DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF MAHAWELI DEVELOPMENT

THE STUDY ON EXTENSION OF THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT

UPDATING THE FEASIBILITY STUDY

VOLUME-I MAIN REPORT

PHASE-I

MAY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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REPORT

PREFACE

In response to the request of the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a Study on Extension of the Feasibility Study on the Moragahakanda Agricultural Development Project and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Sri Lanka a study team headed by Mr. Shin-ichi YANO, Nippon Koei Co., Ltd., from January to April, 1988.

The team exchanged views with the officials concerned of the Government of Sri Lanka and conducted field surveys in the same area as the Previous Feasibility Study. After the team returned to Japan, further studies were made and the present report has been prepared.

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

I wish to express my deep appreciation to the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka for their close cooperation extended to the team.

May, 1988

Kensuke Yanagiya
President
Japan International Cooperation Agency

May, 1988

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report of the updated Feasibility Report (Phase-I) on the Study of Extension of the Moragahakanda Agricultural Development Project in accordance with the Scope of Work agreed upon between the Government of Japan and the Government of the Democratic Socialist Republic of Sri Lanka.

The report submitted herewith consists of:

Volume I	-	Main Report
Volume II	-	Annexes
Volume III	-	Annexes
Volume IV	-	Drawings

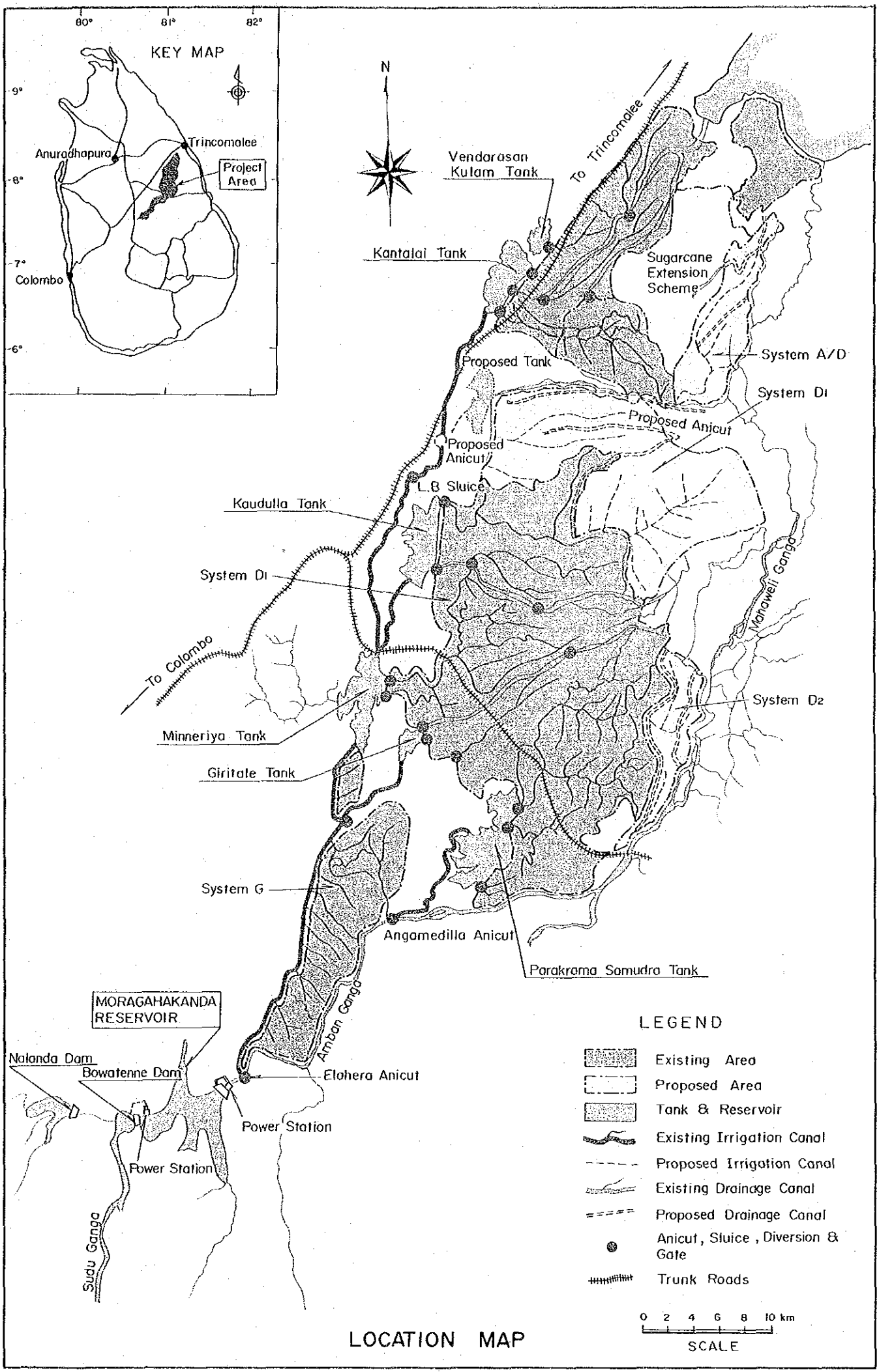
The Main Report contains an agricultural development plan and recommendations for successful development of the project. The Annex Reports contain detailed analyses and discussions in thirteen sectors to support the development plan presented in the Main Report. The plan and its evaluation indicate high economic and technical viability and therefore it is recommended to implement the project at the earliest possible time. The implementation of the project will contribute significantly to the socio-economic development in the project area as well as in Sri Lanka.

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

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

Yours sincerely,

Shinichi Yano
Team Leader


KEY MAP
80°
81°
82°
9°
8°
7°
6°
Anuradhapura
Trincomalee
Project Area
Colombo
N
Vendarasan Kulam Tank
To Trincomalee
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Proposed Anicut
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Power Station
Sudu Ganga
LEGEND
Existing Area
Proposed Area
Tank & Reservoir
Existing Irrigation Canal
Proposed Irrigation Canal
Existing Drainage Canal
Proposed Drainage Canal
Anicut, Sluice, Diversion & Gate
Trunk Roads
0 2 4 6 8 10 km
SCALE
LOCATION MAP

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

01. Since the 1960's, the Government of Democratic Socialist Republic of Sri Lanka (GOSL) has promoted the Mahaweli Ganga Development Project to attain self-sufficiency in foodstuffs, increase job opportunities and eliminate the shortage of electric power. In 1968, a master plan for the Mahaweli Ganga Development prepared with the assistance of the UNDP/FAO comprised irrigation development of about 365 x 10^3 ha and hydropower development of 500 MW in capacity. The GOSL has been proceeding with development on the basis of this master plan since 1968.

02. In 1977, the GOSL revised the master plan to accelerate the Mahaweli Development Programme for yielding the quickest return of project benefits to the nation, and formulated the Accelerated Mahaweli Development Programme (AMDP). The AMDP comprised (1) irrigation development of about 204 x 10^3 ha with 8 irrigation Systems A, B, C, D, G, H, IH and MH, and (2) hydropower development of about 470 MW in installed capacity through the construction of 5 dams: Kotmale, Victoria, Randenigala, Moragahakanda and Maduru Oya dams. The GOSL has almost completed four multi-purpose dams on the Mahaweli Ganga and one multi-purpose dam on the Maduru Oya with a hydropower generating capacity of 473 MW and irrigation development area of about 94,000 ha in Systems B, C, H, MH, and IH based on the AMDP.

03. Having substantially completed several hydropower and irrigation development projects, particularly along the main stem of the Mahaweli Ganga, during the period from 1978 to 1986, the GOSL in 1986 intended to take up the Moragahakanda Agricultural Development Project (the Project) and requested the Government of Japan (GOJ) to carry out the updating of the feasibility study on the Project prepared in 1979 and to formulate an overall agricultural development plan in the Amban Ganga basin, NWDZ and NCDZ. In response to the above request, the GOJ has decided to conduct the Study on Extension of the Moragahakanda Agricultural Development Project including the updating of the Feasibility Study on the Project.

04. This Report presents the results of the field survey and study on updating the Feasibility Study of the Project with about 62,200 ha of a net irrigable land in Systems D, A/D and G and hydro-power development of 26 MW.

BACKGROUND OF THE PROJECT

05. The population of Sri Lanka was approximately 16.1 million with a density of 245 persons/km^2 in 1986. The annual growth rate of the population during the period from 1981 to 1986 has been 1.66%. The population in 2001 is expected to be over 20 million. The number of unemployed persons was estimated to be about 800

x 10^3 or 14% in 1985. Unless radical measure are taken to promote economic activities both in private and public sectors, specially in industrial growth, the unemployment rate is expected to rise to 19% by 1989.

06. The Gross Domestic Product (GDP) in 1986 was about Rs. 163.7 billion with an annual growth rate of 4.8%. Per capita GDP is estimated to be Rs. 10,157 (about US$360). Agriculture in Sri Lanka has played an important role in its economy, contributing about 27% to GDP and employing about 45% of the active labour force. Earnings from agricultural exports moreover amount to Rs. 15.8 billion or 46% of the total exports in 1986.

07. Production of rice, the main staple food in Sri Lanka, has recently substantially increased and Sri Lanka is expected to attain self-sufficiency in the very near future. The plantation products, tea, coconuts and rubber, provided about 42% of total exports in 1986, while industrial products, textile and garment in particular have grown remarkably in recent years.

08. The current policies of the GOSL emphasizes (i) attaining self-sufficiency in important basic food crops, (ii) expanding the export of agricultural products through diversification of crops, and (iii) raising the living standards of the people through improvement of employment opportunities and income.

09. The entire public power supply in Sri Lanka is managed and operated by the Ceylon Electricity Board (CEB). Total installed capacity of the CEB was 1,116 MW in 1987 comprising 916 MW of hydropower plants and 200 MW of thermal powerplants. Annual energy generated in 1986 by the CEB was 2,650 GWh of which the hydropower accounted for approximately 95%.

THE PROJECT AREA

10. The project area is located in both Polonnaruwa and Trincomalee Districts in the north-eastern part of Sri Lanka, which corresponds to Systems D1, D2, G and A/D delineated in the Master Plan of the Mahaweli Development Project (UNDP/FAO in 1968). The project area covers approximately 118,000 ha composed of about 41,000 ha of paddy fields, about 3,000 ha of sugarcane fields, about 57,000 ha of marshy, forest and bush, and about 17,000 ha of homestead and others. The area is gently undulating ranging from 60 m to 10 m in elevation.

11. The Moragahakanda damsite is located at a narrow gorge of the Amban Ganga, approximately 2 km upstream from the existing Elahera anicut. The reservoir area has rather flat topography covered largely by forest.

12. The main water resources available in the project area are composed of natural runoff from its own basin of the Amban Ganga, runoff from the catchment areas of five (5) large existing tanks and diverted water from the Mahaweli Ganga main stem through the Polgolla diversion tunnel completed in 1975. The annual average natural runoff at

the Moragahakanda damsite with its catchment area of 782 km^2 and the Angamedilla anicut with about 1,363 km^2 of catchment area are 776 MCM and 1,440 MCM respectively. The total inflow to the major five tanks is 321 MCM on an average. The average annual natural runoff of the Mahaweli Ganga at the Polgolla diversion weir site with about 1,292 km^2 of catchment area is about 2,440 MCM of which approximately 1,282 MCM, according to the previous report, could be diverted from the main stem to the Amban Ganga basin. Out of the above diverted water, about 520 MCM for Systems H, IH and MH areas and 27 MCM for the Dewahuwa region are distributed per annum on an average.

13. A tropical monsoon climate prevails in the project area. The mean annual temperature at the Maha-Illuppallama meteorological station located at about 50 km west of the project area shows little variation throughout the year ranging 25°C to 28°C. Average annual rainfall is approximately 1,650 mm at Hingurakgoda station of which about 75% occurs during the Maha season from October to March. Annual pan evaporation is over 2,000 mm.

14. The population in the project area was estimated to be 177 x 10^3 with a density of 150 persons/km^2 in 1981 census year of which about 162 x 10^3 or 91% were in Polonnaruwa District. The average annual growth rate in the project area is estimated at 2.7% excluding that of transmigration during the period from 1971 to 1981, which was about 1.6 times the national rate. An employed population registered in 1981 in Palonnaruwa District was 84,100 of which about 61% was engaged in agricultural sector.

15. Soils in the project area are composed of Alluvial soils covering about 20%, Reddish Brown Earth (RBE) occupying about 50% and Low Humic Gley soils (LHG) covering about 25% in the project area. The soils in the project area are generally suitable for agricultural development if irrigation and drainage systems are appropriately provided and operated.

16. Paddy cultivation is prevailing in the project area blessed with five (5) large tanks, Minneriya, Giritale, Kaudulla, Kantalai and Parakrama Samudra. Due to insufficient irrigation water, paddy cultivation is presently practiced on about 34,200 ha (85%) in Maha and about 26,700 ha (66%) in Yala. Only one percent of the project area (350 ha) in Maha and a negligible area in Yala are planted to upland crops like green gram, chillies, groundnuts, etc.

17. The average yield of paddy in the irrigated paddy fields is fairly high at 4.7 ton/ha in Maha and 4.0 ton/ha in Yala as compared with 4.0 ton/ha in Maha and 3.8 ton/ha in Yala in the major irrigation schemes at a national level. The average production of paddy in the major tank irrigation schemes during the period from 1984 to 1987 was 164 x 10^3 tons in Maha and 107 x 10^3 tons in Yala respectively. The production of sugarcane has been declining substantially recently due mainly to insufficient irrigation water supply, and was only about 83 x 10^3 tons in 1986.

18. Extension services to the farmers are carried out by Kursi Vapthi Sevaka (KVS) under instructions of the Department of Agrarian-Service and Agricultural Development Authority. Each KVS covers 200 to 300 farmers. There are two Seed Complexes under the Seed Division at Hingurakgoda and Polonnaruwa. The Seed Divisions produce approximately 10% of the total certified paddy seed required in the project area.

19. Two existing anicuts, Elahera and Angamedilla, are located on the Amban Ganga. Water diverted from the Elahera anicut is supplied to the existing four (4) tanks, Minneriya, Giritale, Kaudulla and Kantalai through the existing Elahera-Minneriya canal, which commands approximately 34,000 ha of the existing farm lands in Systems G and D1. The Angamedilla anicut provides water to the existing field of about 10,100 ha in System D2 through the existing Parakrama Samudra tank.

THE PROJECT

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

- to increase and stabilize yields and production through stable water supply and proper irrigation and drainage management,
- to introduce diversified cropping pattern by provision of year-round irrigation,
- to increase agricultural production by expanding new agricultural land,
- to generate hydropower through construction of a dam and power plant,
- to create employment opportunities in the rural area through the agricultural development,
- to settle landless farmers in the newly reclaimed area, and
- to improve living standards and to achieve more equitable distribution of income and welfare of the people.

21. Out of approximately 118,000 ha of the gross area, about 62,200 ha of net irrigation area were delineated taking into account the land suitability, topography, present land use, irrigability and drainability.

22. From the viewpoint of farmer's familiarity with the crops, soil properties, climatic conditions and market prospects in Sri Lanka in future, paddy will be predominantly introduced in the project area, i.e. 55,000 ha in Maha season and 44,000 ha in Yala season. In order to maximize the farmers' incomes, diversified crops such as onion, chillies, vegetables, etc. will be introduced particularly in the Yala season. About 7,200 ha of sugarcane is proposed to be grown according to the Government development programme.

23. After implementation of the project, the following crop yields and production are to be expected:

Crop	Area (ha)	Yield (ton/ha)	Production (ton)
Paddy (Maha)	55,000	6.0	330,000
Paddy (Yala)	44,000	6.0	264,000
Sugarcane	7,200	85.0	612,000
Chillie	3,100	1.9	5,890
Onion	2,900	15.0	43,500
Vegetables	3,000	12.0	36,000
Pulses	1,700	1.5	2,550
Sweet potato	300	12.0	3,600

24. The average diversion irrigation requirement for the project area with 62,200 ha is estimated to be approximately 1,821 MCM per annum. Canal conveyance and operation losses are estimated to be 30% of the diversion requirement. The peak diversion requirement for newly reclaimed area is estimated to be 1.91 l/sec/ha. The design drainage requirement varies from 4.5 l/sec/ha to 3.1 l/sec/ha depending on the topography and its vegetation conditions.

25. Total energy generation of the CEB in 1986 was 2,650 GWh. Its peak power demand and annual load factor were 540 MW and 56.1%, respectively. According to the demand forecast of the CEB, the growth rate of power in Sri Lanka will be about 9.5% per annum in the future. It is anticipated to reach about 2,018 MW of peak power demand and approximately 10,430 GWh of annual power generation in 2002.

26. The proposed Moragahakanda damsite is to be located about 2 km upstream of the existing Elahera anicut on the Amban Ganga. Several alternative studies were made of irrigation requirements based on cropping patterns anticipated, available runoff, storage capacity, costs and benefits accrued. As a result, the following features of the dam and power station are considered to be optimal:

a) Reservoir

H.W.L	EL.195.00 m
L.W.L	EL.170.00 m
Active storage capacity	686 MCM

b) Dam

Item	Unit	Main Dam	1st Saddle	2nd Saddle
Crest elevation	m	199.0	197.5	199.0
Crest length	m	490.0	396.0	490.0
Dam height	m	72.0	62.5	42.0
Dam type		Rockfill	Concrete	Rockfill
Volume of Dam	10^3m^3	2,430	376	430

c) Power Station

Installed capacity	26	MW (1 set)
Max. discharge	56.6	m^3/sec
Rated head	54.8	m
Annual energy output	145.3	GWh

27. The following table shows the principal features of the irrigation and drainage system including the improvement of systems and rural development.

a) Rehabilitation and improvement

Elahera-Minneriya canal	22	km
Main and branch canals	38	km
On-farm facilities	38,100	ha

b) New construction

Branch and minor branch canals	116	km
O&M and connecting road	147	km

c) Downstream development

Jungle clearing	17,400	ha
Rough levelling	13,900	ha
On-farm facilities	13,900	ha

d) Drainage canals

Main and branch canals	91	km

e) Community development 17,000 families

28. The time required for the implementation of the project is estimated to be approximately seven (7) years including design work, tendering and contract awards, and land settlement. The actual construction time required for dam and power scheme would be about four (4) years.

29. The total construction cost is estimated to be US$ 310 million equivalent including physical and price contingencies at the exchange rate of Rs. 30.5 = Yen 140 = US$ 1.0. The following table shows the summary costs incurred:

Unit: Million US$

	Item	Dam & Power	Irrigation	Total
(1)	Direct Construction	120	95	215
(2)	General Expenses	8	5	13
(3)	Engineering Services	10	8	18
	Sub-total	138	108	246
(4)	Physical Contingency	21	16	37
	Total	159	124	283
(5)	Price Contingency	12	15	27
	Grand Total	171	139	310
	(Billion J. Yen equiv.)			(¥43.4)

30. With proper water management of the irrigation system and improved farming after implementation of the project, the incremental agricultural economic benefit is estimated to be US$35.7 million per annum. In addition, an economic hydropower benefit of about US$8.3 million per annum is expected to be derived from the Moragahakanda hydropower station from its commissioning.

31. The economic feasibility of the Project has been evaluated in terms of economic internal rate of return (EIRR). The result shows 13.0% of EIRR as a whole, which indicates the economic soundness of the Project.

32. In addition to the direct benefits mentioned above, substantial secondary direct benefits stemming from the project outputs and induced by the project inputs as well as various indirect and intangible benefits and socio-economic impacts are expected from the implementation of the project. In particular, employment opportunities to the local people will be substantially increased by the construction works and through the development of agro-based industries related to the project implementation.

RECOMMENDATIONS

33. The Project with about 62,200 ha of agricultural development and 26 MW of hydropower development is technically and economically feasible. Furthermore, the Project would provide substantial and sustainable socio-economic benefits and impacts not only to the project area but also to the whole of Sri Lanka. In particular, the implementation of the Moragahakanda dam will create approximately 686 MCM of active storage of water which will guarantee year-round irrigation to the project

area and will permit supply of water to NCP area in the future. Thus, it is recommended to implement the project as early as possible.

34. The water resources in the Mahaweli Ganga basin can provide for extremely important effects on the national economy, particularly on agriculture and power generation, so efficient and beneficial use of water is essential. In order to exploit to the full and maximum potential of the land for agricultural development, more diversified cropping is proposed to be taken into consideration from the view-point of encouraging agro-based industries. In this context, the present institutions for agricultural support services, in particular, marketing and cropping management, are recommended to be strengthened through increase of staff and budget allocation.

35. The annual runoff of the Mahaweli Ganga main stem at Polgolla diversion weir site has been very low in recent years, resulting in a shortage of water in the existing reservoirs, Victoria and Randenigala. Accordingly, the diversion of water from the Polgolla weir to the Amban Ganga basin is crucial in the water management of the entire Mahaweli river system. Even in the case of the present water diversion policy of about 875 MCM per annum to the Amban Ganga basin including diversion of about 550 MCM to the NCDZ, the average runoff available from the Amban Ganga basin itself including inflow from the drainage basins of the existing five tanks will be sufficient for irrigation requirement of 62,200 ha in the project area.

36. The existing irrigated lands in the NCDZ (Systems H, I, IH and MH) have been recently suffering from drought particularly in the Yala season, resulted in less than 50% cropping intensity due to shortage of irrigation water. An optional alternative for the GOSL is that even if the new reclamation area of 13,900 ha proposed in the project would be curtailed to some extent, the irrigation water made available from the Polgolla diversion and the Moragahakanda reservoir could be supplied to the existing irrigated lands in the NCDZ which would result in great benefits without additional investment. According to the present diversion policy, 875 MCM per annum is diverted to the Amban Ganga basin. Since average annual flow of the Mahaweli Ganga could exceed the power and irrigation requirements of the Victoria, Randenigala and Rantembe complex and agricultural development of Systems A, B, C and E, it is recommended that the operation procedure for Victoria, Randenigala and Rantembe reservoirs is formulated in a manner that, while meeting their requirements, would prevent unnecessary spillage at these reservoirs. Excess water available could be used to the optimum by increasing the diversion at Polgolla. This additional water would provide great benefits to the NCDZ.

37. In view of the self-sufficiency of rice attainable in the near future in Sri Lanka, the diversification of crops from paddy to upland crops is essential in the agricultural development. In addition, an irrigation requirement of upland crops is much lower than that of paddy in general. It is therefore recommended that the following points are taken into consideration in formulating the future development:

    i) More diversified crops be introduced not only in Yala season but in Maha season from the view points of encouraging agro-based industries which

could result in substantial increase of rural employment opportunities, and saving irrigation water available in the basin.

ii) Average annual river flow of the Amban Ganga between Elahera and Angamedilla anicuts including the Kalu Ganga provides approximately twice as much as irrigation water required for the Parakrama Samudra Scheme of about 13,000 ha. The surplus river flow of the Kalu Ganga after implementation of its reservoir created is to be diverted to the NCDZ through NCP canal proposed or other means, for which preliminary study will be carried out in Phase II Study.

PRINCIPAL FEATURES OF THE PROJECT

DAM AND RESERVOIR

Catchment Area	782 km^2
Reservoir Area	40.5 km^2
Effective Storage Capacity	686 MCM
High Water Level	El. 195 m
Low Water Level	El. 170 m

Parameter of Dams

	Main Dam	1st Saddle-dam	2nd Saddle-dam
Type	Rockfill	Concrete Gravity	Rockfill
Crest Elevation	EL.199.0 m	EL.197.5 m	EL.199.0 m
Max. Height	72.0 m	62.5 m	42.0 m
Crest Length	490 m	396 m	490 m
Dam Volume ($x10^3m^3$)	2,430	376	430

Spillway

Type	Overflow Weir and Stilling Basin
Gates	4 Nos. 17.5 m x 8.5 m
Design Flood Inflow	4,650 m^3/sec. (1.2 times of 200 year flood discharge)
Design Flood Outflow	3,400 m^3/sec.

Penstock

Diameter	3,900 mm - 3,200 mm
Length	87 m

Power Station (First Stage only)

Installed Capacity	26 MW
Turbine	1 unit of Vertical Shaft, Francis
Generator	1 unit of 30.5 MVA
Rated head	54.8 m
Max. Discharge	56.6 m^3/sec.
Dependable Peak Power	16.1 MW
Annual Energy Output	145.3 GWh

Transmission Line

Voltage	132 kV, Single Circuit
Distance	16 km

AGRICULTURAL DEVELOPMENT

Proposed Project Area

Existing Area	44,100 ha (109,000 ac) Including 4,100 ha by EEC
Other Scheme Newland	4,200 ha by Sugar Corporation
Moragahakanda Newland	13,900 ha (34,400 ac)
Total	62,200 ha (153,800 ac)

Water Requirements

Mean Annual Diversion Requirements	1,821 MCM
Unit Diversion Requirements	1.91 l/sec/ha

Irrigation and Drainage Facilities

Items	System			
	D1	D2	AD	Others
A. Improvement of Existing Facilities				
1. Elahera anicut	-	-	-	No Improvement
2. Angamedilla anicut	-	Rehabilitation	-	-
3. Elahera-Minneriya canal	-	-	-	21.6 km
4. Main and branch canals	16.3 km	22.1 km	-	-
5. Improvement of on-farm facilities	28,000 ha	10,100 ha	-	-
B. New Construction Works				
1. Branch canals	41.6 km	19.9 km	23.6 km	-
2. Minor branch canals	8.1 km	22.9 km	-	-
3. Major drainage canals	44.1 km	32.5 km	14.8 km	-
4. Related structures	190 nos.	95 nos.	118 nos.	-
5. Inspection roads	50 km	43 km	24 km	-
6. Connecting roads	24 km	5 km	2 km	-
7. Downstream development	9,100 ha	2,200 ha	2,600 ha	-
- Jungle clearing	11,400 ha	2,700 ha	3,300 ha	-
- Rough levelling	9,100 ha	2,200 ha	2,600 ha	-
- D and F canals	630 km	150 km	180 km	-
- Drainage canals	540 km	130 km	150 km	-
- On-farm roads	450 km	110 km	130 km	-
C. Settlement Programme				
1. Farmer settlers (Families)	9,100	2,200	2,600	-
2. Non-farmer settlers (Families)	2,000	500	600	-

INVESTMENT COSTS AND BENEFITS

Unit: 10^6 US$

Item	Dam & Power	Irrigation	Whole Project
A. Construction Cost			
1. Direct Costs	120	95	215
2. Land Acquisition, Government Administration & Engineering Services	18	13	31
3. Contingencies	33	31	64
Total	171	139	310
B. Annual Incremental Benefits	8.3	35.7	44.0

ECONOMIC INTERNAL RATE OF RETURN (EIRR) : 13.0%

THE STUDY ON EXTENSION OF THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT

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ABBREVIATIONS

CB	Central Bank of Sri Lanka
CEB	Ceylon Electricity Board
CECB	Central Engineering Consultancy Bureau
CISIR	Central Institute for Scientific and Industrial Research
DA	Department of Agriculture
DCS	Department of Census and Statistics
FAO	Food and Agriculture Organization - United Nations
FD	Forest Department
GDP	Gross Domestic Product
GNP	Gross National Product
GOJ	Government of Japan
GOSL	Government of Sri Lanka
IBRD	International Bank for Reconstruction and Development (World Bank)
ID	Irrigation Department
IDB	Industrial Development Board
JICA	Japan International Cooperation Agency
MADR	Ministry of Agricultural Development and Research
MASL	Mahaweli Authority of Sri Lanka
MEA	Mahaweli Economic Agency
MECA	Mahaweli Engineering and Construction Agency
MFP	Ministry of Finance and Planning
MLLD	Ministry of Lands and Land Development
MMD	Ministry of Mahaweli Development
MTI	Ministryof Trade and Industries
NCDZ	North Central Dry Zone
NCP	North Central Province
NCRB	North Central River Basin
NWDZ	North-Western Dry Zone
RVDB	River Valley Development Board
SEDZ	South-Eastern Dry Zone
SD	Survey Department
UNDP	United Nations Development Programme
WMP	Water Management Secretariat
GA	Government Agent Division

AGA	Assistant Government Agent Division
GS	Grama Sevaka Division
T&V	Training and Visit System
KVS	Kursi Vapthi Sevaka (GS level instructor)
CRCS	Comprehensive Rural Credit Scheme
MPCS	Multi-Purpose Co-operative Societies
ASC	Agrarian Service Centre
NCRCS	New Comprehensive Rural Credit Scheme
AI	Agricultural Instructor
PMB	Paddy Marketing Board
MRKFED	Co-operative Marketing Federation
FCD	Food Commissioner's Department
CWE	Co-operative Wholesale Establishment

REPORT

MGDP	Master Plan of Mahaweli Ganga Development Project (UNDP/FAO, 1968)
AMDP	Accelerated Mahaweli Development Programme (NEDECO, 1977)
ISS	Implementation Strategy Study (NEDECO, 1978)
HCP	Hydrological Crash Programme (NEDECO, 1981)
TDS	Transbasin Diversion Study (Electrowatt, 1981 & 1984)
MWRMP	Mahaweli Water Resources Management Project (ACRES, 1986)

ABBREVIATIONS OF MEASUREMENT

Length

mm = Millimeter
cm = Centimeter
m = Meter
km = Kilometer
ft = Foot
yd = Yard

Area

cm^2 = sq.cm = Square centimeter
m^2 = sq.m = Square meter
ha = Hectare
km^2 = sq.km = Square kilometer

Volume

cm^3 = cu.cm = Cubic centimeter
l = lit = liter
kl = Kiloliter
m^3 = cu.m = Cubic meter
gal. = Gallon
MCM = Million Cubic Meters

Weight

mg = Milligram
g = Gram
kg = Kilogram
ton = Metric ton
lb = Pound

Time

sec = s = Second
min = Minute
h = Hour
d = Day
y = Year

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Killowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = Percent
PS = Horsepower
° = Degree
' = Minute
" = Second
°C = Degree centrigrade
10^3 = Thousand
10^6 = Million
10^9 = Billion (milliard)

Dirived Measures

m^3/s = m^3/sec = Cubic meter per second
cusec = Cubic feet per second
mgd = Million gallon per day
kWh = Kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = Kilowatt hour per year
kVA = Kilovolt ampere
BTU = British thermal unit

Money

Rs. = Sri Lanka Rupees
US$ = US dollar
Yen = Japanese Yen

CONVERSION FACTORS

	From Metric System			To Metric System		
Length	1 cm	=	0.394 inch	1 inch	=	2.54 cm
	1 m	=	3.28 ft = 1.094 yd	1 ft	=	30.48 cm
	1 km	=	0.621 mile	1 yd	=	91.44 cm
				1 mile	=	1.609 km
Area	1 cm^2	=	0.155 sq.in	1 sq.ft	=	0.0929 m^2
	1 m^2	=	10.76 sq.ft.	1 sq.yd	=	0.835 m^2
	1 ha	=	2.471 acres	1 acre	=	0.4047 ha
	1 km^2	=	0.386 sq.mile	1 sq.mile	=	2.59 km^2
Volume	1 cm^3	=	0.0610 cu.in	1 cu.ft	=	28.32 lit
	1 lit	=	0.220 gal. (imp.)	1 cu.yd	=	0.765 m^3
	1 kl	=	6.29 barrels	1 gal. (imp.)	=	4.55 lit
	1 m^3	=	35.3 cu.ft	1 gal. (US)	=	3.79 lit
	10^6 m^3	=	811 acre-ft	1 acre-ft	=	1,233.5 m^2
Energy	1 kWh	=	3,413 BTU	1 BTU	=	0.293 Wh
Temperature	°C	=	(°F-32) 5/9	°F	=	1.8°C + 32
Derived Measures						
	1 m^3/s	=	35.3 cusec	1 cusec	=	0.0283 m^3/s
	1 kg/cm^2	=	14.2 psi	1 psi	=	0.703 kg/cm^2
	1 ton/ha	=	891 lb/acre	1 lb/acre	=	1.12 kg/ha
	10^6 m^3	=	810.7 acre-ft	1 acre-ft	=	1,233.5 m^3
	1 m^3/s	=	19.0 mgd	1 mgd	=	0.0526 m^3/s

EXCHANGE RATE

US$1.0 = J. Yen 140.0 = Rs. 30.5

1. INTRODUCTION

1.1 Authorities

This report is prepared in accordance with the Scope of Work agreed upon between the MMD and JICA in October 1987, and presents the results of the field survey and study for updating the Feasibility Study of the Moragahakanda Agricultural Development Project (Phase I Study, hereinafter referred to as the Project) prepared by JICA in 1979. The overall frameworks of the Project, in principle, followed the procedures adopted in the previous Feasibility Study in 1978, however updated construction costs and project benefits were applied.

There are several possible diversion policies for operation of the diversion weir at Polgolla to maximize the benefits of irrigation and hydropower generation at a national level. In updating the previous Feasibility Study, it is well-known that the diversion policy significantly effects the benefits of the Project. However due to the limitations of time and the Scope of Work, the updating was carried out within the frameworks formulated in the previous Feasibility Report and the main features of the project were kept unchanged. These will be examined in the Phase II study (Master Plan) to follow later.

1.2 Background of the Project

Agriculture dominates the national economy of the Democratic Socialist Republic of Sri Lanka, contributing to its GDP, export earnings and employment. Agricultural production reached Rs. 44,400 x 10^6 in 1986, which is accounting for 27% of a GDP of Rs. 164,000 x 10^6. Agriculture is also the main source of employment for 2.3 x10^6 or about 45% of the active labour force. Besides, earnings from agricultural exports also account for Rs. 15,800 x 10^6 or 46% of total exports of Rs. 34,000 x 10^6 (REF.1).

Self-sufficiency, especially in rice, and elimination of unemployment have been the pressing main targets for the GOSL. Through the Government promotion, rice production in 1986 reached to 2.6 x 10^6 ton, which is nearing the self-sufficiency level. Rice production, however, is still vulnerable to weather conditions due to lack of irrigation water in the dry season. On the other hand, unemployment is still critical for the GOSL, as its rate is forecasted to rise to 19% by 1989, if radical measures are not adopted to spur economic growth in spite of the fact that it was down to 14% in 1985 (REF.2).

In 1960's, to attain self-sufficiency in foodstuffs, increase job opportunities and eliminate the shortage of electric power, the GOSL has promoted the Mahaweli Ganga Development Project, which aims to develop the potential arable lands in the central and north-central parts of Sri Lanka by supplying water diverted from the Mahaweli Ganga and its tributaries which are blessed with abundant water resources. In 1968, a master plan for the Mahaweli Ganga Development prepared with the assistance of UNDP/FAO comprised irrigation development of about 365,000 ha and hydropower development of 500 MW in

capacity. Based on the master plan, the Government has been proceeding with development in the Mahaweli Ganga Basin since 1968.

However, since the implementation period of the master plan was over 30 years and expected project benefits could not be anticipated in the earliest time, in 1977 the Government revised the master plan to accelerate the Mahaweli Development Programme for yielding the quickest return to the nation. The revised plan, which is called the Accelerated Mahaweli Development Programme (AMDP), involves (1) irrigation development of about 204,000 ha with 8 irrigation systems, from A to D, G, H, IH and MH, and (2) hydropower development schemes of about 470 MW in installed capacity through the construction of 5 dams: Kotmale, Victoria, Randenigala, Moragahakanda and Maduru Oya dams.

In 1978/1979, the GOSL carried out a feasibility study on the Moragahakanda Agricultural Development Project under a technical assistance of the JICA within the frameworks of the AMDP. The project aims at the irrigation development of 62,200 ha in Systems D, G and A/D areas and hydropower generation with a capacity of 26 MW through the construction of the Moragahakanda dam on the Amban Ganga, a major tributary of the Mahaweli Ganga.

In 1978/1979, the GOSL also carried out the Implementation Strategy Study on Mahaweli Development Programme (ISS) to formulate an optimum development strategy and policy. As regards the Moragahakanda reservoir only, it is noted that the irrigation functions of the Moragahakanda reservoir in the AMDP have been taken over by the Kotmale reservoir, and recommended that more detailed studies should be done at a later stage in conjunction with the study of the NCP area, and that special attention should be given to downstream development.

In 1979-1981, the GOSL also conducted a study on the Hydrological Crash Programme (HCP) which has the main objectives of (1) collecting of high and low river flow data and (2) checking and where possible upgrading existing hydrological data base in the potential development areas by using the water resources of the Mahaweli Ganga. Based on the HCP, the hydrological data-base system was established and is available for use in further water resources development planning.

In 1980-1984, the GOSL carried out a study on the Transbasin Diversion Study covering potential irrigation area in the South East Dry Zone (SEDZ), North West Dry Zone (NWDZ) and North Central River Basin (NCRB). All possible conveyance systems between the Mahaweli Ganga and the SEDZ, NWDZ, and NCRB were studied and compared. It was recommended that priority should be given to the development of the SEDZ followed by the NWDZ and the NCRB. Moreover, it was recommended that the Polgolla diversion policy should be examined in consideration of (1) variation of the policy as a means of irrigating more land in the NWDZ, assuming the existence of high Moragahakanda reservoir, and (2) a more precise determination of the optimum active capacity of the Moragahakanda reservoir needed in conjunction with the development of sub-system NW1 in a part of the NWDZ.

In 1983-1985, the GOSL carried out the Mahaweli Water Resources Management Project (MWRMP) to maximize economic and social benefits. It is noted that through the water balance study in committed Mahaweli Ganga development areas and K-M complex stations (Canyon, New and Old Laxapana, Samanala and Wimalasurendra), excluding the Moragahakanda reservoir, an expansion area of 18,500 ha in Systems A, B and D1 could be irrigated within reasonable reliability. In addition to this expansion, a preliminary examination of the availability of water in the lower Mahaweli Ganga at Minipe indicated that approximately 470 MCM per annum could be diverted by new conveyance works for the potential arable areas. System H should receive priority over energy generation as the firm energy capability of the electrical system is not jeopardized. In the MWRMP report, it is also suggested that given the social and regional development benefits of fostering irrigated agriculture in the existing Amban Ganga irrigation area, it is unlikely that significant reduction in Polgolla diversion could be justified, unless saving water use in Systems D, G and H could be achieved.

Since 1978 the Government has commenced the implementation of the hydropower generation and irrigation development projects in the Mahaweli Ganga basin as recommended in the AMDP in 1977. As of 1987, the Government had almost completed four multi-purpose dams on the Mahaweli Ganga and one multi-purpose dam on the Maduru Oya with a hydropower generating capacity of 473 MW and irrigation development area of about 94,000 ha in Systems B, C, H, MH, and, IH based on the AMDP. In the hydropower development sector, the GOSL obtained good result which is nearing the sector target of 473 MW in the AMDP. On the other hand, irrigation development has taken slower movement: irrigation systems covering only about 94,000 ha have been or are being implemented, which corresponds to about 46% of the sector target.

Under these situations, the GOSL intends to promote irrigation development based on the following basic concepts:

- to exploit the most effective use of the water resources in the Mahaweli River System for irrigation development considering the required water distribution to irrigation systems and hydropower generation,

- to maximize the irrigation area with available water and to increase crop intensity in the existing irrigation areas, and

- to work out a proper implementation programme for irrigation development considering the present difficulties in implementation, socio-economic conditions, development priorities, etc.

As discussed in the preceding paragraph, the GOSL is going to complete the principal components of the AMDP except System A and the Moragahakanda Agricultural Development Project. The GOSL has kept the strong policy to complete the AMDP, even though about 10 years have passed after completion of the feasibility study on the Moragahakanda Project. However, socio-economic conditions in the country have greatly changed since completion of the said feasibility study and such changes have adversely

affected the implementation schedule of irrigation development proposed in the AMDP and the said Moragahakanda Project.

Under these situations, the GOSL requested the GOJ in March 1986 to review and update the Feasibility Study on the Moragahakanda Agricultural Development Project prepared in 1979 (JICA), and to formulate an overall development plan (Master Plan) in the Amban Ganga basin, NWDZ and NCDZ. In response to the request of the GOSL, the GOJ through JICA sent a Preliminary Survey Team in October 1987. The Scope of Work for the Study on Extension of the Moragahakanda Agricultural Development Project and the Minutes of Meeting were agreed upon and signed on 28th October 1987 between the MMD and JICA.

1.3 Works Performed

In accordance with the Scope of Work agreed upon between the MMD and JICA, review and updating works for the previous Feasibility Study made in 1979 have been carried out by JICA Team in collaboration with counterpart experts assigned from MASL, MECA, MEA, ID, DA, University of Colombo and CECB. The members of the counterpart and JICA team are listed in Table 1.1. The field works, including surveys in the project area and collection of updated data and information to review changes in socio-economic, agricultural, and agro-economic conditions, were carried out from 1st February 1988 through 28th March 1988.

In parallel with the above works, collection of data and information was carried out to formulate an overall agricultural development (Master Plan) to be carried out in the Phase II study.

1.4 Acknowledgement

During the execution of updating studies, the study team, both JICA team and counterparts, received generous assistance and cooperation from the authorities concerned both in Colombo and at the site. The team takes this opportunity to express its heartfelt gratitude to all the individuals, authorities, agencies, etc. concerned. The study team sincerely hopes that the joint effort and cooperation extended to the study will contribute to agricultural development in the project area and eventually to socio-economic development in Sri Lanka.

2. GENERAL BACKGROUND

2.1 Land and Population

Total land area of the country is 65,510 km^2. Regarding administrative structure, Sri Lanka is divided into 9 Provinces, the Provinces into Government Agent divisions which is called GA or Districts, the District into Assistant Government Agent divisions (AGA), and AGA into Grama Sevaka (GS) divisions.

Sri Lanka has a population of 16.1 x 10^6 corresponding to the density of 245 persons/km^2. The growth in population was about 1.66% per annum during the period from 1981 to 1986. The population in the year 2001 is expected to be 20.6 x 10^6. The labour force was estimated at 5.09 x 10^6 in 1981 census year and therefore the labour participation rate was 34.3%. Public Investment 1987-1991 comments that though the unemployment rate was recorded at 14% in 1985, it is forecasted to rise to 19% by 1989 if radical measures are not adopted to spur industrial growth.

2.2 National Economy

The Gross Domestic Product (GDP) of Sri Lanka was estimated at Rs. 163.7 x 10^9 in 1986. The Sri Lanka economy has achieved stable movement during the last five years, growing at an average annual rate of 4.8%. Per capita GDP was estimated at Rs. 10,157 (about US$360) in 1986. Its real growth is about 3.3% at an average annual rate. The share of the agricultural sector in the total GDP, remained at about the same level of around 27% throughout the period. Paddy production reached 2.59 x 10^6 tons in 1986, and would attain self-sufficiency in the near future. It also provides employment to about 2.3 x 10^6 people. The leading growth sectors of the economy in the period are the manufacturing subsector (average growth rate of 6.6% per annum), electricity, gas and water-supply subsector (6.6%), and the services subsector (5.4%).

Government fiscal performance reflects the economic development policy which is to attain an increase of both employment opportunity and family income in order to improve living standards in the country. It has shown the following conspicuous characteristics in recent years: (1) the expenditure has increased since 1977 and kept the high level of the ratio of expenditure to GDP at more than 18% except in 1984, which was about 9% in 1977, and (2) to meet the budget deficit, the Government finance has been depending on domestic and foreign loans. Owing to retrenchment in expenditure in recent years, the ratio of net cash deficit to the GDP has declined year by year except in 1985. Despite these budgetary constraints, the Government aims to maintain its economic development policy.

Since 1978, the Colombo Consumer's Price Index has increased at the rate of more than 10% per annum, though it went down to 1.5% in 1985. In 1986, however, it recorded a sharper increase of 8.0% per annum. The price increase is thought to be caused mainly by the following economic factors: (1) a high degree of dependence upon imports; and (2) the upward trend in the prices of subsidized consumer commodities and in public

utility prices because of retrenchment in the Government expenditure. The wholesale price index has also recorded a high rate of increase since 1978. In 1985, however, the index declined by 15.2% and in 1986 also it went down by 3.0%. These declines were caused to a great extent by the drop in export prices of tea and coconut products which is a major contributory factor towards the declines. As a result, the rate of increase of wholesale prices for the five years 1982-1986 was about 6.6%.

Foreign trade is one of the most important economic activities for the Sri Lanka economy. Since 1977, foreign trade rapidly increased because of import liberalization. Sri Lanka economy being thus sensitive to foreign trade trends, the fluctuations of international prices of agricultural products, particularly tea, rubber and coconut directly influence the economy.

Plantation products have played an important role in the exports from Sri Lanka but their proportion of total exports has gradually decreased. In particular, the trade amount of tea export has increased slowly in recent years because of competitive markets, except in 1984 and 1985. On the other hand, industrial products such as textiles and garments in particular have grown in major export articles. Then share is now equal to the agricultural exports. As regards imports, the share of consumer commodities in particular is going down because of self-sufficiency endeavours. On the other hand, intermediate goods, petroleum in particular, represent a large portion of total imports. Investment goods have grown at a high rate because of the development policy of the Government.

2.3 Agriculture

Agriculture dominates the national economy of Sri Lanka, contributing about 27% of GDP and employing about 45% of the workforce in 1986. The active population involved in agriculture-related activities will be more than about 50% of the national active population. Agriculture will continue to be outstanding staples and major supports of the national revenue in Sri Lanka.

Sri Lanka's climate is suitable for year-round cultivation, and variations in precipitation, topography, temperature, and soils enable production of a wide range of crops. The production of agricultural crops was accounting for about 46.3% of total export earnings. The major export crops are tea, rubber, and coconut of which the production are approximately 211 x 10^3 tons, 138 x 10^3 tons, and 3,040 x 10^6 nuts respectively in 1986. The major food crop is rice, of which the production was about 2.6 x 10^6 tons of paddy in 1986, and the net cultivated area and production of the paddy are summarized below:

Item		Yala	Maha	Total
Net cultivated area	(10^3 ha)	271	469	740
Production (Paddy)	(10^3 tons)	900	1,688	2,588
Yield per ha	(tons/ha)	3.3	3.6	3.5

Source: (REF.1)

Self-sufficiency in foodstuffs, especially in rice, was one of the main targets to be urgently attained for the Government. The growth in rice production has been significant in recent years, and production is nearing the self-sufficiency level. However, rice production is still vulnerable to weather condition due to the lack of irrigation water in the Yala season.

Irrigation is essential for the cultivation in the Yala season and some supplemental irrigation is necessary for the Maha season cultivation. Irrigated rice production in Sri Lanka is a long practiced and well-understood art through the traditional tank system operation. The traditional irrigation schemes are based on the storage tanks designed to supplement the irrigation water to the Maha crops, and to store residual water used for the limited Yala season cropping. There are more than 180 such schemes in total having a storage capacity in excess of 2.5 MCM and countless number of smaller schemes. The operation and maintenance of these schemes has been the responsibilities of the farmer, with only major headworks and main canals under Government purview.

The current policies of the Government emphasize (i) to attain the self-sufficiency of the important basic food crops which are not only rice but also maize, sugar, beans etc., (ii) to expand the export of the agricultural production and diversification of the export crops, and (iii) to improve the income level and the employment in the rural area. In addition, for the long-term, the Government is emphasizing expansion of irrigated agriculture with proper operation, improved water management practice, and introduction of appropriate cropping systems, substantial increase in cropped area into the dry zone through the development of Sri Lanka's major river basins, such as the Mahaweli Ganga basin.

2.4 Electricity

The entire public power supply system in Sri Lanka is managed and operated by the Ceylon Electricity Board (CEB), which is the statutory Authority of the GOSL. The CEB supplies electrical power and energy to its consumers both directly and indirectly through the Lanka Electricity Company (LECO).

The CEB owned powerplants of 1,116 MW in total installed capacity in 1987, consisting of 916 MW of hydropower plants and 200 MW of thermal powerplants. The CEB system is predominantly depending on a hydroelectric system. Thermal powerplants are used to back up the shortfall of hydropower and to tide over interim periods between

commissioning of hydropower plants. After completion of the Victoria hydro-power plant (210 MW), electrical energy generated by hydro-power plants has rapidly increased to 2,090-2,390 GWh or 92-97% of the annual generated energy of 2,260-2,460 GWh in 1984 and 1985. In 1984, fuel energy costs decreased substantially, due to the large share of generated output attributable to hydropower. These facts show the importance of hydropower development in Sri Lanka which is a non-oil producing country and presently suffers from a trade balance deficit.

The main load centre in Sri Lanka is Colombo and the other load centres envisaged are distributed over the island nearby at Katunayake Free Trade Zone, Trincomalee, etc. The present power demand in the CEB system in 1986 was 2,231 GWh in sold energy and 540 MW in peak power. The future power demand is expected to grow at about 9% per annum and additional installations of powerplants will be annually required.

The GOSL has continuously promoted rural electrification by construction of transmission and distribution lines. The rural electrification programme is being conducted with assistance of foreign aid.

2.5 Transportation

Total land area of Sri Lanka is 65,510 km^2, and the main land area is about 430 km at the longest part from north to south and about 220 km from east to west. Trunk roads, the national roads A-1 to A-4, start from the former capital of Colombo toward Kandy, Trincomalee, Galle, Anuradhapura, etc. of capitals of each District. Trunk roads are asphalt-paved, and re-alignment and widening of the pavement as well as improvement of bridges are being undertaken to some extent with the financial assistance of foreign aid.

The network of the national railway connects major District capital cities, Galle, Kandy, Baticaloa, Trincomalee, Anuradhapura, Jaffna, etc. Due to the civil disturbances, transportation activities in the northern, eastern and north central regions have been low in recent years.

Marine transportation is provided by Colombo, Galle and Trincomalee ports. Colombo port has been developed to facilitate the international port standards in order to cater for the increased traffic of the country in recent years. In 1987, the 1st stage of the Colombo port expansion project including construction of a container terminal berth was completed. It is expected that the marine transportation will increase with the enhancement of port facilities.

Katunayake International Airport is located at about 18 km north of Colombo.

2.6 Agricultural Support Services

Agricultural support services provide essential assistance to small-holders who are brought into the development projects. They foster significant change in production and

livelihood through research, extension, credit, proper marketing and other forms of support.

(1) Research

Innovative research sustains steady agricultural growth. Agricultural research is conducted by 15 research institutions under seven ministries and the Office of the President. There are two main groups: (1) long-established research institutions for tea, rubber and coconuts; and (2) many research institutes concerned with a variety of crops, livestock, fisheries, and forests within various ministries. Communication among research activities is not effective so far. As a result, a Council of Agricultural Research Policy (CARP) was established in 1986, under the Ministry of Agricultural Development and Research (MADR) to formulate an overall strategy for research and to set national research policy.

(2) Extension Services

There are six major organizations concerned with extension services within the GOSL. These are as follows:

- The Department of Agrarian-Service (DAS) and Agricultural Development Authority (ADA) of the MADR,
- The Department of Animal Husbandry Production and Health of the Ministry of Rural Development,
- The Mahaweli Authority of Sri Lanka (MASL) of the Ministry of Mahaweli Development (MMD),
- The Land Commissioner's Department (LCD) and Irrigation Department of the Ministry of Lands and Land Development (MLLD),
- The Coconut Cultivation Board of the Ministry of Coconut Industries, and
- The Ministry of Plantation Industry.

Among these organizations, the DAS is dominantly in charge of extension services for paddy and upland production in the country. It has adopted "the Training and Visit (T&V) System" in the nation-wide since 1979, instead of conventional instruction training extension method. The T&V system contains: systematic visits by extension staff (KVS) to meet farmers on their fields; working through contact farmers; a simplified report system; fortnightly training of KVS and monthly research extension dialogue; frequent in- service training facilities for KVS; and greater emphasis on on-farm adaptive research activities.

(3) Credit

Rural banking and credit system is implemented through two schemes, namely a cultivation loan scheme and a marketing loan scheme. The former scheme is loans to farmers to undertake the cultivation through commercial banks as an agricultural credit. The latter scheme is loans for a marketing organization of agricultural products.

Agricultural credit is generally provided through the following four channels:

- The People's Bank provides cultivation loans to farmers through the Comprehensive Rural Credit Scheme (CRCS) which has been in operation since 1973. The CRCS has been effective with a large volume of loans being granted to farmers for the purpose of cultivation. This scheme has been operated through the Multi-purpose Co-operative Societies (MPCSs or so-called co-operatives), which acted as channeling agencies of credit under the CRCS.

- The Bank of Ceylon provides loans through Agrarian Service Centre (ASC). It started agricultural credit services in 1973, when the CRCS was introduced. Its service channel is small, so it does not cover the whole island of Sri Lanka.

- The Hatton National Bank provides loans directly to farmers under the CRCS. Therefore, the service area is limited into large cities and their suburbs.

- In 1986, the New Comprehensive Rural Credit Scheme (NCRCS) was introduced in place of the CRCS. A loan provided under the NCRCS is not a crop specific loan. A farmer is allowed the flexibility to undertake the cultivation of any crop he prefers, taking into consideration the availability of water, the market prices of produce and profitability. The NCRCS is provided through the Regional Rural Development Bank (RRDB) and the Thrift and Credit Co-operative Societies (TCCSs).

(4) Marketing

The marketing of agricultural products including procurement, storage, processing, distribution, importation, financing and pricing is controlled by the Government through a number of ministries, public corporations and other agencies. There are two pervasive marketing channels such as public and private.

In public marketing of paddy, the MADR is the leading ministry through the Paddy Marketing Board (PMB) and other agencies and co-operatives. In addition, Multi-purpose Co-operative Societies (MPCSs) and Food Commissioner (FC) of the Ministry of Food play important roles in public marketing channel. The former is in purchasing and the latter in distribution. The private free marketing channel is commonly from farmers (1) to farm-unit level assemblers, (2) to trucker buyers and (3) to rice millers, etc. Since enforcement of the liberalization policy, the share of

the public marketing channel of paddy has gone down to about 10% of the production.

In subsidiary food crops, the marketing flows through the same public and private channels as the paddy marketing. In these crops, however, the following agencies work in the public marketing channel instead of the PMB in paddy marketing: the Marketing Department (MD), Co-operative Marketing Federation (CMF) and Co-operative Wholesale Establishment (CWE).

3. THE PROJECT AREA

3.1 Location

The project area is located in both Polonnaruwa and Trincomalee Districts in the north-eastern part of Sri Lanka, and lies between the Mahaweli and Amban rivers to the east and the national road A-6 to the west. The irrigation area corresponds to Systems D1, D2, G and A/D delineated in the Master Plan (UNDP/FAO).

The total area covered by the project is 117,900 ha (291,000 ac). The area is divided into six (6) regions, i.e. five (5) regions irrigated by using the regulated water of the five (5) existing tanks and one region directly from the Elahera- Minneriya canal.

The proposed Moragahakanda damsite as a principal water source for the project is located at a narrow gorge on the Amban Ganga approximately 1.6 km upstream of the existing Elahera headworks, and near the border of Polonnaruwa and Matale Districts.

3.2 Regional Economy

Polonnaruwa District is a typical rural area in Sri Lanka and its dominant industry is agriculture, especially paddy production. The District occupies 3,293 km^2 of administrative area or 5.0% of the national total land and 294 x 10^3 of population or 1.8% of the country in 1986. Regarding paddy production, the District produced 243 x 10^3 tons in 1985/1986, accounting for 9.4% of the national production of 2,588 x 10^3 tons. District-wise performance of paddy in the District gets the third position, following the District of Kurunegala and Ampara. In terms of unit yield, the District attains the second largest productivity in Maha (1985/86) and fourth in Yala (1986). There are no plantation estates for major export crops such as tea, rubber and coconuts. Thus, the District economy is sustained mostly by the paddy production.

Minor food crops are generally grown in scattered homestead gardens, so it is difficult to make comparisons. Among several minor food crops, however, chillies contribute to the District economy. Its production accounts for 6.5% of the national production. Production of other minor crops in the District is not significant.

Livestock and poultry production relies on the crop production by farmers. There are a few ventures into large-scale livestock and poultry breeding. Buffalo and cattle populations were 60,800 and 81,140 in 1982, accounting for 6.8% and 4.8% of the national populations respectively. Thus, the livestock and poultry subsector is also contributing to the District economy.

The District has many tanks and ponds, where inland fish farming is quite popular. In 1981, the District produced about 3,400 tons which accounted for 11.7% of the national inland fishery production. But the production is only 1.7% of the total fishery production.

Concerning industrialization, the District is quite backward at the present time. There are a few manufacturing industries in the District. According to the survey of manufacturing industry, the only major manufacturing industries in the District are textile and leather production. Production accounted to Rs. 65 x 10^6 in 1981, accounting for 2.0% of national production. This also corresponded to 0.3% of total national production of the manufacturing subsector. The number of workers registered at 1,070 accounting for 0.7% of the total national workers in the manufacturing industry subsector. Besides textile and leather production, other manufacturing industries are negligible from the point of regional economic view.

3.3 Infrastructure

The main transport facilities linking the project area to prospective major market places of Colombo, Kandy and Trincomalee are roads and railway. The trunk road A-6 linking Colombo to Trincomalee running along the western boundary of the project area and A-11 running through the project area are asphalt-paved and relatively well-maintained. Paved roads along Elahera - Minneriya canal and connecting the trunk roads to villages, and villages to villages provide an important transportation facilities for marketing of agricultural inputs and outputs. Road density in Polonnaruwa District, i.e., total length per total area, is 0.26 km/km^2, which is lower than the density of the national level of 0.39 km/km^2. At present, substantial quantities of farm products, particularly rice, are transported by means of trucks.

The municipal water supply system is very limited. Most families get potable water from wells. Rural electrification is also backward compared with the national standard. In 1984, 162 public and private schools existed with registered pupils of about 64,600. There were 16 hospitals and clinics, with 648 hospital beds in 1986. There is one hospital or clinic for every 18,000 population, which is fairly better than the national average of one hospital for every 32,000 population.

3.4 Natural Resources

3.4.1 Topography

The topography of Sri Lanka is characterized by three steps of peneplains composed of highest, middle and lowest plains, being more than 750 m, 750-90 m and less than 90 m in altitude respectively. The highest peneplain corresponds to the so-called central highland surrounding Nuwara Eliya. The middle and lowest peneplains are surrounding the central highlands and decrease in height gradually toward the coast.

The Mahaweli Ganga rises in the highest peneplain and flows down to the Indian Ocean through the middle and lowest peneplains. The Project area is divided into the Moragahakanda dam and reservoir area, and the agricultural area. The former area is located on the Amban Ganga, the main tributary of the Mahaweli Ganga. The latter extends

on the lowest peneplain on the left banks of the lower Mahaweli Ganga and the lower Amban Ganga.

The general topography of the Moragahakanda damsite and the reservoir area is gentle slope mountain or hilly plain in the midstream of the Amban Ganga, having 150-600 m in altitude. The Amban Ganga has tributaries of the Sudu Ganga, the Nalanda Oya, etc., in its upstream reaches. These tributaries rise in the mountain area which surrounds Matale and Naula towns. The river flow, the direction and continuation of hills and mountain ridges have the clear trend of north-south, reflecting the geological structure.

The Moragahakanda damsite is located at a narrow gorge of the Amban Ganga, cutting the north-south mountain ridge. Just from the damsite, the upper area is formed of the basin topography. The altitude of the river bed at the damsite is about 135 m. Two serial keen cols are located on the north mountain ridge across the proposed damsite. The altitudes of these cols are about 150 m and 180 m, respectively. The damsite and reservoir areas are composed of gentle slope mountain covered by jungle, and have favourable topography so that no landsliding or rockfall is expected.

The agricultural area lies on the left bank of the lower Mahaweli Ganga and the lower Amban Ganga. The area has gentle undulation showing typical features of the lowest peneplain. The altitude of the project area in System D1 is 60-10 m, and the area is covered by jungle. Systems D2 and A/D areas are in the swamp zone ranging from 30 m to 6 m in altitude, and some places are inundated in the Maha season. The Mahaweli Ganga and its tributaries meander on the lowest peneplain, and their flow trends are rather complicated.

3.4.2 Geology

The geology of the project area is composed of very old, highly crystalline metamorphic rocks, so-called Highland series (Pre-cambrian) and Vijayan series (Cambrian). The Moragahakanda damsite area is located on the region of the Highland series, and agricultural area is on both series.

The Highland series is classified into three groups by its rock types; these are Khondalite group, Charnockites and Kadugannawa gneisses. The Vijayan series are Cambrian polymetamorphic rocks, formed by metamorphism of the Highland series rocks (Pre-cambrian). The above two series are classified by metamorphic grade, and there is transition zone of complicatedly mixed with the two series. The transition zone develops along the both banks of the Mahaweli Ganga from south to north 16 to 19 km in the width. East side of the transition zone lies on the Highland series region and west side on the Vijayan series region.

The geological structure of the Highland series region is characterized by a series of parallel folds, NNE-SSW in direction. The Vijayan series region and transition zone have also many folds, but in those regions, the folding direction is less uniform and less continuous than in the Highland series region. Dipping of the rock beds of these two series is generally gentle.

Quaternary deposits cover over the above base rocks. One of these deposits is river bed deposits, along the Mahaweli Ganga and its tributaries. The other is reddish brown or light brown coloured sand, silt and loam, which prevail over most of the project area. The river bed deposits are generally loose unconsolidated sediments, composed of sandy silt and clay, sometimes containing gravels. On the Moragahakanda damsite, the thickness of the above deposits is 6 m to 8 m, and it seems to be similar in the agricultural project area. The sand and loam deposits covering other than the river bed are also unconsolidated sediments, which are assumed to be mostly residual deposits. At the damsite, its thickness is 1 m to 2 m, and also supposed to be similar or a little deeper in the agricultural project area.

3.4.3 Soils

According to the previous JICA study report, soils of the project area of 117,900 ha are composed of Reddish Brown Earth (RBE, 50%), Low Humic Gley (LHG) soils (25%), Alluvial soils (20%), Solonetz (2%) and Lithosols (3%). These soils except Solonetz and Lithosols in the project area are generally suitable for agricultural development.

Alluvial soils extend over the alluvial plain of the Mahaweli Ganga, extending over Systems D1, D2 and A/D. Generally soil texture of these soils varies from heavy clay to coarse sand, depending on locations. About three quarter of these soils are imperfectly/poorly drained soils which have higher suitability for low land rice cultivation. The rest are well to moderately well drained soils, occuring on river levees and flood plains. The RBE soils extend over the undulating higher elevated land. 60% of land covered by the RBE soils is well drained and the rest 40%, imperfectly/poorly drained. The RBE soils having well drainability extend over the upper portion of the slope land in Systems D, G and A/D areas. A wide range of upland crops of the dry zone in this soil can be grown. The RBE soils having imperfectly/poorly drainability occur on the typical ridge-valley lands. These soils could be used for cultivation of rice, sugarcane and pasture.

The LHG soils develop over the low-lying old alluvium in Systems D, A/D and G areas. Generally they are found in association with the RBE soils in a catenary sequence, and the soils are best suited for paddy cultivation due to their soil characteristics.

Other soils are Solonetz and Lithosols. The land covered with Solonetz extends over a part of System D. Lithosols are developed on mountain and rock knob. These soils are not suited to irrigation farming due to shallow soil depth.

Among the project area, soils of an undeveloped area within Systems D1, D2 and A/D have been surveyed in detail. The results of classification and the distribution of soil units are shown in Table 3.1 and Figs. 3-1 to 3-3, respectively.

Land classification study was carried out on the basis of Sri Lanka national classification system (see Table 3.2). The results show that about 90% of the total area are suitable for crop cultivation, of which about 30% are suitable for upland crops, about 29% for upland crops and paddy cultivation, and 41% are best suitable for paddy cultivation.

3.4.4 Climate

The climate in the project area is characterized by a tropical monsoon with dry and rainy seasons. The monthly mean temperature at the Maha-Illuppallama meteorological station shows little variation throughout the year, ranging from 25°C to 28°C. Both the monthly mean daily maximum and minimum temperatures range from 28°C to 33°C, and from 20°C to 24°C, respectively. The annual mean relative humidity is about 80% with little fluctuation between 75% in September and 88% in December. North-east winds prevail in the Maha season (rainy season from October to March) and south-west winds in the Yala season (dry season from April to September). The monthly average of daily maximum wind velocity ranges from 5.5 km/hr in November to 16.4 km/hr in June.

The average annual rainfall is approximately 1,650 mm (65 inches) at Hingurakgoda meteorological station (1950-1977 records), located in the central part of the project area. About 75% of annual rainfall occurs during the north-east monsoon period (the Maha season) and the balance during the south-west monsoon period (the Yala season). The variations in annual rainfall are quite large, ranging from 2,830 mm (111 inches) to 970 mm (38 inches).

Mean annual evaporation is over 2,000 mm (80 inches). The monthly mean pan evaporation ranges from 120 mm (4.8 inches) in November to 230 mm (9 inches) in July. Potential evaporation is estimated to be 1,850 mm (73 inches) on an annual average.

Table 3.4 and Fig. 3-4 summarize the main features of climate in the project area.

3.4.5 Water Resources

The available water resources to the Project consist of the natural runoff from its own basin of the Amban Ganga and diverted water from the Mahaweli Ganga through the Polgolla diversion tunnel completed in 1975. The Amban Ganga flow augmented by the Polgolla diversion is once impounded at the Bowatenna reservoir. Part of the regulated water is diverted from the Bowatenna reservoir to Kalawewa regions so-called Systems H, IH and MH areas with an irrigation area of 48,600 ha, located in the other basins. Further diversion is made from the Nalanda reservoir about 10 km upstream of the Bowatenna reservoir to Dewahuwa area with an irrigation area of 1,220 ha in another basin. Available water to the Project is estimated as the balance of the above diversions and the natural runoff in the basin.

Diversion water at Polgolla from the Mahaweli Ganga to the Amban Ganga is utilized for hydropower generation at the Ukuwela power station with an installed capacity of 38 MW. Bowatenna power station with a capacity of 40 MW is operated by using the water release to downstream of the Amban Ganga.

Downstream of the Bowatenna reservoir, there are two existing intake weirs at Elahera and Angamedilla. Intake water at the Elahera anicut is led to the existing fields in Systems G and D1 through Elahera-Minneriya-Kantalai canal which links four existing tanks, Minneriya, Giritale, Kaudulla and Kantalai. Water diverted at the Angamedilla

anicut is impounded at the Parakrama Samudra tank and the regulated water is supplied to the existing fields in System D2. The water flow system is illustrated in Fig. 3-5.

(1) Hydrology

The Mahaweli Ganga has a catchment area of 1,292 km^2 at the Polgolla diversion weir site. The Gurudeniya gauging station located at about 16 km downstream is the nearest one. Based on the records at Gurudeniya, the average annual natural runoff at Polgolla was estimated to be 2,439 MCM (77 m^3/sec) from 1950 to 1977 (see Table 3.5). The variation of annual runoff is very large, ranging from 1,322 MCM (42 m^3/sec) in 1976 to 3,208 MCM (102 m^3/sec) in 1975 (see ANNEX-B).

The Amban Ganga has a catchment area of 782 km^2 at the proposed the Moragahakanda damsite. The only gauging station on the Amban Ganga is the Elahera station located at about 2 km upstream of the damsite with a catchment area of 779 km^2. Runoff records at the Elahera station are adopted as the runoff at the proposed damsite without any correction, since the difference in both catchment areas is negligible small. The average annual natural runoff was estimated to be 776 MCM (25 m^3/sec) (see Table 3.5 and ANNEX-B).

At Angamedilla with about 1,363 km^2 of catchment area, the average annual natural runoff was estimated to be about 1,440 MCM (46 m^3/sec), ranging from 775 MCM (25 m^3/sec) in 1974 to 2,363 MCM (75 m^3/sec) in 1977, as estimated by NEDECO (REF. 3, and see Table 3.5 and ANNEX-B).

The flood discharge at the proposed damsite was estimated to be about 3,480 m^3/sec for a return period of 100 years and about 3,880 m^3/sec for a return period of 200 years (see ANNEX-B). Since the flood conveyance capacity of the downstream of the Mahaweli Ganga is limited, the swamp areas are created and might be subject to periodic inundation even though the series of dams were completed on the Mahaweli Ganga, but such inundation will be decreased.

The water quality of the Mahaweli Ganga and the Amban Ganga is classified as C1 or C2 of electrical conductivity being less than 475 micro-mhos/cm, and S1 of Sodium Adsorption Ratio (SAR) being less than 10 in accordance with the criteria of U.S. Salinity Laboratory. No harm for irrigation will occur in respect of salinity and alkalinity.

(2) Polgolla Diversion

The construction of the Polgolla diversion tunnel and the Bowatenna dam and irrigation tunnel permitted water to be diverted into the Amban Ganga and the Kala Oya from the Mahaweli Ganga. These projects include hydropower plants at Ukuwela and Bowatenna with installed capacities of 38 MW and 40 MW respectively.

Upto a certain level of Mahaweli Ganga development, maximum irrigation and power benefits were achieved by maximizing possible diversion water at Polgolla and minimizing downstream release. These situation might be slightly changed due to the progress of the irrigation and hydropower development in the downstream of the main stream of the Mahaweli Ganga. Diversion policy at Polgolla will be one of the most important factors for future water resources development in the Mahaweli river basin. However, these studies are out of the Scope of Work for this Phase-I, but will be carried out in Phase-II.

As formulated in the previous Feasibility Study in 1979, the same diversion policy was followed at this stage. In the diversion policy of UNDP/FAO Master Plan, the maximum diversion capacity of the Polgolla tunnel was limited to 56.6 m^3/sec (2,000 cusec) and the minimum downstream release to 4.25 m^3/sec (150 cusec). Based on the above policy, the average annual diversion water was estimated to be 1,282 MCM, ranging from 963 MCM in 1976 to 1,513 MCM in 1960.

After completion of the Kotmale reservoir, the regulated flow at Polgolla will be available to increase Polgolla diversion, if the UNDP/FAO policy would be applicable i.e. the minimum downstream release of 4.25 m^3/sec (150 cusec). Possible average annual diversion at Polgolla could then be augmented from 1,282 MCM without Kotmale to 1,538 MCM with Kotmale. The average monthly diversion is shown in Table 3.5 and details in ANNEX-H. In the previous study, inflow to the proposed damsite and all the project features were estimated and formulated on the basis of Polgolla diversion without the Kotmale dam.

(3) Diversion to Other Basins

The Amban Ganga flow augmented by the Polgolla diversion is once impounded at the Bowatenna reservoir. Part of the regulated water is diverted to the Kalawewa regions called Systems H, IH and MH areas with an irrigated area of 48,600 ha through an irrigation tunnel with a design capacity of 28.3 m^3/sec (1,000 cusec).

In the previous Feasibility Study in 1979, the policy was modified to maximize the diversion water duly in consideration of the shortage of irrigation water due to expansion of the irrigation area beyond that originally planned in Systems H, IH and MH. The downstream release for power generation was limited to 1.03 MCM per day for 3 hrs peak generation. Based on the modified policy, the average annual diversion water was estimated to be 519 MCM, ranging 235 MCM in 1960 to 862 MCM in 1956 (see Table 3.5 and ANNEX-H).

Further diversion is made from the Nalanda reservoir about 10 km upstream of the Bowatenna reservoir to the Dewahuwa region with an existing irrigation area of 1,220 ha in another basin. The annual diversion flow is 26.6 MCM on an average and the monthly average diversion flows are summarized in Table 3.5.

(4) Inflow to Tanks

In the project area, there are five tanks; Minneriya, Giritale, Kaudulla and Kantalai linked by the Elahera-Minneriya-Kantalai canal, and Parakrama Samudra. The total annual inflow to these tanks from their own catchment areas was estimated at 321 MCM on an average and monthly average inflow to each tank is shown in Table 3.6 (See ANNEX-H).

(5) Available Water Resources

Based on the diversion policies at Polgolla and Bowatenna, the average potential annual inflow to the proposed Moragahakanda dam was estimated to be 1,552 MCM, ranging between 907 MCM in 1977 and 2,242 MCM in 1960 (1950-1977 records). The potential average monthly inflow at the damsite is presented in Table 3.5 and the details in ANNEX-H.

Runoff from the remaining catchment area excluding that of the proposed dam is utilized for the irrigation at Angamedilla. All the above are incorporated in the study and the details are described in ANNEX-H.

3.5 Land Use and Agriculture

3.5.1 Human Resources

The population within the project area was estimated at 177,000 in 1981 census year. Of the total population, 162,000 or 92% is in Polonnaruwa District and 15,000 or 8% in Trincomalee District. Since Polonnaruwa and Trincomalee Districts have populations of 262,000 and 256,000 respectively, the population of the project area in each District accounts for 62% and 6%, respectively.

The average population growth rate in the project area during the ten years from 1971 to 1981 was 4.6% and that in Polonnaruwa District was 3.1%, while growth rate in Sri Lanka was 1.6% during the same period. Thus, the project area and Polonnaruwa District have a very high rate of growth as compared with the nation.

In 1981 census year, the employed population was registered at 84,100 in Polonnaruwa District, of which 51,300 or 61% was engaged in agricultural works. This rate is considerably higher than the national rate of 50%. The remainder broke down as follows: 8,800 or 10% in industrial work, and 14,600 or 17% in services' work. 90% of employed population was male and 10% female.

3.5.2 Present Land Use

Agricultural land in the project area is 44,400 ha or 38% of the total land. The rest of 73,500 ha are non-agricultural lands consisting homesteads, marshy land, reservoir/tank area, bush, forest land, etc. The agricultural land comprises paddy fields (41,400 ha) and

sugarcane fields (3,000 ha). Paddy field are subdivided into two categories: (i) paddy field (41,100 ha) under major irrigation systems and (ii) paddy field (300 ha) under minor irrigation systems. Water source of the major irrigation systems is dependent on the Amban Ganga through the two existing intake weirs at Elahera and Angamedilla. In principle, these systems provide year-round irrigation. The minor irrigation systems depend on the local small tributaries and are irrigated only during the Maha season. Sugarcane fields are also irrigated in principle. However the cropping intensity in the agricultural land is low and shows 146% on an average during the period of three years from 1985 to 1987. The major constraints for such low cropping intensity may occur because of insufficient water supply not only during the Yala season but also during the Maha season. It is considered that increasing cropping intensity is one of the most important key factors to realize an agricultural potential in the project area.

The present land use of the project area is summarized and illustrated in Table 3.7 and Fig. 3-6, respectively.

3.5.3 Present Cropping Pattern and Farming Practices

The project area has been advanced in paddy cultivation blessed with the large tanks i.e. Minneriya, Giritale, Parakrama Samudra, Kaudulla and Kantalai tanks. The main crop of the project area is low land paddy. There are two cropping seasons for the paddy, i.e. Maha cultivation (October-March) and Yala cultivation (April-September). Due to insufficient irrigation water supply, however the paddy fields of the irrigation systems are not fully planted. In Maha about 85% (34,200 ha) and Yala about 66% (26,670 ha) were planted by paddy. About 350 ha (1%) in Maha and 100 ha in Yala were planted in the paddy fields by upland crops like green gram, chillies, cowpea, groundnuts from 1984/85 Maha to 1987 Yala (see Table 3.8).

Sugarcane is grown in Kantalai Sugar Estate by the Sri Lanka Sugar Corporation. The average acreage grown between 1985 and 1987 was 1,650 ha, which correspond to 55% of the sugarcane field (3,000 ha) due to the breakage of a dike of the Kantalai tank in 1986, the ethnic disturbance and irrigation water shortage.

Paddy is planted by transplanting method for the Maha season and by direct sowing method for the Yala season. Main varieties are BG- 379-2 and BG-34-8. About 100 kg of seeds are sown per hectare. Amounts of fertilizers applied have reached to a satisfactory level except P_2O_5 and K_2O, i.e. about 120 kg N/ha, about 40 to 50 kg P_2O_5/ha and about 50 kg K_2O/ha, respectively.

Insect and pest controls are sometimes carried out when severe damage is observed. Harvesting is done by hand. Threshings are carried out by trampling by 4 wheel tractors in most cases. Total labour requirements are estimated at 70 to 90 man-days/ha.

Green gram is one of the typical upland crops in the project area. MI-1 and MI-4 varieties are used in most cases. Seeds are sown at a rate of about 20 kg/ha. Fertilizers are applied at a rate of about 50 kg N/ha, about 20 kg P_2O_5/ha and about 10 kg K_2O/ha. Total labour requirements are estimated at about 230 man-days/ha.

Sugarcane is grown as the estate crop. Main variety is CO775 from India. Growing period is 12 months for plant canes and 11 months for ratoon canes. Normally ratoon canes are harvested 2 times after planting. Seed canes are sown at a rate of 12.4 ton/ha and fertilizers are applied at rates of about 100 kg N/ha, 40 kg P_2O_5/ha and 60 kg K_2O/ha.

Crop production costs of the paddy and upland crops are published in "Cost of Cultivation of Agricultural Crops" prepared in 1987 by Division of Agricultural Economics and Projects, the Department of Agriculture. According to the report, crop production costs are summarized below:

- Paddy, irrigated, Maha	:	11,692 (Rs./ha)
- Paddy, irrigated, Yala	:	9,678 (Rs./ha)
- Green gram, irrigated, Yala	:	12,883 (Rs./ha)

Production cost of sugarcane was estimated at Rs. 42,327/ha for Sugar Corporation's canes and Rs. 24,623/ha for allottees sugarcane based upon the various reports prepared by the Sugar Corporation.

3.5.4 Crop Yield and Production

The project area is one of the most advanced areas in the paddy cultivation in the country. The average yield of paddy in the major irrigation systems in Polonnaruwa District between 1984 to 1987 is estimated at 4.0 ton/ha for Yala and 4.7 ton/ha for Maha, indicating higher unit yield compared with 3.8 ton/ha for Yala and 4.0 ton/ha for Maha in the major irrigation schemes in the national level (Table 3.9). The average production of paddy in the major tank irrigation systems in the project area during the period from 1984/85 Maha and 1987 Yala season was estimated at 164 x 10^3 tons for Maha and 107 x 10^3 tons for Yala as shown in Table 3.10.

The minor irrigation systems in the project area is situated in Polonnaruwa District and are planted with lowland paddy in only Maha season. The average yield was estimated at 3.2 ton/ha Maha season from 1984 to 87 as shown in Table 3.11.

Though present yield of paddy is relatively higher, potential unit yield, however, is not yet fully realized. Major reasons are considered as follows:

- Insufficient irrigation water supply, especially during the Yala season,
- Low inputs of fertilizer of P_2O_5 and K_2O,
- Predominant use of paddy varieties having short growing period, and
- Improper water management resulted from deterioration of irrigation and drainage facilities.

Sugar production by the Kantalai Mill has been declining year by year as shown in Table 3.12. Unit yield and total production of sugarcane were estimated at 40 tons/ha and

66.4 x 10^3 tons on an average from 1985 to 1987. Such decline of performance can be attributable to the following reasons:

- Insufficient irrigation water supply to the cane field,
- Ethnical disturbance,
- Breakage of a dike of Kantalai tank, and
- Shortage of spare parts and difficulty of repairing because of lack of uniformity in model or type of machinery and equipment.

With respect to major upland crops, unit yields of chillie and green gram were estimated at 1.5 tons/ha and 1.0 ton/ha, respectively. Production of these crops is negligibly small due to small cultivated area. In addition fruit trees such as coconuts and banana are grown in homesteads mainly for self- consumption.

3.5.5 Livestock

There were 79,200 buffaloes and 132,000 cattle in Trincomalee and Polonnaruwa Districts estimated in 1982 (Table 3.13). Buffaloes are used for the levelling, puddling and threshing for the paddy cultivation, but are gradually replaced by machinery powers such as hand tractors and 4 wheel tractors. Bullocks are used for transport of agricultural commodities and for cultivation of upland areas.

3.6 Agricultural Support Services

3.6.1 Extension Services

The Department of Agrarian-Service (DAS) is dominantly in charge of agricultural extension services in the country. The DAS provides an assistant director of agro-service for each AGA division. The assistant director has a meeting once a month in principle to communicate extension programme to AGA division instructors. Then, an Agricultural Instructor (AI) of AGA level has a meeting also every two weeks in principle to communicate the programme to Kursi Vapthi Sevaka (KVS), GS level instructor. A KVS covers about 750 farm families as a unit, through 12 to 18 Contact Farmers (CFs). He holds a meeting or field instruction with CFs at intervals twice a week to instruct the extension programme for members of the unit in obedience to a pre-arranged time table. At these meetings the KVS instructs CFs on the particular extension message based on the area, crop calendar, etc. The remainder of the unit is set as "Follower Farmers (FF)". A number of FFs may attend the regular meeting and demonstration. In general, CFs are expected to give instruction to FFs by the time for the next regular meeting.

The Agricultural Development Authority (ADA) also provides agricultural extension services through Agrarian Service Centre (ASC). Under the ASC, Cultivation Officers (CO) are trying to instruct agricultural cultivation directly to farmers, corresponding to KVS system of the DAS.

As of 1987, the following instructors for agricultural extension services are provided through District offices of both the DAS and ADA in Polonnaruwa District (1) 4 subject matter specialists, 9 AIs and 62 KVSs under the DAS; and (2) 9 Regional officers of the ASC and 58 COs under the ADA.

3.6.2 Seed Multiplication

Improved crop varieties are developed by the research programmes of the Department of Agriculture (DA). The main seeds of the improved varieties are produced by the Seed Division of the DA. Basic seeds of all crops are produced in 32 seed production farms attached to this division. Almost all the certified seeds are produced through selected contract growers particularly in paddy, tomatoes, beans and potatoes. Seed processing is done by 14 original seed processing units and complexes of the Seed Division covering every district. The Seed Division produces about 10% of the total paddy seed requirement.

3.6.3 Agricultural Credit

In Polonnaruwa District, the Bank of Ceylon is a popular channel for agricultural credit system as well as the MPCS. The Bank provides agricultural loans for paddy cultivation through the ASC. In 1986, it granted Rs. 33 x 10^6 to 7,250 farmers (operators). Of the total amount, Rs. 8.5 x 10^6 or 25% was not repaid as an outstanding credit as of 1987, in spite of the fact that an outstanding amount was almost 10% or less of granted amount before 1986.

The NCRCS has provided its service to farmers since Yala in 1986. Its performance is still quite small (0.4% of the total loans in 1986 crop year), but the NCRCS is expected to grant a large volume of loans to farmers for the purpose of cultivation. The total amount of paddy loans will continue to increase with some fluctuation, but the growth of credit for cultivation of minor food crops seems to increase somewhat faster than paddy loans. The NCRCS thus appears to support the crop diversification policy.

3.6.4 Co-operatives

The co-operative system is still functioning in rural areas. Originally the Multi-Purpose Co-operative Societies (MPCSs) provided such services as credit, input supply, extension and marketing to its members, but it has been decreasing in its social role since introduction of the government's free-market policy. As of 1982, there were nine co-operatives in Polonnaruwa District. They are nowadays understood to deal with the following services for their members:

- Supplying foodstuffs and kerosene to low income people free of charge through the food stamps. Incidentally, food stamps are distributed by the Government to low income people to purchase basic foodstuffs and kerosene (for cooking fuel and lighting) to support their lives, as a social welfare policy of the country. In ````1987, 150,040 of food stamps were issued, distributing as follows: 35,650 for 0-8 years old; 69,810 for 12 years old and over; and 30,620 for kerosene stamps;

- Furnishing farmers with cultivation loans through the Rural Bank, under the CRCS. This agricultural credit system is still the most popular channel for rural farmers at present time,

- Supplying household commodities for rural families. In undeveloped rural area, the co-operative is the only distribution channel of commodities, and

- Functioning as an information channel not only for living affairs but also for agricultural extension services. It is not officially interwoven with agricultural extension services, but it is still functioning in some rural areas because of its long historical background.

There were 29 x 10^3 members of co-operatives in Polonnaruwa District in 1987, when the District had a population of 299 x 10^3 in the same year. About 10% of the population was affiliated to co-operatives as of 1987.

3.6.5 Agricultural Marketing

There are following 7 major agricultural marketing bodies in Sri Lanka:

- Paddy Marketing Board (PMB)
- Marketing Department (MD)
- Co-operative Marketing Federation (MARKFED)
- Co-operative Wholesale Establishment (CWE)
- Multi-Purpose Co-operative Societies (MPCSs)
- Food Commissioner's Department (FCD)
- Private Enterprises

The PMB was established in 1971 as the public organization to stabilize market prices of paddy, maize, chillies, soyabeans, pulses, sesame and groundnuts by maintaining floor prices. The FCD holds ceiling retail prices of food grains by importing and distributing at fixed prices. The PMB's share of handling in paddy has been reduced to about 10% of the production. The PMB collects paddy through agents such as Co-operative Societies, Agrarian Service Committees and private traders, and mills the collected paddy through private rice mills on contract basis. The milled rice is sold to co-operatives, army, navy police, hospitals, etc. as well as to the Rice Sales Centres for individual consumers.

The MD is involved in the marketing of agricultural commodities particularly vegetables but the MD's handling volume is small and has a little impact on the market. The MARKFED collects nearly 8-10% of the fruits and vegetables traded, through co-operatives and sells them in the principal markets in the cities. The MARKFED also handles pulses, chillies, pepper, potatoes, onions, rice, spices and fruits.

The CWE is the most important state organization for local procurement and distribution of chillies and onions. The CWE distributes them through the co-operatives and their retail shops. Co-operatives are the most popular public sector organization

engaged in paddy procurement from farmers. Co-operatives work as agents of the PMB in most cases in paddy procurement.

In private marketing channels, rice millers, village boutique owners, assemblers, commission agents, wholesaler and retailers play important roles. They handle about 90% of the marketed agricultural products. Rice millers are the largest market outlet for the paddy producers. In the case of coarse grains, village boutiques are the biggest market outlet for producers.

Local assemblers sell the collected produces to wholesalers through commission agents in cities or purchase agricultural produces on behalf of traders in the big cities. The largest outlet of the marketed fruits and vegetables are local assemblers. The local assemblers sell their produce to commission agents who operate as wholesaler in the big urban markets.

Farm gate prices of the major agricultural production in 1987 were as follows:

Paddy	-	Rs. 4.4/kg
Green gram	-	Rs. 14/kg
Chillies	-	Rs. 31/kg
Sugarcane	-	Rs. 500/ton
Red onion	-	Rs. 8.3/kg

The GOSL has been implementing a guaranteed price scheme for paddy and a floor price scheme for subsidiary crops since 1948 to stabilize prices. Fertilizers have been subsidized since 1962 to promote their use to increase of crop production. In 1988, 36% of the retail price of urea, 50% of price of Triple Super Phosphate (TSP) and 28% of price of Muriate of Potash (MP) are subsidized. The details of the Government support prices of agricultural commodities are shown in the following table:

Item	Government Support Price in 1987	
Paddy	Rs. 3.35/kg	
Maize	Rs. 4.00/kg	
Groundnuts	Rs. 7.00/kg	
Chillies	Rs 28.00/kg	(Grade I)
	Rs. 26.00/kg	(Grade II)
Cowpea	Rs. 8.50/kg	
Red Onions	Rs. 2.30/kg	(Local)
	Rs. 3.05/kg	(Vethalan)
Urea	Rs. 2,990/ton	
Triple Super Phosphate (TSP)	Rs. 2,990/ton	
Muriate of Potash (MP)	Rs. 2,890/ton	
Certified paddy seed	Rs. 6.3/kg	

According to the 1982 Census of Agriculture, the average holding size of a farm in the project area was about 1.1 ha, and therefore the planted areas of crops were calculated at 0.9 ha for Maha paddy, 0.73 ha for Yala paddy, 0.06 ha for Maha upland crops and 0.04 ha for Yala upland crops. Agricultural income of a typical farm was estimated at about Rs. 14,300/year.

3.6.6 Settlement Standard

New farming families will be settled in the new land which will be developed under the agricultural development project. In order to support agricultural activities and to prepare living circumstances, managerial assistance and physical support facilities are imperative for new settlers. Since the MASL has executed certain settlement schemes within the Mahaweli Development Projects, the standards of settlement are established in every respect. The following settlement policies are quoted and modified from "System C Development Plan 1981":

- In addition to farm settlers, there will be non-farm families brought in under the project management system, such as project-management staff and staff for schools, hospitals and other social facilities. There will be further spontaneous settlers to form the agricultural labour force and to provide trades and services. Thus, sufficient land should be reserved to allow flexibility in the settlement system.

- Infrastructures for agricultural production and marketing and for social services have to be based on the norms adopted for Mahaweli areas. The phasing of such infrastructures is as critical as the level of service to be provided and is dependent on the programme for agricultural development.

- The settlement plan should be taken into consideration the impact on existing towns. The role of the new service centres would need to be assessed from the point of view of their regional context.

- The main framework of the physical plan is its grouping of settlers into several servicing areas levelled by a hierarchy of centres adopted in Mahaweli areas. The grouping of facilities in relation to the hierarchy is shown in Fig. 3-7. The central place of each centre is recommend to be established on the basis of the following norms:

Central Place	Population of total farm families	Size of Centre (ha)	Distance Apart (km)
Town Centre	8,000-12,000	100	16-40
Area Centre	2,000	21	7-14
Village Centre	1,000	8	4-5
Hamlet Centre	250	6	2-3
Housing Group	8-15	-	0.5-1.5

3.7 Irrigation and Drainage System

3.7.1 Irrigation System

There are two existing intake weirs at Elahera and Angamedilla on the Amban Ganga. Intake water at Elahera anicut is supplied to the existing fields of 34,000 ha (84,000 acres) in Systems G and D1 through the Elahera-Minneriya canal. The canal links four existing tanks; Minneriya, Giritale, Kaudulla and Kantalai. Water diverted at Angamedilla anicut is once impounded at the Parakrama Samudra tank and regulated water is distributed to the existing field of 10,100 ha (25,000 acres) in System D2. These anicuts, canals and tanks have ancient origins. All systems in the project area lie in the administrative districts of Polonnaruwa and Trincomalee. Systems D1 and D2 are operated and maintained by the ID, and System G by the MEA. The existing irrigation system in each system is summarized in Table 3.14.

System G includes the Old Elahera Colony settled in 1947, having 1,900 ha (4,800 acres) of existing fields. The existing paddy fields are irrigated by water directly fed from the Elahera - Minneriya canal. In 1979, the rehabilitation of the Old Colony scheme was commenced and completed in 1986. New land development in the area of 4,100 ha (10,000 acres) located between the Old Colony scheme and the Amban Ganga was commenced in 1979 and will be completed in 1988. Even after completion of the Polgolla -Bowatenna Complex, System G will be facing the shortage of water in the Yala season as discussed in Sub-section 4.6.3.

In Systems D1 and D2 located in Polonnaruwa and Trincomalee Districts, there are five tanks having ancient origins. The Minneriya tank was originally constructed in about A.D. 3rd Century and the tank capacity was increased to 137 MCM (110,000 acre-feet) to serve 7,300 ha (18,000 acres) during 1950's. The Giritale tank was also constructed in A.D. 7th Century, and in 1950's the tank capacity was enlarged to 25 MCM (18,800 acre-feet) to serve 3,000 ha. The Parakrama Samudra tank originally constructed in A.D. 12th Century was restored during 1940's, and the tank capacity was increased to 135 MCM (110,000 acre-feet) to serve 10,000 ha (25,000 acres). The Kaudulla tank has an ancient origin and restored in 1950's. The tank capacity was increased to 128 MCM (104,000 acre-feet) to serve 5,300 ha (13,000 acres). The Kantalai tank was originally constructed in about 7th Century. The tank capacity is 136 MCM (110,000 acre-feet) to serve 9,700 ha (23,900 acres). At present, all these tanks and irrigation and drainage facilities are operated and maintained by the ID (Table 3.15).

In Polonnaruwa District, the Irrigation System Management Project (ISMP) has been undertaken by the GOSL under the USAID's assistance since 1986. The ISMP aims at improvements in water management, and the operation and maintenance (O&M) of the existing irrigation systems in order to achieve increased agricultural production, and thereby increased incomes for small farmers and general improvements in rural standards of living. The project is on-going and has 6 main objectives; (1) farmers' organization development, (2) O&M improvement, (3) financial management improvement, (4) monitoring, evaluation and feedback, (5) training capacity enhancement, and (6) research. The project will be completed in 1991. Unit rehabilitation costs in Polonnaruwa District was estimated at about 166 US$/ha (1,820 Rs./acre) in 1986 price level, which is 30% of the total unit costs of the ISMP.

In the Kantalai tank system, rehabilitation of the storage tank and feeder canals is on-going under the assistance of the WB, and will be completed in 1990. The rehabilitation of the system includes restoration of the Kantalai and Van Ela tanks and improvement of Minneriya-Kantalai and Van Ela feeder canals to increase capacity.

After completion of the Polgolla-Bowatenna complex, shortage of water in Systems G, D1 and D2 might be reduced, however in progress of the development the project area will still face a certain shortage of irrigation water due to the considerable large variations in annual rainfall ranging from 970 mm (38 inches) to 2,830 mm (111 inches) as discussed in Sub-section 4.6.4 (see ANNEXes B and H).

3.7.2 Drainage System

At present, natural streams and rivers so-called Oya and Ganga are principal drainage channels in the project area. The drainage water collected through these finally joins the Mahaweli Ganga. Lowland areas along the Mahaweli Ganga are repeatedly inundated during the Maha season, due to the flat and low-lying lands as well as low river discharge capacity. Without flood dikes along the Mahaweli Ganga in this region, the river would spread over several kilometers on both sides every Maha season.

In System A/D area, an embankment along the Mahaweli Ganga is provided, however the lower parts are poorly drained and assuming marshy conditions due to topographic conditions being nearer to the river mouth. In the project area, no artificial improvement of the streams and rivers has been provided for drainage purposes. The rivers are meandering with low flow capacity and often flooding widely over existing paddy fields along their courses during the Maha season.

4. PROSPECTIVE LAND AND WATER RESOURCES DEVELOPMENT

4.1 Project Concept

The project area which covers 62,200 ha in net including existing fields of 44,100 ha, other scheme area of 4,200 ha and new reclamation area of 13,900 ha is formulated to maximize the expected project benefits. The main concepts of the project are to: (1) increase and stabilize yields and production through a stable supply of irrigation water, proper drainage improvement, and introduction of improved irrigation farming, (2) introduce a diversified cropping pattern under the provision of year-round irrigation, (3) increase agricultural production by expanding new agricultural lands having favourable physical conditions for agricultural development, (4) provide hydropower generation through the construction of a dam, (5) create a job opportunities in the rural areas through the agricultural development, (6) settle landless farmers in newly reclaimed areas, and (7) increase farm income and achieve a general improvement in rural standards of living.

4.2 Irrigable Area

Land in the project area is classified into agricultural land and non-agricultural land (villages, roads, rivers, etc.). Of 117,900 ha of land in the project area, 44,100 ha have been used as existing fields, 4,200 ha for expansion area of the Sugar Corporation, and 13,900 ha are proposed as new irrigation areas. New irrigation areas in Systems D1, D2, and A/D are estimated to be 9,100 ha, 2,200 ha and 2,600 ha, respectively. The tank-wise existing and new expansion areas are summarized in Table 3.14 and soil classification in respective system is given in Table 4.1.

Existing fields include fields so-called as "under specification" and "under unauthorized". Fields under specification were originally planned to irrigate under the schemes or the projects. On the other hand, fields under unauthorized were expanded after completion of the projects or schemes, and are facing the shortage of irrigation water during the Yala season. As presented in Table 3.14, there are 7,600 ha of fields under unauthorized, out of 44,100 ha of all the existing fields. In this project, the existing irrigation area was considered to include acreage under both authorized and unauthorized fields.

4.3 Agricultural Development

4.3.1 Proposed Cropping Pattern

Basically selection of crops and the cropping pattern were decided on the basis of the following conditions:

- National policy for the agricultural development,

- Agronomic suitability of crops in terms of climate and soil conditions,
- Marketability in domestic market,
- Profitability of crop per ha, and
- Familiarity of crop cultivation to local farmers.

Under such conditions, the following seven crops were selected; (1) paddy, (2) chillie, (3) onion, (4) sugarcane, (5) vegetables, (6) pulses and (7) sweet potato.

The cropping pattern and corresponding hectarage were determined on the basis of the procedures as follows:

(1) Annual cropping intensity was set to be 200% except sugarcane area, taking account of present intensity of 146%.

(2) The project should assure the basic food need of paddy, chillie, onion, vegetables, pulses and sweet potato for the local people in and around the project area as follows:

	Demand* (ton)	Anticipated Yield (ton/ha)	Hectarage (ha)
Paddy	99,430	6	16,600
Chillie	1,830	1.9	1,000
Onion	4,070	15	300
Vegetables	35,850	12	3,000
Pulses	2,540	1.5	1,700
Sweet potato	4,400	12	300

* Details are shown in Sub-section 4.3.4.

(3) Prospective hectarage of sugarcane was determined to be 7,200 ha according to the expansion plan of the Kantalai Sugar Corporation.

(4) Vegetable, pulses and sweet potatoes were considered to be supplied only for local people in and around the project area as self-consumption.

(5) The cultivating area allocated to the selected crops except sugarcane was decided in order based on the profit of crop per ha.

The profit per ha for each crop in terms of economic value and its rank are shown below:

Kind	Economic Profit per ha (Rs.)	Rank
Onion	71,608	1
Chillie	23,584	2
Paddy	19,999	3

The prospective marketable demand which the project will be able to share among the total domestic demand was estimated at 44.8 x 10^3 tons for onion and 6 x 10^3 tons for chillie. Details are explained in Sub-section 4.3.4. Based on the anticipated yields of these crops, prospective hectarage was decided at 2,900 ha for onion and 3,100 ha for chillie which would contain the hectarage needed for basic demand of the local people in and around the project area.

The prospective domestic marketable demand of paddy is expected to be 4.21 x 10^6 tons in 2000. The market study on paddy indicates that outlet of paddy production in the project area can be found even if the project area is fully developed for rice production. Therefore the prospective hectarage for paddy will become 99,000 ha.

(6) Upland crops of chillie, onion, vegetables, pulses and sweet potato will be planned to be cultivated only during the Yala season.

In conclusion the proposed cropping pattern in the project area is summarized below and illustrated in Fig. 4-1.

Kind of Crops		Hectarage
Yala Season	Maha Season	(ha)
Paddy	Paddy	44,000
Onion	Paddy	2,900
Chillie	Paddy	3,100
Sweet potatoes	Paddy	300
Vegetables	Paddy	3,000
Pulses	Paddy	1,700
Sugarcane	Sugarcane	7,200
Total		62,200
Cropping intensity total area		188%
Cropping intensity except sugarcane		200%

4.3.2 Proposed Farming Practices

Proper farming practice is the most essential factor for realizing full exploitation of the agricultural potential in the project area. The project will provide perennial irrigation

water and base to increase unit yield of crops and crop production through completion of irrigation, drainage and related structures. Under such situations the farmers in the project area will be able to provide the optimum farm inputs without risk. The recommended farm inputs are shown below:

Unit: kg/ha

	Paddy	Onion	Chillie	Sugarcane	Vegetables*1	Pulses*2
Seed	107	8.4	1.85	12.4*3	41	26
Fertilizer						
N	120	104	150	98	28	25
P_2O_5	80	108	100	43	199	60
K_2O	80	92	100	60	74	60
Agro. Chemical (Rs./ha)	298	2,678	4,131	1,116	1,955	623
Labor (man-day)	87	552	229	18,565*4	346	229

Note: *1: represented by long beans
*2: represented by green gram
*3: ton/ha
*4: including cost of labour and machinery power (Rs.)

Details of the proposed farming practices are given to Table 4.2.

4.3.3 Anticipated Yield and Production

As discussed in the preceding Sub-sections, with the introduction of stable year round irrigation water supply, farmers will be able to diminish risks of unreliable irrigation water, rainfall or river flow for crop cultivation and be able to increase the farm inputs to optimum level with less risks. Units yields of crops were estimated both in future with and without project condition. Unit anticipated yields of crops in future without project were estimated as present yield except paddy. Paddy yield in future without project was estimated on the basis of the target yield of the on-going irrigation management and rehabilitation project, and past trend of paddy. The anticipated yield of paddy would be 6.0 ton/ha both for Maha and Yala seasons in the full development stage taking account of unit yield under the well irrigated land in and around the project area. The anticipated yield of sugarcane under cultivation of plant cane and ratoon cane would be around 85 ton/ha on an average. The target yields of chillie, red and Bombay onions, pulses, vegetables and sweet potatoes would be 1.9 ton/ha, 15 ton/ha, 1.5 ton/ha, 12 tons/ha on an average, respectively. Anticipated yields of crops in future without project were estimated to be 3.2 to 5 ton/ha for paddy, 1.0 ton/ha for pulses, 39 ton/ha for sugarcane and 1.5 ton/ha for chillie, respectively.

Anticipated production under improved and irrigated farming was estimated for the project. Annual paddy production would reach 594 x 10^3 tons. Annual sugarcane production would reach 595 x 10^3 tons. Annual productions of chillies and onions as major upland crops are anticipated to be 5.9 x 10^3 tons and 43.5 x 10^3 tons, respectively. Annual production of crops proposed in the project area are given in Table 4.3.

4.3.4 Marketing and Price Prospects

(1) Marketing

The prospective marketable amounts of the proposed crops in the project area were estimated at the year of 2000 when the project would reach at the full development stage.

The prospective marketable amounts of vegetables, pulses and sweet potatoes were conceived to be self-consumption of the basic food for the local people in and around the project area. With respect to paddy, chillie, onion and sugarcane, prospective marketable amounts were examined at the national level.

The food demand in the year of 2000 for each crop was estimated on the basis of the following formula:

$$D = T \times Q \times (1 + I \times G)^n$$

where,
- D: food demand of each prospective crop in the year of 2000
- T: population in 2000
- Q: per capita consumption of each proposed crop in 1985
- I: income elasticity for each proposed crop
- G: income growth rate
- n: year (= 15 years)

The results of food demands are shown in Table 4.4. On the other hand supply of crops in the year of 2000 was estimated on the basis of past trend of production. The results are shown in Table 4.5.5 (see ANNEX-E).

The supply of paddy in the country was estimated at 4.18×10^6 tons based on the empirical formula which reflects the recent high agricultural development trends in Mahaweli area. It was considered that the forecasted supply of paddy would include production of paddy derived from the Project. While the demand of paddy in 2000 in the country was estimated at 4.21×10^6 tons. So the demand and supply of paddy, including production in this project, will be balanced.

The demand of chillie in the country was estimated at 77.6×10^3 tons in the year of 2000. On the other hand supply of chillie in the country including chillie produced in this project area was expected to become 77.6×10^3 tons. The prospective marketable amounts shared by this project was assumed to be 7.7%, taking account of the targeted share of production in Polonnaruwa District which was formulated by the Ministry of Agricultural Development and Research. The prospective marketable amount of chillie was estimated at 6×10^3 tons.

The demand and supply of onion in the country was estimated at 172.5×10^3 tons and 83×10^3 tons respectively in the year of 2000. It was assumed that the prospective marketable amounts shared by this project would be 44.8×10^3 tons

which is equivalent to 50% of difference between demand and supply in the year of 2000.

As far as sugar is concerned, Sri Lanka has imported a large quantity of sugar. The imported quantity of sugar ranges from 263 x 10^3 tons to 388 x 10^3 tons in the recent 5 years and averages 326 x 10^3 tons. The project will be expected to produce 595 x 10^3 tons of sugarcane or 51 x 10^3 tons of sugar at the full development stage which is equivalent to 16% of the average imported quantity. This fact suggests that sugar produced by this project will be easily substituted with the imported sugar.

The prospective marketable demand of vegetables, pulses and sweet potatoes will be demand for self-consumption of the local people in and around the project area. The prospective demand in the year of 2000 was estimated at 2,500 tons for pulses, 35,900 tons for vegetables and 4,500 tons for sweet potatoes.

(2) Price Prospect

Economic prices of tradable agricultural outputs (paddy and sugarcane) and farm inputs (urea, triple super phosphate and muriate of potash) were estimated on the basis of IBRD projections of world market prices for the year of 2000.

Economic prices of non-tradable outputs and inputs were estimated at 85% of farm gate prices in 1987, taking account of standard conversion factor (0.85). Economic unskilled labor was estimated at 70% of wage rate of agricultural labor taking account of shadow wage rate (0.70). Financial prices of agricultural outputs and inputs were assumed to be farm gate price in 1987 in principle.

Economic and financial prices of the agricultural commodities are summarized below, and details are shown in ANNEX-E.

Unit: Rs./ton

	Economic Price	Financial Price
Paddy	5,500	4,400
Sugarcane	389	500
Chillie	26,000	31,000
Onion	7,100	8,300
Vegetables	3,700	4,300
Pulses	12,000	14,000
Urea	7,638	2,990
Triple Super Phosphate (TSP)	7,607	2,990
Muriate of Potash (MP)	4,984	2,890