6. DESIGN AND COST ESTIMATE

6.1 Design Criteria

(1) Hydropower and Multipurpose Dam

The typical cross section of the dam was assumed, by reference to existing, under construction and proposed dams in Sri Lanka, as follows:

Concrete gravity dam

Width of crest	:	8 m
Upstream surface slope	:	1:0.05
Downstream surface slope	:	1:0.75

Rockfill dam

Center core type		
Width of crest	:	10 m
Core zone slope	:	1:0.30
Filter zone slope	:	1:0.35
Upstream surface slope	:	1:1.80
Downstream surface slope	:	1:1.60

A straight open spillway with gates was adopted in the design. The design flood of the dams was determined to be the 1,000-year probable flood adopted for the existing high dams in Sri Lanka as the standard design in Sri Lanka, as described in ANNEX-B. The spillway was designed to be capable of the peak design flood at the design flood water level of the reservoir. A horizontal stilling basin with sub-dam was adopted as the energy dissipator taking into consideration the economic superiority, and riparian and social circumference downstream of the dam.

The low water level of the reservoir was set to be approximately 2.5 times the diameter of the waterway tunnel or conduit above the 100-year sedimentation surface in the reservoir. Annual sediment yield was estimated to be 250 m^3/km^2 as described in ANNEX-B.

No flood control space is provided above the high water level except for the Caledonia reservoirs in the study. Freeboard above the high water level of the reservoir to the dam crest was fixed to be 2.0 m for concrete gravity dam and 3.0 m for rockfill dam.

An open channel type or tunnel type was adopted for the diversion systems during construction depending on topographical conditions. The following probable floods were applied for diversion systems:

- Rock fill dam : Experienced maximum or 50-year probable flood
- Concrete dam : 10-year probable flood

The headrace tunnel is of pressure type with circular cross section. The flow velocity in the tunnel ranges from 2.5 m/sec to 3.5 m/sec. The flow velocity in the penstock pipe varies from 5.0 m/sec to 7.5 m/sec.

River outlet facilities consisting mainly of hollow jet valves were assumed to be provided. The facilities will be used for irrigation purposes in the downstream area, when generating equipment is shut down, or insufficient water is discharged through power waterway and turbine.

(2) Irrigation Tank

The typical cross section of an irrigation tank was assumed as follows:

Description	Unit	Rockfill	Earthfill	
			High Dam	Low Dam
		H>15 m	H>15 m	H≦15 m
1. Width of crest	m	10	8	7
2. Slope of center core	-	0.35	-	-
3. Upstream slope	-	1.8	3.5	3.0
4. Downstream slope	-	1.6	3.0	2.5
5. Min. bottom width of core	m	10	8	7
6. Surcharge depth				
- Gate type	m	0.5	0.5	0.5
- Weir type	m	1.5	1.5	1.5
7. Freeboard	m	2.5	2.5	2.5

Design criteria other than the above are the same described in the preceding sub-section.

(3) Transbasin Conveyance System

The pre-feasibility design of the transbasin conveyance system was carried out on the assumption of the following criteria:

- Trapezoidal concrete lining canal with a side slope of 1:1.5, flume section with 3:1 and 2R horse shoe type,

- Allowable velocity

(Unit: m/sec)

Type	Allowable Velocity
- Earth canal	0.5 - 0.7
- Concrete lining canal	0.9 - 1.5
- Tunnel and culvert	1.5 - 3.0
- Syphon	1.0 - 2.5

(4) Downstream Development

The downstream development is composed of the works for main canals down to field canals. Depending on its command area, canals were classified into five as follows:

Canal	Commanding Area (ha)	Discharge (m^3/sec)
Main canal	2,500 <	5.5 <
Branch canal	500 - 2,500	1.1 - 5.5
Minor branch canal	250 - 500	0.5 - 1.1
Distribution (D) canal	10 - 250	0.03 - 0.5
Field (F) canal	< 15	< 0.03

In order to minimize seepage loss and O&M costs, concrete lined canals were adopted for the main, branch, minor branch and distribution canals. Field canals were assumed to be trapezoidal earth canals.

6.2 Cost Estimation Criteria

The estimated construction costs consist of direct construction costs, compensation cost for ground facilities including the relocation costs for facilities and land compensation cost, administration cost, engineering service cost, and contingency. The direct construction cost is comprised of the civil works cost, hydromechanical works cost and electrical works cost.

The basic conditions and assumptions applied for the cost estimate are set out below:

- All the costs were estimated at 1988 price levels and no price escalation was included.

- The following exchange rates were applied:

  US$1.0 = Rs. 32.5 = Japanese Yen 140

- Unit prices of those works are composed of labour cost, material cost, depreciation and operation cost of construction plants and machineries and contractor's overhead. The unit prices applied were referred to those in the Updated Feasibility Study of the Moragahakanda Project (Phase I, Ref. 29), and in implemented hydropower and irrigation schemes under AMDP, as well as in the government fixed unit prices for major work items (MECA). The unit prices for major items are given in Table 35.

- The cost estimate was made on the assumption that the construction works would be performed by international contract system through competitive tender except for on-farm development comprising jungle clearing, rough levelling and construction of distribution and field canals, etc.

- The work quantities of the civil works such as excavation, concrete, dam embankment, transbasin conveyance canals, irrigation tanks, etc. were calculated from the pre-feasibility design drawings as presented in DRAWINGS.

- The cost of generating equipment and transmission line were estimated on the basis of the prevailing international prices.

- The compensation cost was estimated on the basis of the prevailing government expropriation compensation assessments for land, buildings and other private properties.

- The cost of the government administration and the engineering services for implementation of the project was estimated at 10% of the total estimated direct cost.

- The physical contingency was assumed as 20% of the total estimated direct cost.

6.3 Multipurpose and Hydropower Schemes

Principal features of the candidate multipurpose or hydropower schemes are presented in Tables 19 and 20, and the summary of construction costs for respective schemes is presented in Table 36. The details are presented in ANNEXES-G and J. The followings are summaries of the candidate schemes:

(1) Watawala Scheme

The proposed Watawala damsite is located about 2 km upstream from the bridge near Watawala on the main stem of the Mahaweli Ganga. The valley narrows at this point, and topographic and surface geological conditions indicate that it will be possible to construct a concrete gravity dam to the height required at this location.

The hydrological data estimated in the present study are;

Catchment area	:	69	km^2
Annual inflow	:	119	MCM or 3.8 m^3/sec
50-year design flood	:	600	m^3/sec
200-year design flood	:	700	m^3/sec
1000-year design flood	:	800	m^3/sec

Field observations show the bedrocks types of the damsite to be mainly interbedded garnetiferous quartz-feldspathic gneiss (type khondalite) and charnockitic gneiss. With an anticlinal axis running off the left wing of the damsite parallel to the valley, the bedding shows a monoclinic setting with the strike nearly similar to the river direction and the dip of about 45 degrees from the left bank toward the right bank, or

N20°W/40° to 50°NE. The dip of the bedding plane may be unfavorable for stability of slope on the left bank. Apart from isolated blocks of gneiss at the riverbed level, there is little talus overburden. The rock in limited exposure is well weathered and drilling will be required to determine the depth of the weathering.

The reservoir high and low water levels were designed to be EL. 1,032 m and EL. 1,010 m respectively. The said drawdown creates a net storage capacity of 17.7 MCM.

A diversion tunnel 6 m diameter and 150 m long with upstream and downstream cofferdams would be constructed on the left bank to keep dry conditions for dam construction.

From the above topographic and geological conditions, a concrete gravity type was selected as the dam type. The dam crest is set at EL. 1,034 m. The dam has a total volume of 92,000 m^3 with 60 m high and 200 m long. The gated overflow spillway is located in the middle of the dam.

The headrace tunnel (2,100 m long and 2.4 m in diameter) is routed along the river course on the left bank. The penstock and powerhouse were designed to be of above-ground type. The penstock line has a length of 220 m and inside diameter varying from 2.2 m to 1.7 m. The powerhouse is positioned just downstream of the waterfall. The tailwater level is set at EL. 840 m. The rock formation of the headrace tunnel route and powerhouse site is all interbedded gneiss (charnockite) through garnetiferous quartz-feldspathic gneiss with graphite flakes (most prevalent) to limestone, although no exposures of the latter were observed at the site. The powerhouse accommodates two units (9MW each) of generating equipment.

The proposed quarry site is a thick-bedded and massive charnockite hill with thin overburden located on the right bank of the Mahaweli Ganga. The charnockite is a good resistant construction material which forms a satisfactory concrete aggregate. The transportation distance will be 1 to 2 km. The total construction cost was estimated to be US$44.2x$10^6$.

The general plan and profile of the Watawala scheme are shown in Fig. 28, and the prefeasibility design of the dam is shown in DRAWINGS.

(2) Ulapane Scheme

The proposed Ulapane damsite is situated about 600 m downstream from the confluence of the Kotmale Oya and the main stem of the Mahaweli Ganga. This site is suitable for construction of a dam across the relatively narrow gorge.

The catchment area at the damsite was estimated at 220 km^2 excluding the catchment area of 562 km^2 at the existing Kotmale dam. The average annual runoff of 381 MCM or 12.1 m^3/sec from its own catchment area.

Field observations show that the rock types of the damsite consist mainly of interbedded garnetiferous quartz-feldspathic gneiss (type khondalite) and charnockitic gneiss. Apart from blocks of gneiss at riverbed level, there is little talus overburden. It seems that there is no geological problem for construction of a rockfill dam, if an appropriate foundation treatment is applied.

A 10 m drawdown of the reservoir between the high water level at EL. 600 m and the low water level at EL. 590 m creates a net storage capacity of 150 MCM.

The rockfill dam has a total fill volume of $2.4 \times 10^6 m^3$ with the crest at EL. 603 m (500 m in crest length and 70 m high). The proposed quarry site is located on the left bank hill, which is formed of a thick-bedded and massive charnockite. This rock is suitable for fill materials and concrete aggregates. The transportation distance will be 2 to 3 km. Impervious materials will be obtained from a gently sloping hill on the right bank about 2.5 km downstream of the damsite. Available rockfill and impervious materials will be sufficient for the required volume of fill.

An overflow spillway equipped with gates is proposed on the right abutment of the rockfill dam. The diversion conduit is in the spillway body to divert river water during dam construction. Immediately after completion of the diversion conduit with an appropriate height of spillway body, the upstream and downstream cofferdams will be constructed.

The headrace tunnel (5,000 m long and 4.5 m in diameter) was designed to be aligned in the left bank of Mahaweli Ganga. The penstock line (200 m long) and powerhouse are of the above-ground type. The diameter of the penstock pipe varies from 2.8 m to 2.4 m. The powerhouse, which accommodates the generating equipment with two units of 22 MW, is located on the opposite side of the outlet of the tailrace tunnel of the existing Kotmale power station. The tailwater level is set at EL. 480 m. The rock formation for the headrace tunnel route and power station site is composed of a basic hypersthene gneiss (charnockite) and limestone. The total construction cost was estimated to be US117.0×10^6.

The general plan and profile of the Ulapane Hydropower scheme are presented in Fig. 29, and the pre-feasibility design of the dam is presented in DRAWINGS.

(3) Caledonia Scheme

The Upper Kotmale Hydropower Development consists of the Caledonia scheme and the Talawakele scheme. The Caledonia scheme is the upstream scheme. The general plan and profile of the Upper Kotmale Hydropower Development are exhibited in Fig. 30. The preliminary design of the project structures was made in the Feasibility Study prepared by JICA in 1987. The following is a summary of the scheme.

The proposed Caledonia damsite is located about 800 m downstream from the confluence of the Dambagastalawa Oya and Agra Oya, upper tributaries of the Kotmale Oya. The catchment area at the damsite is 235 km^2 including those of the

tributary intakes, which would yield an annual average runoff of 13.1 m^3/sec or 412 MCM. Reservoir high and low water levels were determined at EL. 1,360 m and EL. 1,341 m respectively. The drawdown provides a net storage capacity of 30 MCM. A flood control space of 3.5 m is reserved above the high water level.

Rock at the Caledonia damsite is very hard and compact charnockite with relatively minor jointing and schistosite. Foundation of the dam accordingly puts no particular constraints on selection of dam type. A comparative study in terms of construction cost resulted in choice of the concrete gravity type as more economically favorable. The main dimensions of the dam are: crest EL. 1,365 m, 270 m long in crest, and 70 m high. The dam has a total concrete volume of 250,000 m^3.

A non-gated open spillway was designed to be provided over nearly the entire width of the dam. The spillway is of the overflow type.

A standard horseshoe type diversion tunnel was selected with 7.2 m diameter and 395 m long laid out on the left bank.

The headrace tunnel route from Caledonia dam to Caledonia power station was planned along the St.Clair syncline. As few fissures are present in the syncline structure, it is well suited for a tunnel. Accordingly no special problems are anticipated in tunnel excavation. The headrace tunnel has a total length of 2,982 m and an inside diameter of 3.9 m.

The penstock line, powerhouse and tailrace were designed to be of the underground type. The penstock tunnel, consisting of inclined and horizontal portions, is 218 m in total length and an inside diameter varying from 4.1 m to 3.2 m. The powerhouse will have sufficient space to house the generating equipment: one unit of 44 MW. The tailwater level is controlled by the reservoir water level of the Talawakele scheme, varying from EL. 1,200 m to EL. 1,193 m. The total construction cost was estimated to be US$156.4x$10^6$.

The general plan and typical cross section of the Caledonia dam are exhibited in Fig.31. The feasibility design of the dam abstracted from the Feasibility Report prepared by JICA in 1987 (Ref. 19) is presented in DRAWINGS.

(4) Talawakele Scheme

The Talawakele scheme is the downstream scheme of the Upper Kotmale hydropower development. The preliminary design was prepared in the Feasibility Study performed by JICA in 1987 (Ref. 19). The following is a summary of the scheme.

The Talawakele damsite is located about 350 m downstream from Talawakele railway bridge. However, the reservoir inundates the town of Talawakele, and extensive road and rail facilities. The valley narrows at this point and is therefore suitable for dam construction.

The Talawakele area is underlain by metamorphosed sediments of the Khondalite series, comprising quartzite, khondalite (quartz-feldspar-garnet gneiss), and charnockite (medium-grained gabbroic rock). At the damsite, the predominant rock type is a massive charnockite which is satisfactory as foundation and for concrete aggregates.

The Talawakele scheme has four tributary intakes, consisting of the Devon Oya, Puna Oya No.1 and No.2 and Pudal Oya intakes. The catchment areas of the Talawakele scheme were estimated at 363 km^2 including those of the tributaries. The annual average runoff from these catchment basins is 20.2 m^3/sec or 636 MCM.

The concrete gravity dam consisting of a gated overflow section and a non-overflow section was selected as the dam type on technical and economical grounds. The dam has a concrete volume of 18,000 m^3 with crest at EL. 1,203 m, crest length 102 m and height 20 m.

The 7 m drawdown between the high water level at EL.1,200 and low water level at EL. 1,193 m provides a net storage capacity of 2 MCM utilized for daily regulation.

The half closure coffering method will be adopted for diversion in view of the lower construction cost and construction period as compared to a diversion tunnel method.

The Talawakele scheme has a long headrace tunnel, and both headrace and tailrace tunnels are under pressure. The headrace tunnel, 13,066 m long and 4.4 m diameter, passes through the Talawakele structure bend and intersects the Belton-Meddecumbura anticline, parallel to the NW-SE tending lineament.

As the power station is to be underground, the penstock is likewise an underground structure. For the underground penstock, the penstock structure is of the buried type, with concrete backfilling between the excavated line and pipe, in view of the good geological conditions and for economy. The pipe inside diameter varies from 4.7 m to 3.4 m. The penstock length is 734 m.

For topographical reasons, the power station was planned to be of an underground type. The powerhouse has enough space to accommodate three units (68 MW each) of generating equipment. The Talawakele power station was planned for construction within a broad syncline structure. As almost all excavation is to be within level gneiss (khondalite), no special problems are expected. Bedding is highly stratified, and the danger of a rock burst is anticipated to be minor. The tailrace outlet is located on the left bank of the Kotmale Oya, about 20 km downstream from the confluence with the Pundal Oya. The total cost was estimated to be US$215.7x$10^6$.

The plan and elevation of the Talawakele dam are presented in Figs. 30 and 32.

(5) Kotmale Extension Scheme

The existing Kotmale Project is one of the five major headworks projects undertaken under AMDP. The Kotmale Project has a 87 m high rockfill dam at Kadadora village in Nuwara Eliya District, across Kotmale Oya, a right bank tributary of the Mahaweli Ganga. The catchment area at the damsite is 562 km^2. The dam created a reservoir having an effective storage capacity of 174 MCM between the high water level at EL. 703 m and low water level at EL. 665 m, corresponding to about 18% of the average annual inflow of 984 MCM at the damsite (1949-86). A chute spillway equipped with 4 radial gates is located on the left abutment of the dam.

Water impounded in the reservoir is taken from a power intake situated on the right periphery of the reservoir at about 230 m upstream of the dam axis. It is conveyed through a headrace tunnel of horse-shoe shape, 4.3 m diameter in initial 165 m and 4.4 m diameter in the balance 6,395 m upto surge shaft, and a pressure shaft of circular shape, 4.3 m diameter in the first 215 m and 3.8 m diameter in the balance 185 m long.

An underground powerhouse accommodates 3 units of generating equipment (3 units x 67 MW) with Francis turbines operating under a rated head of 201.5 m. The powerhouse cavern is located on the left bank of the Attabage river near its confluence with the Mahaweli Ganga. A 1,402 m long tailrace consisting of a 1,128 m long tunnel and 275 m long cut and cover conduit of horse-shoe section of 4.4 m diameter connects to the Mahaweli Ganga. The tailwater level is at EL. 480 m.

The basic design for future raising of the dam and spillway (extension) was made in the Report on Future Raising of Dam and Spillway prepared by MASL in October 1985. The following is a summary of the design.

The reservoir high water level is raised from EL. 703.5 m to EL. 731.5 m and the existing low water level is maintained. This raising arises the increase of the effective storage volume from 174 MCM to 383 MCM, corresponding to about 39% of the recorded average annual inflow at the damsite (1949-86).

The dam crest is set at EL. 735 m. The construction to be carried out by raising of the dam crest consists of additional foundation excavation, foundation treatment and additional embankment of about $4.3 \times 10^6 m^3$. The crest level of spillway is proposed to be at EL. 716.5 m as against EL. 688 m of the existing level. The additional construction works of spillway is composed of additional concrete work of spillway section, provision of non-overflow blocks at the left abutment and dismantling and relocation of existing radial gates.

The powerplant has an installed capacity of 240 MW (3 units of 80 MW) operating under a rated head of 233 m. The increase of the effective reservoir storage capacity will produce an incremental energy of 59 GWh per annum. The said storage also contributes transfer from secondary energy to firm energy. The annual energy output of the expanded powerplant comprises a firm energy output of 479 GWh and

secondary energy output of 35 GWh against 270 GWh and 185 GWh of the existing one respectively. The total cost was estimated to be US$236.6x10^6.

The general plan and typical section of the Kotmale raising scheme are shown in Fig. 33.

(6) Upper Uma Oya Scheme (Scheme-1000)

The Upper Uma Oya Scheme(Scheme-1000) is the upper part of the two-stage development of the Uma Oya system for hydropower production.

The scheme has three intakes, comprising the Mahatotila Oya, Uma Oya and Hal Oya intakes. These intakes require a seasonal regulation reservoir or a daily regulation pondage. The Mahatotila dam is located about 250 m upstream from the existing national road bridge or about 600 m upstream from the confluence of the Uma Oya and the Mahatotila Oya.

The catchment area of the Upper Uma Oya scheme is composed of the following tributary basins and the annual runoff from these catchment basins was estimated to be 11.2 m^3/sec or 354 MCM:

Mahatotila	168 km^2
Uma Oya	204 km^2
Hal Oya	49 km^2
Total	421 km^2

The whole of the proposed Upper Uma Oya Scheme-1000 is situated within the highly metamorphosed rocks of the Highland series consisting of quartz feldspar gneiss, biotite gneiss, garnetiferous gneiss, charnockite and charnockitic gneiss, with some pegmatitic intrusion. At the Mahatotila damsite, the predominant rock types are charnockite and gneiss. There is no geological difficulty to construct a rockfill dam at this site. For the other two low concrete gravity dams, there should also be no geological problem.

The Mahatotila reservoir having a net storage capacity of 60 MCM with 60 m drawdown between the high water level at EL. 970 m and low water level at EL. 910 m is created by a rockfill dam of 90 m high and 560 m in crest length. The crest elevation is set at EL. 973 m, with 3 m freeboard above the high water level. The total embankment volume of the Mahatotila dam is 3.9x10^{6}m^3.

A gated overflow spillway was designed to be provided in the right abutment of the dam, and is of an overflow type having a stilling basin as the energy dissipator.

The Uma Oya intake is situated about 3 km upstream from the confluence with the Mahatotila Oya. Water taken from the Hal Oya flows into the headrace tunnel at 5 km point from the Mahatotila intake. The Uma Oya and Hal Oya intakes have

daily regulation pondage, which are 1 MCM each. Those dams are of the low concrete gravity type.

The necessary materials for the construction of a rockfill dam appear to be available near the site. Core material may be obtained from weathered charnockite (much better suited for this purpose than weathered quartz-feldspar gneiss).

A diversion conduit is provided under the spillway body to divert river water during dam construction. Upstream and downstream cofferdams are constructed to keep dry conditions in the rockfill dam construction area.

From the Mahatotila dam, the headrace tunnel runs to the west and then northwest to cross underneath the Uma Oya where an intake structure captures the run-off as mentioned above. The tunnel and the intake structure are within the charnockites and the various gneisses of the Highland series, and no particular geotechnical problems are anticipated. From the Uma Oya crossing the headrace tunnel runs due north to the Hal Oya from where it continues in a northeasterly direction to the surge shaft/penstock tunnel and powerhouse complex on the left bank of the Uma Oya. Along this alignment, the tunnel crosses a number of synclines and anticlines and intersects obliquely some airophoto lineaments. Good tunnelling conditions are expected.

The headrace tunnel is of a circular cross-section having a total length of 12.2 km and a 4.5 m diameter. The penstock tunnel connecting to the above-ground powerhouse has an inside diameter, varying from 3.8 m to 2.9 m and a total length of 700 m. The above-ground powerhouse was designed to house the generating equipment with 3 units of 50 MW. The tailwater from the turbine is returned to the Uma Oya. The tailwater level is at EL. 500 m. The surge chamber and penstock tunnel are expected to be in competent rock. Most of the powerhouse excavation will be in rock with thin overburden. The total construction was estimated to be US$249.1x10^6.

The general plan and profile are presented in Figs. 34 and 35, and the prefeasibility design of the dam is presented in DRAWINGS.

(7) Lower Uma Oya Scheme (Scheme-500)

The Lower Uma Oya scheme is the lower part of the two stage development of the river for hydropower generation. It will exploit the head between the tailwater level of the Upper Uma Oya Scheme-1000 and the Randenigala reservoir water level. Water release to the Randenigala reservoir will have the following advantage compared with water release to the Rantembe reservoir: 1) covering of water deficit for irrigation caused in the Randenigala reservoir in hydrologically dry years, and 2) in case of the water release to the Rantembe reservoir, no improvement of the operational situation of the Mahaweli cascade is hydrologically expected, because of the small storage volume. The tailwater will fluctuate between EL. 232 m and EL. 203 m according to the operating water level of the Randenigala reservoir.

The scheme utilizes the runoff from the remaining Uma Oya catchment basin (100 km^2) and the Madulu Oya catchment basin (101 km^2) in addition to the regulated flow from the upper Uma Oya (421 km^2), totaling a catchment area of 622 km^2. An annual average runoff of 16.6 m^3/sec or 523 MCM was estimated to flow from these catchment basins.

The Uma Oya Scheme-500 intake weir is located about 1.5 km downstream from the Upper Uma Oya power station, or 26 km upstream from the confluence with the Mahaweli Ganga. The dam was designed to be a concrete gravity type with a daily regulation capacity of 1.5 MCM and 25 m in height, consisting of the overflow (spillway) and non-overflow sections. The normal intake water level was designed at EL. 500 m.

The Madulla intake weir is located at the 6.5 km point of the headrace tunnel from the Uma Oya intake and has a daily regulation pondage of 1.5 MCM. The weir is of concrete gravity type having a height of 25 m, composing of overflow (spillway) and non-overflow sections. The normal intake water level is at EL. 505 m.

The Uma Oya weir site lies in the zone of the Khondalite Series, consisting of charnockitic gneiss, quartz-feldspathic gneiss, quartzite and limestone. The riverbed is formed by outcrops of fresh rock, mainly charnockite and quartz feldspar gneiss in places covered by thin layer of sandy or gravelly alluvial deposits. Due to the massive nature of the bedrock, energy dissipation at the downstream end of the spillway chute will not cause any problems. The geological conditions for the Madulla Oya weir site would be almost similar to those for the Uma Oya weir site.

The geological condition of the headrace tunnel from the Uma Oya intake to the Madulla Oya intake consists of generally massive charnockite, which would offer favorable tunneling conditions. The headrace and penstock tunnels connecting the Madulla Oya intake with the powerhouse and tailrace tunnel are formed by lithological units such as charnockite, quartz-feldspar gneiss, quartzite, etc. The underground structural conditions in this section would be also favorable.

The headrace tunnel is of circular cross-section with an inside diameter of 4.8 and its total length of 15 km. The underground penstock line has a total length of 1,000 m and an inside diameter varying from 4.1 m to 3.0 m. An underground type was selected for the powerhouse, with enough space for three units of 32 MW. Water from the turbine is diverted to the Randenigala reservoir through the tailrace tunnel with a total length of 700 m and an inside diameter of 5.0 m. The total construction cost was estimated to be US$228.5x$10^6$.

The profile and general plan of the Lower Uma Oya scheme is shown in Figs. 34 and 36 respectively.

(8) Wewatenna Scheme

The Wewatenna scheme is located about 7.5 km upstream from the confluence of the Mahaweli Ganga and the Badulu Oya. Water from the Badulu Oya is diverted to

the Loggal Oya through the power waterway, for irrigation use. Diverted water is routed into the existing Minipe RB transbasin canal together with the runoff from the Loggal Oya catchment basin. Therefore, the Wewatenna scheme was planned as a dual purpose scheme for power and irrigation.

The topographic maps and site observation indicate that the valley narrow at the proposed damsite. The site is located near a tentatively-drawn boundary between the metamorphic sedimentary gneiss of the Khondalite Series, to the south and west, and the "transition zone" between these gneiss and a widespread series of biotite and granitic gneiss which lie farther east. The Khondalite series rock types that may be encountered are remnants of quartzite, quartz-feldspathic gneiss (garnetiferous in part) and possibly limestones. These will be associated with areas of biotite gneiss and granitic gneiss of the Vijayan Series.

From the said topographical and geological conditions, the rockfill type was selected for the dam. The main dimensions of the dam are crest EL. 233 m, 500 m in crest length and 80 m in height. The dam volume was estimated at $2.7 \times 10^6 m^3$. The spillway located in the left abutment of the dam is equipped with gates and is of an overflow type. The reservoir would have a net storage capacity of 90 MCM, created by a 30 m drawdown between the high water level at EL. 230 m and the low water level at EL. 200 m. The average annual runoff of 6.6 m^3/sec or 207 MCM would flow into the reservoir from the catchment basin with 267 km^2.

Suitable material for rockfill, filters, and concrete aggregates would be available in the vicinity of the damsite in form of charnockite or biotite granitic gneiss. The impervious material would also be available in the vicinity of the damsite, by excavating overburden.

The power waterway connecting the Wewatenna reservoir with the Loggal Oya would exploit a net head, ranging from 125 m to 90 m. The power waterway consists of the headrace tunnel and penstock line. The headrace tunnel has a total length of 3,000 m and an inside diameter of 3.1 m. The penstock line was designed as an above-ground type in view of the topographic and economic conditions. The penstock line is 150 m in length with an inside diameter varying from 2.0 m to 1.7 m. The powerhouse is situated about 11.5 km upstream from the confluence of the Mahaweli Ganga and the Loggal Oya. The above ground powerhouse accommodates the generating equipment having two units of 11 MW. The tailwater level will be at EL. 105 m. The total construction cost was estimated to be $US\$85.5 \times 10^6$.

(9) Sudu Ganga Scheme

The Sudu Ganga scheme was planned as a single purpose scheme to utilize diverted water from the Mahaweli Ganga through the Polgolla diversion and the runoff from the Sudu Ganga's own catchment basin with a catchment area of 305 km^2 and its head obtained by damming up. The average annual diverted discharge and average annual runoff were estimated at 27.7 m^3/sec and 8.5 m^3/sec, or 875 MCM and 269 MCM, respectively.

The damsite is located about 8 km upstream from the confluence of the Amban Ganga and the Sudu Ganga. The rock in this area belongs to the Khondalite series of Archaean metamorphic rocks, mainly charnockitic gneiss and quartz-feldspathic gneiss, with interbedded quartzite and limestone. The rocks observed at the site are mainly good massive charnockitic gneisses with some minor interbedded quartzite. No limestone was seen within the contemplated reservoir level. There is an extremely light overburden at the site. The stream bed itself is entirely rock and the dam axis lies along a rocky ridge of charnockite. The charnockite would be used as suitable materials for rockfill and concrete aggregates.

In view of these geological conditions and the availability of materials, a rockfill type was selected for the dam. The gated spillway and non-overflow section as concrete gravity type for the purpose of arrangement of the powerhouse is located on the left abutment of the dam. The spillway is of an overflow type. The reservoir has a net storage capacity of 100 MCM with a 25 m drawdown between the high water level at EL. 325 m and low water level at EL. 300 m.

A coffering and diversion conduit method was designed to be applied for river diversion during construction of the rockfill dam. The diversion conduit is provided in the spillway body.

The powerhouse is located adjacent to the spillway immediately downstream of the dam. The powerhouse is connected with the reservoir by a 120 m long penstock with an inside diameter varying from 3.5 m to 3.1 m. The powerhouse accommodates two units of 22.5 MW of generating equipment. The tailwater is set at EL. 270 m. The total construction cost was estimated to be US$83.1x10^6.

The general plan and profile are presented in Fig. 37, and the prefeasibility design of the dam is presented in DRAWINGS.

6.4 Irrigation Schemes

The construction costs of transbasin canals, irrigation tanks, main and branch canals for the respective alternatives were estimated based on the unit prices and work quantities. The unit prices applied were referred to those in the updated Feasibility Study (Phase I) of the Moragahakanda Agricultural Development Project (Ref. 29). The work quantities for transbasin canals and irrigation tanks were estimated on the basis of the prefeasibility design attached in DRAWINGS. Those of the main and branch canals were estimated by using the topographic maps at a scale of two inches to one mile (1/31,680).

Direct construction costs of on-farm development other than the above were estimated on the basis of actual work quantities in Systems C and B, and the above unit prices, as follows:

Category	Work Involved	Unit Direct Construction Cost (US$/ha)
- Existing major irrigation scheme	Rehabilitation, a part of canal lining and improvement of structures	200
- Cashew Land	Jungle clearing	300
- Rainfed or minor irrigation scheme	On-farm development except clearing and leveling	2,200
- New irrigation scheme	Overall on-farm development	2,500

Based on the above-mentioned basic conditions and assumptions, the cost estimate was made for the respective conveyance systems and irrigation schemes. A summary of the construction costs for respective alternative conveyance systems and agricultural development schemes is presented in Table 37. The details are presented in ANNEX-J.

6.5 Economic Cost

The estimated financial cost based on market prices was adjusted to the economic cost, by adopting a Standard Conversion Factor (SCF) of 0.85 for the local currency portion. Since there is substantial unemployment in rural areas, the shadow wage rate of 70% of market wage for unskilled labour is taken into account. The economic costs, O&M costs and replacement costs of respective schemes for hydropower and irrigation are presented in Table 37.

7. BENEFITS

7.1 Agricultural Benefit

Agricultural benefits accrue from incremental production by a balance of "with" and "without" project condition. Typical crop budgets are estimated on the basis of the recommended farming practices. Economic prices of farm inputs and products of international tradable goods were estimated by referring to the IBRD price forecast. For estimating the economic prices of non-tradable goods, the Standard Conversion Factor (SCF) of 0.85 was applied. Economic value of unskilled labour was estimated to be 70% of the actual market wage for them, in the same way as applied in the cost estimation in the preceding Chapter.

Economic farm gate prices under the above conditions are given in the following table:

(Unit: Rs./ton)

Crop	Prices	Crop	Prices
Paddy	5,500	Long Bean	3,700
Chilli	26,000	Cashew (Raw Nuts)	23,000
Green Gram	12,000	Urea	7,638
Maize	4,300	Triple Super Phosphate (TSP)	7,607
Bombay Onion	7,100	Muriate of Potash (MP)	4,984

Crop budgets of the proposed crops were prepared on the basis of gross income and production cost under both without- and with-project conditions in the future. The details are described in ANNEX-E. The economic net benefits of each crop are summarized below and are shown in Tables 38 and 39.

(Unit: Rs.1,000/ha)

Crop		Without Project	With Project
Paddy	Maha	10.3	20.9
	Maha (System H)	15.4	20.9
	Yala	8.0	18.4
	Rainfed	6.7	-
Chilli		23.8	32.7
Pulses (Green gram)		2.7	6.4
Maize		1.4	6.6
Onion		41.5	71.6
Long Bean		3.0	10.1
Cashew (Non-irrigated)		-	19.9

Based on the above conditions, agricultural benefits accruing annually from the projects were estimated and the details of benefits by System are shown in Table 40.

(Unit: Rs. 10^6)

Crop	NCRB*	NWDZ	Total
Paddy	3,672	284	3,956
Chilli	425	22	447
Pulses	31	32	63
Maize	39	13	52
Onion	236	23	259
Cashew	397	0	397
Others	62	20	82
Total	4,862	394	5,256
Total Equivalent to US$10^6	150	12	162

Remark: * Including the incremental benefits in Systems H, IH and MH.

7.2 Power Benefits

The conventional approach to economic analysis of a hydropower project is to define its benefit as the cost saved in construction and operation (fuel cost) of the cheapest alternative facility that could provide power supplies of equivalent quality to the intended beneficiaries.

The cheapest alternative thermal facilities to meet system load sharing portions are gas turbine and diesel generator for peak load, oil-fired steam plant for middle load and coal-fired steam plant for base load. For this project, diesel generation, considered as the most viable alternative to hydropower by CEB, was selected as the cheapest alternative energy source, since the proposed hydropower plants are characterized by peak generation, with 5.0 hours of firm operation. The necessary construction and operation costs for such facilities required to replace the project were adopted as the project benefits.

Accordingly, the peak generation supply was evaluated on the basis of the diesel alternative. Thus, for power output (kW) and firm energy (kWh) which correspond to supply for peak load, a diesel station was considered as an alternative. While, for secondary energy, fuel costs of coal thermal stations were considered as an alternative, since the secondary energy of hydropower will save fuel consumption at coal thermal stations, as mentioned above. For the secondary energy, full amount is assumed effective for fuel cost saving in coal thermal generation, as there will be abundant thermal generation which can effectively be replaced by generation under the project.

The unit benefit values were calculated to be US$93.1 per kW for capacity value, US$0.0674 per kWh for firm energy value and US$0.0298 per kWh for secondary energy value respectively. The details of calculation are presented in Table 41, and described in ANNEX-G.

In addition to the above benefits, the proposed hydropower schemes would contribute to the transfer from secondary energy to firm energy for the downstream power stations resulting from the firming-up of discharge by regulation. The benefits to be yielded

by the said energy transfer was defined as incremental benefit. In other words, the incremental benefit is the balance between the benefits with and without the upstream hydropower development.

Both the annual power benefits and the annual incremental benefits obtainable by the downstream power stations for the respective schemes were estimated as shown in Tables 42 and 43 and the results are summarized as follows:

(Unit: US$10^6)

Scheme	Annual Benefit	Incremental Annual Benefit	Total Benefit
1. Watawala	4.11	1.41	5.52
2. Ulapane	9.32	4.51	13.83
3. Caledonia	10.75	4.79	15.54
4. Talawakele	52.75	-	52.75
5. Kotmale Extension	13.25	7.66	20.91
6. Upper Uma Oya (Scheme-1000)	29.74	2.21	31.95
7. Lower Uma Oya (Scheme-500)	25.39	0.75	26.14
8. Wewatenna	5.24	-	5.24
9. Sudu Ganga	8.63	0.73	9.36

8. OVERALL AGRICULTURAL DEVELOPMENT PLAN

8.1 Comparison of Transbasin Conveyance System

The comparison of the three alternative transbasin conveyance plans and irrigable areas in NCRB and NWDZ under the present Polgolla diversion policy of 875 MCM was carried out based on the results of water balance simulation described in Chapter 5, and costs and benefits in Chapters 6 and 7. The detailes are given in ANNEX-H.

All conveyance systems were evaluated under the condition that the irrigation schemes under AMDP should be given first priority to supply water within an allowable water deficit as a base case for comparison. As seen in Tables 33 and 34, total area of 303,750 ha including the irrigation area of AMDP can be irrigated within the allowable deficit. And decrease of hydropower generation at the existing power stations was considered as a negative benefit. Table 33 shows the results of a water balance in case of the present Polgolla diversion of 875 MCM, and the summary is shown below:

Item	Unit	Alternative Plan			Present Condition
		Case A145	Case B151	Case C145	Case D
1. Combination of Irrigation Area		AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP - -
2. Irrigation Area*	ha	323,750	323,750	323,750	200,300
3. Pump Station					
- Pumping volume	MCM	761	1,515	896	-
- Energy consumption	GWh	146	498	219	-
4. Energy Output					
- Existing hydropower	GWh	2,138	2,020	2,017	2,264
- Proposed hydropower	GWh	1,808	1,824	1,824	-
- Total	GWh	3,946	3,844	3,841	2,264

Remark: * Including 20,000 ha of non-irrigated cashew land.

Annual equivalent costs of construction for respective cases were calculated at a discount rate of 8% per annum. Hydropower benefit was valued on the basis of the production costs of alternative thermal stations, as summarized in Chapter 7 and detailed in ANNEX-G. Energy consumption at pumping stations was valued at a mean value of firm and secondary energy on the assumption that pump operation would be restricted to the use of off-peak energy output, referring to the results of water balance studies. Table 44 shows the results of the studies, and following table shows the summary of the comparison of these cases:

Item	Unit	Alternative Plan		
		Case A145	Case B151	Case C145
1. Total Irrigation Area*1	ha	323,750	323,750	323,750
2. Annual Benefits	US$10^6	155.6	149.8	149.7
3. Annual Costs*2	US$10^6	135.6	176.2	151.1
4. Economic Comparison				
- B/C	-	1.15	0.85	0.99
- B-C	US$10^6	20.0	-26.4	-1.4

Remarks: *1 Including 20,000 ha of non-irrigated cashew land.
*2 A discount rate of 8% was applied. No consideration was given to the implementation schedule and the built-up period of the scheme.

As seen in the above table, there is a clear trend that due to the heavy energy consumption at the pump station, the economic viability is greatly affected. Therefore, it is noted that the optimum solution for the transbasin diversion should be the plan to minimize energy consumption at the pump station, and at the same time to keep irrigated agriculture to the maximum extent. Case B shows the negative benefit, and Case C shows the marginal benefit at a discount rate of 8%. Therefore, Case A was selected as the optimum transbasin conveyance system among the three alternatives.

In TDS (refer to Table 6.1 of Main Report, Ref. 27), it was also noted that there was a very clear trend similar to the above figures as shown in Table 46.

8.2 Screening of Agricultural Land Development Plan

As discussed in preceding Section, Case A proposed in this study was selected as the optimum plan in terms of B-C and B/C. Moreover, each of the two alternative development plans with Case A conveyance system were studied under the present Polgolla diversion of 875 MCM and possible alternative diversion of 1,280 MCM adopted in the Moragahakanda Project in 1979 (Ref. 8). Details are described in ANNEX-H. Table 34 presents the results of water balance simulation runs, and the following table shows the summary:

Item	Unit	Present Diversion Policy 875 MCM		Alternative Diversion Policy 1,280 MCM	
		A118	A145	A209	A242
1. Combination of Irrigation Area		AMDP NCRB -	AMDP NCRB NWDZ	AMDP NCRB -	AMDP NCRB NWDZ
2. *Irrigation Area**	ha	310,500	323,750	310,500	323,750
3. Pump Station					
- Pumping volume	MCM	653	761	360	435
- Energy consumption	GWh	125	146	70	84
4. Energy Output					
- Existing hydropower	GWh	2,221	2,138	1,967	1,998
- Proposed hydropower	GWh	1,818	1,808	1,866	1,868
- Total	GWh	4,039	3,946	3,833	3,866

Remark: * Including 20,000 ha of non-irrigated cashew land.

By adopting the same procedures described in the preceding section, the economic comparison of the above cases was carried out on the basis of the results of the water balance studies. Table 45 shows the results of the studies and the following shows the summary of the comparison:

Item	Unit	Present Diversion Policy 875 MCM		Alternative Diversion Policy 1,280 MCM	
		A118	A145	A209	A242
1. Total Irrigation Area*1	ha	310,500	323,750	310,500	323,750
2. Annual Benefit	US$10^6	147.5	154.7	133.7	147.4
3. Annual Costs*2	US$10^6	122.1	135.6	113.3	126.3
4. Economic Comparison					
- B/C	-	1.21	1.14	1.18	1.17
- B-C	US$10^6	25.4	19.1	20.4	21.1

Remarks: *1 Including 20,000 ha of non-irrigated cashew land.
*2 A discount rate of 8% was adopted. No consideration was given to the implementation schedule and the built-up period of the schemes.

As seen in the table, the development plan without NWDZ, Case A-118, shows the most economical plan in terms of B-C and B/C among four alternatives. The reduced energy output on the Mahaweli main stream, i.e. the existing hydropower stations under AMDP, gives a rather substantial affect to the comparison. This trend is clearly seen in the development of NWDZ, due to the available head being utilized in hydropower generation. If the value of fossil fuel increases, it will show a much clearer trend. Contrary to this, if the value of agricultural products increases more than the increase in fossil fuel value, the above trend will be less. Therefore, it is recommend that the present Polgolla diversion should be kept for the time being, and at the final stage of the development in the NCRB area, the Polgolla diversion policy should be reassessed.

8.3 Screening of Hydropower Development Plan

Based on the estimated costs and benefits as described in Sections 6.3 and 7.2, economic analysis was made for each scheme as shown in Table 47, and the following is EIRR and ranking of each scheme:

Scheme	B/C*	EIRR	Ranking
1. Watawala	1.25	9.8%	4
2. Ulapane	1.21	9.6%	5
3. Caledonia	1.55	11.9%	2
4. Talawakele	1.99	15.1%	1
5. Kotmale Extension	0.90	7.0%	8
6. Upper Uma Oya (Scheme-1000)	1.31	10.3%	3
7. Lower Uma Oya (Scheme-500)	1.17	9.2%	6
8. Wewatenna	0.62	4.4%	9
9. Sudu Ganga	1.14	8.6%	7

Remarks: * Discount rate = 10%. No consideration was given to the implementation schedule and the build-up period of the schemes (refer to ANNEX-G).

As seen above, the Caledonia, Talawakele, Upper Uma Oya (Scheme-1000) are more economically promising than the other six schemes. The Wewatenna scheme is given the lowest priority among the above schemes, and is not economical at the present value of hydropower benefit. The Wewatenna scheme is deleted from this study, but should be subject to the future study in connection to the agricultural development of the SEDZ area.

The Feasibility Study on Upper Kotmale Hydroelectric Power Development was carried out by JICA in 1987 (Ref. 19). The above comparison proves that the Upper Kotmale project comprising the Caledonia and Talawakele schemes is the most attractive and economically viable combination of schemes. Implementation of these schemes is imperative because of the rapid increase of electric power demand as shown in Fig. 41. The above eight (8) schemes, omitting the Wewatenna scheme, are included in the proposed Master Plan.

As shown in the above table, the Kotmale Extension and the Sudu Ganga schemes were given the lowest and 2nd lowest ranking in the proposed Master Plan. These schemes would provide certain agricultural benefits to the NCRB area, however these were not quantified in this study. As discussed in the preceding Section 8.2, at the final stage of development in the NCRB area, the Sudu Ganga scheme will play an important role in minimizing the difference between available heads for hydropower generation in the Mahaweli main stream and the Amban Ganga. Therefore, it is recommended that at the final stage of development in NCRB, all possibilities should be reassessed, taking into account the possibility of increasing the Polgolla diversion to the Amban Ganga, and the implementation of the Minneriya pump station and the Sudu Ganga hydropower scheme. As for the Kotmale Extension scheme, it will be valuable to review this in detail in the future for maximum utilization of valuable hydropower potential. Therefore, the Kotmale Extension scheme was included in this Master Plan, but given the lowest priority.

9. MASTER PLAN

9.1 General

An economic analysis in this Master Plan is carried out to ascertain economic efficiency of the proposed projects from the economic point of view. Economic efficiency is evaluated in terms of Economic Internal Rate of Return (EIRR).

To estimate economic costs and benefits which are basic figures for this evaluation, the economic prices and evaluation conditions are summarized as follows:

- Foreign exchange rates are applied at US$1.00 = Rs. 32.50 = J. Yen 140.00.
- The reference date for the cost estimation is October, 1988.
- The Standard Convention Factor (SCF) is estimated at 85% in general, to convert the financial costs into economic costs (Ref. 28).
- The construction period of the project is assumed to be 5 years.
- The economic life of the project is taken as 50 years after completion of the project.

All the project costs include several joint facilities such as multi-purpose dam and transbasin conveyance canal. These joint costs are allocated into respective project components related to the project on the basis of the size of benefits given by the proposed project.

9.2 Stagewise Agricultural Development

(1) Stagewise Development

The irrigation development project is promoted under the following basic concept:

- 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.

Based on the above basic concept, the agricultural development in NCRB is recommended in the preceding Sub-section 8.2, as a result of economic

comparison, water balance simulation and social impact in the area in consideration of food production target. Development of NCRB is too large to be developed as one package. From the point of view of practical implementation, a stagewise implementation programme is necessary to temper technical and socio-economic constraints.

The proposed irrigation project in NCRB is divided into three packages to work out a proper implementation programme in consideration of the sequence of overall water resources development. Joint facilities necessary for each package and development area are enumerated in Table 48, and the details are described in ANNEX-L. Stagewise development plan is illustrated in Fig. 38, and the summary of respective packages is given as follows:

Package No.	Development Category	Beneficiary Area	Systems or Schemes
Package-I	Joint Facilities	-	Kalu Ganga dam NCP canal (Kalu Ganga - Huruluwewa)
	New Irrigation Area	23,900 ha	System F, Yan Oya (M) Huruluwewa Extension (MH)
	Cashew Land	10,000 ha	Huruluwewa Extension (MH)
	Rehabilitation	25,500 ha	Hululuwewa (MH) A part of System H
Package-2	Joint Facilities	-	NCP canal (Huruluwewa - Mahakandarama) Minipe LB canal (Minipe - Minneriya tank)
	New Irrigation Area	26,600 ha	Holowupotana (M) Malwatu (I), Mahakandarama Extension (I)
	Rehabilitation	38,600 ha	System IH, A part of System H Mahakandarama (I), Malwatu Oya (I)
Package-3	Joint Facilities	-	NCP canal (Mahakandarama - Tammannewa) Minneriya Pump Station
	New Irrigation Area	27,000 ha	Tammannewa (I)
	Cashew Land	10,000 ha	System I

Investment costs of 3 packages amount to US$543.2x10^6, US$435.8x10^6, and US$373.0x10^6 respectively, and the summary of investment costs is presented in Table 48. These include costs of all the joint facilities such as the Kalu Ganga dam, the NCP canal, the new Minipe LB canal and the Minneriya pump station.

(2) Economic Costs

Allocated costs of 3 packages amount to US$411.1x10^6, US$507.8x10^6 and US$364.5x10^6 in economic terms respectively, which are broken down in Table 49 (refer to ANNEXES-J and L in detail). These costs include the all irrigation facilities such as the Kalu Ganga dam, transbasin canals, tanks and on-farm facilities but exclude social facilities for settlement such as schools, clinics, etc. Their disbursement of each package is assumed to extent over 5 years according to the implementation schedule presented in Fig. 39. The economic costs of joint facilities are distributed into each package in proportion to size of benefit accruing from the schemes in each package.

The operating and maintenance (O&M) costs of 3 packages are estimated as US$5.68x10^6, US$6.85x10^6 and US$4.76x10^6 respectively, of which the details are described in ANNEX-J. Although during construction period the reclaimed areas in new settlement schemes increase year by year as the newly developed area is enlarged, water distribution management cannot be carried out before completion of the project. Thus, the O&M costs are set to take place just after completion of the project.

While the economic project life is assumed to be 50 years, some of facilities have shorter life than the civil works. Then, their lives are assumed to be 25 years for irrigation mechanical equipment. The replacement costs are considered to be 90% for investment value at the end of life, because of salvage value. The replacement costs of each package are estimated at US$38.80x10^6, US$54.26x10^6 and US$23.62x10^6 after subtracting the salvage value, respectively.

These packages will be implemented in accordance with the stagewise implementation schedule as illustrated in Fig. 39. The total economic costs of all packages are, US$1,283x10^6, US$17.3x10^6 for O&M cost after the stage of completion of all packages, and US$116.7x10^6 for replacement cost in total.

(3) Economic Benefit

The agricultural benefit is estimated in terms of incremental benefit by a balance of "without" and "with" project conditions. The annual agricultural benefits are shown in Table 50 and explained in ANNEX-E in detail at the stage of project completion. The net economic benefits at matured time amount to US$50.9x10^6 for Package 1, US$60.4x10^6 for Package 2, and US$39.2x10^6 for Package 3, respectively.

By the time of project completion, the annual benefit increases as the irrigation system is enlarged. To estimate the increasing annual benefits up to the time of attaining matured benefits, the following growth programmes are assumed:

- In new settlement schemes, the reclaimed areas as irrigated field are cultivated as rainfed fields by completion of the project.

- The newly reclaimed areas in new settlement schemes increase as they are developed year by year for 5 years of construction period as follows: 20% of the total area in the third year from the start of construction, 40% in the fourth year, 70% in the fifth year, and 100% after completion.

- In new settlement schemes, the unit yield increases from 50% of the target yield at the first year cultivation to 100% at the sixth year cultivation, i.e., annual growth of 10% up to the matured yield.

- In rehabilitation schemes, the unit yield increases after completion of the project, and it attains to the matured yield 3 years after completion.

- Cashew is harvested in the third year after the plantation starts. It is harvested at the yield of 20% of the target in the third year and attained to the matured yield in 8th year.

Applying the economic costs and benefits estimated in the proceeding sub-sections, the cost and benefit of each Package are given in Table 51, respectively. The economic efficiency, examined by EIRR, is 9.3% for Package 1, 9.2% for Package 2 and 8.0% for Package 3 respectively as seen in the table. The following shows the summary of investment costs, economic costs, benefit and EIRR for respective packages:

Package	Area (ha)	Investment Cost (US$10^6)	Allocated Economic Cost (US$10^6)	Agricultural Benefit (US$10^6)	EIRR (%)
Package-1	59,400	543.2	411.1	50.9	9.3
Package-2	65,200	435.8	507.8	60.4	9.2
Package-3	37,000	373.0	364.5	39.2	8.0
Whole Project	161,600	1,352.0	1,283.4	150.5	8.9

Refer to ANNEX-L.

9.3 Socio-Economic Impact and Indirect Benefits

In addition to the direct benefits stipulated in the preceding Section, substantial secondary direct benefits stemming from the project outputs and induced by project inputs, and favourable intangible socio-economic impacts are expected from the implementation of the proposed project.

(1) Foreign Exchange Saving

With implementation, paddy production will increase a certain amount from the present level. Domestic production of grains at present will not be sufficient to meet consumption by the end of the target year, and as a result, the deficit has to be

supplemented by imports. Accordingly, the increased paddy production will contribute to the saving of foreign exchange.

The hydropower stations will also generate annual energy aggregating 1,820 GWh. This generated energy will replace energy to be generated by thermal stations and will result in saving in fuel costs, which will also save foreign exchange.

(2) Increase in Employment Opportunities

Employment opportunities for local people will increase by the project implementation, and will have a favourable impact on the national economy. Furthermore, people engaged in the project will gain more experience and technical skill in various working fields. These benefits would be applied to the future development of Sri Lanka.

In addition to the above, other employment opportunities will be created through farming practices after completion of the project. The project will create another demand for farm labour requirement accrued from increased farm activities due to intensive use of the land and high productivity.

(3) Improvement of Living Standards

Upon completion of the proposed projects, living standards of the people in the basin will improve as their family income will increase in proportion to the rise of regional economy. The level of living standards should reach the average level of the country. Thus, the agencies concerned should endeavor to help the people to improve the quality of their lives through increased income and improvement of industrial productivity by means of appropriate incentives.

(4) Inequality of Income Distribution and Redistribution Policy

After completion of the proposed projects, people in the project area will benefit from development. For instance, the net farm income under new irrigation schemes is expected to increase by 3.0-4.0 times of the present income derived from the minor irrigation area and rainfed area. Even in rehabilitation schemes, it is expected to increase by 2.2-3.2 times. The better the proposed projects go on, the bigger becomes the difference in farm income between inside the project areas and outside. Although it will provide an incentive for increasing agricultural productivity, inequality in income distribution is inevitable in the course of implementing the projects. In this context, a redistribution policy will be quite important in order to attain more equitable distribution of the fruits of development. In the selection of such a redistribution policy, the real disparities should be taken into consideration not only in the agricultural sector but also in the economic sectors. The essence of this policy must be stimulation of activities in the private sector.

(5) Inland Fishery

In 1986, Sri Lanka produced 35×10^3 tons of fish from inland fishery, or around 20% of the national fishery production of 183×10^3 tons. The study area produced 16×10^3 tons of inland fish or 45% of the national inland fishery production. Through implementation of the project, there is a certain possibility to expand inland fishery in reservoirs and irrigation tanks. Although it takes a certain time to mature inland fishery, some increase in inland fishery production may be expected in the proposed reservoir areas.

(6) Rural Agro-industry

GOSL is promoting the establishment of agro-industries in rural areas, in order to create more employment opportunities through crops diversification. The project area is blessed with natural resources such as climate for agriculture, fertile soils as well as irrigation water upon completion of the project. The proposed cropping pattern would include vegetables such as tomatoes, cucumbers, eggplants, etc. There are certain possibilities to introduce small scale rural agro-industries for production of tomato juice, pickles of cucumbers, etc. being subject to improvement of variety and future studies.

(7) Subsidiary Crops in Homestead

The new settlers would be allocated 0.2 ha of homestead land in addition to 1.0 ha farming plot. In these homesteads, almost settlers will plant subsidiary crops such as coconuts, cashew nuts, papaya, bananas, grapes, mangoes, etc. Since it might be difficult to quantify and identify subsidiary crops, such benefits from homesteads are not incorporated in the economic benefit. However, these are considered as indirect benefits through the settlement program.

9.4 Action Plan

The early implementation of Package-1 as recommended in the preceding Section is necessary to ensure the achievement of the contemplated overall development target by the year 2020, and the attainment of the socio-economic target. For Package-1, necessary actions are to prepare the scope of works and preparation of Terms of Reference for a feasibility study. Moreover, budgetary arrangement for the following is essential:

- Mapping of the irrigation area of net 49,000 ha at a scale of 1/5,000 with a contour interval of 0.5 m (gross mapping area of about 150,000 ha) in Systems F, MH and M,

- Topographic mapping at a scale of 1/500 of irrigation tank sites,

- Topographic maps at a scale of 1/5,000 with a contour interval of 0.5 m along the diversion canal between the Kalu Ganga and Elahera, and along the NCP canal down to the Huruluwewa, and

- Core drilling at the Kalu Ganga dam site (500 m), and irrigation tank site (300 m x 2 site), and along the tunnel section of 7.2 km (30 m x 30 = 900 m)

Topographic maps in the irrigation areas and along the transbasin conveyance canal (NCP canal) mentioned above should be ready before the feasibility study.

In addition to the above Package-1 for the agricultural development, it is also strongly recommend that the necessary and prompt action be taken for implementation of the Upper Kotmale project consisting of Talawakele and Caledonia schemes.

LIST OF REFERENCES

1. CROP WATER REQUIREMENT, IRRIGATION AND DRAINAGE PAPER NO. 24, FAO, 1977
2. EFFECTIVE RAINFALL IN IRRIGATED AGRICULTURE, IRRIGATION AND DRAINAGE PAPER NO. 25, FAO, 1974
3. MAHAWELI GANGA IRRIGATION AND HYDRO-POWER SURVEY, FAO, 1968
4. FEASIBILITY REPORT ON THE INGINIMITIYA RESERVOIR PROJECT, JICA, 1977
5. VICTORIA SCHEME, MAHAWELI DEVELOPMENT PROJECT, HUNTING TECHNICAL SERVICES LIMITED, ENGLAND, 1978
6. FEASIBILITY REPORT, KOTMALE PROJECT, MAHAWELI GANGA PROJECT, WATER AND POWER DEVELOPMENT CONSULTANT SERVICES, INDIA, 1978
7. MAHAWELI GANGA DEVELOPMENT PROGRAMME, IMPLEMENTATION STRATEGY STUDY, NEDECO, 1979
8. FEASIBILITY STUDY ON THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT, JICA, 1979
9. SYSTEM C, MAHAWELI DEVELOPMENT PROJECT, FEASIBILITY STUDY, HUNTING TECHNICAL SERVICES LIMITED, ENGLAND, 1979
10. FEASIBILITY STUDY ON MADURU OYA PROJECT, SYSTEM B, ACRES, 1980
11. ENVIRONMENTAL ASSESSMENT, ACCELERATED MAHAWELI DEVELOPMENT PROGRAM, TAMS, 1980
12. RANDENIGALA PROJECT, MAHAWELI GANGA DEVELOPMENT, FEASIBILITY REPORT, JOINT VENTURE RANDENIGALA, 1980
13. HYDROLOGICAL CRASH PROGRAMME, MAHAWELI GANGA DEVELOPMENT PROJECT, NEDECO, 1981
14. TRANSBASIN DIVERSION STUDY, DRAFT FINAL REPORT, ELECTROWATT, 1981
15. TRANSBASIN DIVERSION STUDY, REVIEW REPORT, ELECTROWATT, 1984
16. TRANSBASIN DIVERSION STUDY, EVALUATION OF OPTIONS FOR DIVERSION AT POLGOLLA TO THE AMBAN GANGA, ELECTROWATT, 1986
17. MAHAWELI GANGA DEVELOPMENT PROGRAM, MACRO MODEL STUDIES, NEDECO, 1984
18. MAHAWELI WATER RESOURCES MANAGEMENT PROJECT, STUDIES OF OPERATING POLICY OPTIONS, ACRES, 1985
19. FEASIBILITY STUDY ON UPPER KOTMALE HYDROELECTRIC POWER DEVELOPMENT PROJECT, JICA, 1987
20. THE STUDY ON EXTENSION OF THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT, JICA, 1988
21. MAHAWELI, PROJECT 7 PROGRAMME - 1988, MLLD AND MMD 1987
22. SEASONAL SUMMARY REPORT (1984 - 1988) WMS OF MASL

23. WATER MANAGEMENT STUDY AT KAUDULLA IRRIGATION SCHEME, SRI LANKA, (1979-1981), HYDRAULICS RESEARCH STATION, WALLINGFORD, ENGLAND

24. MAHAWELI GANGA DEVELOPMENT, ACCELERATED PROGRAMME, SYSTEM-D DEVELOPMENT, ID, 1980

25. OPERATION AND MAINTENANCE MANUAL ON PILOT DEMONSTRATION FARM IN SYSTEM C, ACCELERATED MAHAWELI PROJECT, NIPPON KOEI, TOKYO, 1984

26. EXPERTS' STUDY REPORT, ON UMA OYA BASIN DEVELOPMENT FOR HYDROPOWER AND IRRIGATION, GTZ, 1988

27. TRANSBASIN DIVERSION STUDY, FINAL REPORT, ELECTROWATT, 1987.

28. SUPPLEMENTARY NOTE ON UPDATED FEASIBILITY STUDY, THE STUDY ON EXTENSION OF THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT (PHASE-I), JICA, FEBRUARY 1989

29. UPDATED FEASIBILITY STUDY ON EXTENSION OF THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT, PHASE-I, JICA, MAY 1988

30. SUPPLEMENTARY NOTE ON UPDATED FEASIBILITY STUDY ON EXTENSION OF THE MORAGAHAKANDA AGRICULTURAL DEVELOPMENT PROJECT, JICA, MARCH 1989

TABLES

Table 1 PARTICIPANTS IN THE STUDY

Name	Position	
A. Advisory Committee		
1. Mr. M. Aihara	Chairman of Advisory Committee	(MAFF)
2. Mr. S. Hayashi	Member, Project Evaluation	(OECF)
3. Mr. H. Nakada	Member, Agriculture & Agro-economy	(MAFF)
4. Mr. I. Ueda	Member, Irrigation and Drainage	(MAFF)
5. Mr. N. Enami	Member, Geology and Soil Mechanics	(MAFF)
6. Mr. T. Shino	Coordinator	(JICA)
Advisory Team (Phase-II, February-December 1988)		
1. Mr. M. Aihara	Leader/Chairman of Advisory Committee	(MAFF)
2. Mr. T. Shino	Coordinator, JICA	
3. Ms. Y. Yamashita	Coordinator, JICA	
4. Mr. K. Tominaga	Coordinator, JICA	
B. Study Team		
1. Mr. S.Yano	Team Leader	
2. Mr. S.Muramoto	Irrigation & Drainage Engineer (I)	
3. Mr. H.Ikewada	Agricultural Development Specialist	
4. Mr. K.Yamazaki	Construction Plan/Cost Estimate Engineer	
5. Mr. T.Tashino	Agro/Project-Economist	
6. Mr. E.Araida	Hydro-power Generation Planner	
7. Mr. N.Okabe	Hydrologist	
8. Mr. K.Okuwa	Irrigation & Drainage Engineer (II)	
9. Mr. S.Makino	Pedologist	
10. Mr. S.Hanada	Structural Design Engineer and Supervision of Survey	
11. Mr. H.Oguri	Geologist	
C. Counterpart		
1. Mr. C.W.E. Rosa	Project Director	(MASL)
2. Dr. A. Attanayake	Director, PMU	(MASL)
3. Dr. A. Ekanayake	Agro-economist, PMU	(MASL)
4. Mr. G.G. Jayawardhane	General Manager	(CECB)
5. Mr. M.N.G. Perera	Chief Engineer	(CECB)
6. Mr. A.G.A. Gunawardema	Irrigation Engineer I	(MECA)
7. Mr. Mr. A.K.A. Mahinda	Irrigation Engineer II	(MECA)
8. Mr. M.C. Liyanagama	Irrigation Eng./Hydrogist	(MECA)
9. Mr. M.H. Jayasooriya	Agronomist	(MECA)
10. Mr. D.A. Handapangodage	Agronomist	(MEA)
11. Mr. S.W.S.B. Dasanayake	Agro-economist	(Uni. of Colombo)
12. Dr. J. Handawela	Pedologist	(MADP)
13. Mrs. T.P. Perera	Hydrologist I	(ID)
14. Mr. W.A.D.L.W. Siriwardena	Hydrologist II	(CECB)
15. Mr. B.S. Liyanagama	System Analyst, WMS	(MASL)
16. Mr. K.L.S. Sahabandu	Hydropower Planner	(CECB)
17. Mr. B.W. Rupasinghe	Electrical Engineer	(CECB)
18. Mr. P.D. Hennayake	Cost Estimate/Design Engineer	(CECB)
19. Mr. H.P.B.K. Amarasena	Design Engineer	(CECB)
20. Mr. H.M.M.S.K. Herath	Civil Engineer	(CECB)
21. Mr. C. Tennakoon	Geologist	(CECB)
22. Mr. A. Kumara	Geologist	(CECB)
23. Mr. H.M.K. Jayatilaka	Geologist	(CECB)
24. Mr. U.K.G.K. Padmalal	Environmentalist	(Ministry of State)
25. Mr. M.M.W.D.S. Perera	Environmentalist	(Ministry of State)
26. Mr. S.G. Jayasooriya	Surveyor	(SD)
27. Mr. R.M. Ranasinghe	Surveyor	(SD)

Table 2 POPULATION PROJECTION : 1987-2020

(Unit : Million)

Year	Growth Rate Hypothesis		
	Low	Medium	High
1987	16.4	16.4	16.4
1992	17.1	17.2	17.2
1995	18.3	18.6	18.8
2000	19.3	19.9	20.4
2010	20.7	22.1	23.5
2020	21.4	24.0	26.7

Refer to ANNEX-A.

Table 3 GROSS DOMESTIC PRODUCT AT CONSTANT 1982 PRICES : 1982 - 1987

Industrial Sector	Gross Domestic Product (Rs.10^9)						Percentage Distribution (%)					
	1982	1983	1984	1985	1986	1987	1982	1983	1984	1985	1986	1987
1. Agriculture	25.0	32.2	40.1	41.1	44.4	47.9	26.4	28.3	28.7	27.7	27.1	27.0
Agriculture	20.8	27.1	35.1	35.6	37.9	40.6	21.9	23.8	25.0	24.0	23.1	22.8
Forestry	1.7	1.9	2.2	2.5	3.1	3.6	1.8	1.7	1.6	1.7	1.9	2.0
Fishing	2.5	3.2	2.9	2.9	3.4	3.7	2.6	2.8	2.1	2.0	2.1	2.1
2. Industry	24.9	30.0	36.9	38.9	43.5	48.8	26.3	26.3	26.3	26.2	26.6	27.4
Mining & Quarring	2.2	2.8	3.2	3.3	4.2	4.9	2.4	2.5	2.3	2.2	2.5	2.8
Manuafacturing	13.6	16.0	20.9	21.8	24.9	28.5	14.4	14.0	14.9	14.7	15.2	16.0
Construction	8.0	9.8	11.2	11.6	12.3	13.0	8.4	8.6	8.0	7.8	7.5	7.3
Elec., gas & Water	1.1	1.4	1.6	2.0	2.3	2.3	1.2	1.3	1.2	1.4	1.4	1.3
3. Services	44.8	51.7	63.0	68.4	75.8	81.0	47.3	45.4	45.0	46.1	46.3	45.6
Transport & Communic.	10.7	12.6	15.5	16.6	17.9	18.7	11.3	11.0	11.1	11.2	10.9	10.5
Trade	19.7	21.8	27.2	29.3	31.8	34.5	20.8	19.1	19.4	19.7	19.4	19.4
Finance	3.7	4.2	4.7	5.7	6.8	7.5	3.9	3.7	3.4	3.8	4.2	4.2
Other Services	10.8	13.2	15.6	16.9	19.3	20.4	11.4	11.6	11.2	11.4	11.8	11.5
Total	94.7	113.9	140.0	148.3	163.7	177.7	100.0	100.0	100.0	100.0	100.0	100.0
GDP per Capita (Rs.)	6,233	7,387	8,977	9,365	10,158	10,863	-	-	-	-	-	-
(US$)	292	296	342	342	356	353	-	-	-	-	-	-

Source : Ref.003

Table 4 COMPONENT OF EXPORT AND IMPORT : 1978 - 1987

Item	Amount (Rs.10^6)				Percentage Distribution (%)				Annual Growth Rate (%)		
	1978	1982	1986	1987	1978	1982	1986	1987	78/82	82/86	86/87
I. Export											
1. Agricultural Export	10,117	11,656	15,764	17,437	76.7	54.3	46.3	42.4	3.6	7.8	10.6
Tea	6,401	6,342	9,253	10,654	48.5	29.6	27.2	25.9	-0.2	9.9	15.1
Rubber	2,021	2,323	2,622	2,929	15.3	10.8	7.7	7.1	3.5	3.1	11.7
Coconut	972	1,496	2,389	2,140	7.4	7.0	7.0	5.2	11.4	12.4	-10.4
Minor Crops	723	1,495	1,500	1,714	5.5	7.0	4.4	4.2	19.9	0.1	14.3
2. Industrial Export	2,475	8,271	15,878	20,004	18.8	38.6	46.6	48.6	35.2	17.7	26.0
Textile & Garments	481	3,502	9,629	12,897	3.6	16.3	28.3	31.4	64.3	28.8	33.9
Petroleum Products	945	3,280	2,358	2,592	7.2	15.3	6.9	6.3	36.5	-7.9	9.9
Others	1,049	1,489	3,891	4,515	8.0	6.9	11.4	11.0	9.2	27.1	16.0
3. Mineral Export	-	859	1,182	1,759	-	4.0	3.5	4.3	-	8.3	48.8
Gems	531	685	755	1,447	4.0	3.2	2.2	3.5	6.6	2.5	91.7
Others	-	174	427	311	-	0.8	1.3	0.8	-	25.2	-27.2
4. Un-classified	-	668	1,249	1,933	-	3.1	3.7	4.7	-	16.9	54.8
Total	13,193	21,454	34,073	41,133	100.0	100.0	100.0	100.0	12.9	12.3	20.7
	*673	*934	*1,036	*1,080	-	-	-	-	*8.5	*2.6	*4.3
II. Import											
1. Consumer Goods	5,618	8,616	18,609	21,900	37.2	20.5	34.1	36.3	11.3	21.2	17.7
Rice	689	925	1,052	687	4.6	2.2	1.9	1.1	7.6	3.3	-34.7
(Quantity 1000ton)	(-)	(174)	(231)	(113)					(-)	(7.3)	(-51.1)
Wheat Flour	-	62	90	96	-	0.1	0.2	0.2	-	9.8	6.7
Sugar	620	970	1,764	2,389	4.1	2.3	3.2	4.0	11.8	16.1	35.4
(Quantity 1000ton)	(-)	(134)	(322)	(376)					(-)	(24.5)	(16.8)
Textile & Clothing	531	2,167	6,353	8,086	3.5	5.2	11.6	13.4	42.1	30.9	27.3
2. Intermediate Goods	5,591	21,640	22,265	26,310	37.0	51.6	40.8	43.6	40.3	0.7	18.2
Wheat	-	1,787	2,371	1,924	-	4.3	4.3	3.2	-	7.3	-18.9
(Quantity 1000ton)	(-)	(495)	(681)	(578)					(-)	(8.3)	(-15.1)
Fertilizer	252	560	1,282	1,074	1.7	1.3	2.3	1.8	22.1	23.0	-16.2
Chemical	446	729	1,587	1,587	3.0	1.7	2.9	2.6	13.1	21.5	0.0
Petroleum	2,403	12,274	6,293	8,716	15.9	29.3	11.5	14.5	50.3	-15.4	38.5
3. Investment Goods	3,367	11,591	10,556	11,332	22.3	27.6	19.3	18.8	36.2	-2.3	7.4
4. Un-classified	110	114	3,130	762	0.7	0.3	5.7	1.3	0.9	128.9	-75.7
Total	15,100	41,961	54,560	60,304	100.0	100.0	100.0	100.0	30.0	6.8	10.5
	*771	*1,826	*1,658	*1,583	-	-	-	-	*24.0	*-2.4	*-4.5
III. Balance of Trade	(1,907)	(20,507)	(20,487)	(19,171)	-	-	-	-	81.1	0.0	-6.4
	*-97	*-892	*-623	*-503	-	-	-	-	74.1	-8.6	-19.3

Remark : * denotes SDR million prices.
Refer to ANNEX-A.

Table 5 PRODUCTION OF MAJOR CROPS : 1978 - 1987

Item	Unit	Production				Ave. Annual Growth Rate (%)		
		1978	1982	1986	1987	78/82	82/86	86/87
1. Major Export Crop								
Tea	10^3 ton	199	188	211	213	-1.4	2.9	0.9
Rubber	10^3 ton	156	125	138	122	-5.4	2.5	-11.6
Coconut	10^6 nuts	-	2,521	3,039	2,291	-	4.8	-24.6
2. Minor Export Crop								
Cinamon	10^3 ton	26	32	14	-	5.3	-18.7	-
Pepper	10^3 ton	17	18	9	-	1.4	-15.9	-
Cocoa	10^3 ton	12	14	6	-	3.9	-19.1	-
3. Food Crop								
Paddy	10^3 ton	1,891	2,156	2,588	2,128	3.3	4.7	-17.8
Manioc	10^3 ton	499	638	503	348	6.3	-5.8	-30.8
Potetoes	10^3 ton	30	65	108	103	21.3	13.5	-4.6
Red Onion	10^3 ton	72	93	77	96	6.6	-4.6	24.7
Maize	10^3 ton	35	45	41	45	6.5	-2.3	9.8
Chillies	10^3 ton	28	27	46	28	-0.9	14.2	-39.1
Cowpea	10^3 ton	23	36	17	23	11.9	-17.1	35.3

Refer to ANNEX-A.

Table 6 PRINCIPAL FEATURES OF EXISTING AND ON-GOING IRRIGATION PROJECT UNDER AMDP

Irrigation System	Diversion Point	Benefitted Tank	Active Storage Capacity of Tank (MCM)	Extents under Cultivation (ha)	Full Development Area (Committed) (ha)
H	Bowatenna	Dambulu Oya	6.3	2,200	2,200
		Kandalama	30.0	4,900	4,900
		Kalawewa	108.4	27,600	27,600
		Rajangana	88.7	6,700	6,700
		Angamuwa	130.0	1,000	1,000
IH		Nachchaduwa	37.8	2,830	2,830
		Nuwarawewa	37.1	1,100	1,100
		Tissawewa	3.3	400	400
		Bassawakkulam	9.3	370	370
MH		Huruluwewa	56.7	4,300	4,300
G	Elahera	Elahera-Minneriya Canal	-	5,100	5,400
DI		Minneriya	126.4	8,900	8,900
		Giritale	22.2	3,000	3,000
		Kaudulla	102.9	4,500	14,500
		Kantalai/Vendarasan	133.1	9,900	14,100
D2	Angamedilla	Parakrama Samudra	102.9	10,100	10,100
E	Minipe	Under Minipe LB Canal	-	6,100	6,100
C		Soraborawewa	16.9	500	500
		Mapakandawewa	8.7	700	700
		Dambarawawewa	11.7	600	600
		Ulhitiya/Ratkinda	45.3	14,500	22,700
B	Maduru Oya	Pimburattewa	36.2	1,800	1,800
		Maduru Oya	477.6	7,200	36,500
		Vakaneri	11.0	3,700	3,700
A		Allai Scheme	-	7,000	20,300
Total			1,602.5	135,000	200,300

Refer to ANNEX-F.

Table 7 PRINCIPAL FEATURES OF EXISTING MULTIPURPOSE DAMS OF MAIN SYSTEM (1/2)

Item		Unit	M-1 Kotmale Dam	M-2 Polgolla Dam	M-3 Victoria Dam	M-4 Randenigala Dam	M-5 Rantembe Dam
A. Hydrology							
1. Catchment Area		km2	562	1,292	1,891	2,365	3,111
2. Average Annual Discharge (1949-87)		MCM	985	2,133 *1	1,984 *1	2,528 *1	3,126 *1
		m3/s	31.1	67.9	63.9	81.2	101.8
(Polgolla diversion of 875MCM)							
B. Reservoir							
1. Extreme Max. WL		El.m	704.3	446.4	441.2	236.2	155.0
2. Normal Max. WL		El.m	703.0	440.8	438.0	232.0	152.0
3. Min. Operating WL		El.m	665.0	438.4	370.0	203.0	140.0
4. Low WL		El.m	(665.0)	-	(357.6)	(170.0)	-
5. Storage Capacity	- Normal Max. WL	MCM	172.9	4.1	721.2	861.4	22
	- Min. Ope. WL	MCM	22.2	2	34	303.4	4.4
6. Design Spillway Discharge		m3/s	5,560	-	7,900	8,085	10,235
7. Low Level Outlet Capacity		m3/s	133	1	760	200	180
C. Dam				-			
1. Type of Dam		-	Rockfil	C.Gravity	C.Arch	Rockfill	C.Gravity
2. Crest Length		m	600	144	520	485	415
3. Height		m	87	14.6	122	94	43.5
D. Hydraulic Turbine							
1. Number of Unit		Nos.	3	2	3(6)	2	2
2. Type of Turbine		-	V.Francis	V.Francis	V.Francis	Francis	V.Francis
3. Rated Power		MW	3x67	2x19	3x70	2x63	2x24.5
4. Rated Head		m	201.5	78	190	78	31.5
5. Discharge		m3/s	3x38	2x28.3	3x46.7	2x90	2x90
E. Generator							
1. Rated Power		MW	3x90	2x21.4	3x82.5	2x82	2x34.5
2. Power Factor		-	0.85	0.85	0.85	0.85	
3. Efficiency		%	98	99	97	98	
F. Conveyance Structure							
1. Intake Tunnels	- Length	m	6,560	5,200	5,665	-	-
	- Diameter	m	6.2	5.9	6.2	-	-
	- Capacity	m3/s	114	56.6	140	-	-
2. Penstock	- Length	m	120	239	209	270	20
	- Diameter	m	4.8-5.5	2x2.7	3x3.0	6.2	2x4.2
	- Capacity	m3/s	3x38	2x28.3	3x46.7	2x90	2x90
G. Remarks							

Remark: *1 Runcase D109 (Polgolla diversion; 898 MCM)

Source: Ref. 18

Table 7 PRINCIPAL FEATURES OF EXISTING MULTIPURPOSE DAMS OF MAIN SYSTEM (2/2)

Item	Unit	M-6 Minipe Dam	M-7 Bowatenna Dam	M-8 Moragahakanda Dam*2	M-9 Elahera Dam	M-10 Angamedilla Dam
A. Hydrology						
1. Catchment Area	km2	3,120	506	782	782	1,363
2. Average Annual Discharge (1949-81)	MCM	3,126	1,343 *1	968 *1	921 *1	964*1
	m3/s	102	42.1	29.0	37.5	19.1
(Polgolla diversion of 875MCM)						
B. Reservoir						
1. Extreme Max. WL	El.m	120.0	252.8	195.6	-	
2. Normal Max. WL	El.m	114.0	251.8	195.0	138.8	
3. Min. Operating WL	El.m	Weir crest	243.8	170.0	Weir Crest	
4. Low WL	El.m	114.0m	-	(150)	138.8m	
5. Storage Capacity - Normal Max. WL	MCM	LB Sill	52.0	902.8	E-M Sill	
- Min. Ope. WL	MCM	11.9m	17.1	217.2	133.8m	
6. Design Spillway Discharge	m3/s	RB Sill	4,340	3,400		
7. Low Level Outlet Capacity	m3/s	111.1m	1	(100)		
C. Dam						
1. Type of Dam	-	C.Gravity	C.Gravity	Rockfill	Concrete	
2. Crest Length	m	229	226	+C.Gravity	29	
3. Height	m	9.0	30	Max.	No Power	
		No Power			Unit	
D. Hydraulic Turbine		Unit			C.Canal	No Power
1. Number of Unit	Nos.	C.Canal	1	2	E-M Canal	Unit
2. Type of Turbine	-	Minipe LB	V.Francis	Rockfill,	42.5m3/s	C.Canal
		18.4m3/s		C.Gravity	31,100ha	To P.Samudra
3. Rated Power	MW	6,100ha	40	2x12.5	To Minneriya	14.2m3/s
4. Rated Head	m	Minipe RB	52.7	54.8	42.5m/s	10,100ha
5. Discharge	m3/s	64.0m3/s	94.9	56.6	22,700ha	
		55,400ha			To Giritale	
E. Generator					8.5m3/s	
1. Rated Power	MW		47.1	30.5	3000ha	
2. Power Factor	-		0.85	0.85		
3. Efficiency	%		99	-		
F. Conveyance Structure						
1. Intake Tunnels - Length	m		1,240	-		
- Diameter	m		6.1	-		
- Capacity	m3/s		94.9	-		
2. Penstock - Length	m		72	87		
- Diameter	m			3.9-3.2		
- Capacity	m3/s		94.9	56.6		
G. Remarks			Irr. Tunnel D=3.9m Leng.=6,836m Q=28.3m3/s			

Remarks: *1 Runcase D109 (Polgolla diversion; 898 MCM)
*2 Supplementary Note on the updated study on Moragahakanda Agricultural Development (Phase-I) JICA, February 1989

Source: Ref. 18

Table 8 EXISTING GENERATION CAPACITY - 1988 (CEB POWER SYSTEM)

	Capacity (MW)		Mean Annual Energy (GWh)		
	Units (No.xCap.)	Total Installed	Firm	Secondary	Total
1. Hydropower					
Kehelgamu - Maskeli Complex					
Old Laxapana I	3x8.33	25	253	42	295
Old Laxapana II	2x12.5	25	-	-	-
New Laxapana	2x50	100	439	80	519
Wimalasurendra	2x25	50	84	36	120
Samanala	3x37.5	75	384	75	459
Canyon I	1x30	30	144	35	179
Sub-total		305	1,304	268	1,572
Mahaweli Complex					
Ukuwela	2x19	38	164	-	164
Bowatenna	1x40	40	49	15	64
Victoria	3x70	210	447	439	886
Kotmale	3x67	201	270	232	502
Randenigala	2x61	122	304	190	494
Sub-total		611	1,234	876	2,110
Total Hydropower		916	2,538	1,144	3,682
2 Thermal Power					
Kelanitissa (Gas Turbine)	6x20	120	725	-	725
Sapugaskanda (Diesel)	4x20	80	540	-	540
Total Thermal		200	1,265	0	1,265
Total System		1,116	3,803	1,144	4,947

Remarks: Plant Factor : Firm ; 0.32
Hydropower, Total; 0.46

Total System, Firm ; 0.39
Total; 0.51

Refer to ANNEX-G.

Table 9 INSTALLED CAPACITY AND GENERATION ENERGY BY HYDROPOWER PLANTS AND THERMAL POWERPLANTS

Year	Installed Capacity (MW)			Annual Generated Energy (GWh)			Increase (1)/(2)	
	Hydro	Thermal	Total	Hydro (1)	Thermal	Total (2)	Rate (%)	(%)
1975	291	70	361	1,078.4	0.1	1,078.5	6.6	100.0
1976	329	70	399	1,108.6	24.2	1,132.8	5.0	97.9
1977	329	70	399	1,214.4	2.1	1,216.5	7.4	99.8
1978	329	70	399	1,338.5	42.7	1,381.2	13.5	96.9
1979	329	70	399	1,461.2	64.3	1,525.5	10.4	95.8
1980	329	90	419	1,479.4	188.8	1,668.2	9.4	88.7
1981	369	130	499	1,571.2	300.1	1,871.3	12.2	84.0
1982	369	190	559	1,608.1	457.6	2,065.7	10.4	77.8
1983	399	190	589	1,217.2	897.4	2,114.6	2.4	57.6
1984	609	200	809	2,090.7	170.0	2,260.7	7.0	92.4
1985	609	200	809	2,394.6	69.4	2,464.0	8.9	97.2
1986	801	264	1,065	2,645.0	7.0	2,652.0	7.6	99.7
1987	801	270	1,071	2,177.0	530.0	2,707.0	2.1	80.4

Refer to ANNEX-G.

Table 10 EXISTING, ON-GOING AND POTENTIAL IRRIGATION AREA

(Unit: ha)

System	Irrigation Unit	Existing (Committed)	New Area	Total Area	System	Irrigation Unit	Existing (Committed)	New Area	Total Area
A	Allai	7,000	-	7,000	IH	Nachchaduwa	2,830	-	2,830
	Kandakadu	13,300	-	13,300		Nuwarawewa	1,100	-	1,100
	(Sub-total)	20,300	-	20,300		Tissawewa	400	-	400
						Bassawakkulam	370	-	370
B	Maduru Oya	36,500	-	36,500		(Sub-total)	4,700	-	4,700
	Pinburattewa	1,800	-	1,800					
	Vakaneri	3,700	-	3,700	MH	Huruluwewa	4,300	-	4,300
	(Sub-total)	42,000	-	42,000		Huruluwewa Ext.	-	12,000	12,000
						(Sub-total)	4,300	12,000	16,300
C	Ulhitiya/Ratkinda	22,700	-	22,700					
	Mapakada-wewa	700	-	700	I	Mahakandalama	2,800	8,000	10,800
	Dambara-wewa	600	-	600		Tammannewa	-	27,000	27,000
	Sorabora-wewa	500	-	500		Maluwatu Oya*	9,900	3,600	13,500
	(Sub-total)	24,500	-	24,500		Pavat kulam	1,800	-	1,800
						Iratperiya	200	-	200
D1	Minneriya	8,900	-	8,900		(Sub-total)	14,700	38,600	53,300
	Giritale	3,000	-	3,000					
	Kaudulla	14,500	-	14,500	J	Pali Aru	-	9,000	9,000
	Kantalai	13,500	-	13,500		Vavunikulam	2,800	-	2,800
	Vendarasan	600	-	600		Parangi Aru	-	10,000	10,000
	(Sub-total)	40,500	-	40,500		(Sub-total)	2,800	19,000	21,800
D2	Parakrama Samudra	10,100	-	10,100	K	Kanagalayan	-	9,000	9,000
E	Minipe LB	6,100	-	6,100	L	Mukunuwewa	-	13,000	13,000
						Padawiya	5,600	-	5,600
F	Kalu Ganga	-	1,900	1,900		Kitulgala	-	16,000	16,000
						(Sub-total)	5,600	29,000	34,600
G	Elahera	5,400	-	5,400					
					M	Holowupotana	-	15,000	15,000
H	Kandalama	4,900	-	4,900		Yan Oya	-	10,000	10,000
	Damburu Oya	2,200	-	2,200		(Sub-total)	-	25,000	25,000
	Kalawewa	27,600	-	27,600					
	Rajangana	6,700	-	6,700	NWDZ	Galgamuwa	-	10,700	10,700
	Angamuwa	1,000	-	1,000		Inginimitiya	2,550	-	2,550
	(Sub-total)	42,400	-	42,400		(Sub-total)	2,550	10,700	13,250
					Total		225,950	145,200	371,150

Remarks: * Including existing Giant tank scheme
Refer to ANNEX-F.

Table 11 METEOROLOGICAL DATA FOR CALCULATION OF POTENTIAL EVAPOTRANSPIRATION

1. Station: Anuradhapura Lat.:8 21'N Long.:80 23'E Barometer;305ft Anemometer;10ft

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
(1) Mean max. Temp., Tmax. (oC)	29.3	31.3	33.8	34.0	32.8	32.7	32.9	33.2	33.3	31.9	30.2	28.8	32.0
(2) Mean min. Temp., Tmin (oC)	20.9	21.2	22.7	24.0	24.7	24.8	24.4	24.4	24.2	23.3	22.5	22.3	23.3
(3) Mean Temp., Tmean (oC)	25.1	26.3	28.3	29.0	28.8	28.8	28.7	28.8	28.8	27.6	26.4	25.6	27.7
(4) Mean max. Relative Humidity,RHmax.(%)	92	90	88	90	90	87	86	85	88	92	93	93	90
(5) Mean min. Relative Humidity,RHmin.(%)	72	66	62	67	71	66	65	62	65	72	77	80	69
(6) Mean Relative Humidity,RHmean (%)	82.0	78.0	75.0	78.5	80.5	76.5	75.5	73.5	76.5	82.0	85.0	86.5	79.1
(7) Wind Speed, V (km/hr)	5.3	5.3	4.9	4.7	9.2	13.1	12.2	12.6	10.7	6.5	4.3	4.7	7.8
(8) Wind Speed, Uday/Unight	2.1	2.0	1.8	2.0	1.6	1.6	1.5	1.5	1.7	1.9	1.7	2.1	1.8
(9) Sunshine Hour, n (hr/day)*	7.4	8.7	9.0	8.8	8.5	8.0	7.7	8.3	7.6	7.0	6.0	5.8	7.7

Remarks: *No data is available at Anuradhapura Meteological station, Figures shows data at Mahaillupallama.

2. Station: Batticaloa Lat.:7 43'N Long.:81 42'E Barometer: 9ft Anemometer:20ft

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
(1) Mean max. Temp., Tmax. (oC)	27.8	28.7	30.1	31.6	33.1	33.9	33.3	33.0	32.3	30.8	29.3	28.1	31.0
(2) Mean min. Temp., Tmin (oC)	23.2	23.3	24.1	25.2	25.7	25.6	25.2	25.0	24.7	24.3	23.7	23.5	24.5
(3) Mean Temp., Tmean (oC)	25.5	26.0	27.1	28.4	29.4	29.8	29.3	29.0	28.5	27.6	26.5	25.8	27.7
(4) Mean max. Relative Humidity,RHmax.(%)	86	85	86	87	84	78	78	78	83	89	90	88	84
(5) Mean min. Relative Humidity,RHmin.(%)	77	74	74	73	70	61	64	64	68	75	79	81	72
(6) Mean Relative Humidity,RHmean (%)	81.5	79.5	80.0	80.0	77.0	69.5	71.0	71.0	75.5	82.0	84.5	84.5	78.0
(7) Wind Speed, V (km/hr)	11.4	11.5	10.0	8.7	8.2	7.9	8.0	8.0	8.4	8.2	8.9	12.3	9.3
(8) Wind Speed, Uday/Unight	1.7	1.5	1.7	2.0	2.1	2.3	2.5	2.4	2.4	2.1	1.7	1.4	2.0
(9) Sunshine Hour, n (hr/day)	6.6	8.1	8.8	8.7	8.5	8.2	8.0	8.3	8.0	7.3	6.7	5.8	7.8

3. Station: Trincomalee Lat.:9 35'N Long.:81 15'E Barometer: 10ft Anemometer:14ft

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
(1) Mean max. Temp., Tmax. (oC)	27.6	28.9	30.8	32.8	34.3	34.3	34.1	34.0	33.9	31.7	29.2	27.9	31.6
(2) Mean min. Temp., Tmin (oC)	24.4	24.6	25.1	25.8	26.4	26.4	25.8	25.5	25.1	24.6	24.1	24.3	25.2
(3) Mean Temp., Tmean (oC)	26.0	26.8	28.0	29.3	30.4	30.4	30.0	29.8	29.5	28.2	26.7	26.1	28.4
(4) Mean max. Relative Humidity,RHmax.(%)	79	79	82	84	80	77	78	77	80	85	86	84	81
(5) Mean min. Relative Humidity,RHmin.(%)	74	72	71	70	65	60	61	60	64	71	78	81	69
(6) Mean Relative Humidity,RHmean (%)	76.5	75.5	76.5	77.0	72.5	68.5	69.5	68.5	72.0	78.0	82.0	82.5	74.9
(7) Wind Speed, V (km/hr)	15.4	11.1	7.8	7.7	12.7	15.8	14.0	13.6	12.0	10.0	10.8	15.5	12.2
(8) Wind Speed, Uday/Unight	1.1	1.2	1.3	1.3	1.3	1.2	1.2	1.2	1.3	1.4	1.3	1.2	1.3
(9) Sunshine Hour, n (hr/day)	7.1	8.4	9.1	8.9	8.2	7.8	7.5	8.0	7.5	7.0	5.9	5.5	7.6

Refer to ANNEX-B.

Table12 MONTHLY POTENTIAL EVAPORATION (ETO) WITH CONPARISON OF ETO ESTIMATED BY THE PREVIOUS REPORT

Unit: mm

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Anuradhapura	135	152	191	183	191	195	199	216	193	157	121	115	2048
Batticaloa	144	156	189	194	202	191	198	203	187	168	129	122	2083
Trincomalee	163	164	195	193	218	223	215	225	199	168	132	131	2226

COMPARISON OF ETO ESTIMATED BY THE PREVIOUS REPORT

Unit: mm

Report	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
I.S.S. (NEDECO) (Ref. 7)	Anuradhapura	124	136	168	152	168	187	191	197	188	139	108	108	1866
MWRMP (ACRES) (Ref. 18)	Anuradhapura	129	154	178	174	190	212	215	218	223	164	124	113	2094
MWRMP (ACRES) (Ref. 18)	SYSTEM - A (110% of above)	142	169	196	191	209	233	237	240	245	180	136	124	2302
SYSTEM C (HUNTING) (Ref. 9)	Anuradhapura	124	136	168	152	168	187	191	197	188	139	108	108	1866
Moragahakanda (JICA) (Ref. 8)	Mahaillupallama	119	125	157	150	163	175	191	193	191	157	109	114	1847
Inginimitiya (JICA) (Ref. 4)	Mahaillupallama	119	125	157	150	163	175	191	193	191	157	109	114	1847

Refer to ANNEX-F.

Table 13 AVERAGE MONTHLY NATURAL INFLOW AT CONTROL NODES

NO.	Station (Reservoir, Tank, etc.)	Catchment Area (sq.km)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (MCM)	(mm)
1 M	Caledonia	235	50	44	32	22	11	10	15	28	48	55	52	44	412	1751
2 M	Talawakelle	363	78	69	49	33	18	16	23	43	75	85	80	68	636	1752
3 M	Kotmale R	562	120	106	76	52	27	24	36	67	116	131	123	106	984	1751
4 M	Watawel R	69	15	13	9	6	3	3	4	8	14	16	15	12	119	1728
5 M	Uapame R	782	168	148	106	71	37	33	50	93	161	182	172	145	1365	1745
6 M	Polgolla B	1292	272	254	173	93	51	48	85	160	265	273	249	219	2141	1657
7 M	Victoria R	1921	343	357	291	178	101	77	124	211	316	325	301	265	2890	1504
8 M	Randenigala R	2365	387	436	411	287	159	104	149	238	332	345	321	286	3455	1461
9 M	Rantambe R	3113	436	509	501	377	222	148	205	291	363	376	345	313	4084	1312
10 M	Minipe A	3120	436	510	502	377	222	148	205	291	363	377	345	313	4089	1311
11 M	Manampitiya	7418	660	952	1465	1289	779	486	458	460	464	465	437	416	8330	1123
12 M	Mahatotila Oya R	168	11	16	20	20	14	10	12	12	7	7	5	6	141	840
13 M	Upper Uma Oya	421	27	41	51	50	35	25	31	29	17	18	13	15	354	840
14 M	Lower Uma Oya	622	41	61	75	74	52	36	46	44	26	26	20	22	523	840
15 M	Ukuwela P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 M	Sudu Ganga R	305	21	34	55	45	28	18	17	13	10	10	8	8	269	880
17 M	Bowatanna R	506	35	57	92	75	47	30	29	22	16	16	14	14	445	880
18 M	Moragahakanda R	782	58	101	180	159	95	60	51	39	28	26	24	23	843	1078
19 M	Elahera	782	58	101	180	159	95	60	51	39	28	26	24	23	843	1078
20 M	Angamedilla A	1363	88	174	400	361	230	126	99	59	37	37	35	36	1682	1234
21 M	Kalu-Ganga R	204	20	44	88	67	44	24	25	16	3	3	3	4	340	1667
1 S	Dambulu-Oya R	342	7	15	20	6	3	3	7	3	0	0	0	1	65	189
2 S	Kalawewa T	842	18	37	50	15	7	8	17	7	0	1	1	3	163	193
3 S	Rajangana T	1611	34	70	93	29	13	14	32	13	1	2	1	5	308	191
4 S	Angamuwa T	130	3	6	7	2	1	1	3	1	0	0	0	0	25	188
5 S	Kandalama T	98	2	5	7	2	1	1	2	1	0	0	0	0	22	228
6 S	Nachchaduwa T	611	8	15	27	6	3	4	9	4	0	0	0	1	78	127
7 S	Nuwarawewa T	83	1	2	3	1	0	0	1	1	0	0	0	0	9	111
8 S	Tissawewa T	5	0	0	0	0	0	0	0	0	0	0	0	0	1	100
9 S	Basawakkulama T	9	0	0	0	0	0	0	0	0	0	0	0	0	1	100
10 S	Galgamuwa T	11	0	1	0	0	0	0	0	0	0	0	0	0	2	182
11 S	Inginimitiya R	557	15	26	19	9	5	6	14	6	1	1	1	2	105	189
12 S	Minipe LB canal	197	8	36	63	40	20	9	11	5	0	1	1	1	195	991
13 S	Kalu-Ganga R	204	20	44	88	67	44	24	25	16	3	3	3	4	340	1667
14 S	Kiri-Oya R	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 S	Huruluwewa T	199	3	8	12	3	2	2	3	1	0	0	0	0	33	167
16 S	Horowupotana R	950	11	27	65	34	17	10	7	6	1	1	2	2	182	192
17 S	Yan-Oya R	1320	15	38	91	47	24	14	10	8	1	2	2	2	253	192
18 S	Mahakandarawa R	326	4	8	11	3	2	2	4	2	0	0	0	1	36	111
19 S	Malwatu-Oya R	2113	17	38	87	51	28	25	20	13	6	5	4	4	298	141
20 S	Tammannewa R	64	1	1	4	2	1	1	0	0	0	0	0	0	11	167
21 S	Mukunuwewa R	142	5	7	16	4	4	3	2	2	0	0	0	1	43	306
22 S	Padawiya T	539	20	26	59	15	15	10	8	7	1	2	1	2	164	305
23 S	Iratperiya Kulam T	32	2	3	4	1	1	0	1	0	0	0	0	0	12	363
24 S	Pavat Kulam T	298	18	29	35	9	6	3	8	2	0	0	0	0	109	367
25 S	Kithulaqala R	104	4	5	11	3	3	2	2	1	0	0	0	0	32	305
26 S	Kanagarayan Aru R	85	7	10	12	3	3	1	3	2	0	0	0	0	40	474
27 S	Paragi Aru R	427	25	41	50	12	8	5	12	3	0	0	0	0	157	367
28 S	Pali Aru R	91	5	9	11	3	2	1	3	1	0	0	0	0	33	366
29 S	Vavuni Kulam T	228	13	22	27	7	4	2	6	2	0	0	0	0	84	368
30 S	System G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 S	Giritale T	24	1	2	3	1	1	0	1	0	0	0	0	0	9	375
32 S	Minneriya T	241	6	19	30	11	6	4	6	3	0	1	0	1	87	361
33 S	Kaudulla T	338	8	27	41	14	7	4	7	4	0	1	1	2	116	343
34 S	Kantalai T	199	6	17	26	9	6	4	7	3	0	1	0	3	81	408
35 S	Vendarasan Kulam T	11	0	1	2	1	0	0	0	0	0	0	0	0	5	409
36 S	Parakkrama Samudra	73	2	6	11	4	3	1	2	1	0	0	0	0	29	399
37 S	Badulu Oya R	267	8	40	65	42	23	8	12	5	0	1	1	2	207	775
38 S	Mapakadawewa T	7	0	1	2	1	1	0	0	0	0	0	0	0	5	743
39 S	Dambarawawewa T	19	1	3	5	3	2	1	1	0	0	0	0	0	15	774
40 S	Soraborawewa	44	1	7	11	7	4	1	2	1	0	0	0	0	34	773
41 S	Ulhitiya-Ratkinda R	282	9	43	70	47	25	9	12	6	0	1	1	2	223	791
42 S	Maduru Oya R	453	14	49	109	72	42	19	15	12	3	3	3	4	344	759
43 S	Vakaneri T	11	0	1	3	2	1	1	0	0	0	0	0	0	8	764
44 S	Pimburattewa R	20	1	2	5	3	2	1	1	1	0	0	0	0	15	755
45 S	Gallodai Aru R	95	2	7	21	15	10	4	2	1	0	0	0	1	63	666
46 S	Maha Oya R	230	13	23	38	24	17	7	8	6	1	1	1	1	141	615
47 S	Rambukkan Oya R	140	8	14	23	14	11	4	5	4	0	1	1	1	86	615
48 S	Magalwatavan R	115	7	11	19	12	9	3	4	3	0	1	1	1	71	615
49 S	Rukan T	115	3	8	25	19	12	4	2	2	1	1	1	1	77	666
50 S	Unnichchi T	274	12	24	51	35	24	9	8	6	1	1	1	2	174	635
51 S	System A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Remarks: Unit: MCM
R: Reservoir, A: Anicut, M: Main System,
S: Sub-System, T: Tank

Refer to ANNEX-B.

Table 14 SUMMARY OF SOIL CLASSIFICATION

	F		H		IH		MH	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
1. Alluvial Soils	(600)	(11.3)	(2,600)	(2.9)	(500)	(7.0)	(3,700)	(6.4)
- well drained	500	9.4	900	1.0	0	0.0	100	0.1
- imperfect/poddy drained	100	1.9	1,700	1.9	500	7.0	3,600	6.3
2. Old Alluvial	0	0.0	0	0.0	0	0.0	0	0.0
3. Solonetz	0	0.0	0	0.0	0	0.0	600	1.0
4. Low Humic Gley Soils (LHG)	0	0.0	33,500	37.6	4,100	57.7	7,800	13.6
5. Raddish Brown Earth (RBE)	(4,100)	(77.4)	(47,600)	(53.3)	(1,800)	(25.4)	(42,200)	173.6
- well drained	3,300	62.3	47,600	53.3	1,500	21.1	31,600	55.1
- imperfectly drained	800	15.1	0	0.0	300	4.3	10,600	18.5
6. Red Yellow Podozolic Soils	100	1.9	0	0.0	0	0.0	0	0.0
7. Grumusols	0	0.0	0	0.0	0	0.0	0	0.0
8. Lithosols	500	9.4	5,500	6.2	300	4.2	2,300	4.0
9. Others	0	0.0	0	0.0	400	5.7	800	1.4
Total	5,300	100.0	89,200	100.0	7,100	100.0	57,400	100.0

	I		M		NW-1 (NWD2)		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
1. Alluvial Soils	(24,000)	(16.6)	(14,400)	(16.9)	(5,500)	(15.4)	(51,300)	(12.1)
- well drained	600	0.4	0	0.0	0	0.0	2,100	0.5
- imperfect/poddy drained	23,400	16.2	14,400	16.9	5,500	15.4	49,200	11.6
2. Old Alluvial	0	0.0	0	0.0	500	1.4	500	0.1
3. Solonetz	200	0.1	3,100	3.6	0	0.0	3,900	0.9
4. Low Humic Gley Soils (LHG)	33,900	23.5	4,600	5.4	6,000	16.9	89,900	21.2
5. Raddish Brown Earth (RBE)	(81,000)	(56.0)	(58,200)	(68.3)	(21,500)	(60.4)	(256,400)	(60.4)
- well drained	74,300	51.4	37,600	44.1	18,100	50.8	214,000	50.4
- imperfectly drained	6,700	4.6	20,600	24.2	3,400	9.6	42,400	10.0
6. Red Yellow Podozolic Soils	0	0.0	0	0.0	0	0.0	100	0.02
7. Grumusols	200	0.1	0	0.0	0	0.0	200	0.1
8. Lithosols	3,100	2.1	4,500	5.0	1,200	3.0	17,400	4.1
9. Others	2,100	1.5	500	0.5	900	2.5	4,700	1.1
Total	144,500	100.0	85,300	100.0	35,600	100.0	424,400	100.0

Refer to ANNEX-D.

Table 15 LAND CLASSIFICATION

Land Class	Sub-Class	F (ha)	F (%)	H (ha)	H (%)	IH (ha)	IH (%)	MH (ha)	MH (%)
1		1,600	30.2	39,700	44.4	0	0.0	2,300	3.4
2	d	800	15.1	1,700	1.9	500	7.0	1,100	0.0
	k	1,200	22.6	900	1.0	600	8.5	15,800	28.0
	kt	0	0.0	0	0.0	400	5.6	2,300	4.6
	v	500	9.4	0	0.0	0	0.0	100	0.0
3	d	0	0.0	0	0.0	300	4.2	0	0.0
	kt	300	5.7	0	0.0	0	0.0	2,600	4.2
4	Rd	100	1.9	33,500	37.6	4,100	57.7	20,900	35.8
	Rdv	0	0.0	0	0.0	0	0.0	0	0
	Stk	0	0.0	7,900	8.9	500	7.0	4,900	9.5
6	b	300	5.7	5,500	6.2	0	0.0	2,300	4.4
	s	0	0.0	0	0.0	0	0.0	0	0.0
	sd	0	0.0	0	0.0	700	10.0	1,400	2.8
	t	500	9.4	0	0.0	0	0.0	3,700	7.3
Total		5,300	100.0	89,200	100.0	7,100	100.0	57,400	100.0

Land Class	Sub-Class	I (ha)	I (%)	M (ha)	M (%)	NW-1 (NWDZ) (ha)	NW-1 (NWDZ) (%)	Total (ha)	Total (%)
1		1,400	1.0	0	0.0	15,700	44.1	60,700	14.3
2	d	600	0.4	600	0.7	3,400	9.6	8,700	2.0
	k	47,900	33.1	26,400	30.9	2,400	6.7	95,200	22.4
	kt	23,400	16.2	0	0.0	0	0.0	26,100	6.1
	v	0	0.0	0	0.0	0	0.0	600	0.1
3	d	0	0.0	0	0.0	0	0.0	300	0.1
	kt	900	0.6	900	1.1	0	0.0	4,700	1.1
4	Rd	64,200	44.4	39,000	45.7	11,500	32.3	173,300	41.0
	Rdv	0	0.0	0	0.0	500	1.4	500	0.1
	Stk	700	0.5	9,400	11.0	0	0.0	23,400	5.5
6	b	3,100	2.1	4,500	5.3	0	0.0	15,700	3.7
	s	2,100	1.5	0	0.0	0	0.0	2,100	0.5
	sd	200	0.1	3,600	4.2	900	2.5	6,800	1.6
	t	0	0.1	900	1.1	1,200	3.4	6,300	1.5
Total		144,500	100.0	85,300	100.0	35,600	100.0	424,400	100.0

Refer to ANNEX-D.

Table 16 PRESENT LAND USE

Land Use Category	F (ha)	F (%)	H (ha)	H (%)	IH (ha)	IH (%)	MH (ha)	MH (%)
1.Agricultural Land	3,000	56.6	72,200	80.9	5,900	81.0	21,900	38.2
1.1 Paddy	1,200	22.6	58,300	65.3	5,900	81.0	8,300	14.5
-irrigated	600	11.3	58,100	65.1	5,900	81.0	7,500	13.1
-rainfed	600	11.3	200	0.2	0	0.0	800	1.4
1.2 Upland	1,800	34.0	13,700	15.4	0	0.0	11,300	19.7
1.3 Perennial Crop	0	0.0	200	0.2	0	0.0	2,300	4.0
2.Homestead	600	11.3	15,400	17.4	1,100	17.5	1,600	2.8
3.Forest	1,700	32.1	200	0.2	0	0.0	6,500	11.3
4.Shrub	0	0.0	400	0.4	100	1.5	22,600	39.4
5.Urban Area	0	0.0	100	0.1	0	0.0	300	0.5
6.Tank	0	0.0	700	0.8	0	0.0	300	0.5
7.Barren Land	0	0.0	200	0.2	0	0.0	4,200	7.3
8.Marsh	0	0.0	0	0.0	0	0.0	0	0.0
Total	5,300	100.0	89,200	100.0	7,100	100.0	57,400	100.0

Land Use Category	I (ha)	I (%)	M (ha)	M (%)	NW-1 (NWDZ) (ha)	NW-1 (NWDZ) (%)	Total (ha)	Total (%)
1.Agricultural Land	65,100	45.1	23,500	27.6	12,100	34.0	203,700	48.0
1.1 Paddy	20,800	14.4	3,200	3.8	3,700	10.4	101,400	23.9
-irrigated	20,200	14.0	3,200	3.8	3,200	9.0	98,700	23.3
-rainfed	600	0.4	0	0.0	500	1.4	2,700	0.6
1.2 Upland	44,000	30.5	19,800	23.2	8,300	23.3	98,900	23.3
1.3 Perennial Crop	300	0.2	500	0.6	100	0.3	3,400	0.8
2.Homestead	6,600	4.6	900	1.1	500	1.4	26,700	6.3
3.Forest	58,700	40.5	34,400	40.3	22,600	63.5	124,100	29.2
4.Shrub	6,800	4.7	17,000	19.9	400	1.1	47,300	11.1
5.Urban Area	100	0.1	100	0.1	0	0.0	600	0.1
6.Tank	6,800	4.7	500	0.6	0	0.0	8,300	2.0
7.Barren Land	400	0.3	7,800	9.1	0	0.0	12,600	3.0
8.Marsh	0	0.0	1,100	1.3	0	0.0	1,100	0.3
Total	144,500	100.0	85,300	100.0	35,600	100.0	424,400	100.0

Refer to ANNEX-D.

Table 17 ESTIMATED PRESENT PLANTED AREA BY SYSTEM

(Unit : ha)

Crop	F		H		IH		MH	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
1. Irrigated								
Paddy	430	220	40,600	11,900	4,700	1,080	4,300	990
Chillie	-	50	400	7,100	-	280	-	260
Pulses	-	20	500	8,500	-	430	-	390
Maize	-	-	900	-	-	-	-	-
Sub-total	430	290	42,400	27,500	4,700	1,790	4,300	1,640
2. Rainfed								
Paddy	440	60	-	-	-	-	-	-
Chillie	70	-	-	-	-	-	-	-
Pulses	300	-	-	-	-	-	3,200	80
Maize	370	-	-	-	-	-	1,600	-
Others	290	120	-	-	-	-	400	450
Sub-total	1,470	180	-	-	-	-	5,200	530
3. Fallow	-	1,430	-	14,900	-	2,910	3,800	11,130
Cultivated Area	1,900	1,900	42,400	42,400	4,700	4,700	13,300	13,300
4. Not Utilized	-	-	-	-	-	-	13,000	13,000
Total	1,900	1,900	42,400	42,400	4,700	4,700	26,300	26,300
(Cropping Intensity)		(1.25)		(1.65)		(1.38)		(0.88)

Crop	I		M		NWZD (NW-1)		Total	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
1. Irrigated								
Paddy	12,400	2,600	2,500	400	2,550	1,100	67,480	18,290
Chillie	300	260	-	100	-	50	700	8,100
Pulses	-	340	-	200	-	-	500	9,880
Maize	-	-	-	-	-	-	900	-
Sub-total	12,700	3,200	2,500	700	2,550	1,150	69,580	36,270
2. Rainfed								
Paddy	500	-	-	-	350	350	1,290	410
Chillie	-	-	-	-	20	-	90	-
Pulses	21,000	-	5,200	-	400	150	30,100	230
Maize	6,000	-	2,700	-	40	-	10,710	-
Others	3,500	5,000	700	700	100	120	4,990	6,390
Sub-total	31,000	5,000	8,600	700	910	620	47,180	7,030
3. Fallow	4,100	39,600	6,400	16,100	1,990	3,680	16,290	89,750
Cultivated Area	47,800	47,800	17,500	17,500	5,450	5,450	133,050	133,050
4. Not Utilized	13,500	13,500	7,500	7,500	7,800	7,800	41,800	41,800
Total	61,300	61,300	25,000	25,000	13,250	13,250	174,850	174,850
(Cropping Intensity)		(1.09)		(0.71)		(0.96)		(1.20)

Remarks: Cropping intensity of the total project area is estiamted below:

Item	Net Area	Maha	Yala	Total Area Cultivatec	Intensity
Irrigated	69,580	69,580	36,270	105,850	1.52
Rainfed*	63,470	47,180	7,030	54,210	0.85
Total	133,050	116,760	43,300	160,060	1.20

Note: * Including fallow area.

Refer to ANNEX-E.

Table 18 ESTIMATED PRESENT CROP PRODUCTION

(Unit : 1,000 ton)

System		Paddy		Chillie		Pulses		Maize		Others *1	
		Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
F	Irrigated	1.56	0.59	-	0.06	-	0.02	-	-	-	-
	Rainfed	1.36	0.11	0.04	-	0.34	-	0.41	-	0.19	0.08
	Sub-total	2.92	0.70	0.04	0.06	0.34	0.02	0.41	-	0.19	0.08
H	Irrigated	175.80	32.61	0.45	10.65	0.49	8.25	0.84	-	-	-
IH	Irrigated	14.19	2.70	-	0.41	-	0.45	-	-	-	-
MH	Irrigated	12.99	2.48	-	0.38	-	0.41	-	-	-	-
	Rainfed	-	-	-	-	2.56	0.08	1.36	-	0.28	0.27
	Sub-total	12.99	2.48	-	0.38	2.56	0.49	1.36	-	0.28	0.27
I	Irrigated	34.84	5.25	0.15	0.38	-	0.35	-	-	-	-
	Rainfed	0.73	-	-	-	16.80	-	8.76	-	2.42	2.95
	Sub-total	35.57	5.25	0.15	0.38	16.80	0.35	8.76	-	2.42	2.95
M	Irrigated	7.03	0.81	-	0.15	-	0.21	-	-	-	-
	Rainfed	-	-	-	-	4.16	-	2.30	-	0.48	0.41
	Sub-total	7.03	0.81	-	0.14	4.16	0.21	2.30	-	0.48	0.41
NWDZ	Irrigated	8.44	3.04	-	0.06	-	-	-	-	-	-
	Rainfed	0.84	0.80	0.03	-	0.22	0.08	0.03	-	0.04	0.07
	Sub-total	9.28	3.84	0.03	0.06	0.22	0.08	0.03	-	0.04	0.07
Total in Study Area											
	Irrigated	254.85	47.48	0.60	12.07	0.49	9.68	0.84	-	-	-
	Rainfed	2.93	0.90	0.07	-	24.08	0.16	12.87	-	3.41	3.78
	Total	257.78	48.38	0.67	12.07	24.57	9.85	13.70	-	3.41	3.78
	Grand Total		306.16		12.74		34.41		13.70		7.19

Remark: *1 Typified by sesame.

Refer to ANNEX-E.

Table 19 MAJOR FEATURES OF CANDIDATE HYDROPOWER SCHEMES (1/2)

Item	Unit	Watawala	Ulapane	Caledonia	Talawakele	Kotmale*1 Extension
1. General						
River		Mahaweli Ganga	Mahaweli Ganga	Kotmale Oya Mahaweli Ganga	Kotmale Oya Mahaweli Ganga	Kotmale Oya Mahaweli Ganga
Catchment area	(km2)	69	220	235	363	562
Annual average Runoff	(m3/s) (MCM)	3.8 119	12.1 381	13.1 412	20.2 636	31.2 984
2. Dam						
Type		Concrete gravity	Rockfill with Concrete gravity	Concrete gravity	Concrete gravity	Rockfill
Crest elevation	(EL. m)	1,034	603	1,365	1,203	735
Crest length	(m)	200	500	270	102	945
Height	(m)	60	70	70	20	115
Volume	(1000m3)	92	2,370	250	18	4,270
3. Spillway						
Design capacity	(m3/s)	800	6,500 (782 km2)	2,470 (175 km2)	3,500 (297 km2)	5,560
Dimension nos.xBxH	(m)	2x8x7	3x18x15	-	3x8x12	3x14x15
4. Reservoir						
Flood water level	(EL. m)	1,032	600	1,363.5	1,200	732.8
High water level	(EL. m)	1,032	600	1,360	1,200	731.5
Rated water level	(EL. m)	1,024	597	1,353	1,198	723
Low water level	(EL. m)	1,010	590	1,341	1,193	665
Net storage volume	(MCM)	17.7	150	30	2	382.9
5. Headrace Tunnel						
Length	(m)	2,100	5,000	2,982	13,066	6560
Inside diameter	(m)	2.4	4.5	3.9	4.4	4.4
6. Surge Tank						
Height	(m)	55	50	55	93	168
Inside diameter	(m)	7	15	15	15	12
7. Penstock Tunnel/Line						
Type		Above-ground	Above-ground	Tunnel	Tunnel	Tunnel
Length	(m)	220	200	218	734	402
Inside diameter	(m)	2.2-1.7	2.8-2.4	4.1- 3.2	4.7-3.4	4.8-5.5
8. Power Station						
Firm discharge	(m3/s)	2.3	9.5	6.7	9.2	29.8
Max. plant discharge	(m3/s)	11.5	47.5	35.0	50.0	112.3
Gross head	(m)	192-170	120-110	167-141	545-490	251.5-185
Rated head	(m)	179	109	144	468	233
Installed capacity	(MW)	2x9	2x22	1x44	3x68	3x80
Dependable peak power	(MW)	15.9	40.6	44	204	39 *
Annual energy output	(GWh)	49	91	135	674	59 *
Firm		31	75	70	364	209 *
Secondary		18	16	65	310	-150 *
Type		Above-ground	Above-ground	Underground	Underground	Underground
Nos.of unit		2	3	1	3	3
Type of Turbine		Francis	Francis	Francis	Francis	V.Francis
Tailwater level	(EL-m)	840	480	1,200-1,193	731.5-703	480
9. Construction Cost	(US$10^6)	44.2	117	156.4	215.7	236.6

Remarks: * shows incremental value.
*1 Referred to 'Kotmale Hydropower Project', Report on Future Raising of Dam and Spillway, October 1985, Halcrow Water

Refer to ANNEX-G.

Table 19 MAJOR FEATURES OF CANDIDATE HYDROPOWER SCHEMES (2/2)

Item	Unit	Upper Uma Oya Scheme - 1000	Lower Uma Oya Scheme - 500	Wewatenna	Sudu Ganga
1. General					
River		Uma Oya Mahaweli Ganga	Uma Oya Mahaweli Ganga	Badulu Oya Mahaweli Ganga	Sudu Gganga Mahaweli Ganga
Catchment area	(km2)	421	622	267	305
Annual average	(m3/s)	11.2	16.6	6.6	36.2
Runoff	(MCM))	354	523	207	1,144 *
2. Dam					
Type		Rockfill with Concrete gravity	Concrete gravity	Rockfill with Concrete gravity	Rockfill with Concrete gravity
Crest elevation	(EL. m)	973	502	233	328
Crest length	(m)	565	150	500	400
Height	(m)	90	25	80	55
Volume	(1000m3)	3,900	15	2,700	1,320
3. Spillway					
Design capacity	(m3/s)	1,700	3,700	1,500	2,000
Dimension nos.xBxH	(m)	3x7x10	3x10x12	3x8.5x12	3x9x12
4. Reservoir					
Flood water level	(EL. m)	970	500	230	325
High water level	(EL. m)	970	500	230	325
Rated water level	(EL. m)	947	498	220	317
Low water level	(EL. m)	910	495	200	300
Net storage volume	(MCM)	60	1.5	90	100
5. Headrace Tunnel					
Length	(m)	12,200	15,000	3,000	-
Inside diameter	(m)	4.5	4.8	3.1	-
6. Surge Tank					
Height	(m)	80	30	50	-
Inside diameter	(m)	15	15	12	-
7. Penstock Tunnel/Line					
Type		Tunnel	Tunnel	Above-ground	Above-ground
Length	(m)	700	1,000	150	120
Inside diameter	(m)	3.8-2.9	4.1-3.0	2.0-1.7	3.5-3.1
8. Power Station					
Firm discharge	(m3/s)	7.9	9.1	4.3	23.6
Max. plant discharge	(m3/s)	39.7	45.5	22.8	101.2
Gross head	(m)	470-400	297-263	125-90	55-30
Rated head	(m)	434	251	114	47
Installed capacity	(MW)	3x50	3x32	2x11	2x22.5
Dependable peak power	(MW)	128.9	96	19.7	23.8
Annual energy output	(GWh)	342	310	69	122
Firm		201	192	36	74
Secondary		141	118	33	48
Type		Above-ground	Under-ground	Above-ground	Above-ground
Nos.of unit		3	3	2	2
Type of Turbine		Pelton	Francis	Francis	Francis
Tailwater level	(EL-m)	500	232-203	105	270
9. Construction Cost	(US$10^6)	249.1	228.5	85.5	83.1

Remark: * includes Polgolla diversion.

Refer to ANNEX-G.

Table 20 DESIGN WATER LEVEL AND STORAGE CAPACITY OF RESERVOIR AND TANK

Name of Reservoir	Catchment (km)	H.W.L. (m)	Storage (MCM)	F.S.L. (m)	Storage (MCM)	L.W.L. (m)	Storage (MCM)	Active Storage (MCM)
Hydropower Scheme								
Caledonia	235	1,360	45.7	1360	45.7	1,341	15.7	30.0
Talawakele	363	1,200	2.6	1200	2.6	1,193	0.6	2.0
Kotmale Extension	562	732.8	408	731.5	405.1	665	22.2	382.9
Watawala	69	1,032	24	1,032	24	1,010	7	17.0
Ulapane	782	600	420	600	420	590	260	160.0
Uma Scheme-1000	168	970	65.3	970	65.3	910	5	60.3
Uma Scheme-500	622	500	5.5	500	5.5	498	4.5	1.0
Wewatenna	267	230	122	230	122	200	32	90.0
Sudu Ganga	305	325	150	325	150	300	46.5	103.5
Irrigation Tank								
Kalu Ganga	204	171.5	350.0	170.0	330.0	148.0	40.0	290.0
Horowupotana	950	67.0	490.0	65.5	410.0	58.0	70.0	340.0
Yan oya	1,320	42.5	380.0	41.0	300.0	30.0	15.0	285.0
Kitulgala	104	86.5	76.0	85.0	55.0	73.0	6.5	48.5
Mukunuwewa	142	92.5	228.0	91.0	197.0	73.0	9.0	188.0
Galgamuwa	11	101.5	64.0	100.0	58.0	90.0	13.0	45.0
Tammannewa	64	115.0	285.0	113.5	236.0	104.0	32.0	204.0
Malwatu	2,113	57.5	405.0	56.0	270.5	49.5	55.0	215.5
Parangi Aru	427	57.5	368.0	56.0	286.0	47.0	26.0	260.0
Pali Aru	91	76.5	166.0	75.0	135.0	64.0	4.0	131.0
Kanagarayan	85	80.5	140.0	79.0	110.0	68.5	11.0	99.0
Gallodai Aru	95	87.0	240.0	85.5	210.0	63.0	7.0	203.0
Maha Oya	230	81.5	270.0	80.0	232.0	62.0	14.0	218.0
Ranbukan Aru	140	81.5	198.0	80.0	170.0	60.0	6.0	164.0
Magalawatawan	115	74.5	200.0	73.0	176.0	50.0	4.0	172.0

Refer to ANNEX-J.

Table 21 TARGET PRODUCTION FOR FUTURE FOOD DEMAND : 2020

(Unit : 1,000 ton)

Crop	Total Requirement in Sri Lanka			Target Production		
	Domestic	Export	Total	Sri Lanka	Administrative Study Area	Study Area
1. Paddy	4,220	-	4,220	4,220	1,688	1,350
2. Maize	61	40	101	101	40	32
3. Pulses	145	90	235	235	94	75
4. Chilli	74	15	89	89	45	36
5. Onion	124	7 *3	131	131	66	52
6. Garlic	- *2	1	1	1	0	0
7. Ginger	- *2	3	3	3	1	1
8. Sesame	- *2	50	50	50	20	16
9. Cashew (Kernels)	- *2	25	25	25	13	10
10. Caster Seed	- *2	6	6	6	2	2
11. Sugar *1	899	-	899	539	216	173
12. Oil Palm	-	50	50	50	20	16
13. Cotton	20	-	20	20	10	8
14. Vegetables & Fruits	2,249	45	2,294	2,294	918	734

Remarks : *1 60% of consumption is supplied by domestic industry.
*2 Domestic requirement is included in the item 14 of Vegetables and Fruits.
*3 Assumed that Sri Lanka attains the level of Thailand's export in 1987.

Refer to ANNEX-E.

Table 22 FUTURE CROPPING AREA BY SYSTEM UNDER WITH-PROJECT CONDITION

(Unit: ha)

Crop	F		H		IH		MH	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
1. Irrigated								
Paddy	1,800	1,500	40,300	23,280	4,500	3,900	15,500	12,900
Chilli	-	100	800	10,300	100	400	330	1,400
Pulses	60	90	420	3,300	60	130	200	670
Maize	-	90	300	2,300	-	120	130	700
Onion	40	30	280	920	40	30	140	150
Others	-	90	300	2,300	-	120	-	480
Sub-total	1,900	1,900	42,400	42,400	4,700	4,700	16,300	16,300
2. Rainfed								
Cashew	-	-	-	-	-	-	10,000	10,000
Sub-total	-	-	-	-	-	-	10,000	10,000
Total	1,900	1,900	42,400	42,400	4,700	4,700	26,300	26,300

Crop	I		M		NWZD		Total	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
1. Irrigated								
Paddy	48,600	41,100	23,700	20,000	8,250	8,250	142,650	110,930
Chilli	1,000	2,900	500	1,500	-	700	2,730	17,300
Pulses	550	3,000	190	1,570	2,860	2,120	4,340	10,880
Maize	370	1,800	200	800	1,000	1,000	2,000	6,810
Onion	430	700	210	330	140	180	1,280	2,340
Others	350	1,800	200	800	1,000	1,000	1,850	6,590
Sub-total	51,300	51,300	25,000	25,000	13,250	13,250	154,850	154,850
2. Rainfed								
Cashew	10,000	10,000	-	-	-	-	20,000	20,000
Sub-total	10,000	10,000	-	-	-	-	20,000	20,000
Total	61,300	61,300	25,000	25,000	13,250	13,250	174,850	174,850

Refer to ANNEX-E.

Table 23 DESIGN CRITERIA OF PROPOSED FARMING PRACTICES

Item	Paddy	Chillie	Bombay Onion
Variety	BG-379-2 BG-34-8	MI-1 MI-2	Ponna Red Early Grand
Growing Period	BG-379-2: 4 Months BG-34-8: 3 Months	MI-1: 150 days MI-2: 150 days	3 Months
Planting Method	Transplanting	Transplanting	Transplanting
Seed Sown	107 kg/ha	1.85 kg/ha	8.4 kg/ha
Nursery Period	20 days	25-30 days	1.5 Months
Planting Space	15cm x 15cm	MI-1: 60cm x 60cm 75cm x 60cm MI-2: 60cm x 60cm	15cm x 10cm 10cm x 10cm
Ferilizer			
N	120 kg/ha	150 kg/ha	104 kg/ha
P2 O5	80 kg/ha	100 kg/ha	108 kg/ha
K2 O	80 kg/ha	100 kg/ha	92 kg/ha
Labour Requirement	86 man-days/ha	229 man-days/ha	552 man-days/ha
Family Labour	25 man-days/ha	147 man-days/ha	408 man-days/ha
Hired Labour	61 man-days/ha	82 man-days/ha	144 man-days/ha

Item	Green Gram	Long Bean	Maize
Variety	MI-5 IPEM-79-13-45		T-48 Thai Composits
Growing Period	75 - 90 days	90 days	90 days
Planting Method			
Seed Sown	26 kg/ha	41 kg/ha	20 kg/ha
Nursery Period			
Planting Space	30cm x (7-8)cm	5 - 10cm x 5 - 10cm	0.5-1.0m x 0.5-1.0m
Ferilizer			
N	25 kg/ha	28 kg/ha	60 kg/ha
P2 O5	60 kg/ha	149 kg/ha	68 kg/ha
K2 O	60 kg/ha	56 kg/ha	32 kg/ha
Labour Requirement	229 man-days/ha	375 man-days/ha	70 man-days/ha
Family Labour	174 man-days/ha	280 man-days/ha	55 man-days/ha
Hired Labour	55 man-days/ha	95 man-days/ha	15 man-days/ha

Refer to ANNEX-E.

Table 24 INCREMENT OF AGRICULTURAL AREA AND CROP PRODUCTION IN STUDY AREA

Item	Present Condition	Future Condition		Production Target	
		Without Project	With Project	Study Area Total	National Total
1. Net Agricultural Area (ha)					
Irrigated	69,580	69,580	154,850	-	-
Rainfed	63,470	63,470	20,000 *1	-	-
Not Utilized	41,800	41,800	0	-	-
Total	174,850	174,850	174,850	-	-
2. Production (1,000 ton)					
Paddy	306.1	335.9	1,339.2	1,350	4,220
Chilli	12.7	13.3	38.1	36	89
Pulses *2	34.4	34.6	23.3	75	235
Maize	13.7	19.0	30.8	32	101
Onion	-	-	54.3	52	131
Cashew (Kernels)	-	-	4.5	10	25
Others *3	34.1 *4	34.1	67.5	734	2,294
3. Increment from Present Production (1,000 ton)					
Paddy	-	29.8	1,033.1	-	-
Chilli	-	0.5	25.4	-	-
Pulses *2	-	0.2	-11.1	-	-
Maize	-	5.3	17.1	-	-
Onion	-	-	54.3	-	-
Cashew (Kernels)	-	-	4.5	-	-
Others *3	-	0.0	33.4	-	-

Remarks : *1 Cultivated for cashew production.
*2 Estimated as green gram.
*3 Estimated as long bean
*4 Equivelant to long bean.

Refer to ANNEX-E.

Table 25 NET FARM INCOME AND CAPACITY TO PAY

Item	F	H	IH	MH	I	M	NWDZ
(A) A Typical Existing Farmer							
- Average Size of Farm Holding (ha)	0.7	1.1	1.1	1.1	1.1	1.4	0.8
I. Without Project Condition in Irrigated Field							
1. Planted Area (ha)							
Paddy (Maha)	0.70	1.05	1.10	1.10	1.07	1.40	0.80
(Yala)	0.36	0.31	0.25	0.25	0.23	0.22	0.35
Chilli	0.08	0.19	0.07	0.07	0.05	0.06	0.02
Pulses	0.03	0.23	0.10	0.10	0.03	0.11	0.00
Maize	0.00	0.02	0.00	0.00	0.00	0.00	0.00
2. Net Farm Income (Rs./annum)							
Paddy (Maha)	5,382	9,721	8,458	8,458	8,258	10,765	6,151
(Yala)	2,031	1,751	1,433	1,436	1,277	1,270	1,957
Chilli	2,944	7,037	2,370	2,405	1,754	2,025	567
Pulses	286	2,048	883	875	258	982	0
Maize	0	66	0	0	0	0	0
Total	10,643	20,622	13,144	13,175	11,548	15,042	8,676
3. Capacity to Pay (Rs./annum)	(6,277)	3,702	(3,776)	(3,745)	(5,372)	(1,878)	(8,244)
II. With Project Condition							
1. Planted Area (ha)							
Paddy (Maha)	0.66	1.05	1.05	1.05	1.04	1.33	0.50
(Yala)	0.55	0.60	0.91	0.87	0.88	1.12	0.50
Chilli	0.04	0.29	0.12	0.12	0.08	0.11	0.04
Pulses	0.06	0.10	0.04	0.06	0.08	0.10	0.30
Maize	0.03	0.07	0.03	0.06	0.05	0.06	0.12
Onion	0.03	0.03	0.02	0.02	0.02	0.03	0.02
Others	0.03	0.07	0.03	0.03	0.05	0.06	0.12
2. Net Farm Income (Rs./annum)							
Paddy (Maha)	10,706	16,879	17,003	16,887	16,824	21,426	8,042
(Yala)	7,760	8,481	12,817	12,224	12,375	15,727	6,995
Chilli	1,763	13,778	5,599	5,586	4,001	5,359	2,022
Pulses	856	1,495	689	909	1,179	1,526	4,656
Maize	236	480	200	399	331	399	859
Onion	2,595	3,132	1,648	1,969	2,438	3,042	1,944
Others	813	1,655	689	795	1,131	1,374	2,962
Total	24,729	45,899	38,644	38,768	38,278	48,853	27,480
3. Capacity to Pay (Rs./annum)	7,809	28,979	21,724	21,848	21,358	31,933	10,560
4. Incremental Farm Income (Rs./annum)	14,086	25,277	25,500	25,594	26,731	33,810	18,804
(B) A New Settler							
- Average Size of Farm Holding (ha)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
I. With Project Condition							
1. Planted Area (ha)							
Paddy (Maha)	0.95	0.95	0.96	0.95	0.95	0.95	0.62
(Yala)	0.79	0.55	0.83	0.79	0.80	0.80	0.62
Chilli	0.05	0.26	0.11	0.11	0.08	0.08	0.05
Pulses	0.08	0.09	0.04	0.05	0.07	0.07	0.38
Maize	0.05	0.06	0.03	0.05	0.04	0.04	0.15
Onion	0.04	0.03	0.01	0.02	0.02	0.02	0.02
Others	0.05	0.06	0.03	0.03	0.04	0.04	0.15
2. Net Farm Income (Rs./annum)							
Paddy (Maha)	15,294	15,344	15,457	15,352	15,294	15,305	10,052
(Yala)	11,086	7,710	11,652	11,113	11,250	11,234	8,743
Chilli	2,518	12,525	5,090	5,078	3,637	3,828	2,528
Pulses	1,223	1,359	626	827	1,072	1,090	5,820
Maize	337	436	182	362	301	285	1,074
Onion	3,706	2,847	1,498	1,790	2,216	2,173	2,430
Others	1,162	1,504	626	722	1,028	981	3,703
Total	35,326	41,726	35,131	35,244	34,799	34,895	34,350
3. Capacity to Pay (Rs./annum)	18,406	24,806	18,211	18,324	17,879	17,975	17,430

Remarks : (1) A typical farm size is derived from asn average size of a District with which a System is concerned.

(2) Net farm income (Rs./ha) was as follows:

	Paddy (M)	Paddy (Y)	Chillie	Pulses	Maize	Onion	Others
Without-Projec	7,689	5,671	36,165	8,771	2,823	-	13,124
With-Project	16,144	14,042	47,845	15,486	7,117	100,604	24,532

But paddy in System H was Rs.9,225/ha in Maha under without project condition.

(3) Living expense is assumed at Rs.16.920/family (Ref. 30).

Table 26 IRRIGATION WATER DEMAND AND POTENTIAL WATER RESOURCES

	Existing (Committed) (ha)	Potential Irr. Area (ha)	Total	Ave. Annual I.W. Demand		Potential W. Resources (MCM)
				Present Eff. (MCM)	Improved Eff. (MCM)	
A	20,300	-	20,300	581	542	5,800 *1
B	42,000	-	42,000	1,328	1,239	367
C	24,500	-	24,500	635	533	277
D1	40,500	-	40,500	938	875	298
D2	10,100	-	10,100	223	208	29
E	6,100	-	6,100	165	138	195
F	-	1,900	1,900	58	54	-
G	5,400	-	5,400	147	137	-
H	42,400	-	42,400	923 *2	1,087	333
IH	4,700	-	4,700	122	114	89
MH	4,300	12,000	16,300	475	444	33
M	-	25,000	25,000	692	646	220
I	14,700	38,600	53,300	1,507	1,406	319
J	2,800	19,000	21,800	542	506	241
K	-	9,000	9,000	225	210	40
L	5,600	29,000	34,600	885	826	196
NWDZ	2,550	10,700	13,250	314	293	105
Total	225,950	145,200	371,150	9,760	9,258	8,542

Remarks : *1 Waste water to sea was estimaetd at about 2,500 MCM based on the water balance simulation run.
*2 Crop Intensity = 1.65

Refer to ANNEXes B and F.

Table 27 AVERAGE IRRIGATION WATER DEMANDS AT RESPECTIVE SYSTEMS (1/2)
(Case-1 PRESENT EFFICIENCY)

(Unit: MCM)

System	Area(ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A	20,300	60.3	47.7	10.2	24.1	99.4	114.9	87.4	26.7	2.5	50.5	36.3	21.0	581.0
B	42,000	128.2	127.8	26.7	43.5	176.8	266.8	213.0	112.0	11.1	37.5	132.6	52.1	1,327.9
C	24,500	29.6	55.5	18.9	24.7	110.9	130.9	122.5	54.0	3.9	33.6	41.1	9.1	634.6
D1	40,500	67.6	104.1	57.9	40.5	134.5	171.4	140.5	84.7	29.1	38.8	51.3	17.7	938.3
D2	10,100	16.5	22.5	7.0	8.9	38.1	42.9	37.7	18.1	1.4	12.9	14.3	2.8	223.0
E	6,100	8.8	15.0	7.4	7.2	31.2	34.9	28.7	7.8	0.0	6.8	14.1	3.0	164.6
F	1,900	5.0	5.0	0.0	0.1	7.3	11.7	10.8	5.6	0.4	4.0	5.9	2.0	57.9
G	5,400	12.7	13.5	2.3	0.1	18.0	30.8	27.8	16.9	1.6	4.1	14.8	4.2	146.8
H *1	42,400	143.3	126.1	27.4	13.7	57.0	111.9	112.8	78.2	24.1	44.1	102.4	81.5	922.7
IH	4,700	14.0	14.2	3.2	3.9	17.4	22.4	18.6	5.6	1.2	3.0	9.9	8.1	121.7
MH	16,300	54.9	54.5	12.1	16.6	67.5	82.2	69.3	21.9	4.6	13.2	43.8	34.8	475.1
I *2	53,300	175.7	175.0	38.6	51.4	216.8	266.1	224.5	66.8	9.7	32.7	134.1	115.0	1,506.7
J	21,800	65.0	59.5	10.4	0.8	62.3	109.2	104.6	53.2	2.9	10.1	38.8	25.2	542.2
K	9,000	24.1	22.2	3.8	0.4	30.1	49.8	46.6	23.8	1.3	3.3	11.9	7.5	224.8
L	34,600	103.8	83.9	12.3	1.3	104.2	179.0	170.3	86.5	4.5	32.6	67.9	38.5	884.7
M	25,000	84.1	73.2	17.5	1.5	76.5	132.5	121.9	61.6	4.0	24.2	55.4	39.5	691.8
NWDZ	13,250	41.8	24.2	0.0	10.2	44.8	57.0	53.7	19.4	2.2	17.7	20.6	22.2	314.1
Total	371,150	1,035.4	1,023.9	255.7	248.9	1,292.8	1,814.4	1,590.7	742.8	104.5	369.1	795.2	484.2	9,757.9

Remarks: *1 Crop Intensity CI=1.65
*2 Including Water Demand at Existing Giant Tank

Table 27 AVERAGE IRRIGATION WATER DEMANDS AT RESPECTIVE SYSTEMS (2/2)
(Case-2 IMPROVED EFFICIENCY)

(Unit: MCM)

System	Area(ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A	20,300	56.3	44.5	9.5	22.5	92.8	107.2	81.5	24.9	2.4	47.1	33.9	19.6	542.3
B	42,000	119.6	119.2	25.0	40.6	165.0	249.1	198.7	104.5	10.2	35.0	123.7	48.7	1,239.4
C	24,500	24.9	46.6	15.9	20.7	93.2	109.9	102.8	45.4	3.3	28.2	34.5	7.6	533.1
D1	40,500	63.2	97.3	54.2	37.8	125.5	160.1	131.2	79.0	27.1	36.2	47.9	16.6	875.6
D2	10,100	15.4	21.0	6.5	8.3	35.6	40.0	35.2	16.9	1.3	12.0	13.3	2.6	208.1
E	6,100	7.4	12.6	6.2	6.0	26.2	29.3	24.1	6.5	0.0	5.7	11.8	2.5	138.3
F	1,900	4.7	4.7	0.0	0.1	6.8	10.9	10.1	5.2	0.3	3.8	5.5	1.9	54.0
G	5,400	11.9	12.6	2.1	0.1	16.8	28.8	25.9	15.7	1.5	3.9	13.8	3.9	137.0
H *1	42,400	133.8	117.7	25.6	24.0	101.6	183.3	166.6	99.5	22.5	41.2	95.6	76.0	1,087.3
IH	4,700	13.1	13.2	3.0	3.7	16.2	20.9	17.3	5.2	1.2	2.8	9.3	7.6	113.5
MH	16,300	51.2	50.8	11.4	15.4	63.0	76.7	64.7	20.4	4.3	12.4	40.9	32.3	443.5
I *2	53,300	163.9	163.3	36.0	48.0	202.4	248.3	209.6	62.3	9.0	30.5	125.2	107.4	1,406.2
J	21,800	60.7	55.5	9.8	0.7	58.2	102.0	97.6	49.7	2.6	9.4	36.3	23.5	506.1
K	9,000	22.5	20.7	3.6	0.3	28.1	46.5	43.5	22.2	1.2	3.0	11.1	7.0	209.8
L	34,600	96.9	78.3	11.5	1.1	97.1	167.0	158.9	80.9	4.2	30.4	63.4	35.9	825.6
M	25,000	78.5	68.3	16.3	1.3	71.5	123.7	113.8	57.5	3.7	22.6	51.7	36.9	645.7
NWDZ	13,250	39.0	22.6	0.0	9.6	41.8	53.2	50.1	18.1	2.1	16.5	19.3	20.7	293.2
Total	371,150	963.0	948.9	236.6	240.2	1,241.8	1,756.9	1,531.6	713.9	96.9	340.7	737.2	450.7	9,258.7

Remarks: *1 Crop Intensity CI=2.0
*2 Including Water Demand at Existing Giant Tank

Refer to ANNEX-F.

Table 28 BASIC FACTORS FOR ESTIMATION OF IRRIGATION WATER DEMAND FOR RESPECTIVE IRRIGATION SYSTEMS

System	Percolation (mm/Month)		Land Preparation (mm)			Irrigation Eff. (Case-1 Present)		Irrigation Eff. (Case-2 Future)	
	LHG	RBE	LHG	RBE	Upland	Paddy	Upland	Paddy	Upland
A	60	120	200	300	75	0.56	0.42	0.6	0.45
B	75	150	200	300	75	0.56	0.42	0.6	0.45
C	60	120	200	300	75	0.50	0.37	0.6	0.45
D1	30	60	200	300	75	0.56	0.42	0.6	0.45
D2	30	60	200	300	75	0.56	0.42	0.6	0.45
E	60	120	200	300	75	0.50	0.37	0.6	0.45
F	60	120	200	300	75	0.56	0.42	0.6	0.45
G	60	120	200	300	75	0.56	0.42	0.6	0.45
H	60	120	200	300	75	0.56	0.42	0.6	0.45
IH	60	120	200	300	75	0.56	0.42	0.6	0.45
MH	60	120	200	300	75	0.56	0.42	0.6	0.45
NWDZ	60	120	200	300	75	0.56	0.42	0.6	0.45
I	60	120	200	300	75	0.56	0.42	0.6	0.45
J	60	120	200	300	75	0.56	0.42	0.6	0.45
K	60	120	200	300	75	0.56	0.42	0.6	0.45
L	60	120	200	300	75	0.56	0.42	0.6	0.45
M	60	120	200	300	75	0.56	0.42	0.6	0.45

Refer to ANNEX-F.

Table 29 IRRIGATION WATER DEMANDS ESTIMATED IN PREVIOUS STUDIES

System	TDS*3		MWRMP*4		JICA*5	
	Area (ha)	Irrigation Water Demand (MCM)	Area (ha)	Irrigation Water Demand (MCM)	Area*2 (ha)	Irrigation Water Demand (MCM)
A	-	135 (including E)	7,000	157	20,300	542
B	-	949	41,300	1,091	42,000	1,239
C	-	468	22,700	521	24,500	533
D1	-	699 (including G)	25,700	493	40,500	876
D2	-	193	10,100	191	10,100	208
E	-	-	6,100	156	6,100	138
F	-	-	-	-	1,900	54
G	-	-	5,400	114	5,400	137
H	-	482 (including IH and MH)	30,800	836	42,400	1,087
IH	-	-	-	-	4,700	114
MH	-	-	-	-	16,300	444
I*1	-	-	-	-	53,300	1,406
J*1	-	-	-	-	21,800	506
K*1	-	-	-	-	9,000	210
L*1	-	-	-	-	34,600	826
M*1	-	-	-	-	25,000	646
NWDZ*1	-	547	-	-	13,250	293

Remarks: *1 Potential irrigable area
*2 Including existing scheme
Source: *3 Ref.27
*4 Ref.18
*5 Refer to ANNEX F. (Improved Efficiency)

Table 30 PEAK DEMAND AND GENERATION FORECAST
(JULY 1987)

Year	Peak Demand (MW)	Generation Forecast (GWh)	Growth Rate (%)	Load Factor (%)
1988	593	2,986	-	57.5
1989	630	3,230	8.2	58.5
1990	682	3,495	8.2	58.5
1991	744	3,845	10.0	59.0
1992	818	4,229	10.0	59.0
1993	900	4,652	10.0	59.0
1994	990	5,118	10.0	59.0
1995	1,089	5,629	10.0	59.0
1996	1,193	6,166	9.5	59.0
1997	1,306	6,750	9.5	59.0
1998	1,430	7,391	9.5	59.0
1999	1,566	8,094	9.5	59.0
2000	1,714	8,861	9.5	59.0
2001	1,860	9,614	8.5	59.0
2002	2,018	10,431	8.5	59.0
2005	2,578	13,323	8.5	59.0
2010	3,788	19,578	8.0	59.0
2015	5,438	28,106	7.5	59.0
2020	7,627	39,419	7.0	59.0

Remarks: The demand up to 2002 was taken from the "Long Range Generation Expansion Plan", CEB, August 1987, and the projected demand was extended to 2020.

Refer to ANNEX-G.

Table 31 LIST OF WILDLIFE RESERVES AND SANCTUARIES OF THE STUDY AREA

	Protected Area	Extent (ha)
A)	STRICT NATURAL RESERVES	
1.	Ritigala	1,528
2.	Hakgala	1,142
B)	NATIONAL PARKS	
3.	Wilpattu	131,692
4.	Maduru Oya	56,802
5.	Somawathiya	36,337
6.	Wasgomuwa	33,765
7.	Gal Oya	25,900
8.	Floodplain	17,350
C)	NATURE RESERVES	
9.	Trikonamadu	25,027
10.	Horton Plains	3,160
D)	SANCTUARIES	
11.	Victoria-Randenigala-Rantambe	41,600
12.	Madhu Road	26,677
13.	Trincomalee Naval	18,130
14.	Seruwila-Allai	15,540
15.	Gal Oya SW	15,280
16.	Gal Oya NW	12,432
17.	Kokkilai	12,400
18.	Chundikulam	11,150
19.	Senanayake Samudra	9,324
20.	Minneriya-Giritale	6,692
21.	Padaviya Tank	6,475
22.	Vavunikulam T	4,851
23.	Giants Tank	3,942
24.	Anuradhapura	3,502
25.	Mahakandarawewa	2,000
26.	Ravana Ella	1,932
27.	Buddhangala	1,841
28.	Polonnaruwa	1,523
29.	Mihintale	997
30.	Wilpattu North	624
31.	Udawatakelle	111

Refer to ANNEX-K.

Table 32 FLOW DURATION AT MANAMPITIYA

Year	Maximum (m3/s)	95th Days (m3/s)	185th Days (m3/s)	275th Days (m3/s)	355th Days (m3/s)	Minimum (m3/s)	Remarks
1954	1511	295	165	107	81	75	
1955	1141	327	222	153	75	63	
1956	1450	175	118	83	48	41	
1957	3273	309	148	85	53	47	
1958	1869	293	172	104	54	49	
1959	1259	251	131	88	38	29	
1960	1676	305	190	127	84	59	
1961	1567	214	135	100	65	59	
1962	1179	253	158	102	69	57	
1963	1862	272	149	104	70	62	
1964	1742	231	145	100	53	43	
1965	1910	286	166	106	70	64	
1966	1372	257	142	82	55	49	
1967	1822	254	150	96	62	58	
1968	1114	230	150	92	57	49	
1969	1480	196	126	83	47	40	
1970	1423	253	139	96	60	40	
1971	1472	259	149	109	59	51	
1972	1507	275	127	69	36	27	
1973	1547	150	92	58	36	31	
1974	1425	190	127	87	40	29	
1975	1095	239	146	91	46	39	
1976	1360	132	50	23	13	11	
1977	1418	164	69	39	21	16	
1978	1815	230	101	53	26	19	
1979	1133	193	65	21	10	7	
1980	641	84	35	17	9	7	
1981	1269	98	46	28	12	9	
1982	1461	98	39	17	8	6	
1983	-	-	-	-	-	-	Insufficient data
1984	1328	228	98	24	5	3	
1985	1009	172	100	53	25	19	
1986	1580	166	72	36	13	12	
1987	915	162	80	29	10	6	
Average-1	1577	251	148	96	57	48	Period : 1954-1975
Average-2	1474	219	121	75	43	36	Period : 1954-1987
Average-3	1266	157	69	31	14	10	Period : 1976-1987

Remarks: Catchment Area : 7418 Sq.Km

Refer to ANNEX-B.

Table 33 SUMMARY OF WATER BALANCE SIMULATION FOR SCREENING OF TRANSBASIN CONVEYANCE SYSTEM

Alternative Case / Run Case	Unit	Polgolla Diversion: 875 MCM			
		Alternative Case			Present
		Case-A A145	Case-B B151	Case-C C145	Case-D D109
1. Irrigation System		AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP - -
2. Irrigation Area					
- Under AMDP	ha	200,300	200,300	200,300	200,300
- New Irrigation Area	ha	103,450	103,450	103,450	-
- Existing	ha	15,250	15,250	15,250	-
- New Dev. Area	ha	88,200	88,200	88,200	-
- Cashew Area (Non-irrigated)	ha	20,000	20,000	20,000	
- Total	ha	323,750	323,750	323,750	200,300
3. Spillout at					
- Angamedilla	MCM	380	399	377	718
- Minipe	MCM	154	146	185	1,435
- Kandakadu	MCM	2,538	2,541	2,594	4,290
4. Pump-up Volume	MCM	761	1,515	896	-
5. Irr. Demand-Deficit Ratio					
- Sub-system-1	%	9(10)	9(13)	10(13)	7(9)
- Sub-system-2	%	8(9)	7(6)	9(12)	-(-)
- Sub-system-3	%	10(10)	9(11)	9(12)	7(9)
- Sub-system-4	%	1(0)	1(0)	1(0)	0(0)
- Sub-system-5	%	2(2)	2(3)	2(3)	1(2)
- Sub-system-6	%	7(9)	8(12)	8(10)	4(5)
- Sub-system-7	%	2(3)	4(5)	3(5)	0(1)
- Sub-system-8	%	5(7)	4(7)	4(7)	-(-)
- Average	%	7(-)	7(-)	8(-)	5(-)
6. Energy Output					
- Existing Plant	GWh	2,138	2,020	2,017	2,264
- Proposed Hydropower	GWh	1,808	1,824	1,824	-
- Total	GWh	3,946	3,844	3,841	2,264

Remarks: AMDP Area : Existing and comitted irrigation area under the AMDP
Potential Irrigation Area : NWDZ + NCRB
Case A : New alternative (Minipe-Minneriya-Pump St.-NCP)
Case B : TDS's solution (Minipe-Hettipola-Pump St.-Elahera-NCP)
Case C : UNDP/FAO as revised by NEDECO (Minipe-Existing Minipe LBC-Anganedilla-Pump St.-NCP)
Case D : Present case including committed irrgation area
( ) : Number of years exceeding irrigation deficit-demand ratio of more than 10%.

Refer to ANNEX-I.

Table 34 SUMMARY OF WATER BALANCE SIMULATION FOR SCREENING OF DEVELOPMENT PLAN

Run Case	Unit	Polgolla Diversion 875 MCM A118	Polgolla Diversion 875 MCM A145	Polgolla Diversion 1,280 MCM A209	Polgolla Diversion 1,280 MCM A242
1. Irrigation System		AMDP NCRB -	AMDP NCRB NWDZ	AMDP NCRB -	AMDP NCRB NWDZ
2. Irrigation Area					
- Under AMDP	ha	200,300	200,300	200,300	200,300
- New Irrigation System	ha	90,200	103,450	90,200	103,450
- Existing	ha	12,700	15,250	12,700	15,250
- New Irrigation Area	ha	77,500	88,200	77,500	88,200
- Cashew Area (Non-irrigated)	ha	20,000	20,000	20,000	20,000
- Total	ha	310,500	323,750	310,500	323,750
3. Spillout at					
- Angamedilla	MCM	421	380	363	392
- Minipe	MCM	197	154	177	151
- Kandakadu	MCM	2,626	2,538	2,577	2,561
4. Pump-up Volume	MCM	653	761	360	435
5. Irr. Demand-Deficit Ratio					
- Sub-system-1	%	9(9)	9(10)	8(11)	6(9)
- Sub-system-2	%	7(7)	8(9)	9(9)	9(11)
- Sub-system-3	%	7(7)	10(10)	10(10)	10(11)
- Sub-system-4	%	1(0)	1(0)	1(0)	1(0)
- Sub-system-5	%	2(2)	2(2)	2(4)	3(4)
- Sub-system-6	%	6(8)	7(9)	9(12)	10(13)
- Sub-system-7	%	2(3)	2(3)	3(4)	3(4)
- Sub-system-8	%	5(7)	5(7)	5(7)	5(7)
- Average	%	6(-)	7(-)	7(-)	7(-)
6. Energy Output					
- Existing Plant	GWh	2,221	2,138	1,967	1,998
- Proposed Hydropower	GWh	1,818	1,808	1,866	1,868
- Total	GWh	4,039	3,946	3,833	3,866

Remarks: AMDP Area : Existing and comitted irrigation area under the AMDP
Potential Irrigation Area : NCRB, or NWDZ + NCRB
Case A : New alternative (Minipe-Minneriya-Pump St.-NCP)
( ) : Number of years exceeding 10% of irrigation deficit-demand ratio

Refer to ANNEX-I.

Table 35 UNIT RATE FOR MAJOR ITEMS

Hydropower		Unit	FC (US$)	LC (Rs)	Total (US$)
Excavation	Common	m^3	2.3	32.5	3.3
	Rock	m^3	5.6	78.0	8.0
Embankment	Core	m^3	4.6	65.0	6.6
	Filter	m^3	9.8	136.5	14.0
	Rock	m^3	5.3	71.5	7.5
Concrete		m^3	90.0	975.0	110.0
R-Bar		ton	595.0	8,287.5	850.0
Metal Works		ton	6,210.0	22,425.0	6,900.0
Consolidation Grout		m	72.8	1,014.0	104.0
Curtain Grout		m	105.0	1,462.5	150.0
Clearing		ha	198.0	4,290.0	330.0

Transbasin & Irrigation	Unit	FC (US$)	LC (Rs)	Total (US$)
Excavation Canal	m^3	1.4	3.3	1.5
Excavation Rock	m^3	5.6	78.0	8.0
Embankment	m^3	2.4	19.5	3.0
Filter	m^3	9.8	136.5	14.0
Concrete Lining	m^3	50.0	650.0	70.0
Concrete Structure	m^3	56.0	780.0	80.0

Refer to ANNEX-J.

Table 36 SUMMARY OF DIRECT CONSTRUCTION COST OF CANDIDATE HYDROPOWER SCHEMES

(Unit: US$1,000)

	Watawala	Ulapane	Caledonia	Talawakele	Kotmale Extension
1. Direct Construction Cost					
(1) General items	3,300	3,300	5,400	12,800	9,900
(2) Diversion tunnel/canal	1,400	2,300	-	-	-
(3) Main dam	10,000	23,600	42,600	4,000	141,000
(4) Spillway	-	4,100	-	-	19,600
(5) Tributary intake (1)	-	-	4,800	9,300	-
(6) Tributary intake (2)	-	-	-	-	-
(7) Intake	200	300	900	1,700	-
(8) Headrace tunnel	3,100	20,100	9,400	47,200	-
(9) Surge tank	500	1,200	1,300	3,600	-
(0) Penstock tunnel/line	200	200	1,000	3,600	-
(11) Powerhouse & outdoor s/yard	1,700	4,400	21,700	26,000	-
(12) Hydromechanical works	2,600	6,100	3,100	9,800	7,500
(13) Electrical Works	9,600	18,500	13,900	41,200	-
Total	32,600	84,100	104,100	159,200	178,000
2. Land Aquisition & Compensation Cost	1,000	5,000	15,800	4,600	1,400
3. Government's Administration cost (10% of Direct Construction Cost)	600	2,000	2,100	3,600	1,800
4. Engineering Service Cost (10% of Direct construction Cost)	2,700	6,400	8,300	12,300	1,600
Total of Items 1 to 4	36,900	97,500	130,300	179,700	197,200
5. Physical Contingencies (20% of Items 1 to 4)	7,300	19,500	26,100	35,900	39,500
Grand Total	44,200	117,000	156,400	215,700	236,600

	Upper Uma Oya Scheme-1000	Lower Uma Oya Scheme-500	Wewatenna	Sudu Ganga
1. Direct Construction Cost				
(1) General items	5,000	4,400	3,900	3,900
(2) Diversion tunnel/canal	2,200	2,900	2,700	2,900
(3) Main dam	36,400	17,400	27,800	15,600
(4) Spillway	3,300	-	3,800	3,500
(5) Tributary intake (1)	13,900	11,600	-	-
(6) Tributary intake (2)	11,600	-	-	-
(7) Intake	300	400	200	200
(8) Headrace tunnel	49,200	67,700	6,200	-
(9) Surge tank	1,800	800	1,300	-
(0) Penstock tunnel/line	3,300	4,800	100	-
(11) Powerhouse & outdoor s/yard	8,300	7,500	2,500	4,100
(12) Hydromechanical works	23,400	30,100	3,400	5,200
(13) Electrical Works	27,300	23,700	11,400	24,800
Total	186,000	171,300	63,300	60,200
2. Land Aquisition & Compensation Cost	3,000	2,000	1,000	3,000
3. Government's Administration Cost (10% of Direct Construction Cost)	4,300	3,900	1,600	800
4. Engineering Service Cost (10% of Direct Construction cost)	14,300	13,200	4,700	5,200
Total of Items 1 to 4	207,600	190,400	70,600	69,200
5. Physical contingencies (20% of Items 1 to 4)	41,500	38,100	14,900	13,800
Grand Total	249,100	228,500	85,500	83,100

Table 37 SUMMARY OF CONSTRUCRION COST (CASE-A118) (1/6)

Item No.	Work Items		Const. Cost Total Eq. US$ (10^6)	Economic Cost Total Eq. US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB									
A	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	60	11.1	10.6	0.9		79	2,185	0.9
3.	NCP Elahera-Kirioya	60	78.5	75.2	6.1		564	247	6.7
4.	NCP Kiri Oya-Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa-Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe LB 0-62Km	60	54.2	51.1	4.2		383	485	4.6
7.	Minipe LB 62Km-113 Km	60	93.5	89.2	7.3		669	247	8.0
C	Pump station	m^3/sec							
1.	Minneriya 23 MW	30	143.0	140.4	11.5	6.1	3,511	58,169	21.1
D	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,352.0	1,283.3	104.8	6.1	11,181	116,682	122.1
II.	NWDZ								
1.	Galgamuwa		0.0	0.0	0.0		0	0	0.0
2.	Additional Bowatenna Tunnel	24 m3/sec	0.0	0.0	0.0		0	0	0.0
3.	NWDZ Transbasin Canal	25 m3/sec	0.0	0.0	0.0		0	0	0.0
4.	System-NWDZ	0	0.0	0.0	0.0		0	0	0.0
	NWDZ TOTAL	0	0.0	0.0	0.0		0	0	0.0
Grand Total		161,600	1,352.0	1,283.3	104.8	6.1	11,181	116,682	122.1
Power+Irrigation		161,600	2,682.6	2,569.2	-	6.1	22,507	327,107	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Refer to ANNEX-J.

Table 37 SUMMARY OF CONSTRUCRION COST (CASE-A145) (2/6)

Item No.	Work Items		Const. Cost Total Eq. US$ (10^6)	Economic Cost Total Eq. US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB									
A	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	55	10.9	10.4	0.8		78	2,185	0.9
3.	NCP Elahera-Kirioya	55	75.2	72.0	5.9		540	247	6.4
4.	NCP Kiri oya-Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa-Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe LB 0-62Km	65	56.5	53.2	4.3		399	485	4.7
7.	Minipe LB 62Km-113 Km	65	97.0	92.5	7.6		694	247	8.3
C	Pump station	m^3/sec							
1.	Minneriya 23 MW	35	163.4	160.5	13.1	7.1	4,013	58,169	24.2
D	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,374.7	1,305.5	106.7	7.1	11,700	116,682	125.5
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin Canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	NWDZ TOTAL	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,495.2	1,419.5	116.0	7.1	12,517	119,798	135.6
Power+Irrigation		174,850	2,825.8	2,705.4	-	7.1	23,843	330,223	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Refer to ANNEX-J.

Table 37 SUMMARY OF CONSTRUCTION COST (CASE-B151) (3/6)

Item No.	Work Items		Const. Cost Total Eq. US$ (10^6)	Economic Cost Total Eq. US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Total Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	HYDROPOWER SCHEME		1,330.5	1,285.9	-		11,326	210,425	-
Direct cost									
I.	NCRB								
A.	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera Regulating Tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Level Crossing		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B.	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	80	42.6	40.9	3.3		307	409	3.6
2.	Elahera Head Works	90	13.4	12.7	1.0		96	2,185	1.1
3.	NCP Elahera-Kiri oya	90	101.7	97.5	8.0		731	247	8.7
4.	NCP Kiri oya-Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa-Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe 0-74 km	65	38.8	36.3	3.0		273	485	3.2
7.	Minipe 74-113 km	65	0.0	0.0	0.0		0	0	0.0
C.	Pump station	m^3/sec							
1.	Hettipola 78 MW	65	434.5	427.8	34.9	24.2	10,694	58,169	69.8
D.	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCP TOTAL	161,600	1,587.0	1,517.0	124.0	24.2	17,963	116,435	166.1
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	Sub total	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,707.6	1,631.0	133.3	24.2	18,781	119,551	176.2
Power+Irrigation		174,850	3,038.1	2,916.9	-	24.2	30,107	329,976	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Refer to ANNEX-J.

Table 37 SUMMARY OF CONSTRUCTION COST (CASE-C145) (4/6)

Item No.	Work Items		Const. Cost Total Eq. US$ (10^6)	Economic Cost Total Eq. US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Economic Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
I.	NCRB								
A.	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera Regulating Tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Level Crossing		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B.	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	45	10.4	9.9	0.8		74	2,185	0.9
3.	NCP Elahera-Kirioya	45/90	94.3	90.5	7.4		679	247	8.1
4.	NCP Kiri oya- Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa- Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe 0-74 km existing	65	38.8	36.3	3.0		273	485	3.2
7.	Minipe 74 km - Angamedilla	65	72.7	68.2	5.6		511	247	6.1
8.	Angamedilla-Wewala	45	48.1	46.2	3.8		346	247	4.1
9.	Angamedilla-Kaudula	20	23.8	22.4	1.8		168	247	2.0
10.	Kaudula-Kantalai	10	20.8	19.6	1.6		147	247	1.8
C.	Pump station	m^3/sec							
	Wewala 40 MW	45	221.6	218.2	17.8	10.6	5,456	58,169	33.9
D.	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,502.4	1,428.2	116.7	10.6	13,628	117,423	140.8
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	NWDZ TOTAL	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,622.9	1,542.3	126.0	10.6	14,448	120,539	151.1
Power+Irrigation		174,850	2,953.4	2,828.2	-	10.6	25,774	330,964	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Refer to ANNEX-J.

Table 37 SUMMARY OF CONSTRUCTION COST (CASE-A209) (5/6)

Item No.	Work Items		Const. Cost Total Eq. US$ (10^6)	Economic Cost Total Eq. US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB									
A	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	75	11.3	10.7	0.9		81	2,185	1.0
3.	NCP Elahera-Kirioya	75	93.0	89.2	7.3		669	247	8.0
4.	NCP Kiri oya- Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa- Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe LB 0~62Km	55	52.0	48.9	4.0		367	485	4.4
7.	Minipe LB 62Km-113 Km	55	90.1	85.9	7.0		645	247	7.7
C	Pump station	m^3/sec							
1.	Minneriya 23 MW	15	77.3	75.9	6.2	3.4	1,897	58,169	11.5
D	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,295.3	1,227.4	100.3	3.4	9,633	116,682	113.3
II.	NWDZ								
1.	Galgamuwa		0.0	0.0	0.0		0	0	0.0
2.	Additional Bowatenna Tunnel	24 m3/sec	0.0	0.0	0.0		0	0	0.0
3.	NWDZ Transbasin Canal	25 m3/sec	0.0	0.0	0.0		0	0	0.0
4.	System-NWDZ	0	0.0	0.0	0.0		0	0	0.0
	NWDZ TOTAL	0	0.0	0.0	0.0		0	0	0.0
Grand Total		161,600	1,295.3	1,227.4	100.3	3.4	9,633	116,682	113.3
Power+Irrigation		161,600	2,625.9	2,513.3	-	3.4	20,959	327,107	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Refer to ANNEX-J.

Table 37 SUMMARY OF CONSTRUCTION COST (CASE-A242) (6/6)

Item No.	Work Items		Const. Cost Total Eq. US$ (10^6)	Economic Cost Total Eq. US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB									
A	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	70	11.1	10.6	0.9		79	2,185	0.9
3.	NCP Elahera-Kirioya	70	89.8	86.1	7.0		646	247	7.7
4.	NCP Kiri oya- Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa- Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe LB 0-62Km	55	52.0	48.9	4.0		367	485	4.4
7.	Minipe LB 62Km-113 Km	55	90.1	85.9	7.0		645	247	7.7
C.	Pump station	m^3/sec							
1.	Minneriya 19 MW	20	100.2	98.4	8.0	4.1	2,460	58,169	14.6
D	Downstream development	ha							
1.	System-P	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,314.9	1,246.7	101.9	4.1	10,172	116,682	116.1
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin Canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	NWDZ TOTAL	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,435.5	1,360.7	111.2	4.1	10,989	119,798	126.3
Power+Irrigation		174,850	2,766.0	2,646.6	-	4.1	22,315	330,223	-

Remarks: *Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Refer to ANNEX-J.

Table 38 CROP BUDGET UNDER WITHOUT-PROJECT CONDITION

(Unit: Rs./ha)

Crop	Item	Gross Income	Production Cost								Net Benefit
			Material					Draught/			
			Seed	Fertilizer			Agro-chemicals	Machinery Power	Labour	Total	
				N	P2O5	K2O					
Paddy											
Irrigated (Maha)	Quantity	3.50	100	105	51	24					
	Financial	15,400	440	683	332	115	298	3,144	2,700	7,711	7,689
	Economic	19,250	550	1,743	842	199	256	2,672	2,678	8,940	10,310
Irrigated (Yala)	Quantity	3.00	100	77	51	24					
	Financial	13,200	440	501	332	115	298	3,144	2,700	7,529	5,671
	Economic	16,500	550	1,278	842	199	253	2,672	2,678	8,472	8,028
Irrigated (System H) (Maha)	Quantity	4.50	100	115	55	30					
	Financial	19,800	440	748	358	144	298	3,144	2,700	8,036	11,764
	Economic	24,750	550	1,909	908	249	256	2,672	2,678	9,379	15,372
Rainfed	Quantity	2.50	100	77	15	15					
	Financial	11,000	440	501	98	72	298	3,144	1,575	6,127	4,873
	Economic	13,750	550	1,278	248	125	253	2,672	1,890	7,015	6,735
Chilli											
Irrigated	Quantity	1.50	2	150	100	100					
	Financial	46,500	368	975	650	480	4,131	761	2,970	10,335	36,165
	Economic	39,000	313	2,490	1,650	830	3,511	647	5,796	15,237	23,763
Rainfed	Quantity	0.80	2	150	100	100					
	Financial	24,800	368	975	650	480	4,131	761	2,250	9,615	15,185
	Economic	20,800	313	2,490	1,650	830	3,511	647	4,379	13,820	6,980
Bombay Onion											
Irrigated	Quantity	10.00	9	78	81	69					
	Financial	83,000	11,050	507	527	331	1,868	2,678	4,860	21,821	61,179
	Economic	71,000	9,393	1,295	1,337	573	1,588	2,276	13,041	29,502	41,499
Green Gram											
Irrigated	Quantity	1.00	20	52	23	14					
	Financial	14,000	520	338	150	67	1,955	354	1,845	5,229	8,771
	Economic	12,000	520	863	380	116	1,662	301	5,418	9,260	2,740
Rainfed	Quantity	0.50	10	36	16	10					
	Financial	7,000	260	234	104	48	1,369	248	1,125	3,388	3,612
	Economic	6,000	260	598	264	83	1,163	211	3,276	5,855	145
Long Bean											
Irrigated	Quantity	5.00	41	28	149	56					
	Financial	21,500	3,239	182	969	269	523	0	3,195	8,376	13,124
	Economic	18,500	2,747	465	2,459	465	530	0	8,852	15,517	2,983
Rainfed	Quantity	3.00	31	21	112	42					
	Financial	12,900	2,449	137	728	202	392	0	2,070	5,977	6,923
	Economic	11,100	2,077	349	1,848	349	398	0	5,765	10,785	315
Maize											
Irrigated	Quantity	2.00	20	60	68	32					
	Financial	7,200	400	390	442	154	1,506	1,035	450	4,377	2,823
	Economic	8,600	600	996	1,122	266	1,280	880	2,048	7,192	1,408
Rainfed	Quantity	1.00	20	20	0	0					
	Financial	3,600	400	130	0	0	0	935	225	1,690	1,910
	Economic	4,300	600	332	0	0	0	1,100	1,890	3,922	378

Remarks : (1) Unit of Quantity : Crop yield - t/ha; Seed and fertilizer - kg/ha

(2) Unit values (Rs./kg) were as follows:

Item		Paddy	Chillie	Onion	G.Gram	L.Bean	Maize	Fertilizer		
								N	P2O5	K2O
Product	Financial	4.40	31.00	8.30	14.00	4.30	3.60			
	Economic	5.50	26.00	7.10	12.00	3.70	4.30			
Seed	Financial	4.40	199	1,300	26	79	20	6.50	6.50	4.80
	Economic	5.50	169	1,105	26	67	30	16.60	16.50	8.30

Refer to ANNEX-E.

Table 39 CROP BUDGET UNDER WITH-PROJECT CONDITION

(Unit: Rs./ha)

Crop	Item	Gross Income	Production Cost								Net Benefit
			Material					Draught/ Machinery Power	Labour	Total	
			Seed	Fertilizer			Agro-chemicals				
				N	P2O5	K2O					
Paddy											
Maha	Quantity	5.50	100	115	55	30					
	Financial	24,200	440	748	358	144	298	3,144	2,925	8,056	16,144
	Economic	30,250	550	1,909	908	249	256	2,672	2,835	9,379	20,872
Yala	Quantity	5.00	100	100	55	30					
	Financial	22,000	440	650	358	144	298	3,144	2,925	7,959	14,042
	Economic	27,500	550	1,660	908	249	253	2,672	2,835	9,127	18,374
Chilli	Quantity	1.90	1.85	150	100	100					
	Financial	58,900	368	975	650	480	4,131	761	3,690	11,055	47,845
	Economic	49,400	313	2,490	1,650	830	3,511	647	7,213	16,654	32,746
Bombay Onion	Quantity	15.00	8.50	104	108	92					
	Financial	124,500	11,050	676	702	442	1,868	2,678	6,480	23,896	100,604
	Economic	106,500	9,393	1,726	1,782	764	1,588	2,276	17,388	34,917	71,584
Green Gram	Quantity	1.50	20	25	60	60					
	Financial	21,000	520	163	390	288	1,955	354	1,845	5,515	15,486
	Economic	18,000	520	415	990	498	1,662	301	7,213	11,599	6,401
Long Bean	Quantity	8.00	41	28	199	74					
	Financial	34,400	3,239	182	1,294	355	523	0	4,275	9,868	24,532
	Economic	29,600	2,747	465	3,284	614	530	0	11,813	19,453	10,148
Maize	Quantity	3.50	20	75	85	40					
	Financial	12,600	400	488	553	192	1,882	1,294	675	5,483	7,117
	Economic	15,050	600	1,245	1,403	332	1,600	1,100	2,205	8,485	6,566
Cashew	Quantity	1.00	(0.225 ton/ha of kernels)								
	Financial	22,000	625	300	(Total of		100	490	1,800	3,315	18,685
	Economic	23,000	625	750	Fertilizer)		85	420	1,260	3,140	19,860

Remarks : (1) Unit of Quantity : Crop Yield - t/ha; Seed and fertilizer - kg/ha

(2) Unit values (Rs./kg) were as follows:

Item		Paddy	Chillie	Onion	G.Gram	L.Bean	Maize	Cachew	Fertilizer		
Product	Financial	4.40	31.00	8.30	14.00	4.30	3.60	22.00			
	Economic	5.50	26.00	7.10	12.00	3.70	4.30	23.00	N	P2O5	K2O
Seed	Financial	4.40	199	1,300	26	79	20	-	6.50	6.50	4.80
	Economic	5.50	169	1,105	26	67	30	-	16.60	16.50	8.30

Refer to ANNEX-E.

Table 40 AGRICULTURAL ECONOMIC BENEFIT BY SYSTEM

Item	F	H	IH	MH	I	M	NCRB	NWDZ	Total
I. Net Area (ha)	1,900	42,400	4,700	26,300	61,300	25,000	161,600	13,250	174,850
II. Without Project condition									
Net Benefit (Rs.10^6)									
Paddy	9.6	719.6	57.1	52.3	152.1	29.0	1,019.7	39.8	1,059.5
Chilli	1.7	178.2	6.7	6.2	13.3	2.4	208.5	1.3	209.8
Pulses	0.1	24.7	1.2	1.5	3.9	1.3	32.7	0.1	32.8
Maize	0.1	1.3	0.0	0.6	2.3	1.0	5.3	0.0	5.3
Others	0.1	0.0	0.0	0.3	2.7	0.4	3.5	0.1	3.6
Total	11.6	923.8	65.0	60.9	174.3	34.1	1,269.7	41.3	1,311.0
III. With Project Condition									
Net Benefit (Rs.10^6)									
Paddy	65.1	1,268.9	165.6	560.5	1,769.6	862.1	4,691.8	323.8	5,015.6
Chilli	3.3	363.5	16.4	56.7	127.7	65.5	633.1	22.9	656.0
Pulses	1.0	23.8	1.2	3.6	22.7	11.3	63.6	31.9	95.5
Maize	0.6	17.1	0.8	5.4	14.2	6.6	44.7	13.1	57.8
Onion	5.0	85.9	5.0	20.8	80.9	38.7	236.3	22.9	259.2
Cashew	0.0	0.0	0.0	198.6	198.6	0.0	397.2	0.0	397.2
Others	0.9	26.4	1.2	4.9	21.8	10.1	65.3	20.3	85.6
Total	75.9	1,785.6	190.2	850.5	2,235.5	994.3	6,132.0	434.9	6,566.9
IV. Incremental Benefit									
Paddy	55.5	549.3	108.5	508.2	1,617.5	833.1	3,672.1	284.0	3,956.1
Chillie	1.6	185.3	9.7	50.5	114.4	63.1	424.6	21.6	446.2
Pulses	0.9	(0.9)	0.0	2.1	18.8	10.0	30.9	31.8	62.7
Maize	0.5	15.8	0.8	4.8	11.9	5.6	39.4	13.1	52.5
Onion	5.0	85.9	5.0	20.8	80.9	38.7	236.3	22.9	259.2
Cashew	0.0	0.0	0.0	198.6	198.6	0.0	397.2	0.0	397.2
Others	0.8	26.4	1.2	4.6	19.1	9.7	61.8	20.2	82.0
Total									
(Rs.10^6)	64.3	861.8	125.2	789.6	2,061.2	960.2	4,862.3	393.6	5,255.9
(US$10^6)	2.0	26.5	3.9	24.3	63.4	29.5	149.6	12.1	161.7
V. Benefit per Unit Area									
(US$/ha)	1,041	625	820	924	1,035	1,182	926	914	925

Remark : *1 Raw nut basis

Refer to ANNEX-E.

Table 41 CALCULATION OF POWER BENEFIT

1) Alternative facility : Diesel generator or coal thermal
2) Capacity : 20 -30 MW class
3) Unit construction cost : US$480/kW
4) Service life : 20 years
5) Adjustment factor :

(Unit:%)

	Diesel	Coal Thermal	Hydro
Transmission loss	1.0	3.0	4.0
Forced outage	5.0	3.0	0.5
Auxiliary power use	2.0	7.0	0.5
Overhaul	18.0	15.0	1.0

- Capacity (kW) adjustment factor =

$$\frac{(1-0.04) \times (1-0.005) \times (1-0.005) \times (1-0.01)}{(1-0.01) \times (1-0.05) \times (1-0.02) \times (1-0.18)} = 1.2450$$

- Energy (kWh) adjustment factor for diesel =

$$\frac{(1-0.04) \times (1-0.005)}{(1-0.01) \times (1-0.05)} = 1.0156$$

- Energy (kWh) adjustment factor for coal thermal =

$$\frac{(1-0.04) \times (1-0.005)}{(1-0.03) \times (1-0.03)} = 1.0152$$

6) Capacity value

Discount rate : 10%
Annual capitalized cost:
US$480/kW x ($1+0.12^{*1}$) x 1.245 x 0.1175 = US$78.7/kW
*1: Ratio of replacement cost
Annual O&M cost:
US$480/kW x 0.03 = US$14.4/kW
Total annual cost (kW value):
US$(78.64+14.40)/kW = US$93.1/kW

7) Firm energy value

Fuel Cost *1	:	US$0.275/kg
Caloric value	:	10,800 kcal/kg
Plant efficiency	:	34.0%
Heat rate	:	2,529 kcal/kWh
Energy value	:	US$0.0644/kWh
O&M value	:	US$0.0020/kWh
Net energy value	:	US$0.0664/kWh
Adjusted energy value	:	US$0.0664/kWh x 1.0156 = US$0.0674

Remarks:*1: Fuel cost in 2000 at 1987 constant price recommended by ADB

8) Secondary energy value

Fuel cost	:	US$0.048/kg
Caloric value	:	5,300 kcal/kWh
Plant efficiency	:	27.0%
Heat rate	:	3,185 kcal/kWh
Energy value	:	US$0.0288/kWh
O&M value	:	US$0.0006/kWh
Net energy value	:	US$0.0294/kWh
Adjusted energy Value	:	US$0.0294/kWh x 1.0152 = US$0.0298/kWh

Refer to ANNEX-G.

Table 42 ESTIMATE OF POWER BENEFIT BY SCHEME

Scheme	Dependable P. Power		Firm		Secondary		Total
	Peak Power (MW)	Benefit (US10^3)	Energy (GWh)	Benefit (US10^3)	Energy (GWh)	Benefit (US10^3)	Benefit (US10^3)
1. Watawala	15.9	1,480	31	2,090	18	540	4,110
2. Ulapane	40.6	3,780	75	5,060	16	480	9,320
3. Caledonia	44.0	4,090	70	4,720	65	1,940	10,750
4. Talawakele	204.0	18,980	364	24,530	310	9,240	52,750
5. Kotmale Extension	39.0	3,630	209	14,090	-150	-4,470	13,250
6. Upper Uma Oya (Scheme-1000)	128.9	11,990	201	13,550	141	4,200	29,740
7. Lower Uma Oya (Scheme 500)	96.0	8,930	192	12,940	118	3,520	25,390
8. Wewatenna	19.7	1,830	36	2,430	33	980	5,240
9. Sudu Ganga	23.8	2,210	74	4,990	48	1,430	8,630

Remark: * shows only incremental values.
Refer to ANNEX-G.

Table 43 ESTIMATE OF INCREMENTAL BENEFIT BY SCHEME

Scheme	95% Dependable Discharge (m3/s)	Firm Discharge After Regulation (m3/s)	Incremental Firm Discharge (m3/s)	Total Net Head m	Incremental Firm Energy (10^3 GWh)	Incremental Benefit (US10^3)
1. Watawala	0.5	2.3	1.8	415	37.5	1,410
2. Ulapane	1.7	9.5	7.8	306	119.9	4,510
3. Caledonia	1.7	6.7	5.0	507	127.3	4,790
4. Talawakele	-	-	-	-	-	-
5. Kotmale Extension	29.8	16.8	13.0	300	203.6	7,660
6. Upper Uma Oya	-	4.9	7.9	78	30.9	2,080 <1
(Scheme -1000)	-	1.5	1.5	38	4.4	130 <2
						2,210 <3
7. Lower Uma Oya	-	1.2	1.2	78	7.2	490 <1
(Scheme -500)	-	3.0	3.0	38	8.8	260 <2
						750 <3
8. Wewatenna	-	-	-	-	-	-
9. Sudu Ganga	1.8	4.1	2.3	110	19.5	730

Remarks: <1 Incremental benefit for Randenigala
<2 Incremental benefit for Rantembe
<3 Total incremental benefit

Refer to ANNEX-G.

Table 44 COMPARISON OF TRANSBASIN CONVEYANCE SYSTEMS

	Unit	Alternative Plan A145	Alternative Plan B151	Alternative Plan C145	Present Condition D109
A. Principal Features					
1. Combination of Irrigation Area		AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP - -
2. Irrigation Area					
- AMDP Area	ha	200,300	200,300	200,300	200,300
- New Irrigation Area	ha	103,450	103,450	103,450	-
- Cashew Area (Non-irigated)	ha	20,000	20,000	20,000	-
Total	ha	323,750	323,750	323,750	200,300
3. Pump Station					
- Pumping Volume	MCM	761	1,515	896	-
- Energy Consumption	GWh	146	498	219	-
4. Average Water Deficit	%	6	7	6	4
5. Energy Output					
- Existing Power Station	GWh	2,138	2,020	2,017	2,264
- Proposed Power Station	GWh	1,808	1,824	1,824	-
- Total	GWh	3,946	3,844	3,841	2,264
B. Economic Comparison					
1. Total Irrigation Area	ha	323,750	323,750	323,750	200,300
2. Annual Benefits					
- Agricultural Benefit	US$10^6	161.7	161.7	161.7	-
- Loss of Energy Output	US$10^6	-6.1	-11.9	-12.0	-
Total	US$10^6	155.6	149.8	149.7	-
3. Annual Costs					
- Annual Equivalent Cost*	US$10^6	116.0	133.3	126.0	-
- O&M Costs	US$10^6	12.5	18.8	14.4	-
- Energy Costs for Pump	US$10^6	7.1	24.2	10.6	-
Total	US$10^6	135.6	176.2	151.1	-
4. Economic Comparison					
- B/C		1.15	0.85	0.99	-
- B-C	US$10^6	20.0	-26.4	-1.4	-

Remarks: * A discount rate of 8% was applied.
No consideration was given to the implementation schedule and the built-up period of the scheme.

Refer to ANNEX-H.

Table 45 SCREENING OF AGRICULTURAL DEVELOPMENT PLAN

Item	Unit	Present Policy 875 MCM		Alternative Policy 1,280 MCM	
		A118	A145	A209	A242
A. Principal Features					
1. Combination of Irrigation Area		AMDP NCRB -	AMDP NCRB NWDZ	AMDP NCRB -	AMDP NCRB NWDZ
2. Irrigation Area					
- AMDP area	ha	200,300	200,300	200,300	200,300
- New Irrigation area	ha	90,200	103,450	90,200	103,450
- Cashew Area (Non-irrigated)	ha	20,000	20,000	20,000	20,000
Total	ha	310,500	323,750	310,500	323,750
3. Pump Station					
- Pumping volume	MCM	653	761	360	435
- Energy consumption	GWh	125	146	70	84
4. Average Water Deficit	%	6	7	7	7
5. Energy Output					
- Existing hydropower	GWh	2,221	2,138	1,967	1,998
- Proposed hydropower	GWh	1,818	1,808	1,886	1,868
Total	GWh	4,039	3,946	3,833	3,866
B. Economic Comparison					
1. Total Irrigation Area	ha	310,500	323,750	310,500	323,750
2. Annual Benefit					
- Agricultural benefit	US$10^6	149.6	161.7	149.6	161.7
- Loss due to water deficit	US$10^6	-	-0.9	-1.5	-1.4
- Loss of energy	US$10^6	-2.1	-6.1	-14.4	-12.9
Total	US$10^6	147.5	154.7	133.7	147.4
3. Annual Costs					
- Annual equivalent cost*	US$10^6	104.8	116.0	100.3	111.2
- Energy cost for pump	US$10^6	6.1	7.1	3.4	4.1
- O&M costs	US$10^6	11.2	12.5	9.6	11.0
Total	US$10^6	122.1	135.6	113.3	126.3
4. Economic Comparison					
- B/C		1.21	1.14	1.18	1.17
- B-C	US$10^6	25.4	19.1	20.4	21.1

Remarks: * A discount rate of 8% was adopted.
No consideration was given to the implementation schedule and the built-up period of the schemes.

Refer to ANNEX-H.

Table 46 EVALUATION IN THE TRANSBASIN DIVERSION STUDY (TDS)

		Total Net Benefits (10^6 Rs.)	Capital Cost* (10^6 Rs.)	Energy Lost or Consumed (GWh/year)
1.	SEDZ alone (40,000 ha)	+ 121	3,727	-
2.	NWDZ alone (32,200 ha)	- 225	1,260	72
3.	NCRB, System M only, UNDP/FAO solution (54,200 ha)	- 489	6,430	17
4.	NCRB, Systems I1 & M JVMTDS solution (62,500 ha)	- 604	6,411	126
5.	NCRB, Systems I, M & L1, JVMTDS solution (112,800 ha)	- 941	9,250	440
6.	Full NCRB area, NEDECO solution (195,800 ha)	- 1,585	18,244	1,395

Remarks: * Capital costs for conveyance systems only.

Source: Ref. 27, Table 6.1, Main Report.

Table 47 ECONOMIC COST AND BENEFIT, AND EIRR OF HYDROPOWER SCHEMES

Scheme	Economic Cost (US$10^6)			Benefit (US$10^6)	EIRR (%)	Ranking
	Economic Investment Cost	O&M	Replacement			
1. Watawala	42.8	0.45	10.5	5.52	9.8	4
2. Ulapane	112.0	1.01	21.0	13.83	9.6	5
3. Caledonia	98.3	1.19	14.5	15.54	11.9	2
4. Talawakele	260.7	2.08	43.6	52.75	15.1	1
5. Kotmale, Extension	232.7	1.86	5.9	20.91	7.0	8
6. Upper Uma Oya (Scheme-1000)	240.0	1.92	43.3	31.85	10.3	3
7. Lower Uma Oya (Scheme-500)	220.5	1.76	46.0	26.14	9.2	6
8. Sudu Ganga	80.8	1.05	25.6	9.36	8.6	7

Refer to ANNEX-L.

Table 48 BENEFICIAL AREA AND INVESTMENT COST BY STAGEWISE DEVELOPMENT PLAN

Package Component	System Project Scheme	Area (ha)	Investiment Cost (US$10^6)
Package 1			
1. Joint Facility	- Kalu Ganga dam	-	142.4
	- NCP canal (Kalu Ganga -> Huruluwewa)	-	197.1
	(Sub-total)	-	(339.5)
2. New Area	- System F	1,900	7.7
	- Huruluwewa Extension (System MH)	12,000	61.2
	- Cashew land (System MH, Rainfed)	10,000	4.1
	- Yan Oya (System M)	10,000	51.1
	(Tank)	-	72.5
	(Sub-total)	(33,900)	(196.6)
3. Rehabilitation	- System H (1/2)	21,200	5.9
	- Huruluwewa (System MH)	4,300	1.2
	(Sub-total)	(25,500)	(7.1)
	Total	59,400	543.2
Package 2			
1. Joint Facility	- NCP canal (Huruluwewa -> Mahakandarama)	-	23.8
	- Minipe LB canal	-	147.7
	(Sub-total)	-	(171.5)
2. New Area	- Maluwatu Oya (System I)	3,600	29.9
	(Tank)	-	37.7
	- Mahakandarama Extension (System I)	8,000	46.6
	- Holowupotanna (System M)	15,000	72.2
	(Tank)	-	67.1
	(Sub-total)	(26,600)	(253.5)
3. Rehabilitation	- System H (1/2)	21,200	5.9
	- System IH	4,700	1.3
	- Mahakandarama (System I)	2,800	0.8
	- Maluwatu Oya (System I)	9,900	2.8
	(Sub-total)	(38,600)	(10.8)
	Total	65,200	435.8
Package 3			
1. Joint Facility	- NCP canal (Mahakandarama -> Tammannewa)	-	23.8
	- Minneriya pump station	-	143.0
	(Sub-total)	-	(166.8)
2. New Area	- Tammannewa (System I)	27,000	155.1
	(Tank)	-	47.0
	- Cashew land (System I, Rainfed)	10,000	4.1
	(Sub-total)	(37,000)	(206.2)
	Total	37,000	373.0
	Grand Total	161,600	1,352.0

Refer to ANNEX-L.

Table 49 ECONOMIC COST BY STAGEWISE DEVELOPMENT PLAN

Project Scheme		Area (ha)	Economic Cost (US$10^6) Development Cost	Allocated Cost	Total
A. Joint Facility					
1. Kalu Ganga Dam					133.5
2. NCP (Kalu Ganga - Elahera) Canal					30.0
3. NCP (Elahera - Tammannewa) Canal					203.3
4. Minipe LB Canal					140.3
5. Minneriya Pump Station					140.4
Total					647.5
B. Irrigation Scheme					
I. Package-1					
1. System F	Irrigation	1,900	7.2	-	7.2
2. System H (1/2)	Rehabilitation	21,200	5.6	-	5.6
3. Huruluwewa (System MH)	Rehabilitation	4,300	1.1	-	1.1
4. Huruluwewa Extension (System MH)	Irrigation	12,000	58.0	-	58.0
5. Yan Oya (System M)	Tank &		68.0	-	68.0
	Irrigation	10,000	48.3	-	48.3
6. Cashew Land (System MH)	Rainfed	10,000	3.9	-	3.9
Total		59,400	192.1	219.0	411.1
II. Package-2					
1. System H (1/2)	Rehabilitation	21,200	5.6	-	5.6
2. System IH	Rehabilitation	4,700	1.3	-	1.3
3. Maluwatu Oya (System I)	Tank &		35.9	-	35.9
	Irrigation	13,500	29.1	-	29.1
4. Mahakandarama (System I)	Rehabilitation	2,800	0.7	-	0.7
5. Mahakandarama Extension (System I)	Irrigation	8,000	44.1	-	44.1
6. Holowupotanna (System M)	Tank &		62.8	-	62.8
	Irrigation	15,000	68.4	-	68.4
Total		65,200	247.9	259.9	507.8
III. Package-3					
1. Tammannewa (System I)	Tank &		43.2	-	43.2
	Irrigation	27,000	148.8	-	148.8
2. Cashew Land (System I)	Rainfed	10,000	3.9	-	3.9
Total		37,000	195.9	168.6	364.5
GRAND TOTAL		161,600	635.9	647.5	1,283.4

Table 50 ECONOMIC BENEFIT BY STAGEWISE DEVELOPMENT PLAN

Project Scheme	Economic Benefit (US$10^6)										
	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
I. Package-1											
1. System F	0.0	0.0	0.7	1.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2. System H (1/2)	0.0	0.0	4.4	8.8	13.3	13.3	13.3	13.3	13.3	13.3	13.3
3. Huruluwewa *1 (System MH)	0.0	0.0	1.2	2.6	4.2	5.2	6.4	7.7	8.7	9.2	9.6
4. Huruluwewa Ex. (System MH)	0.1	0.2	4.1	9.7	13.8	14.1	14.4	14.7	14.8	14.8	14.8
5. Yan Oya (M) (System M)	0.0	0.1	3.3	7.5	10.8	11.0	11.2	11.3	11.3	11.3	11.3
Total	0.1	0.3	13.6	29.9	44.0	45.6	47.2	48.9	50.0	50.6	50.9
II. Package-2											
System H (1/2)	0.0	0.0	4.4	8.8	13.3	13.3	13.3	13.3	13.3	13.3	13.3
System IH	0.0	0.0	1.3	2.6	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Maluwatu Oya (System I)	0.0	0.0	4.2	8.5	12.7	12.7	12.7	12.7	12.7	12.7	12.7
Mahakandarama (System I)	0.0	0.0	4.0	8.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Holowupotanna (System M)	0.2	0.4	4.4	12.0	16.5	17.2	17.8	18.3	18.5	18.5	18.5
Total	0.2	0.4	18.4	40.0	58.4	59.2	59.8	60.2	60.4	60.4	60.4
III. Package-3											
Tammannewa *1 (System I)	0.1	0.2	10.0	22.1	32.7	34.1	35.6	37.2	38.3	38.8	39.2
Total	0.1	0.2	10.0	22.1	32.7	34.1	35.6	37.2	38.3	38.8	39.2

Remark: *1 Including cashew benefit

Table 51 ECONOMIC COST AND BENEFIT STREAM OF AGRICULTURAL PROJECT
PACKAGE 1 (1/4)

EIRR : 9.3% (Unit : US$10^6)

Year	Cost				Benefit	Balance
	Construction	O&M	Replacement	Total		
1	20.6	-	-	20.6	0.0	-20.6
2	41.1	-	-	41.1	0.0	-41.1
3	82.2	-	-	82.2	0.1	-82.1
4	123.3	-	-	123.3	0.3	-123.0
5	143.9	-	-	143.9	13.6	-130.3
6	-	5.7	-	5.7	29.9	24.2
7	-	5.7	-	5.7	44.0	38.3
8	-	5.7	-	5.7	45.6	39.8
9	-	5.7	-	5.7	47.2	41.5
10	-	5.7	-	5.7	48.9	43.1
11	-	5.7	-	5.7	50.0	44.3
12	-	5.7	-	5.7	50.6	44.8
13	-	5.7	-	5.7	50.9	45.2
14	-	5.7	-	5.7	50.9	45.2
:	:	:	:	:	:	:
:	:	:	:	:	:	:
34	-	5.7	-	5.7	50.9	45.2
35	-	5.7	38.8	44.5	50.9	6.4
36	-	5.7	-	5.7	50.9	45.2
:	:	:	:	:	:	:
:	:	:	:	:	:	:
54	-	5.7	-	5.7	50.9	45.2
55	-	5.7	-	5.7	50.9	45.2

Refer to ANNEX-L.

Table 51 ECONOMIC COST AND BENEFIT STREAM OF AGRICULTURAL PROJECT
PACKAGE 2 (2/4)

EIRR : 9.2% (Unit : US$10^6)

Year	Cost				Benefit	Balance
	Construction	O&M	Replacement	Total		
1	25.4	-	-	25.4	0.00	-25.4
2	50.8	-	-	50.8	0.00	-50.8
3	101.6	-	-	101.6	0.18	-101.4
4	152.3	-	-	152.3	0.39	-151.9
5	177.7	-	-	177.7	18.40	-159.3
6	-	6.9	-	6.9	40.02	33.1
7	-	6.9	-	6.9	58.43	51.5
8	-	6.9	-	6.9	59.17	52.3
9	-	6.9	-	6.9	59.77	52.9
10	-	6.9	-	6.9	60.21	53.3
11	-	6.9	-	6.9	60.43	53.5
12	-	6.9	-	6.9	60.43	53.5
13	-	6.9	-	6.9	60.43	53.5
14	-	6.9	-	6.9	60.43	53.5
:	:	:	:	:	:	:
:	:	:	:	:	:	:
34	-	6.9	-	6.9	60.43	53.5
35	-	6.9	54.3	61.2	60.43	-0.8
36	-	6.9	-	6.9	60.43	53.5
:	:	:	:	:	:	:
:	:	:	:	:	:	:
54	-	6.9	-	6.9	60.43	53.5
55	-	6.9	-	6.9	60.43	53.5

Refer to ANNEX-L.

Table 51 ECONOMIC COST AND BENEFIT STREAM OF AGRICULTURAL PROJECT
PACKAGE 3 (3/4)

EIRR : 8.0% (Unit : US$10^6)

Year	Cost				Benefit	Balance
	Construction	O&M	Replacement	Total		
1	18.2	-	-	18.2	0.0	-18.2
2	36.5	-	-	36.5	0.0	-36.5
3	72.9	-	-	72.9	0.1	-109.4
4	109.4	-	-	109.4	0.2	-127.6
5	127.6	-	-	127.6	10.0	-117.6
6	-	4.8	-	4.8	22.1	17.4
7	-	4.8	-	4.8	32.7	27.9
8	-	4.8	-	4.8	34.1	29.3
9	-	4.8	-	4.8	35.6	30.9
10	-	4.8	-	4.8	37.2	32.4
11	-	4.8	-	4.8	38.3	33.5
12	-	4.8	-	4.8	38.8	34.1
13	-	4.8	-	4.8	39.2	34.4
14	-	4.8	-	4.8	39.2	34.4
:	:	:	:	:	:	:
:	:	:	:	:	:	:
34	-	4.8	-	4.8	39.2	34.4
35	-	4.8	23.6	28.4	39.2	10.8
36	-	4.8	-	4.8	39.2	34.4
:	:	:	:	:	:	:
:	:	:	:	:	:	:
54	-	4.8	-	4.8	39.2	34.4
55	-	4.8	-	4.8	39.2	34.4

Refer to ANNEX-L.

Table 51 ECONOMIC COST AND BENEFIT STREAM OF AGRICULTURAL PROJECT: WHOLE PACKAGES (4/4)

EIRR : 8.9% (Unit : US$10^6)

Year	Cost				Benefit				Balance
	Construction	O&M	Replacement	Total	Package-1	Package-2	Package-3	Total	
1	25.7	0.0	0.0	25.7	0.0	-	-	0.0	-25.7
2	51.4	0.0	0.0	51.4	0.0	-	-	0.0	-51.4
3	102.8	0.0	0.0	102.8	0.1	-	-	0.1	-102.7
4	154.1	0.0	0.0	154.1	0.3	-	-	0.3	-153.8
5	179.8	0.0	0.0	179.8	13.6	-	-	13.6	-166.2
6	0.0	3.3	0.0	3.3	29.9	-	-	29.9	26.6
7	20.5	3.3	0.0	23.8	44.0	0.0	-	44.0	20.2
8	41.1	3.3	0.0	44.4	45.6	0.0	-	45.6	1.2
9	82.1	3.3	0.0	85.4	47.2	0.2	-	47.4	-38.0
10	123.2	3.3	0.0	126.5	48.9	0.4	-	49.2	-77.3
11	143.7	3.3	0.0	147.0	50.0	18.4	-	68.4	-78.6
12	0.0	6.1	0.0	6.1	50.6	40.0	-	90.6	84.5
13	17.9	6.1	0.0	24.0	50.9	58.4	0.0	109.4	85.4
14	35.9	6.1	0.0	42.0	50.9	59.2	0.0	110.1	68.1
15	71.8	6.1	0.0	77.9	50.9	59.8	0.1	110.8	32.9
16	107.6	6.1	0.0	113.7	50.9	60.2	0.2	111.4	-2.3
17	125.6	6.1	0.0	131.7	50.9	60.4	10.0	121.4	-10.3
18	0.0	17.3	0.0	17.3	50.9	60.4	22.1	133.5	116.2
19	0.0	17.3	0.0	17.3	50.9	60.4	32.7	144.0	126.7
:	:	:	:	:	:	:	:	:	:
34	0.0	17.3	0.0	17.3	50.9	60.4	32.7	144.0	126.7
35	0.0	17.3	23.0	40.3	50.9	60.4	39.2	150.5	110.2
36	0.0	17.3	0.0	17.3	50.9	60.4	32.7	144.0	126.7
:	:	:	:	:	:	:	:	:	:
40	0.0	17.3	0.0	17.3	50.9	60.4	32.7	144.0	126.7
41	0.0	17.3	28.8	46.1	50.9	60.4	39.2	150.5	104.4
42	0.0	17.3	0.0	17.3	50.9	60.4	39.2	150.5	133.2
:	:	:	:	:	:	:	:	:	:
46	0.0	17.3	0.0	17.3	50.9	60.4	39.2	150.5	133.2
47	0.0	17.3	64.9	82.2	50.9	60.4	39.2	150.5	68.3
48	0.0	17.3	0.0	17.3	50.9	60.4	39.2	150.5	133.2
:	:	:	:	:	:	:	:	:	:
65	0.0	17.3	0.0	17.3	50.9	60.4	39.2	150.5	133.2

Refer to ANNEX-L.