days per week.

3.7 Agricultural Support Services

3.7.1 Agricultural extension services

Agricultural extension services of MOA in the parish of St. Catherine are controlled by the Extension Department of the Linstead Land Authority. It has a Deputy Executive Agricultural Officer, Divisional Extension Officers, Area Extension Officers, Home Economic Officer and a Crop Care Officer. The parish of St. Catherine is divided into eight (8) extension divisions with forty-six (46) extension areas. Each extension division is subdivided into five (5) to six (6) extension areas. The study area is covered with two (2) extension divisions, i.e., Old Harbour and Spanish Town division. These two (2) extension division have twelve (12) extension areas of which seven (7) extension areas are in the study area.

3.7.2 Farmers organization

The St. Catherine Vegetable Producers Association (SCVPA), which was established as a Producers Marketing Organization in 1983 is operated in the study area. SCVPA has its office in the town of Old Harbour, the farm store in Gutters and a grading station in Church Pen. SCVPA receives various kinds of assistance from the Small Farmer Production and Marketing Project, which has been evolved by the Marketing and Credit Division of MOA and USAID. In September 1986, 256 members participate in SCVPA holding about 1,010 ha (2,500 acres) with the range between 0.1 ha (0.25 acre) and 160 ha (400 acres) held by each farmer. The median holding size is 2 ha (5 acres).

SCVPA provides member farmers with technical services such as demonstrations, trials, information on farming, etc., and farm inputs supply services through the farm store. SCVPA provides input supply and product sale as a marketing organization, and materials valued at J$ 330,000 in 1984/85 for both domestic and export markets.

Jamaica Agricultural Society (JAS) has 6 branch societies and 543 members in the study area in November, 1986 as follows:

Branch Societies	Membership
Central Village	85
Hartland	50
Church Pen	175
Southern Spanish Town	55
Thompson Pen	75
Old Harbour	103
Total	543

The role and function of JAS are representation, information and publication, organization and marketing, and farm input supply for farmers.

3.7.3 Agricultural credit

There are six (6) People's Cooperative Banks (PCBs) in the parish of St. Catherine as listed below:

PC Bank	Location
Midland	Guys Hill
Upper St. John	Point Hill
N. W. St. Catherine	Marley Hill
Glengoffe	Glengoffe
St. Thomas-Ye-Vale	Bog Walk
St. Dorothy	Old Harbour

The farmers in the study area utilize PCBs of St. Dorothy, St. Thomas-Ye-Vale, North West St. Catherine and Stony Hill. Commercial Banks dealing with the agricultural credit in the study area are the National Commercial Bank Jamaica Ltd. (NCB) and the Bank of Nova Scotia Jamaica Ltd. NCB has two (2) branches, one is in Spanish Town and the other is in Old Harbour. The Bank of Nova Scotia has three (3) branches, two are in Spanish Town and the other is in Old Harbour.

PC Banks provide farmers with loans, short term (up to 2 years), medium term (up to 7 years), and long term (up to 12 years) with an interest rate of 12% per annum.

Commercial banks supply only medium term and long-term loan with an interest rate of 15% per annum.

According to the survey conducted by SCVPA, more than 80% of farmers want to receive loans for agricultural activities and about 50% of farmers have had loan before. Their main source is PC Banks. Out of farmers who have borrowed before, 70% have not repaid their loans and find it hard to do so. Some of these have had problems with water supplies and failed crops. About 30% of farmers, who want loans, have never borrowed.

3.8 Present Irrigation and Drainage

3.8.1 Irrigation

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

(1) Rio Cobre irrigation system

The Rio Cobre water is diverted to the main canal with a maximum water level of El. 41.8 m (140 ft.) at intake. Most of the irrigated land lies between elevations of 3 m (10 ft.) and 30 m (100 ft.), so that irrigation is mostly possible by gravitation. The main canal was designed for a conveyance capacity of 8.8 m^3/sec. However, its present capacity has been reduced to approximately 3.2 m^3/sec due to deterioration of the system. Some of the manually operated gates provided at the headworks enable to control the diversion of water, but the gates on the scouring sluice are out of order. The canal is blocked with vegetation and siltation. A drop structure with weir is located in the main canal, where some water is diverted to the municipal water supply of Spanish Town. This weir causes a considerable decrease in the canal conveyance capacity. Near Spanish Town the main canal bifurcates to the east and to the west.

Mostly, the system is unlined with a total length of 54 km (34 miles). The condition of the canals is rather poor due to insufficient maintenance. The sides of the canals are damaged, causing water losses and this condition is further aggravated by the farmers breaking banks to divert water. The water is supplied 24 hours a day with few measuring devices and the distribution is based on rough estimation. This results in considerable waste of water due to under and/or over supply to the users. The length of canals and the acreage served by the respective canal are shown below:

Name of canal	Length	Area Served
	(km)	(ha)
Main canal A	4.7	150
Main canal B	4.7	-
Turner's Pen branch	3.4	610
Port Henderson branch	5.9	2,075
Cumberland branch	4.3	1,530
Caymanas branch	5.1	1,395
Old Harbour branch	6.1	-
Sydenham branch	3.9	820
Hartlands branch	6.5	560
Old Harbour sub-branch	9.2	2,350
Total	53.8	9,490

(2) St. Dorothy irrigation system

The St. Dorothy irrigation system consists of flood irrigation system which pumped water is delivered through pipeline and open canal and sprinkler irrigation system which pumped water is directly supplied by sprinkler. The flood irrigation system includes the four deep wells i.e. two wells at the Free Town, one well at the Bodles and one well at the Marine Terminal, which have been drilled to pumped water from the limestone aquifer. Major features of these wells and pump equipment are as follows:

Name of Well	Free Town No. 1	Free Town No. 2	Bodles	Marine Terminal
Depth (m)	30.5	30.5	53.4	36.6
Diameter (mm)	610	610	406	406
Pump discharge (m^3/hr)	1,115	863	373	282
Pump power (kw/hr)	128.5	91.3	33.4	27.6

Water pumped up from the Free Town wells is conveyed through the main canal up to Bushy Park. The water carrier system of the main canal consists of three different types with a total length of 14,100 m (46,226 ft.) as follows:

Woodstave pipe : 2,808 m (9,200 ft.) , 860 mm (34 in.) diameter
Concrete flume : 362 m (1,188 ft.)
Lined canal : 10,931 m (35,838 ft.)

Water pumped up from the Bodles well is conveyed by a 406 mm (16 in.) diameter pipeline 0.8 km in length. After this, the water is conveyed to the field by open canal of 1.4 km. The water pumped up from the Marine Terminal is conveied by pipeline with 860 mm (34 in.) diameter of 0.4 km and open canal of 4.7 km in length.

The sprinkler irrigation consists of three deep wells which have been drilled to pump up water from the limestone aquifer. These are independently operated. The principal features of wells and pumps as well as discharge are as follows:

Name of Wells	Sandy Bay	Bowers	Kilbys	Kilbys (Boster)
Depth (m)	-	46.9	45.7	-
Diameter (mm)	406	610	406	305
Pump discharge (m^3/hr)	721	136	84	-
Pump power (kw/hr)	121.6	48.5	12.0	12.0

3.8.2 Drainage

At present, drainage of the plains, mostly irrigated area, is primarily made through man-made channels which act as tributaries of the main streams crossing the plains. The eastern plains area is drained by the Rio Cobre and the Ferry river while the Coleburns gully and Plantain river drain the west. The central area is drained by Salt Island creek and its tributary, the Black river. It has been noted that, apart from the Salt Island creek, the plains are drained well by through-flowing streams and flood drainage channels originating in the hills to the north. There are, however, minor drainage systems originating on the plains, primarily in the west, where the deposits are very clayey. Since the recent alluvium in the east is very permeable, this kind of natural drainage is limited. Most applications of water, natural or artificial, rapidly infiltrate into the ground.

3.9 Agro 21 Crop Diversification/Irrigation Project

3.9.1 General

The purpose of the Agro 21 project is (1) to reinforce the institutional capacity of Agro 21 to promote and develop private commercial agricultural investment, (2) to rehabilitate the existing irrigation infrastructures (off-site) of the Rio Cobre Irrigation Works, (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 small producers become viable.

Agro 21 is the key agency in the Government strategy to increase Agricultural production for export and import substitution. It has been identified as the implementing agency for the Government programme to diversify crop production by both large and small investors and farmers. To strengthen Agro 21 in capability to accomplish these objectives, Agro 21 is being financed with the grant aid and loan provided by the Government of the United States.

3.9.2 Infrastructure rehabilitation

Generally speaking, it is expected that Agro 21 will provide for off-site improvements and that investors will finance on-site improvements such as land levelling, drip and

sprinkler irrigation, shade houses and the like. However, engineering studies and, in some cases, certain types of on-site construction work and land levelling may be done by Agro 21.

It was expected that the Agro 21 project would finance the following in the first year (1985):

- Rehabilitation of 7 wells, construction of 12 new wells including electrical service,
- Construction of a new pumping station on the Rio Cobre (capacity 45 cfs)
- Construction of 2 small pumping stations on canals,
- Reshaping and lining of branch canals,
- Underground piping and hydrants,
- Roads and drainage rehabilitation,
- Canal cleaning, bridge repair and gates,
- Removal of obstructions in canals, and
- Fencing.

Additional infrastructure work in the subsequent two years (1986 and 1987) of the Agro 21 project, was expected to include:

- Rehabilitation or replacement of sluice gates of Rio Cobre dam, including clearing of upstream approaches,
- Drilling and equipping of some 31 new wells,
- Rehabilitation of conveyance canals and dams,
- Rehabilitation of service roads,
- Installation of piping and water control structures, and
- Fencing.

3.9.3 Operation and maintenance

Agro 21 will be responsible for working with the RCIW to enhance its expertise to interface with the water users and to properly manage the multiplicity of water problems. The long term technical staff required for this purpose is an administration/liaison director, who will provide inter-agency co-ordination with respect to the Agro 21 study areas and O&M needs.

Environmental monitoring of the Agro 21 project activities will be the responsibility of the Underground Water Authority. This will include monitoring of (a) water quality with respect to both salinity and contamination by pesticides and other pollutants, (b) groundwater abstraction, and (c) soil salinity.

3.9.4 Small scale farmer linkage

The many small producers for which land is available and those smaller producers near the Agro 21 study area, who will be receiving water from the rehabilitated irrigation system may lack the required skills. The Small Scale Farmer Linkage component of the

Agro 21 project is to assist these smaller producers by the facilitating access to technology, market outlets, land and supplementary employment. The major objective of the activity is to facilitate technology transfer and provide market opportunities to the small farmer.

3.10 Present Organization and Management

There are two (2) irrigation systems in operation in the study area; the Rio Cobre irrigation system and the St. Dorothy irrigation system. The former is currently managed, operated and maintained by the Rio Cobre Irrigation Works (RCIW), a division of MOA, while the latter functions under the St. Dorothy Plain Irrigation Authority (SDPIA) which is run by a board appointed by the Minister of MOA.

The Rio Cobre irrigation system, a gravity flow system, irrigates approximately 9,500 ha (23,500 acres) of land through 54 km (34 miles) of canals. The operation of the irrigation system is carried by 44 staff, headed by a Works Manager. At present, approximately 104 million m^3/year of water is available and sold to some 250 consumers on an annual contract basis. Each contract is for the supply of the specified number of cubic yards per hour at a constant rate throughout the year. The contract rate has been unchanged from J$ 12/cy/hr/year since 1983. The revenue collected is very low. In recent years, the revenue and the budget from the Government covered only the expenditure of personal emoluments.

The St. Dorothy irrigation system consists of seven (7) deep wells, supplies water for approximately 1,870 ha (4,620 acres) by flood and sprinkler irrigation through 2.8 km (1.8 miles) of wood stave pipeline and 28 km (17 miles) of canals. The workings of this system is handled by a staff of 18 headed by a Works Overseer. This system supplies approximately 29 million m^3 of water to some 210 farmers annually. The water is sold on a contract basis at J$ 30/cy/hr/year for flood irrigation and J$ 50/cy/hr/year for sprinkler irrigation. The collecting revenue is high compared with that of RCIW. However, this revenue only covers 6% of the electricity charges for the pumps.

4. THE PROJECT

4.1 Basic Concept of Development

The Government of Jamaica has laid great emphasis on substantially increasing food production through the Agro 21 national plan. The plan aims at reversing the decline in agricultural exports, development of non-traditional crops, development of new employment opportunities, and substitution of agricultural products imports.

In line with the above objective, 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.

Despite the fact that the project area is favourably located near Kingston the capital of Jamaica, and has high potential for agricultural development, agricultural productivity in this area remains low due to limitations of the water supply system and deterioration of infrastructures. In order to achieve successful agricultural development in the project area, the following undertakings will have to be realized:

- reconstruction and rehabilitation of an irrigation network consisting of a diversion headworks, main and branch canals and bifurcation with a pump station as well as a pipeline and concrete flume,
- construction of reservoirs, pump stations, facilities for return flow utilization, etc.,
- rehabilitation of a drainage network consisting of main and branch drains,
- on-farm development including irrigation and drainage system and road network,
- construction of road network,
- operation and maintenance of irrigation and drainage works,
- improvement and strengthening of agricultural support services, and
- improvement of socio-economic infrastructures.

4.2 Demarcation of the Project Area

4.2.1 Potential arable land

The study area covers approximately 27,400 ha (68,500 acres) including farmland, grass land, bush land, urban land, swampy land, rocky land, etc. In order to demarcate the potential arable land from the study area, the following factors were taken into consideration:

(1) Land capability classification

Based on the evaluation of land capability both for upland crops and rice, land classified in Grades I, II, III and IV were proposed for agricultural development. In this evaluation, the relevant factors in the demarcation were soil texture, topography, soil depth, fertility, drainability, soil salinity and acidity, and soil physical properties.

(2) Present land use

Present land use and vegetation were also taken into account in the selection of the potential arable land. In the study area, there are a number of towns and villages. Spanish Town is situated in the northern part of the Rio Cobre area and Old Harbour in the centre of the St. Dorothy area. These towns, residential and commercial areas were excluded from the potential arable land. The eastern and southern seashores of the study area are covered by mangrove forest. In addition, there are considerable miscellaneous areas such as gullied land, beaches, sand mining, etc. These areas are also excluded from the potential arable land.

In due consideration of the above, the potential arable land within the study area was confined to approximately 21,000 ha consisting of 16,200 ha in the Rio Cobre area and 4,800 ha in the St. Dorothy area as summarized below:

(Unit: ha)

Category of Lands	Rio Cobre Area	St. Dorothy Area	Total
Study area	21,600	5,800	27,400
Non-arable land	5,400	1,000	6,400
- Urban land	(3,600)	(600)	(4,200)
- Swampy land	(1,400)	(300)	(1,700)
- Rock land	(100)	(-)	(100)
- Other land	(300)	(100)	(400)
Potential arable land	16,200	4,800	21,000

4.2.2 Selection of the potential development area

In the preceding sections, the extent of the potential arable land was discussed. In selecting the project area, it was necessary to conduct an economic comparative study, which will be discussed in the subsequent section. In this regard, delineation of the

possible development area was made on the basis of the basic concept of development which is to modernize and to expand the present irrigation system by reconstructing and improving the existing infrastructures of the Rio Cobre irrigation system together with Free Town irrigation system.

In order to select the possible development area from the potential arable land, the following factors were taken into consideration:

(1) Irrigability

For reasons of topography, part of the arable land is difficult to irrigate. Northwest of the St. Dorothy area is too high and remote from the surface water source, and a large portion to the north of the St. Dorothy area is too hilly and rugged for irrigation.

In addition, land to the north of Spanish Town is being urbanized rapidly, hence it would be difficult to put this land into irrigation systematically. These areas were excluded from the possible development area.

(2) Drainability

There are low-lying marshy lands, especially to the south of Great Salt Pond District and to the north of Caymanas Estate, which were excluded from the possible development area since they do not seem to be feasibly drainable by mechanical measures.

From the considerations discussed above, the potential development area was selected to be 15,330 ha as summarized below:

Potential Development Area	Area (ha)
Rio Cobre area	12,990
St. Dorothy area	2,340
Total	15,330

4.2.3 Demarcation of the project area

Land irrigable by groundwater (Free Town irrigation system) in the St. Dorothy area was estimated at 1,490 ha on the basis of availability of groundwater. Since the total St. Dorothy area is 2,340 ha, the balance of 850 ha has to be excluded from the groundwater based system. It is possible nevertheless to include this area in the Rio Cobre area by expanding its system. The table below shows the possible development area in the respective irrigation systems.

Possible Development Area	Area (ha)
1. Rio Cobre Irrigation System	
Gravity Irrigation System	
Rio Cobre East	7,100
Rio Cobre West (including 850 ha from St. Dorothy)	6,030
Lift Irrigation System	
Spring Garden and Thetford	710
2. Free Town Irrigation System	
St. Dorothy South	1,490
Total	15,330

For more detailed demarcation of the project area, four (4) alternatives were further examined.

Alternative 1	Alternative 2	Alternative 3	Alternative 4
Area to be developed by rehabilitating the Rio Cobre gravity irrigation system	Area to be developed by rehabilitating the Rio Cobre gravity and Free Town irrigation systems	Area to be developed by rehabilitating and expanding the Rio Cobre gravity irrigation system and rehabilitating the Free Town irrigation system	Area to be developed by lift irrigation in addition to Alternative 3

To compare and evaluate the above alternatives, a water balance study was made on the basis of water availability and requirements. The irrigable area both in rainy and dry seasons for each alternative were worked out as shown in Fig. 9 and summarized as shown below:

(Unit: ha)

	Alternative 1 (9,950 ha)		Alternative 2 (12,370 ha)		Alternative 3 (14,620 ha)*		Alternative 4 (15,330 ha)**	
	R. S	D. S	R. S	D. S	R. S	D. S	R. S	D. S
Rio Cobre East	5,000	3,580	5,800	5,750	7,100	7,100	7,100	7,100
Rio Cobre West	4,950	1,900	5,180	4,250	6,030	6,030	6,030	6,030
St. Dorothy	-	-	1,490	1,490	1,490	1,490	1,490	1,490
Part of Spring Garden	-	-	-	-	-	-	710	710
Total	9,950	5,480	12,370	11,490	14,620	14,620	15,330	15,330

Remarks: *; Reservoirs with 15 million m^3 capacity required.
**; Reservoirs with 20 million m^3 capacity and a 300 kw pump required.
R.S; Rainy Season
D.S; Dry Season

After this, a general economic comparison was made in terms of IRR, B/C ratio and B-C for each alternative. The results are shown in the table below:

Alternative	IRR (%)	B/C*	B-C* (10^6 J$)
1	1.6	0.43	-123
2	22.8	2.57	397
3	23.5	2.49	489
4	19.4	1.99	416

Remark: *; Discount rate: 10%

All the indices of Alternative 1 have very low values, which are attributable to the fact that the irrigable area is very limited and that most of the area proposed would be covered with sugarcane of which benefit is fairly low.

A comparison between Alternatives 2 and 3 shows that the IRR and B-C of Alternative 3 are higher than those of Alternative 2, although B/C of Alternative 2 is slightly higher than that of Alternative 3. This means that the larger area is more beneficial because the ruinate lands, due to lack of irrigation water could be converted to productive farm lands which would result in a higher benefit in relation to the construction costs of the reservoirs.

The indices of Alternative 4 by contrast show rather lower values than Alternatives 2 and 3, due to the higher construction costs of larger reservoirs and the pumping facility compared with the attendant benefits.

As a result, it can be said that Alternative 3 is the most desirable for development. Therefore it is proposed that the project area should be bounded by the 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 Portmore residential area on the east and by the Bowers river on the west as shown below:

(Unit: ha)

Project Area	Gross	Net
Rio Cobre East	7,100	6,140
Rio Cobre West	6,030	5,210
St. Dorothy	1,490	1,330
Total	14,620	12,680

4.3 Agricultural Development Plan

4.3.1 Proposed land use

Proposed land use within the project area under the new irrigation system is formulated based on government policy, present land use and agricultural conditions, soil conditions

and crop suitability, agro-economic and social conditions including the intentions of farmers. The project area is divided into four division, namely, St. Dorothy, Rio Cobre West, Rio Cobre East and Small Farmers area. Table 3 and Fig. 10 shows the proposed land use by each area by category.

(1) St. Dorothy area

According to the present land use and intentions of farmers, land use is formulated as; present pasture and part of ruinate land owned by livestock farmers should be converted into improved pasture, and production of sugarcane should be increased by improvement of cultural practices and expansion of the area to be served by improved irrigation water supplies.

(2) Rio Cobre West area

Government policy for national land use in this area, is that Innswood Estate should continue production of sugarcane for sugar and Amity Hall should expand paddy fields and increase rice production. Sugarcane at Hartlands should be diversified to grains for import substitution. As paddy is an important crop in the self sufficiency programme and economically feasible, paddy is proposed to be the main land use for national and private (Little Hartlands) lands in saline clay areas except for Innswood.

In the western private-owned lands, farmers usually want to continue and/or expand the present sugarcane or vegetable/crop fields and pasture for beef cattle under conditions of sufficient water supply. However, there are some lands suitable for vegetables (recent alluvial soils) and for paddy (saline clay soils). The proposed land use plan will be therefore, that a new vegetable/crop belt should be developed along Coleburns gully, paddy at south-east Bushy Park and present land use be continued and/or expanded in the other lands.

(3) Rio Cobre East area

The Crop Diversification Programme is underway in this area, which divided into nine (9) areas (A to I) and are diversified into winter vegetables with grains, ornamental crops, orchard and aquaculture with sugarcane remaining in one area. In area D however, as soils are moderately saline, paddy is suitable to reduce or to prevent increase in the soil salinity. Therefore, it is planned to introduce paddy-with-grains depending on water supply and the market for other grains. Concerning area H, soils are fertile and have good drainage. Therefore, orchard crops suitable for export market such as mango and papaya are proposed in the land use plan.

(4) Small Farmers area

Designated Small Farmers areas would include private lands such as Hartlands, the land along the Town gully (including Hill Run) and the Government lands of Lawrencefield. Ruinate covers more than 70% in the former two (2) areas. However, mixed culture of orchards and vegetable/crops are already practised by small farmers in Lawrencefield.

Proposed land use is formulated as vegetable/crop with some orchard in Lawrencefield and paddy and aquaculture in Hartlands and Town gully area.

4.3.2 Proposed cropping pattern and farming practices

Depending on proposed land use described above, cropping patterns are proposed for the project as shown on Fig. 11.

(1) Sugarcane

For the cropping of sugarcane, four (4) ratoons are assumed in this plan after spring replants. To achieve higher yields of sugarcane, especially of ratoons, proper management of soils, improvement of fertilization and other farming practices are recommended.

(2) Paddy - paddy

In order to avoid an increase in insect and fungus pests owing to year round staggered planting, the proposed cropping pattern of paddy is planned for a new system of double cropping. Under the system there would be one month of perfect fallow without irrigation during the dry season simultaneously throughout the entire paddy area with the aim of killing completely leaf and plant hoppers or fungus pests by eliminating host plants. In land preparation, specific attention should be given to the levelling of field surfaces. In case of direct sowing, weed control at early stages of growth is the problem. Therefore, a combination of two herbicides (Propanil and Bentiocarb) is recommended as they have excellent synergistic effect with contact and persistent activity as well as inhibitory activity.

(3) Paddy - grain

Cropping of paddy-grains is proposed at Hartlands, Small Farmers areas and Area D for reasons of soil salinity and water supply as mentioned above. Grains would include maize for feed and soybeans, and paddy cultivated around the rainy season (Sept. to Dec.).

(4) Vegetable - grain

This proposed cropping pattern and the farming practices given are based on those which have been planned by Agro 21 and practised by International Agri-management Workyard (IAW) now changed to Intergrow Ltd. at Bernard Lodge. They cultivate vegetables geared for an export market (usually USA) and, practises large scale cultivation of grains such as corn and soybean which are important for the self-sufficiency import substitution programme. The four vegetables grown for these projects are cucumbers, sweet pepper, zucchini squash and cantaloupe melons, with the possible addition of pumpkins.

For all crops, fertilizer would be applied at bed formation and side dressings would be periodically applied during the growing season. Regular weekly spraying programmes would be followed to prevent disease problems and insecticides as necessary. Hand weeding is usually done but small tractors would sometimes be used. Other manual

labour includes pruning and fruit picking. At Bernard Lodge, a relatively small area can be drip irrigated but sprinkler systems are mainly proposed. As these vegetables are short-term crops, harvesting will begin approximately two months after planting.

(5) Vegetable - vegetable

For effective utilization of water and for beneficial marketing, the general growing seasons of vegetables would be the winter season (Sept. to March) and summer season (Feb. to June).

The use of the herbicides has been introduced into the farming practices especially for small farmers in order to decrease labour requirement for weeding. Most labour and material inputs have been increased for corn, red peas, tomato and pumpkin whereas less pesticides are recommended for onions. Fertilizer use has been limited at present to sulphate of ammonia for both leaf and fruit crops, therefore complete fertilizers are to be applied at planting and at onset of flowering. No systemic insecticides are recommended as small farmers tend to allow these near to harvesting.

(6) Orchard

Proposed cultural practices for orchard crops include new planting of some varieties of mango, and papaya: increased fertilizer and spraying applications, pruning and record keeping (mainly for small farmers).

For mango, the Tommy Atkins and Keitt are superior varieties. St. Julian variety is resistant to anthracnose and has good flavour. In case of papaya, Sunrise Solo cultivar is recommended. A fertilizer relatively high in nitrogen and potash but low in phosphate is recommended. Both crops respond favourably to the use of organic manures which may be applied regularly. Chemicals will have to be applied periodically. Regular pruning of mango trees and record keeping of yield and cultural practices should also be done. Interplanting in the early stage of mango orchards with short-term economic crops such as legumes, vegetables, pineapples and papaya may be done.

(7) Ornamentals

All ornamental crops proposed are based on the Agro 21 plan which earmarked Leatherleaf fern, Aglonema and 6 other species of plants. Very high population rates are used for Golden Pothos and Philodendron but yield compensate for the very high initial costs.

Generally, fertilizer practice for most of these crops is application of a 2-1-2 mixture spread over three or four applications. A contact herbicide for aisles plus hand weeding of beds is considered a good method of restraining weed growth. A programme using Basudin or other contact insecticides along with fungicides is helpful to prevent disease/insect damage.

(8) Field operation and labour requirement

Proposed field operations for crops are semi-mechanized systems which are manual for planting, harvesting, fertilizing and weeding and are mechanized for land preparation and spraying, except for all mechanized large-scale paddy and grains. Total daily labour requirements, based on these field operations in the project area, are 3,660 man-day on average and 7,130 man-day at peak in January as shown below:

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
7,130	5,600	5,190	2,890	3,400	3,440	3,810	2,160	2,390	2,190	2,870	2,830	3,660

However, as the agricultural labour force in the study area is estimated to be 7,380 and with 14,300 unemployed, the labour requirement will be fully met and the proposed field operations are therefore feasible.

4.3.3 Anticipated yield and production of crop

Anticipated yields and production of crops are expected to increase substantially year by year. The following table shows the anticipated production of crops at the full implementation stage in the project area.

Crop	Yield	Harvested Area	Annual Production
	(ton/ha)	(ha)	(10^3 ton)
Sugarcane	79.0	2,835	222.8
Paddy	5.0	5,040	25.2
Soybeans	2.5	1,270	3.2
Maize	6.0	3,810	22.9
Vegetables	-	4,470	69.3
Fruits	-	707	8.1
Milk	16.0	981	15.8
Beef	3.8	216	0.8
Fish	7.0	406	2.8

(1) Sugarcane

The difference in average yields of sugarcane is influenced primarily by the yield of ratoons. The higher yield of ratoons on fertile land may significantly be attributed to the lower rate of annual decrease in ratoon yield.Depending on the cultivation programme of sugarcane on Innswood Estate, the anticipated increased percentage in yield is 20 to 30% and that of production is 40 to 60% including increased cultivated area. Based on this information, the average yield and total production of sugarcane within the project area anticipated from improved conditions of soils and cultural practices are 79 ton/ha and 222,800 ton from net area of 2,835 ha (3,261 ha gross), respectively.

(2) Paddy, grains

The average paddy yield of the first crop is about 5 ton/ha (4,500 lb/acre). However, the second crop is not as good as the first crop (estimated at 4.5 ton/ha) owing to weeds and lodging. Although there will be constraints for the cultivation of paddy, the target yield is anticipated at 5 ton/ha (4,500 lb/acre) with improved field conditions and cultural practices, and the introduction of better varieties. Then, annual production is estimated at 25,200 ton from double cropping net area 1,545 ha (1,716 ha gross) x 2 and paddy-grain net area 1,950 ha (2,168 ha gross).

Soybean yield is mainly dependent on the control of insect pests. The anticipated yield of soybean at full development would be 2.5 ton/ha with suitable varieties chosen and improved cultural methods. The main constraints of maize cultivation may be insect, pests and disease. However, when these constraints are controlled by adequate applications of pesticide, sufficient fertilizer and water supply, the yield potential would be up to the average yield in the USA (5 to 7 ton/ha). Target yield in this plan is anticipated at 6,000 kg/ha under the above improved conditions. Within net grain area 5,075 ha (Vegetable-grains 3,125 ha net - 3,472 ha gross, paddy-grains 1,950 ha net - 2,168 ha gross), maize to soybean ratio is assumed to be 3:1.

(3) Vegetable - grain

Assuming an equal area for production of cucumber, sweet pepper and pumpkin, then anticipated production would be approximately 44,300 ton from a net area of 3,125 ha (3,472 ha gross).

(4) Vegetable - vegetable

Production of vegetables should increase sharply owing to availability of sufficient irrigation water, improved cultural practices and increased cropping intensity. The total net area is approximately 674 ha (749 ha gross). Assuming production in summer and winter of the 5 main crops (calaloo, pumpkin, cucumber, sweet pepper and onion) in equal areas, the total production would be anticipated at 25,000 ton per annum.

(5) Orchard

Net area of orchard crops will be increased to 707 ha (786 ha gross) from 77 ha (86 ha gross). Some 630 ha may therefore be primarily for mango and papaya. Based on export volume from 1982 to 1985 in market research data of Marketing and Credit division of MOA, it is anticipated that the ratio of mango to papaya might be at 85:15. Based on this assumption, total net area in mango is 601 ha and for papaya, is 106 ha. Production of mango at full bearing stage (year 8) is 5,750 ton at 9.4 ton/ha and for papaya it is 2,600 ton at 25 ton/ha.

(6) Ornamentals

Most anticipated yields are encouraging as, Golden Pothos yield to planting materials ratio (number of plants) in year 1 is 12.5:1 and increases to 25:1 from year 2 onwards; while

for Aglonema it is 2:1 in the first year and 4:1 from year 2 onwards. However, Dracaena massangeane shows a single yield of 55,300 plants/ha in year 4 representing a 4:1 ratio.

4.3.4 Livestock

(1) Dairy

Improved feeding and management practices for dairy cattle may be divided into care of: dairy cow, the new born calf; housing for dairy calves; the heifer from weaning and of bulls and, introduction of milking equipment on some dairy farms. In caring for the dairy cow, good quality pasture or other nutritious forage crops such as legume species usually forms the bulk of feed. Grain feed, containing a high percentage of energy and protein matter in readily digestible form should be included in the diet of dairy cows especially during lactation. The amount of such feed given will be a standard of 1 kg feed to 3.4 lit. milk produced as a guide. Dairy farmers should provide 6 to 7 grazing paddocks for the milking herd followed by the dry herd and 6 to 7 paddocks for rearing replacement heifers.

(2) Beef

In order to improve beef quality, annual production and the feed conversion ratio, several rearing practices are proposed for beef production. These include rearing systems, feed rations and use of hormones. A combination of two rearing systems of production are recommended. They are the cow and calf system and the weaner feed-lot system. This is because invariably there will be a shortage of weaners for purchase by all farmers. However, the weaner to market system is preferred. In the calf to market system, 6 grazing paddocks for the breeding herd and 8 for weaners should be provided.It is preferred that commercial concentrates be fed. However, it is more economical to apply the appropriate fertilizer dressings to pastures and/or partially substitute with a well-balanced blended feed made from local by-products.Anticipated duration for weaners on feed-lot is 9 months and, calf to market system is expected to be 17 months.

(3) Pasture

For the establishment of new pastures, cuttings of improved species of African Stargrass and Guinea grass are recommended. Pasture with improved species of grass and high protein legumes under adequate fertilization and water supply will give a carrying capacity of 5 or more animal units (AU) per ha (2 AU/acre).Proper natural grazing should be designed to put animals on pasture when the stage of growth provides optimum nutrition while the power of recovery is not reduced and that paddocks get adequate rest (5 weeks for African stargrass). However, the economic optimum stocking rate will be determined by (among other parameters) the type of animal product produced, that is, milk or beef. Dairy cows require a lighter stocking rate than their equivalent in beef animals on the same pasture as milk flow is very sensitive to pasture quality.

(4) Anticipated production

The proposed net area in pasture is 1,197 ha (1,330 ha gross) which may be divided into 981 ha for dairy and 216 ha for beef cattle depending on present and proposed land use.Assuming that 17.8 kg of milk per cow per day under above improved rearing practices, improved pasture with 5 AU/ha carrying capacity would produce 16,000 kg of milk per ha. Then, total milk production will be 15,760 ton from net pasture area of 981 ha.As for beef cattle, assuming a stocking rate of 4.2 per ha of improved pasture (a semi-intensive rearing system) and finished weight of 450 kg; duration of fattening as 6 months, then liveweight production per ha per year may be calculated as 3,780 kg and total annual production approximately 800 ton.

4.3.5 Aquaculture

Proposed improved rearing practices for fish include; decreasing the turn around time between pond stocking; inclusion of brood ponds on small farms; an increased stocking rate, and a revised procedure mechanism for hand-sexing fingerlings. Total net area is 406 ha (580 ha gross). Annual production is calculated to be 2,840 ton based on 2.5 crops/year with an average yield of 2,800 kg/ha per crop under above improved rearing practices.

4.3.6 Post harvest facilities

With respect to sugarcane, despite uncertainty about production of Ethanol at Bernard Lodge, Monymusk and New Yarmouth Sugar Factories are capable of milling the additional production under project conditions.Planned expansion for the Spanish Town Rice Mill in 1987 is 2 sets mills with capacity of 4.5 ton/hr. If improved milling operations are as at present, that is, 16 hours/day for 325 days per year, these mills will be capable of producing 46,800 ton of finished rice per year. Annual production of paddy after project implementation will be approximately 25,200 ton (15,120 ton finished rice) or 32% of the mills output.Soybean will be sent to the Jamaica Soya Products Ltd. for processing. The crushing capacity of the mill is 90,000 ton/year. Since the projected production is approximately 3,000 ton or 3.3% of the mill's capacity,there will be sufficient milling capacity available for the additional soybean produced.The Spanish Town Rice Mill also has the facilities and plans for drying corn. Projected dryer bin capacity will be sufficient to dry the 23,000 ton of corn to be produced.As for the packaging plant for St. Catherine Vegetable Producers Association, it is anticipated that at 25,000 ton of vegetable per year, the plant will still be operating below full capacity.Production of milk is anticipated to be 15,800 ton which can be adequately processed by the expanded facilities at Century Farms and/or Cremo Ltd.

4.3.7 Marketing prospect

(1) General

Future agricultural production in the project area can be viewed in terms of projections of domestic demand and export requirements for crops, livestock and fish. The marketable

surplus of products in the project after implementation of the project may be classified into the following four categories:

(a) Crops for export

Winter vegetables and fruits, and ornamental horticulture will be mainly exported to the fresh markets in North America and Europe.

(b) Commodities for import substitution

Commodities such as rice, maize, soybean, beef, milk and fish, which are currently imported, will be supplied by domestic production.

(c) Crops for domestic consumption

Summer vegetables and some other crops like red pea will be marketed in the local markets in Kingston, St. Andrew, St. Catherine and Clarendon.

(d) Sugarcane

Sugarcane produced in the project area will be purchased by National Sugar Holding according to the Government policy.

(2) Crops for export

According to the studies carried out by Agro 21, it was found that US market had a large potential for imported winter vegetables, fruits and ornamental horticulture.

The market size of the total flower industry in US has expanded from US$ 2 billion annually in 1960's to 1970's to about US$ 7.0 billion annually in 1980's, and is expected to reach US$ 9.0 billion in 1990's. The fresh cut flowers industry alone increased from US$ 3.1 billion in 1981 to US$ 4.3 billion in 1984 and to US$ 4.8 billion in 1985. On the other hand, the number of firms producing fresh cut flowers in US has been declining due to changes in consumer preference for exotic flowers and to increased import competition. It is considered that Jamaica has an opportunity to export fresh cut flowers to US market because of geographical position and price.

Per capita consumption of vegetable in US has steadily increased at a rate of 5% per annum from 1970 to 1983, and reached 95 kg (209 lb) in 1984. US consumer's preference has been shifting towards fresh vegetables which contain high fibre and vitamin, even when the domestic supply is out of season, because of health consideration. In addition to above changes in preference, population growth contributes to increased demand of vegetable. It is expected that the import of fresh vegetable in US will continue to increase especially in the winter season.

In terms of consumption of fruits, per capita in US consumption of fruits reached 42 kg (91.8 lb) for both fresh and processed, and 14 kg (30 lb) for tropical fruits in 1983.

Consumer preference is also changing to fresh fruit from processed fruit. The quality of fruit is high even in the off season, and fresh fruit consumption is income elastic. For these reasons, the demand for and import of fresh fruit is steadily increasing. According to the marketing studies, Jamaica has the opportunity to export mango, papaya, pineapple, passion fruit, navel-orange and guava. About mango, US and Europe imported 39,000 ton in 1983 and 51,000 ton in 1984.

(3) Commodities for import substitution

On the basis of past trends domestic production and import of these commodities, and per capita consumption in 1995 can be forecast. Using forecast per capita consumption in 1995, total demand of each commodity in Jamaica in 1995 can be estimated. The balance between total demand in 1995 and average domestic production during 1981 to 1985 are summarized below:

(Unit: ton)

Commodity	Total Demand in 1995	Average Production 1981-85	Balance	Production in the Project Area in 1995
	(A)	(B)	(A)-(B)	
Rice	100,700	3,300	97,400	25,200
Maize	283,300	3,800	279,500	22,900
Soybean	76,500	700	75,800	3,200
Beef	20,000	13,100	6,900	820
Milk	68,900	49,100	19,800	15,800
Fish	62,900	8,300	54,600	3,400

The above table shows that production of those commodities expected in the project area in 1995 is far behind the estimated demand in 1995.

(4) Crops for domestic consumption

Crops such as summer vegetables and some other crops, which will be harvested out of the export season in the project area, will be marketed for domestic consumption, especially in the parish of Kingston, St. Catherine, St. Andrew and Clarendon.

Demand for these crops in the above market area in future was forecast on the basis of population growth and the increased rate of per capita consumption. The estimation of per capita consumption and total demand in the market area was made for 18 vegetables and 6 other crops.

The balance of demand between 1985 and 1995 will be supplied from the area to the said consuming regions. It is expected that the project area will be the main supplier for the market area after the implementation of the project. Total production in the project area and the balance of total demand between 1985 and 1995 are summarized below:

(Unit: ton)

	Balance between Total Supply in 1985 and Total Demand in 1995	Total Production in the Project Area in 1995
Calaloo	5,600	7,500
Cucumber	2,600	3,000
Onion	2,700	3,800
Pumpkin	9,100	3,500
Sweet pepper	5,900	2,800
Other vegetables	29,700	-
Vegetable total	55,600	20,600
Red pea	1,500	300

(5) Sugarcane

After implementation of the project, production of sugarcane is expected to rise to 222,800 ton by 1995. All the sugarcane produced in the project area will be transported to Monymusk Sugar Mill Factory for milling.

4.4 Irrigation and Drainage Plan

4.4.1 Irrigation water requirement

Measurement of consumptive use of water for sugarcane and vegetables was made during the crop season from July to September 1986. Although the results obtained are reasonably close to the amounts estimated from climatic data, the observed period is too short to be used for predicting irrigation water requirements. Evapotranspiration of crops was therefore estimated from climatic data, since flood irrigation proposed for paddy cultivation has to be taken into account. The percolation rate was estimated to be 1.0 mm/day. Consequently, the summation of evaportranspiration and percolation gives the water requirement of paddy. For upland crops, for which furrow, sprinkler or drip irrigation is proposed, the percolation rate is not taken into account.

Effective rainfall is the product of rainfall efficiency and probable minimal rainfall in a 5 year return period. The rainfall efficiency was estimated by the daily water/moisture balance method using daily rainfall records at two rainfall stations. As a result, rainfall efficiency varies from 70% to 80% of actual rainfall for rice and 65% to 70% for upland crops. The balance of the water requirement and effective rainfall indicates the irrigation water requirement. In order to sustain suitable soil moisture conditions prior to land preparation and sowing, pre-irrigation is required. The quantity of water required for pre-irrigation is calculated to be 90 mm for rice field and 60 mm for upland crop field.

The overall irrigation efficiency (Ei) is estimated as the product of application efficiency (Ea), operation efficiency (Eo) and conveyance efficiency (Ec) as summarized below:

Irrigation Method		Ea	Eo	Ec	Ei
Rice	(flood)	100	80	90	72
Upland crops	(furrow)	60	90	90	49
Upland crops	(sprinkler)	75	-	90	68
Orchard	(drip)	85	-	90	77

The diversion water requirement or gross water requirement for the proposed cropping pattern in the project area area is estimated based on effective rainfall with a dependability of 80%. The unit diversion water requirements of various crops is summarized below:

Crop	Gross Irrigation Requirement	Peak diversion Requirement	Peak Month
	(mm)	(lit/sec/ha)	
Rice (dry season)	1,500	1.26	June
Rice (rainy season)	1,020	0.79	December
Grain (after rice)	930	1.16	April
Grain (after vegetables)	710	0.90	July
Vegetable (summer)	790	0.76	April
Vegetable (winter)	520	0.45	January
Pasture	1,790	1.07	July
Sugarcane	2,650	1.23	July
Orchard	1,160	0.60	July
Horticulture	1,160	0.60	July

4.4.2 Drainage water requirement

Field ditches and collector drains are categorized as on-farm level development, for which a preliminary design is given in Annex-J. The design discharges of these two drains were determined as shown below, based on the assumption that the rain water can be drained within 24 hours.

(Unit: lit/sec/ha)

Field Condition		Design Discharge
Rice field	(flat)	10.7
Upland crop field	(flat)	8.2

Secondary drains transport water from the collector drains to natural gullies or rivers which form the main drains. Unit design discharges of secondary drains under different field conditions may be summarized as follows:

Field Condition	Area	Drainage Time	Design Unit Discharge
	(ha)	(hr)	(lit/sec/ha)
Rice field	100	24	10.7
	500	48	5.3
Upland crop field	100	48	4.1
	500	72	3.3

As far as the main drains are concerned, natural gullies and rivers will be utilized without river training.

4.4.3 Irrigation and drainage plan

Two main water resources are available in the project area, i.e. surface water from the Rio Cobre and groundwater pumped up from both limestone and alluvial aquifers.

(1) Surface water

The annual mean flow discharge of the Rio Cobre is estimated at 315 million m^3. However, the amount of water which can be diverted from the Rio Cobre to the Rio Cobre main canal will depend on the canal's capacity. In order to estimate the amount of water which could be diverted to the canal, three cases of canal capacity, namely 8 m^3/sec, 10 m^3/sec and 12 m^3/sec were examined using daily river discharge data from 1955 to 1983. As a result of the study, the following figures came up.

Canal Capacity	Annual Diverted Discharge
(m^3/sec)	(million m^3/year)
8	187
10	199
12	207

Note: The annual diverted discharge is computed on the basis of a 1:5 year chance of occurrence.

(2) Groundwater

As mentioned in the proceeding sub-section of 3.4.5, Hydrogeology, annual available groundwater from both limestone and alluvial aquifers in the study area were assessed at about 140 million m^3. The annual permissible abstraction of groundwater in the project area was estimated based on the results of the groundwater simulation analysis and summarized as follows:

(Unit: million m^3/year)

Area	Annual Abstraction of Groundwater		
	Limestone	Alluvial	Total
Rio Cobre	28	28	56
St. Dorothy	22*	1	23
Total	50	29	79

Notes: *; including volume pumped up from Free Town wells. Figures above are not included the water pumped for industrial and domestic use.

As mentioned above, the total water resources available for irrigation in the project area may be summarized as follow:

(Unit: million m^3/year)

Area	Surface Water	Groundwater	Total
Rio Cobre	199*	56	255
St. Dorothy	-	23	23
Total	199	79	278

Note: *; Figure shows diverted discharge under the canal capacity of 10 m^3/sec.

4.4.4 Water balance study

A water balance study between availability of supply and requirements was conducted based on the hydrological conditions of 1975 which nearly meets the drought year condition of 1:5 year chance of occurrence. There is a problem with the timely distribution of the available irrigation water from the river flow. There was a seasonal deficit in the months of March and April, and again in June and July. In order to cope with this, it is proposed to create reservoirs in the project area.

4.4.5 Determination of reservoirs capacity

In order to examine the optimum scale of reservoir, a water balance study between demand (water requirement) and supply (surface water and groundwater) was made for the 29 year period from 1955 to 1983. The maximum deficit was estimated to be approximately 110 million m^3 in 1976 whereas the minimum is nil.

In order to estimate the optimum scale for the reservoirs in the dry year (1:5 dry year), a tentative economic comparison was made in terms of the net present values (NPV) which were calculated for combination of the construction cost of reservoirs and the construction and operation cost of wells, for seven different sizes of reservoirs range between 3 million m^3 and 20 million m^3. The study results show that the minimum NPV occurs in 15 million m^3 as shown below (see Annex-I for details):

Reservoir (million m^3)	0	2	5	10	12	15	20
NPV (10^3 US$)	6,957	6,825	6,696	6,667	6,652	6,515	10,564

As a result , the optimum scale of reservoir was estimated at approximately 15 million m^3. It may be noted that the optimum scale thus determined on the basis of the 29 years fulfills the requirement of the dry year once in five years.

4.4.6 Irrigation system

There are two existing irrigation systems in the project area, namely the Rio Cobre irrigation system which depends on surface water from the Rio Cobre and St. Dorothy irrigation system which depends on groundwater. A rehabilitation programme has been undertaken by Agro 21 in the eastern part of the Rio Cobre irrigation area. The irrigation plan was made taking these conditions into account and formulated into a comprehensive development plan.

The general layout of the irrigation system is illustrated in Fig. 12. The major structures to be rehabilitated and/or to be newly constructed may be discussed as follows:

(1) Rio Cobre common water infrastructure

(a) Rehabilitation of the headworks and intake structure

Though the flow discharge to be diverted to the main canal is planned at 9.63 m/sec, raising of the dam crest elevation would be required so as to ensure this discharge to improve performance. The height to be raised with mass concrete on the existing dam crest is 0.6 m (2 ft.) over the whole length of the crest. Rehabilitation of the apron and retaining wall downstream of the dam should also be included. As far as the intake structure is concerned, the structure itself is still durable and has enough capacity to divert the design discharge. The eight sluice gates installed at the intake structure have deteriorated and require replacement with new ones. In order to reduce seepage through dam foundation, it is proposed to carry out certain grouting.

(b) Rehabilitation of the main canal (from the intake structure to No. 1 bifurcation)

The main canal, approximately 4.7 km long with a design capacity of 9.63 m^3/sec, will require lining with concrete. Eight bridges and one aquaduct also require reconstruction. The bifurcation will also be reconstructed and a pumping station will be established to supply water to the Spanish Town Water Works.

(2) Rio Cobre East (Agro 21)

(a) Rehabilitation of the east main canal
(from No. 1 bifurcation to No. 2 bifurcation)

The east main canal which is generally in unlined canal would be lined with concrete. The total length of the canal lining is 4.7 km and all the related structures such as turnouts, drops and checks as well as bridges would be reconstructed.

(b) Reconstruction of the Rio Cobre syphon

The existing syphon crossing of the Rio Cobre by the Caymanas branch canal is exposed on the river bed and faces serious damage by flood. It is proposed to replace it by a new syphon of ductile iron pipe.

The total length of pipe required is 134 m and 900 mm in diameter.

(c) Construction of Town gully reservoir

One reservoir is planned at Corletts Pen along Town gully. The storage capacity of this reservoir will be 9.6 million m^3 in an area of 200 ha. Water would be supplied to the reservoir through Turners Pen branch canal and delivered to both Port Henderson and downstream of Turners Pen branch canals. The height of the dike would vary from a maximum of 10.0 m to a minimum of 4.2 m.

(3) Rio Cobre West

(a) Rehabilitation of the west main canal
(from No. 1 bifurcation to No. 3 bifurcation)

Total length of the west main canal (2.8 km) would be lined with concrete and all related structures would be reconstructed. The design capacity of the canal is planned to meet the irrigation water requirement, necessary discharge to the reservoir (Black river reservoir) and discharge to the sinkhole for artificial recharge.

(b) Rehabilitation of Hartlands branch

The Hartlands Canal branches off to the south from the west main canal, and forms the boundary between the Rio Cobre East (Agro 21) and the Rio Cobre West. However, it irrigates both Bernard Lodge and Innswood Estates lands. It is proposed that the canal be lined with concrete. The canal is 7.1 km long with a design discharge of 2.77 m^3/sec. All the related structures will be reconstructed.

(c) Rehabilitation of Old Harbour branch

The Old Harbour canal branches off to the west from the west main canal. There are three notable features along this branch. One is a sinkhole which facilitate groundwater recharge located on the right bank; the second is a reservoir proposed to be created on the left bank; and the third is the extension canal towards the St. Dorothy area. In order to supply the design discharge, the canal must be raised considerably.

(d) Construction of the Old Harbour branch extension canal

In order to irrigate an area of about 850 ha located in the St. Dorothy area, it is proposed to extend the Old Harbour branch canal into the area. The total length of the canal to be extended with concrete lining canal is 5.1 km. Structures necessary such as syphons, turnouts, checks and culverts would be newly constructed.

(e) Construction of Black river reservoir

This reservoir would be located about 1 km west of the Innswood sugar factory. Storage capacity of the reservoir would be 3.8 million m^3 in an area of 80 ha.

The reservoir would receive water through the Old Harbour branch canal and would deliver to downstream by the Old Harbour branch canal and by the Black river to Amity Hall. The height of dike will vary from a maximum of 8.8 m to a minimum of 4.8 m.

(4) St. Dorothy

(a) Rehabilitation of the Free Town pipeline

Water from the Free Town pump station is carried by a woodstave pipeline constructed in 1963. The pipeline has deteriorated considerably and plenty of water is wasted by leakage. Consequently it is proposed to replace the pipeline with a new one. A ductile iron pipe with a diameter of 700 mm would be proposed for new pipeline. The length of the pipeline is 2.8 km and design discharge is 0.55 m^3/sec.

(b) Rehabilitation of the Free Town pump station

Two pump sets are installed at the Free Town pump station. The total discharge from the two pump is 0.34 m^3/sec at present. In order to increase the discharge from the two wells, two pumps would be replaced by new ones. In addition three pumps would be newly installed at wells which would be newly constructed at Free Town pump station to reach a total discharge of 0.55 m^3/sec.

(c) Rehabilitation of the Free Town canals

The existing open canal system delivers pumped water from Free Town, Marine Terminal, and Bodles pumping stations to farming land. The main canal commences at the outlet point of the Free Town pipeline and several distributory canals branch off from the main canal. Both main and distributory canals would be lined with concrete.

The total lengths of the main and distributory canals were computed to be 7.9 km and 10.3 km respectively.

4.4.7 Drainage system

The drainage canals are classified by function into field ditches and collector drains. These drains are categorized as on-farm level development of which a preliminary design is given in Annex-J. The design discharges of these two types of drain have been given in a previous section (4.4.2).

Secondary drains transport water from collector drains to natural gullies or rivers which form the main drains. Main drains carried water from the secondary drains to the sea.

The unit design discharge under different field conditions has been described in the preceding section. The layout of the secondary drains was planned on the topographical maps at a scale of 1:12,500. Fig. 12 shows the layout of the secondary drains.

4.4.8 On-farm development

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 crops
Basin irrigation	:	Paddy

Standard on-farm designs for each irrigation method and design conditions are shown in Annex-J. The above standard on-farm development designs are proposed for small scale farmers, and would be different for large scale farms. Particular attention was therefore given to designing irrigation facilities which are simple for small scale farmers to operate and maintain.

4.4.9 Road system

Two types of roads are planned in the project area in accordance with their functions, namely operation and maintenance roads (O&M) which will be constructed along the main, branch and minor branch canals, and roads which will be utilized for regional

traffic including transportation of agricultural inputs and outputs and classified as main roads.

The O&M road along the main and branch canals will need enough width to accommodate heavy construction equipment doing canal maintenance and repair works. Therefore these roads were designed to be 5.0 m wide (4.0 m in effective width). On the other hand, the O&M roads along minor branch canals were designed to be 4.0 m wide (3.0 m in effective width). All these roads will be paved with compacted marl 10 cm thick.

The main roads were planned as illustrated on Fig. 12 with due regard to the existing and planned road networks. The width of the main roads will be 8.0 m (6.5 m in effective width) taking expected traffic density into consideration. These roads will be paved with compacted marl also. Farm roads will be generally at right angles to the main roads. The width of farm roads will be at 6.0 m (4.5 m in effective width) taking expected traffic density into consideration and paved with compacted marl

4.5 Project Organization and Management

Management aspects are of fundamental importance to the success of the development plan. The true measure of success of an irrigation project is not the completion of the construction aspects, but the way in which the water and land resources are to be subsequently used for the benefit of the locality. It is the duty of management to ensure the optimum use of these resources.

The St. Dorothy Irrigation system is relatively small and its expansion is limited through lack of good quality water within its boundaries. Since the eastern boundary of the St. Dorothy Irrigation system and the western boundary of the Rio Cobre Irrigation system are contiguous, the two (2) systems could easily be combined to form one (1) Organization for administrative purposes. An amalgamation of these two (2) schemes would result in additional acreage being brought into production, particularly in the Bushy Park area where at present the lands irrigated by the St. Dorothy system suffer severe water shortages.

Therefore, it is proposed that the present Rio Cobre Irrigation Works and St. Dorothy Plain Irrigation Authority should be reorganized and combined into a single organization to fulfill the functions of an irrigation scheme for the whole of the coastal plains. This proposed organization, St. Catherine Irrigation System (SCIS), will function as a branch office of the National Irrigation Commission Limited (NIC) which will be responsible for management, operation and maintenance, and expansion of existing and future irrigation schemes and systems is Jamaica. The objectives of SCIS will be:

- to develop adequate supply,
- to deliver the water as economically as possible,
- to maximize benefits from the project,
- to minimize losses through the system,
- to provide all possible help to the user in the most efficient use of water, and
- to be accountable to NIC for the efficient management of the water passing through the system.

The management structure of SCIS is illustrated in Fig. 13. Detailed management functions to be undertaken by SCIS, duties of SCIS and responsibility, of SCIS staff are given in Annex-L.

4.6 Implementation Schedule

4.6.1 Organization for project execution

MOA will be the executing body for the implementation of the Project. The Technical Service Division will directly be responsible for the project and also responsible for design and supervision of the construction of the project in association with the Engineering Service Division.

A project unit will be established for execution of the project during the construction period. This project unit will be phased out after the completion of the project. The project unit consists of all the necessary staff including foreign consultants, local consultants and other administrative staff who will be employed during the construction period to ensure the smooth and efficient execution of the project. The management structure of the organization for project execution is illustrated on Fig. 14.

4.6.2 Basic considerations of project implementation

The implementation schedule for the project was worked out on the basis of the following basic consideration:

(1) The project consists of three areas:

Rio Cobre East	:	7,100 ha
Rio Cobre West	:	6,030 ha
St. Dorothy	:	1,490 ha
Total Project Area	:	14,620 ha

(2) The construction schedule is drawn up in such a way as to make capital investment productive as soon as possible.

(3) The major civil works and on-farm development works are rationally integrated in due consideration of the agricultural development programme particularly paddy land development.

(4) Rehabilitation and improvement works for the Head Works and Main canal will be carried out without cutting off the existing water supply to the downstream irrigated area and municipal water supply to Spanish Town.

(5) Before commencement of the actual construction works, about 12 months of detailed design, preparation of tender documents, tender calling and tender award are needed. A consultant will be engaged by the Project Office to prepare the detailed design, tender documents supervision of construction works, assistance and guidance in operation and maintenance of the project facilities.

4.6.3 Implementation programme

The time required for construction of the project would be about 4 years including detailed design and contract award. A project implementation schedule is shown in Fig. 15. Immediately after the mobilization of the works made by the Contractor, the rehabilitation and improvement of the headworks and head reach down to bifurcation will be carried out without cutting off the present water flow to the downstream requirement.

Since Agro 21 development plan is under implementation in the eastern half of the project area, both East and West Main canals will be constructed almost in parallel so as to get irrigation benefit as early as possible. In view of rather long time required for reservoir dike construction, construction of Town gully Reservoir will be carried out in parallel with main canal construction so that the eastern half of the project area would benefit partly by the middle of third year and remainder by the end of third year.

As soon as ductile iron pipe for Free Town pipeline is delivered, the construction of St. Dorothy Irrigation system will be commenced, probably beginning in the second year of construction. The improvement works for the Old Harbour branch canals will commence at the beginning of the third year, and be followed by the construction of minor branch canals. The on-farm works in the Rio Cobre West area will be started in the middle of second year and be completed by the middle of fourth year. Irrigation benefits from the project in both Rio Cobre West and St. Dorothy areas would be realised partly from the middle of third year and fully by the end of the fourth year. The construction of drainage system and road network will be commenced in the middle of second year and be completed by the end of fourth year. These works will be carried out taking into account the progress of on-farm development as well as the construction of the minor branch canals.

4.6.4 Construction plan

The quantities of works and main construction materials needed for each area are shown below:

(1) Work quantities

Item	Unit	Main Structure	Rio Cobre East	Rio Cobre West	St. Dorothy Area	Total
Excavation	10^3 m^3	170	241	403	53	867
Embankment	10^3 m^3	27	892	919	44	1,882
Concrete	10^3 m^3	14	10	31	3	58
Gravel	10^3 m^3	2	24	39	3	68
Marl pavement	10^3 m^3	2	16	59	16	93
Riprap	10^3 m^3	-	41	28	-	69
Sand foundation	10^3 m^3	-	42	21	1	64
Reinforced iron bar	ton	274	94	130	46	544

(2) Construction materials

Item	Unit	Main Structure	Rio Cobre East	Rio Cobre West	St. Dorothy Area	Total
Cement	10^3 ton	5	3	9	1	18
Gravel for concrete	10^3 m^3	11	7	35	3	56
Sand of concrete	10^3 m^3	8	6	18	2	34
Fuel	10^3 lit	230	1,070	1,130	60	2,490

Remark: Main structures are dam, main canal and bifurcation.

(3) On-farm development

Item	Unit	Rio Cobre East	Rio Cobre West	St. Dorothy Area	Total
Furrow	ha	-	1,610	640	2,250
Rice field	ha	-	2,800	-	2,800
Sprinkler	ha	-	1,220	610	1,830
Drip	ha	-	-	200	200
Road	km	-	350	100	450
Drainage	km	-	450	130	580

The annual workable days for the construction works are planned to be 250 days (21 per month) with due consideration to the climatic conditions and social practices. The construction equipment needed for project implementation was estimated from the work quantities, construction time schedule, construction method and site specific conditions. (see Annex-M).

4.7 Project Cost

4.7.1 Basic conditions

The costs for implementation of the project were estimated on the basis of preliminary design of the project facilities, and on the following basis:

(1) The exchange rate used in the estimate is:

US$ 1.00 = J$ 5.50 = ¥ 160

(2) The main construction works will be carried out by contractors selected through international competitive bidding. The construction machinery and equipment would be provided by the contractors themselves. Therefore, depreciation cost of machinery and equipment is considered in the estimate of the construction cost.

(3) Taxes on the construction materials, machinery and equipment to be imported from abroad, if needed, would be exempt from estimation in the construction cost.

(4) The construction costs are divided into foreign and local currency portions. Local currency portion is estimated based on the current prices of the materials in Kingston in 1986 and foreign currency portion is estimated based on the CIF prices at Kingston, making reference to FOB prices of materials and equipment in Japan in 1986.

(a) The local currency portion would cover:

- labour force,
- cement, gravel, sand, stone and wooden materials
- RC pipe
- Gate less than 2.0 m x 2.0 m
- Fuel and lubricants
- Inland transportation costs
- General expenses provided by the Government
- Expenses and fees of engineering services for local consultants

(b) The foreign currency portion would cover:

- Depreciation cost of construction machinery and equipment
- Plants to be installed for the project such as pumps, motors, etc.
- Reinforcing bars
- Gate more than 2.0 x 2.0 m
- Contractor's general expenses and profits for foreign contractors
- Expenses and fees of engineering services by foreign consultants
- Procurement cost of O&M equipment of the facilities

(5) Physical contingencies related to the construction quantities is set at about 10% of the direct cost.

(6) Price contingencies; 5% per annum for the foreign currency portion and 10% per annum for the local currency portion, are also included.

4.7.2 Cost estimate

The project cost comprises the direct construction cost, procurement cost of O&M equipment, engineering services and administration costs and physical contingency. The project cost is estimated based on the detail unit cost analysis and quantity calculations for the project works.

Total project cost is estimated to be US$ 64.3 million consisting of US$ 34.1 million foreign currency equivalent and US$ 30.2 million of local currency portion as shown in Table 4. Annual disbursement schedule of capital cost of the project is given in Table 5.

5. PROJECT EVALUATION

5.1 Economic Evaluation

5.1.1 General

The economic feasibility of the Modernization and Expansion of the Rio Cobre Irrigation Scheme was assessed through the economic internal rate of return (EIRR). A sensitivity analysis for the project was also made assuming changes in accrued economic project benefit, economic project cost and over-runs in the agricultural development schedules.

5.1.2 Economic project costs

The economic construction costs estimated at 1986 price levels comprises the costs for (1) preparatory works, (2) civil works including on-farm facilities, (3) administrative expenses, (4) engineering services, (5) operation and maintenance equipment and (6) physical contingency of 10%. Land acquisition costs, price contingency and transfer payments are not included in the economic construction costs. The total economic construction costs of the project were estimated to be J$ 287.7 million (US$ 52.3 million) consisting of J$ 162.3 million (US$ 29.5 million) of foreign currency and J$ 125.4 million (US$ 22.8 million) of local currency component as shown in Table 4. In addition to the above costs, the annual operation and maintenance costs and the replacement costs for irrigation and drainage facilities were included in the economic project costs. (see Annex-M)

It was assumed that the engineering work for the project would commence at the beginning of 1988 and be completed by the end of 1991; whole project works would be implemented within four (4) years. According to the implementation schedule of the project and works quantities, the flow of the economic construction cost, operation and maintenance cost and replacement cost were estimated as shown in Table 7.

5.1.3 Economic project benefits

(1) Economic prices

Economic farmgate prices are the prices for the economic evaluation of the project in view of its place in the national economy. Economic farmgate prices of agricultural products and inputs were estimated by the following categories:

(a) Domestic crops

Crops such as summer vegetables; onion, red pea, etc., will be consumed in Jamaica. Economic farmgate prices for domestic crops were estimated at the average farmgate prices of last five (5) years at 1986 constant prices calculated from current farmgate prices and a deflator for Jamaica prepared by Planning Institute of Jamaica.

(b) Export crops

Crops such as winter vegetables, fruits, sugarcane, etc., will be mainly exported to the markets of the United States and Europe. Economic farmgate prices for export crops were calculated from the average FOB prices of last five (5) years at 1986 constant prices estimated by a current FOB price and a Manufacturing Unit Value Index (MUV) prepared by IBRD.

(c) Import foods

Foods such as rice, maize, soybean, beef, milk, fish, etc., which are currently imported, will be supplied with by project. Economic farmgate prices for import foods were calculated from the average CIF prices of last five (5) years at 1986 constant prices estimated by a current CIF price and MUV.

(d) Farm inputs

Inputs such as seed, fertilizer, agro-chemicals, etc. will be applied to the project. Economic farmgate prices for farm inputs were estimated on the basis of current wholesale prices.

Detail calculation of economic farmgate prices for agricultural products and inputs are given in Annex-N.

(2) Economic project benefit

The economic benefits from irrigation will primarily accrue from increased crop production due to stable irrigation water supply and proper management. These benefits were estimated as the difference between the annual net economic production value from the project under "with project condition" (the condition of the proposed development) and "without project condition" (the present conditions projected into future). Generally, not only will the acreage be increased but productivity as well, and annual economic irrigation benefits will increase to reach their maximum in the 11th year of project implementation. Annual economic irrigation benefits will amount to about J$ 118.0 million (US$ 21.5 million) at full development as shown in Table 6.

In addition to the economic benefits of irrigation mentioned above, the benefits of curtailed operation costs of irrigation wells due to construction of the reservoirs also count in the direct benefit of the project. This benefit is estimated at approximately J$ 1.4 million (US$ 0.3 million) per annum. (see Annex-I)

After completion of the project, about 280 ha of sugarcane in the reservoir areas will be submerged under the reservoir water and non-productive. These losses on account of the project must be deducted from the benefits with the project mentioned above as a negative benefit. The negative benefits were estimated to be J$ 0.8 million (US$ 0.2 million) per annum as given in Annex-G. The loss of agricultural land for project facilities were counted in the estimate of the primary project benefit by deducting these areas from the agricultural land under "with project condition".

Therefore, the total annual economic project benefits amount to J$ 118.6 million (US$ 21.6 million) at the full development stage of the project, after deducting the negative benefit in the reservoir area. The flow of the economic irrigation benefits, the benefit curtailed operation cost of irrigation wells and the negative benefit in the reservoir areas were estimated as shown in Table 7.

5.1.4 Economic evaluation

(1) Economic internal rate of return (EIRR)

The project life is assume to be 50 years. The construction period will be four (4) years including a year for detailed design and selection of contractor. Operation and maintenance costs of the project will commence being disbursed in 1990 when partial operation will commence. The operation and maintenance costs will increase to reach the full amount in 1991 when full operation will start for the whole project area of 14,620 ha. Pumps and gates for irrigation and drainage facilities will be replaced twice during the entire period of the project life and operation and maintenance equipments both heavy and small for the irrigation and drainage system will be replaced every ten (10) and five (5) years respectively.

According to the proposed construction plan, the economic irrigation benefits will being 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.

The economic internal rate of return (EIRR) was calculated from the economic project benefits and costs flows estimated under the above conditions as given in Table 7. The EIRR thus calculated was 24.0%. The result shows that the project was economically feasible.

(2) Sensitivity analysis

Sensitivity analyses were made with respect to change in annual irrigation and drainage benefits and project costs. The following conditions to be anticipated were tested:

(a) Base case
(b) 20% cost increase and benefit as scheduled
(c) 20% benefit decrease and cost as scheduled
(d) 20% cost increase and 20% benefit decrease
(e) Two (2) years over-run in the agricultural development schedule
(f) Two (2) years over-run in the agricultural development schedule and 20% cost increase

The results are summarized below:

Conditions	EIRR (%)
(1)	24.0
(2)	20.5
(3)	19.9
(4)	16.8
(5)	18.0
(6)	15.8

From the above results, the economic feasibility of the project is most sensitive to the change in benefits. Therefore, to maintain its economic feasibility, careful management will be required to attain the anticipated benefits as scheduled.

5.2 Financial Evaluation

5.2.1 General

The financial feasibility of the project was evaluated from the viewpoint of farmer's economy. In this connection, the assessment of the amount of the water charge to be collected from the farmer was made on provisional basis. Assessment of capital cost repayment capability was also made at project level by preparing cash flow table.

5.2.2 Financial project cost

On the basis of current market prices and costs as of 1986, the financial cost of the project was estimated to be J$ 353.7 million (US$ 64.3 million), comprising J$ 187.6 million (US$ 34.1 million) in foreign currency and J$ 166.1 million (US$ 30.2 million) in local currency as shown in Table 4. In this estimate, physical contingencies of 10%, and price contingencies of 5% per annum for foreign currency and 10% per annum for local currency were added to the direct project cost as given in Table 5.

5.2.3 Financial evaluation

(1) Financial prices

Financial farmgate prices are the prices used for appraising the financial variability of the project. Financial prices for agricultural products and inputs were estimated on the basis of current farmgate prices.

(2) Capacity to pay

In evaluation of project feasibility from the financial viewpoint of farmers, average farm budget analyses for each farming type were made with future projections under "with project" conditions. (see Annex-G)

The potential net reserve of each farming type of farmer working in the project was summarized as following table:

Farming Type		Average Size	Net Reserve
		(ha)	(J$/year)
Sugarcane		1,690	2,653,000
Dairy		70	463,600
Vegetables	Large	170	3,468,000
	Small	3.2	101,800
Paddy	Large	710	3,379,600
	Small	3.2	10,500
Orchard		180	419,000
Horticulture		2.0	516,000
Fish		6.0	31,400
Cattle		6.5	22,700

(3) Water charge

It is desirable that a water charge per hectare be imposed on farm lands to cover operation and maintenance costs and the replacement costs of equipment used in the drainage and irrigation system.

The annual operation and maintenance cost of the irrigation and drainage system were estimated to be J$ 9.6 million which is equivalent to about J$ 660/ha of farm land. This corresponds to following percentages of the net annual reserve of each farming type:

Farming Type		Average Size	Net Reserve	Water Charge	Pro-portion
		(ha)	(J$)	(J$)	(%)
Sugarcan		1,690	2,653,000	1,115,400	42.0
Dairy		70	463,600	46,200	10.0
Vegetables	Large	170	3,468,000	112,200	3.2
	Small	3.2	101,800	2,112	2.1
Paddy	Large	710	3,379,600	468,600	13.9
	Small	3.2	10,500	2,112	20.1
Orchard		180	419,000	118,800	28.4
Horticulture		2.0	516,000	1,320	0.3
Fish		6.0	31,400	3,960	12.6
Cattle		6.5	22,700	4,290	18.9

The water charge of J$ 660/ha/annum was considered to be within the capacity of the farmers to pay, and would not serve as a disincentive to production. This charge was taken to be the project revenue in the financial evaluation of the project.

(4) Repayment of the project cost

The financial evaluation of the project was made by examining the repayment capacity for the capital cost of the project. In examining the repayment capability, it was assumed that the capital required for the project implementation would be arranged under the following conditions:

Foreign Currency Portion	Local Currency Portion
The capital will be financed by the Government through a financing institution at an assumed interest rate of 4.75% per annum for a repayment period of 25 years including a grace period of seven (7) years.	The capital will be financed by the Government from its own resources with no repayment.

A repayment schedule for the foreign currency portion was prepared as shown in Table 8. This indicates that the direct revenue from the farmers cannot cover the annual repayment of the foreign currency portion and the repayment of the foreign currency portion has to be made by the Government.

5.3 Socio Economic Impacts

The socio-economic impacts from the implementation of the project and their effects on the regional development were studied. Various socio-economic impacts are expected to result from the implementation of the project. There are:

(a) Foreign exchange saving

The production of rice, maize, soybean, beef, milk, fish in Jamaica is insufficient to meet domestic demand. The average imported volume and value of above commodities from 1981 to 1985, anticipated production of above commodities from the project, and estimated foreign exchange saving are given in table below:

Commodities	Imported from 1985 Volume	From the project Value	Foreign Exchange Volume	Saving
	(ton)	(10^6US$)	(ton)	(10^6US$)
Rice	47,920	17.7	16,380	6.1
Maize	178,450	25.0	22,800	3.2
Soybean	59,110	14.2	3,200	0.8
Beef	1,190	3.8	450	1.4
Milk (powder)	10,490	9.9	2,090	2.0
Fish	14,680	20.7	2,870	4.0
Total	-	91.3	-	17.5

From the above results, approximately US$ 17.5 million per annum of foreign exchange will be saved by substituting for imported these commodities.

(b) Demonstration effects

With the completion of the project, farmers in other agricultural areas as well as those in the project area will become familiar with modern irrigation and drainage practices and the incentive for adopting improved irrigation and drainage practices will be greatly enhanced. Enthusiasm generated from this success may even shorten the development period of the project.

(c) Increased employment opportunities

It is expected that the present unemployment in and around the project area will be reduced by implementation of the project. After completion of the project, more intensive land use resulting from year-round irrigation, drainage, and farm mechanization, will certainly increase employment opportunities. In addition, the experience, technical know-how and skills of the farmers will provide motivation for future development in the parish of St. Catherine and in Jamaica.

(d) Secondary benefits

Implementation of the project works will certainly lead to beneficial changes in the rural economy. The social infrastructure and local transportation system will be improved. This will contribute to the improvement of other rural economic activities. The increased crop production in the project area will also stimulate improvement of the marketing system and the agricultural support services.

(e) In summary

All in all the project benefits will serve to improve the standard of living and the quality of life of the local people in and around the project area and will contribute substantially to strengthening the economy of Jamaica.

6. FUTURE RESEARCH AND DEVELOPMENT PLAN

6.1 Intensification of Research and Extension

6.1.1 General

To achieve successful implementation of the project, it will be indispensable to develop agricultural technology for the proposed cropping pattern through research including soils, crops, etc. and agricultural extension services.

6.1.2 Investigations and research of soils

According to the results of the soil survey and chemical analyses in the project area, it is considered that the crop production in the project area will possibly be affected by salinity and/or alkalinity of soils. Further investigations and research, therefore, are necessary to be performed in order to establish the corresponding technical measures.

Remedial measures on salinization are limited to a general consideration without practical measures. Due to the importance of salinization problem in land conservation in long term and the increasing of crop production, technical measures on salinity are, therefore recommended to be established by the execution of following investigations and research.

- drainability,
- sea water intrusion,
- quality of irrigation water,
- evaluation of leaching water requirement,
- evaluation of drainage improvement under subsoiling and application of organic materials,
- evaluation of soil improvement by soil conditioners, and
- evaluation of soil improvement by introduction of paddy cultivation.

Soils under week and moderate alkalinities shows a nutrient deficiency of upland crops in especial due to a decrease in the solubility of phosphate and minor elements such as boron, iron, copper, manganese and so on.

In order to increase the crop production, technical measures on alkalinity are recommended to be established by the execution of following investigations and research.

- alkalinization-causes in upland fields, especially contents of dominant alkali elements such as sodium carbonate,
- nutrient deficiency due to alkalinity, especially on the solubility and inactivation of minor elements in the pH range of alkaline,
- deficiency symptom of various crops, including the method of chemical application, and
- improvement of alkaline soils by gypsum and sulfur application.

6.1.3 Agricultural research and extension

Within the proposed crops and livestock, sugarcane research and extension are done by SIRI (Sugar Industry Research Institute) and research of dairy and beef cattle and vegetables are conducted at Bodles and other research stations. Recently, Export Crop Project supported by World Bank provides funding for research and extension services of major export crops such as sugarcane, vegetables, ornamental horticulture and other crops.

Rice research was conducted by BRUMDEC (Black River Upper Morass Development Company), but had been discontinued when BRUMDEC was turned over to Jamculture Ltd. in 1985 and not yet be recovered to date. No research has been also carried out in area of irrigation technology at on-farm level. As both technologies are essential for increased production in 3,900 ha (9,600 acres) of proposed paddy field and for effective usage of water in 14,620 ha (36,120 acres) of irrigable area in the project. In this connection, the followings are recommended.

(1) Establishment of Main Rice Research Station at the Bodles Research Station with fundamental and overall research items. This station manages the satellite stations researching the items corresponding to local conditions.

(2) Establishment of test farm for trials of varieties, fertilization, cropping system and soil management under the saline soil condition in the paddy area for the project.

(3) Research and training of extension staff for water usage at on-farm level in the Bodles Research Station.

(4) Establishment of pilot farm for identification and demonstration of research findings and for training of small farmers for their management and farming technologies.

(5) Location of research test and pilot farms is given below:

Item	Location
Fundamental rice research	Bodles Research Station
Water usage research at on-farm level	Bodles Research Station
Test farm and Pilot farm	Central part of Amity Hall area (or West part of Hartland)

6.2 Future Development Plan

6.2.1 Water resources

There are eight rivers and gullies in the project area amongst which the largest is the Rio Cobre. All the other seven have quite limited flows in the dry season. Of these, the Coleburns gully and the Plantain river are through-flowing streams and flood drainage

channels with fairly large catchment areas originating in the hills to the north. As discussed in Annex-B, the annual maximum discharge of the former in 1986 was estimated at approximately 110 m^3/sec with a catchment area of 87.3 km^2, whereas the latter had approximately 65 m^3/sec with a catchment area of 31.5 km^2. It seems possible that these surface water sources could be developed by creating reservoirs.

6.2.2 Area to be developed

(1) Spring Garden and Thetford area

The Coleburns gully flows through the 1,190 ha of arable land of Spring Garden and Thetford. Part of this land is at present used for cropping sugarcane, vegetables, orchard, pasture, etc. by sprinkler irrigation. The remaining area is mostly covered with bush and grass. According to the land capability classification, the land is classified as II and III. In terms of topography, the land is fairly flat with minor undulation. Drainage is favourable because the gully passes through the centre of the area. Thus if surface water can be made available, it should be possible to develop the entire area for agricultural purposes.

(2) St. Dorothy North

The Plantain river flows through the 1,350 ha of arable land of St. Dorothy North. The land is irrigated by sprinkler directly from the wells. Improved pasture, tobacco and vegetables predominate land use, whereas grass, bush and woodlands occupy only a quarter of the area. According to the land capability classification, the land is classified as II. In terms of topography, the land is fairly flat with minor undulation. Drainage is favourable because the Plantain river flows through the area. If surface water could be made available, it should be possible to develop the entire area for agricultural purposes.

6.2.3 Future development plan

For the future development plan, it is proposed to create reservoirs by constructing dams on the Coleburns gully and the Plantain river. Suitable dam sites are located approximately 4 km upstream from Spring Village for the former and 2.5 km upstream from Colbeck for the latter.

In the Coleburns gully, a dam will be constructed on the Troy Limestone, the basal formation of the White Limestone Group. A NNW-SSE fault is observed approximately 700 m east of the site. Little leakage is expected from the reservoir because the Troy Limestone relatively impermeable and the fault is some distance from the site. In the Plantain river, the foundation of the proposed dam site will be in the alluvium or the Troy Limestone. Since the alluvium seems to be relatively permeable, detailed investigation of the foundation will be necessary by drilling the proposed site.

By creating two reservoirs it is expected that approximately 800 ha in the Spring Garden area and 200 ha in St. Dorothy North area would be benefited. It is also anticipated that groundwater conditions downstream would be improved to certain extent from reduced abstraction and seepage water in the upper reaches.

6.2.4 Proposed works

The principal features of the proposed future development plan may be summarized as follows:

	Spring Garden	St. Dorothy North
1. Water resource	Coleburns gully	Plantain river
2. Benefited area	800 ha	200 ha
3. Reservoirs		
- Location of dam	4.0 km upstream from Spring Village	2.5 km upstream from Colbeck
- Type of dam	Earthfill	Earthfill
- Dam height	32 m	14 m
- Crest length	163 m	142 m
- Dam volume	220,000 m^3	60,000 m^3
- Reservoir capacity	6.0 million m^3	1.5 million m^3
4. Canals		
- Length	6.0 km	5.0 km
- Capacity	0.8 m^3/sec	0.2 m^3/sec

6.2.5 Recommendations

In formulating the future development plan, it is recommended that the following investigations and studies should be carried out:

- continued hydrological observation,
- geological investigation at dam and reservoir sites,
- studies on the effects on groundwater recharge,
- material surveys for dams and canals, and
- agricultural, agro-economic and socio-economic investigations in and around the benefited area.

TABLES

Table 1 (1/2) MEMBER LIST

Name	Position
A. Advisory Committee	
1. Mr. Y. Dokyu (Chairman)	Director, Planning Department, Hokuriku Agriculutral Administration Office, MAFF
2. Mr. H. Kawashima (Engineer)	Senior Engineer, Construction Department, Agricultural Structure Improvement Bureau, MAFF
3. Mr. M. Ohta (Agronomist)	Instructor, Rice Cultivation Course, Tsukuba International Agriculutral Training Centre, JICA
4. Mr. K. Arahata (Agronomist)	Officer, Crop Productionl Division, Agricultural Production Bureau, MAFF
5. Mr. H. Ito (Economist)	Assistant Manager, 2nd Division Loan Department III, Overseas Economic Cooperation Fund (OECF)
B. Scope of Work Mission	
1. Mr. Y.Dokyu (Team Leader)	Director, Planning Department, Hokuriku Agricultural Administration Office, MAFF
2. Mr. H. Kawashima (Engineer)	Senior Engineer; Construction Department, Agricultural Structure Improvement Bureau, MAFF
3. Mr. M. Ohta (Agronomist)	Instructor, Rice Cultivation Course, Tsukuba International Agriculutral Training Centre, JICA
4. Mr. K. Arahata (Agronomist)	Officer, Crop Productionl Division, Agricultural Production Bureau, MAFF
5. Mr. M. Aoki (Coordinator)	Senior Officer, Development Planning Division, Agriculture, Forestry and Fisheries, Planning and Survey Department, JICA
C. First Stage (February 1986 to June 1986)	
Advisory Team	
1. Mr. Y.Dokyu (Team Leader)	Director, Planning Department, Hokuriku Agricultural Administration Office, MAFF
2. Mr. H. Kawashima (Engineer)	Senior Engineer; Construction Department Agricultural Structure Improvement Bureau, MAFF
3. Mr. M. Aoki (Coordinator)	Senior Officer, Development Planning Division, Agriculture, Forestry and Fisheries, Planning and Survey Department, JICA
Study Team	
1. Mr. S. Yano	Team Leader
2. Mr. K. Yatabe	Irrigation and Drainage Engineer
3. Mr. I. Iwai	Meteo-Hydrologist
4. Mr. K. Sasaki	Geologist/Hydrogeologist
5. Mr. S. Morita	Design Engineer
6. Dr. S. Terasawa	Soil Chemist
7. Dr. S. Fujii	Agronomist
8. Mr. N. Morioka	Agro-Economist
Counterpart	
1. Mr. T. F. Clarke	Director, Technical Services Division, Special Projects and Programmes, MOA
2. Mr. D. Henry	Project Coordinator/Agronomist, MOA
3. Mr. J.M.L. Mehra	Consultant to Project Coordinator/Irrigation Engineer, MOA
4. Mr. D. Coquhoun	Civil Engineer, MOA
5. Mr. W. Atiba	Hydraulic/Hydrology Engineer, UWA, MOA
6. Mrs. U. Bisasor	Hydrogeologist, UWA
7. Mr. V. Thomas	Computer Programmer, UWA, MOA
8. Mr. Campbell	Rural Physical Planning Division, MOA (part-time)
9. Miss H. Hylton	Rural Physical Planning Division, MOA (part-time)
10. Mr. S.B. Basnayaka	Hydrogeologist, UWA, MOA (part-time)

Table 1 (2/2) MEMBER LIST

Name	Position
D. Second Stage (July 1986 to May 1987)	
Advisory Team	
1. Mr. H. Kawashima (Team Leader)	Senior Engineer, Construction Department Agricultural Structure Improvement Bureau, MAFF
2. Mr. K. Kawaji (Coordinator)	Senior Officer, Development Planning Division, Agriculture, Forestry and Fisheries, Planning and Survey Department, JICA
Study Team	
1. Mr. S. Yano	Team Leader
2. Mr. K. Yatabe	Irrigation and Drainage Engineer
3. Mr. I. Iwai	Meteo-Hydrologist
4. Mr. K. Sasaki	Geologist/Hydrogeologist
5. Mr. S. Morita	Design Engineer
6. Mr. H. Higashino	On-farm Development Engineer
7. Mr. M. Ishidoya	Soil Mechanical Engineer
8. Dr. S. Terasawa	Soil Chemist
9. Dr. S. Fujii	Agronomist
10. Mr. N. Morioka	Agro-Economist
11. Mr. Y. Sekiguchi	Socio-Economist
12. Mr. T. Ohsawa	Construction Planning Engineering
13. Mr. M. Mori	Survey/Design Engineer
Counterpart	
1. Mr. T. F. Clarke	Director, Technical Services Division, Special Projects and Programmes, MOA
2. Mr. J.M.L. Mehra	Consultant to Project Coordinator/Irrigation Engineer, MOA
3. Mr. D. Henry	Agronomist, MOA
4. Mr. D. Coquhoun	Civil Engineer, MOA
5. Mr. W. Atiba	Hydraulic/Hydrology Engineer, UWA, MOA
6. Mrs. U. Bisasor	Hydrogeologist, UWA, MOA
7. Mr. S. B. Basnayake	Hydrogeologist, UWA, MOA (part-time)
8. Miss M. A. Lewis	Agronomist, MOA
9. Mr. R. Budham	Agro-economist, Economic Planning, MOA
10. Mr. Gray	Rural Physical Planning Unit, MOA
11. Mr. Sheriff	Rural Physical Planning Unit, MOA
12. Miss H. Bernard	Socio-economist, Data Bank, MOA
E. Draft Final Explanation (March 1987)	
Advisory Team	
1. Mr. T. Kuroyanagi	Staff, Development Planning Division, Agriculture, Forestry and Fisheries, Planning and Survey Department, JICA
Study Team	
1. Mr. S. Yano	Team Leader
2. Mr. K. Yatabe	Irrigation Engineer
3. Mr. Y. Sekiguchi	Socio-Economist

Table 2 AREAS OF EACH LAND CAPABILITY CLASS IN THE STUDY AREA

Classes	Extent (ha)
A. For Upland Crops	
1. Arable Land	
I	5,070
IIw	810
IIpw	9,080
IIpe	50
IIIwp	1,960
IIIsa	1,120
IVsa	790
Sub-total	18,880
2. Limited Arable Land	
Vsa	2,160
Vde	40
Sub-total	2,200
3. Non-arable Land	
VI	6,360
4. Total	27,440
B. For Rice	
1. Arable Land	
IIp	10,810
IIII	810
IIIps	1,760
IVl	150
Sub-total	13,530
2. Limited Arable Land	
Vl	5,070
Vsa	2,160
Vp	280
Sub-total	7,510
3. Non-arable Land	
VI	6,400
4. Total	27,440

Table 3 PROPOSED LAND USE

	St. Dorothy		Rio Cobre West						Rio Cobre East		Small Farmers		Total	
			Bushy Park West		Rio Cobre West		Sub-total							
	Without	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without	With
Sugar cane	644	712	96	0	2,456	1,873	2,552	1,873	876	676	114	0	4,186	3,261
Vegetable/crop	22	63	118	156	213	424	331	580	4,049	3,472	95	106	4,497	4,221
Grains	0	0	0	0	0	0	0	0	765	0	0	0	765	0
Ornamentals	0	0	0	0	0	0	0	0	166	166	0	0	166	166
Orchards	3	3	83	192	0	14	83	206	0	577	0	0	86	786
Paddy														
rice-rice	0	0	0	0	714	1,716	714	1,716	0	0	0	0	714	1,716
rice-grain	0	0	0	0	0	604	0	604	0	765	0	799	0	2,168
Pasture	531	631	244	464	409	235	653	699	0	0	0	0	1,184	1,330
Grassland	41	0	32	0	89	0	121	0	0	0	297	0	459	0
Bush/grass	133	0	113	0	322	0	435	0	0	0	106	0	674	0
Bush	102	0	126	0	592	0	718	0	0	0	285	0	1,105	0
Woodland	0	0	0	0	76	0	76	0	0	0	8	0	84	0
Aquaculture	14	81	16	16	62	149	78	165	295	295	39	39	426	580
Swamp	0	0	0	0	162	0	162	0	0	0	0	0	162	0
Reservoir	0	0	0	0	107	187	107	187	0	200	0	0	107	387
Total	1,490	1,490	828	828	5,202	5,202	6,030	6,030	6,151	6,151	944	944	14,615	14,615

Note:- Without: Without project condition, With : with project condition

Table 4 SUMMARY OF INITIAL INVESTMENT COST

(Unit: 1,000 US$)

Item	Foreign Currency	Local Currency	Total
1. Direct Construction Cost			
1.1 Main Structure	3,620	2,480	6,100
1.2 Rio Cobre East Area	4,100	2,830	6,930
1.3 Rio Cobre West Area	4,550	4,690	9,240
1.4 St. Dorothy Area	1,830	870	2,700
1.5 Main Road and Secondary Drainage Canal	500	270	770
Sub-total	14,600	11,140	25,740
1.6 On Farm Development	8,160	7,910	16,070
1.7 Total	22,760	19,050	41,810
2. O&M Equipment	800	0	800
3. General Expense	0	350	350
4. Engineering Service	3,300	1,300	4,600
5. Sub-total (1+2+3+4)	26,860	20,700	47,560
6. Physical Contingency	2,690	2,070	4,760
7. Sub-total (1+2+3+4+6)	29,550	22,770	52,320
8. Price Contingency	4,550	7,420	11,970
9. Grand Total (1+2+3+4+6+8)	34,100	30,190	64,290

Table 5 ANNUAL DISBURSEMENT SCHEDULE OF CAPITAL COST

(Unit: 1,000 US$)

Item	1st Year		2ndYear		3rd Year		4th Year		Total		
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	Total
1. Direct Construction Cost									0	0	0
1.1 Main Structure	0	0	3,190	2,020	430	460	0	0	3,620	2,480	6,100
1.2 Rio Cobre East Area	0	0	1,850	1,250	2,250	1,590	0	0	4,100	2,840	6,940
1.3 Rio Cobre West Area	0	0	370	720	1,550	2,100	2,630	1,860	4,550	4,680	9,230
1.4 St. Dorothy Area	0	0	60	140	1,720	620	50	110	1,830	870	2,700
1.5 Main Road and Secondary Drainage Canal	0	0	130	70	250	130	120	70	500	270	770
Sub-total	0	0	5,600	4,200	6,200	4,900	2,800	2,040	14,600	11,140	25,740
1.6 On Farm Development	0	0	1,600	1,600	3,200	3,100	3,360	3,210	8,160	7,910	16,070
1.7 Total	0	0	7,200	5,800	9,400	8,000	6,160	5,250	22,760	19,050	41,810
2. O&M Equipment	0	0	0	0	0	0	800	0	800	0	800
3. General Expense	0	40	0	110	0	100	0	110	0	360	360
4. Engineering Service	950	400	850	350	800	300	700	250	3,300	1,300	4,600
5. Sub-total (1+2+3+4)	950	440	8,050	6,260	10,200	8,400	7,660	5,610	26,860	20,710	47,570
6. Physical Contingency (10%)	95	44	805	626	1,020	840	766	561	2,686	2,071	4,757
7. Sub-total (1+2+3+4+6)	1,045	484	8,855	6,886	11,220	9,240	8,426	6,171	29,546	22,781	52,327
8. Price Contingency	52	48	908	1,446	1,769	3,058	1,816	2,864	4,545	7,416	11,961
9. Grand Total (1+2+3+4+6+8)	1,097	532	9,763	8,332	12,989	12,298	10,242	9,035	34,091	30,197	64,288

Table 6 TOTAL NET PRODUCTION VALUE UNDER WITHOUT AND WITH PROJECT CONDITIONS

Pattern	Gross Area (ha)	Net Area (ha)	Unit Net Production Value (J$/ha)	Total Net Production Value (J$1,000)
Without Project Condition				
SUGARCANE	4,190	3,770	960	3,600
VEGETABLE	4,500	4,050		
Vege./crops	450	400	2,700	1,100
Vege./grain	4,050	3,650	10,890	39,700
GRAINS	770	690	980	700
RICE	710	640		
rice-rice	710	640	2,380	1,500
ORCHARD	80	70	10,260	700
ORNAMENTAL	170	150	282,300	42,300
PASTURE	1,180	1,070	5,100	5,500
AQUACULTURE	430	300	7,400	2,200
OTHERS		(1,290)		
TOTAL NET AREA		10,740		
TOTAL	12,030	12,030		97,300
With Project Condition				
SUGARCANE	3,260	2,930	3,560	10,400
VEGETABLE	4,200	3,800		
Vege./Vege.	750	680	50,600	34,400
Vege./grain	3,450	3,120	29,000	90,500
RICE	2,890	2,590		
rice/rice	710	640	3,600	2,300
rice/rice	1,010	910	4,840	4,400
rice/grain	2,180	1,950	2,820	5,500
ORCHARD	780	700	10,260	7,200
ORNAMENTAL	170	150	282,300	42,300
PASTURE	1,330	1,200	12,720	15,300
AQUACULTURE	590	410	7,400	3,000
OTHERS		(1,440)		
TOTAL NET AREA		11,780		
TOTAL	13,220	13,220		215,300
TOTAL INCREMENTAL BENEFIT				118,000

Table 7 COSTS AND BENEFITS FLOW

(unit: million J$)

Year	Year in Order	Construc-tion Cost	Replace-ment Cost	O&M Cost	Total Cost	Irrigation Benefit	Negative Benefit	Pump Benefit	Total Benefit
1988	1	8.4	0.0	0.0	8.4	0.0	0.0	0.0	0.0
1989	2	86.6	0.0	0.0	86.6	0.0	-0.6	0.0	-0.6
1990	3	112.5	0.0	5.4	117.9	0.0	-0.8	0.0	-0.8
1991	4	80.3	0.0	9.6	89.9	9.6	-0.8	0.0	8.8
1992	5	0.0	0.0	9.6	9.6	54.6	-0.8	1.4	55.2
1993	6	0.0	0.0	9.6	9.6	99.5	-0.8	1.4	100.1
1994	7	0.0	0.0	9.6	9.6	108.1	-0.8	1.4	108.7
1995	8	0.0	0.0	9.6	9.6	110.6	-0.8	1.4	111.2
1996	9	0.0	1.7	9.6	11.3	113.0	-0.8	1.4	113.6
1997	10	0.0	0.0	9.6	9.6	115.5	-0.8	1.4	116.1
1998	11	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
1999	12	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2000	13	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2001	14	0.0	4.4	9.6	14.0	118.0	-0.8	1.4	118.6
2002	15	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2003	16	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2004	17	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2005	18	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2006	19	0.0	1.7	9.6	11.3	118.0	-0.8	1.4	118.6
2007	20	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2008	21	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2009	22	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2010	23	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2011	24	0.0	38.2	9.6	47.8	118.0	-0.8	1.4	118.6
2012	25	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2013	26	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2014	27	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2015	28	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2016	29	0.0	1.7	9.6	11.3	118.0	-0.8	1.4	118.6
2017	30	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2018	31	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2019	32	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2020	33	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2021	34	0.0	4.4	9.6	14.0	118.0	-0.8	1.4	118.6
2022	35	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2023	36	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2024	37	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2025	38	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2026	39	0.0	1.7	9.6	11.3	118.0	-0.8	1.4	118.6
2027	40	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2028	41	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2029	42	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2030	43	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2031	44	0.0	38.2	9.6	47.8	118.0	-0.8	1.4	118.6
2032	45	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2033	46	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2034	47	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2035	48	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6
2036	49	0.0	1.7	9.6	11.3	118.0	-0.8	1.4	118.6
2037	50	0.0	0.0	9.6	9.6	118.0	-0.8	1.4	118.6

Discount Rate (%)	Cost	Benefit	B - C	B/C
23.5	183.14	187.94	4.797	1.026
23.6	182.63	186.45	3.826	1.021
23.7	182.12	184.99	2.870	1.016
23.8	181.61	183.53	1.927	1.011
23.9	181.10	182.10	0.997	1.006
24.0	180.59	180.67	0.079	1.000
24.1	180.09	179.27	-0.827	0.995
24.2	179.59	177.87	-1.721	0.990
24.3	179.10	176.50	-2.603	0.985
24.4	178.60	175.13	-3.473	0.981

EIRR = 24.0%