Chapter V: AGRICULTURAL DEVELOPMENT PLAN

5.1 BROAD OUTLINE OF AGRICULTURAL DEVELOPMENT STRATEGY

Development strategy needs to be based on a critical analysis of the current bottlenecks, contradictions and controversies being faced by the farmers in Systems D_1 and D_2. The main features of such contradictions and controversies have been described in the preceding Chapter, especially in Sections 4.5, 4.6 and 4.7.

In this Section, the basic strategy for agricultural development in the existing fields will be discussed, first, in regard to technical aspects of (i) water management aimed at water conservation, (ii) cultural practices of paddy, particularly transplanting, weeding and fertilizer-application, (iii) post-harvet activities, and (iv) crop cultivation other than paddy and, then, some proposals will be made for a change of farmers' attitude, reformation of institutional framework and diversification of farmers' economic activities. This strategy will be applicable, by and large, for agricultural development of the newly reclaimable lands. Detailed development tactics will be discussed under the following chapter.

5.1.1 Water Control & Management

It has been observed in all the existing colonies that the irrigation/drainage facilities are left in most unsatisfactory conditions and this makes proper water control by the officers concerned (Irrigation Engineers, Technical Assistants and Overseers) extremely difficult. This is also the cause for a lack of enthusiasm and joint-effort among the cultivating farmers for water management along the distributory canals and their own field channels; this also provides temptations for various kinds of illicit water-use by them. For the success of Moragahakanda downstream development, therefore, the infrastructure for water control and management needs to be improved as the first and foremost item of project implementation.

The scope and extent of improvement work of the irrigation/drainage facilities is a policy matter to be decided by the Government of Sri Lanka. However, the Team's opinion is that it should cover those not only in the 'acreage under specification' but also in the 'acreage under unauthorized cultivation.' One condition is that the illicit cultivation in the drainage canals should be stopped once for ever. Upon completion of the improvement work of irrigation/drainage facilities, rotational irrigation will become more precisely possible when and where it is required, and water control and management will become the order of the day through joint-effort of the officers concerned and the farmers themselves.

5.1.2 Water Savings by Shortening Land Preparation Period

As has been observed in the preceding Chapter, land preparation (ploughing, puddling and levelling) of paddyfield takes more than three months and not within one to one-half months as generally committed in the Water Meetings held before water-issue. The main reasons for this delay are: (i) uneven deployment of the means of land preparation, such as buffaloes and tractors, and (ii) unavailability of land preparation fund in good time. All through these three months, the irrigation water is kept flowing into the distribution canals and thence to paddyfields irrespective of whether they are being put under land preparation or not. This is a wasteful water-use method as a large amount of water runs into drainage cannals without being meaningfully used for land preparation. The water thus flowing into the drainage canals is seldomly utilized for irrigation purposes in their downstream areas.

It is, therefore, proposed to adopt organizational approach to solve this problem. The owners of draft animals will be organized into the 'Draft Animal Owners' Association' and the owners of the private tractors, the 'Private Tractor Owners' Association.' The former will agree to make the draft animals under its control available for joint land preparation (and threshing) campaigns to be worked out and taken lead of by the project officers (in the initial fews years, but by the farmers organization leaders in the later stage). The latter will likewise make their tractors available for execution of the same land preparation (and threshing) campaigns, side by side with the draft animals. No objections serious enough to spoil the whole scheme are believed to crop up because 'Draft Animal Owners' Association' will be given top priority in distribution of animal feed and the Government's assurance of full veterinary care for their animals, while the 'Private Tractor Owners' Association' will enjoy the priority supply of parts and spare parts of their machinery as well as their fuel and lubricant and timely maintenance services by the project's mechanics.

Land preparation will be started in the upper-most region of the paddyfield and then gradually and orderly come down towards the downmost region in a manner which may be likened to "carpet bombing", that is, lengthwise and breadthwise, leaving no patch of paddyfield unturned, within the region concerned, by joint use of the draft animals and private tractors made available by their owners' Associations. Water supply will be confined only to the region under immediate, joint land preparation, although tank water has to be flown down along the main canal to the next colony existing in the downstream. Upon completion of the upper-most region, the similar joint land preparation will take place in the upper part and then middle part, and finally in the downstream of the colony's paddyfields. The same procedures will be repeated in other colonies at the foot of the tanks and their downstream colonies, too.

This will help serve two to three purposes at a stroke. The first, enormous economization of irrigation water by stopping wasteful drainage; second, strict adherence to the intensive year-round cropping calendar for both Maha and Yala, avoiding any delay in cultivation in one season to affect that in the succeeding season and spoil the whole cropping pattern; third, simultaneous and even application of basal fertilizer during the joint puddling period which, when combined with common use of a same HYV, will encourage joint work in transplanting, weeding and top dressing among the neighbouring farmers. This last will not only help making the extension services less laborious and thinly-spread but much more aimful also; the input supply can be made more timely and universal, and plant protection more effective. Such will cumulatively result at much higher yield from the region of paddyfield jointly cultivated and, consequently, make the group of farmers more credit-worthy.

It is believed worthwhile to adopt this joint land preparation tactics in a few selected colonies before estimating the net requirement for additional draft animals and farm machinery in the entire existing fields. In the newly reclaimable lands, minimum required draft animals and farm machinery based on the joint land preparation (threshing and transport inclusive) would need to be introduced by the Project.

5.1.3 Nursery, Transplanting, Weeding and Top-dressing of Fertilizers

Seedlings of the paddy of the same HYV which will be most suitable to the soils and climatic conditions of the locality will be prepared in a number of common nurseries, and transplanted in low on the jointly prepared paddyfields which have been applied with basal fertilizer during puddling period. Transplantation will be a joint undertaking by the local young women. 1 1/2 months after transplanting, the first weeding will take place by using rotary weeder, to be followed by two to three weedings before paddy reaches brossoming stage. Top dressing of fertilizer will also be done jointly by the local youngmen's group. Since all the farmers in the region use the same variety of paddy, apply the same kind and amount of basal fertilizer and transplant the seedlings simultaneously, the timing of weeding and the frequencies, kinds and amounts of top-dressing can also be synchronized and jointly done. Thus supply of seeds and fertilizers can be pre-arranged and effected timely and evenly.

5.1.4 Harvesting, Threshing, Winnowing, Transportation and Storing

Harvesting, threshing and winnowing will have to be done on individual basis, but farmers can expect for timely provision of buffaloe- and tractor-services for the purpose from their 'Owners' Associations.' Winnowed paddy will be divided into two heaps on the kamatha, the one is for repayment of paddy cultivation loan and the other, for own consumption by the cultivators' households and later disposals for miscellaneous purposes. The former will be transported by the MPCS's tracks to its godown for outright purchase and the latter will be brought home by the cultivators themselves.

5.1.5 Crop Cultivation other than Paddy

Cultivation of a range of subsidiary food crops is proposed on the paddyfields during Yala. Besides, there are many kinds of crop other than paddy which can be successfully grown in the upland and on the slope during Maha, as well as post-Maha and pre-Yala season. Marketable unit above a certain limit and standardization of the products is essential for commercial cultivation of these crops. This would justify preparation of joint nursery, group transplanting and simultaneous fertilizing and spraying (of insecticides), similar to the case of paddy cultivation on the lowland.

When year-round irrigation of the entire Project area will become feasible in both the existing fields and the newly reclaimed lands, the foundation of optimal agricultural production will be prepared in physical terms. It is the perfection of agricultural supporting services, however, that will guarantee its success. In this connection, coordination and dovetailing of rural credit, input supply, extension, by the Government extension officers and the MPCS' farm guidance experts, marketing, and strengthening of farmer organization to such a level that it would function as an appropriate medium of the above-said farmer services, must be achieved by the initial period of project implementation. Under these circumstances, it would not be very difficult to attain the target yields by the sixth year in the existing fields and the eighth year in the newly reclaimed lands.

5.1.6 Mobilization of the Colonists' Youngsters to the Labour Front and Their Education and Training for Rural Leadership

Optimal agricultural production envisaged under the Project requires more intensive use of labour, draft animals and farm machinery, as well as additional supply of fertilizers and agro-chemicals. Leadership including organizational ability on the field and administrative skill and knowhow for management of institutional business in the office will be increasingly required not from outside but from amongst the rural people. The cultivation method currently adopted by the Project area farmers on individual basis is very much dependent on the hired labour so far available from outside. Since additional supply of draft animals and farm machinery has its own limit and the migrant labourers will be increasingly employed in various development projects in the Mahaweli basin, the farmers will not be in a position to follow the tightly worked out cropping calendar unless they find out another source of labour within their own locality, the labour which is not simply 'naked' but infused with the spirit of development and oriented to group action. There is no need for them to look for such far and wide as there is an enormous pool of idle, at least underemployed, manpower in the rural area in terms of younger generation, both male and female. Their mobilization to the labour front and institutional work is essential and, therefore, they need to be trained and educated from the project implementation point-of-view. This stands for the one vital element of the Moragahakanda Downstream Development Project and will be discussed in detail under Chapter VI: Farmers Services and Inflastructure.

5.1.7 Promotion of Farming Combined with Livestock Raising and Minimum Degree of Mechanization

The superficial expansion of farmland through reclamation of forest land and grassland robbed the cattles of their feedstuff, while use of nutrient by-products from sugar plantations, wheat mills, slaughter houses, etc. has never been seriously considered nor industrialized to provide them with substitute or additional feedstuff. As a result, cattle population in the country has dwindled down to one quarter within 5-6 years (aggravated by rampant 'cattle theft' in the Dry Zone). Consequently, land preparation, threshing and transport has been badly constrained and the lack of organic manures put back into the fields degenerated their soils with diminishing fertility. The Project is going to introduce a program to regenerate the soils and facilitate for cattle population increase and better health and, thereby, help execution of the agricultural production plan easier and more balanced, under the name of the "Livestock Development Program". Nevertheless, introduction of additional farm machinery will be indispensable to enable the farmers to adhere to the intensive cropping calendar being recommended under the Project. They include tractors, trailers, driers, polishers, vans, and their parts and spare-parts. Hence their kinds and number, their allocation among the existing fields and newly reclaimable lands, training program of their operators and mechanics towards the local youngmen, the types of their ownership, and other issues related to operation and maintenance of the farm machinery are discussed under the following Section 5.2, Irrigated Agriculture (5.2.5: Farm Mechanization).

5.1.8 Improvement of Farmer Services through Strengthening of Farmer Organization and Active Participation of Rural Youth in Such Movement

Optimal agricultural production is conditional to various combined factors, such as the reliable water supply on the fields, the timely and adequate provision of credit and input supplies, the farmers' own learning of scientific cultivation methods through the guidance given by the extension services, and marketing. Attainment of the target yields will be foiled if even one of them should fail. This is the reason why the joint farming method has been proposed in the above paragraphs as a shortest cut to arrive at the desired end. Again, these farmer services will not be as effective if they are spoon-fed by the Government to the farmers; the farmers must be encouraged to organize themselves to take best advantage of these services as a group and increasingly share responsibility of operation and maintenance of infrastructure, such as irrigation/drainage facilities, and common facilities like farm machinery, tractor stations, warehouses and godowns, etc. Initiative for such a movement is to be expected seldomly from the old generation but from amongst the educated and trained youngmen.

5.1.9 Democratization and Modernization of Socio-Economic Structure

In the preceding paragraphs, the measures which are believed to be essential for a rapid and an overall rural development have been enumerated, though far from exhaustive and only in a sketchy manner. For their actual implementation, however, there is a basic problem to be solved as pre-requisite. The problem is that of stratification of the colonists into three broad classes of the rich, average, and poor, as described in Section 4.6. The root cause of such socio-economic stratification having been analyzed in the same Section, it is most desirable that Project authority will take necessary measures for liquidation of rural indebtedness. The cultivation right of the land which was originally allocated to the colonist will have to be recovered by its legal holder through liquidation of their indebtedness which caused such alienation. MPCS would be an appropriate institution for this purpose. MPCS will be entrusted to pay off the debts of the colonists who have partly or wholly lost the cultivation rights of their own land by admitting them as its full members and extending long-term loan meant for their debt-liquidation. To allow them produce enough and let them pay back the loan in instalments for years, MPCS will provide appropriate financial, meterial and extension assistances. To deal with the defaulters, including those colonists who are badly handicapped to manage their own land and sooner or later liable to become indebted to the others and eventually lose their land, MPCS will enter into contract with the local youngmen's group with the concurrence of such defaulters and quasi-defaulters for cultivating the latters' land in lieu of its nominal holders. The youngmen's group will get full support of the MPCS in terms of rural credit, input supply, extension and marketing and will be paid for their services by the MPCS. The net proceeds will be retained for the livelihood of the land holders, as well as for repayment of their debts. In such and miscellaneous other ways and means, the MPCS is expected to function as a forerunner of village democratization and the local youngmen and women are its allies.

5.1.10 Diversification of Farmers' Economic Activities

Diversification of agricultural production is planned under the Project through expansion of the area under subsidiary food crops, particularly on the paddyfield during Yala season. To encourage such a tendency, it is desirable to improve GPS and marketing mechanism of subsidiary food crops. Apart from these, diversification of the farmers' economic activities will be planned for implementation under such programs as: (i) Rural Industry (manufacturing of solidified fuel stick out of paddy husks, to alleviate fuel shortage in the Dry Zone); (ii) fresh water fisheries (development of fresh water fisheries in the dam, tanks and main irrigation canals); (iii) livestock (encouragement to livestock breeding, dairy and poultry) and (iv) forestry. Their details will be presented in Section 5.3, Other Agricultural Activities.

5.2 Irrigated Agriculture

5.2.1 Possible Crops

In the Dry Zone - to which our Project Area belongs as a whole-where the annual rainfall, less than 75 inches per year, is heavily concentrated during wet weason, the basic problem for crop as well as animal husbandry is how to make water available during dry months. Soils which are made up mostly of Reddish Brown Earths(R.B.E.)and partly of LHG and alluvial, are suitable for crop production even though their physical or chemical conditions need to be improved through drainage or fertilizer application for obtaining optimal yields. There has been recognized no serious problem such as acidity or alkaline in the Project Area.

Botanical cropping potentials based on soil properties and climatic conditions combined with market prospects at present and in future, provide a range of crops out of which the cultivating farmers may make option. Paddy is a most suitable crop in the lowland area both in Maha and Yala seasons. Pulses including soyabeans, chillies and onions which are categorized as the subsidiary food crops also grow well. Vegetables are important crops as both the economical nutrients and the sources of additional cash incomes for farmers. Production of grains such as maize and sorghum in association with fodder crops of pastures - Brachiaria mutica (for example) - should be encouraged in order to develop animal husbandry on a sound basis so that it could increasingly supply the draught animal power for cultivation and the manures to be ploughed back to the fields for maintenance of their soil fertility. Cultivation of sugar-cane can be expanded in System A/D and in parts of System D1 and its production-increase is as important for self-sufficiency in the nation's food supply as that of paddy and dairy/livestock products.

Crops recommendable for the Project Area because of their botanical potentials and market prospects will be named as follows:

Kind of Crops	MAHA		YALA
Paddy (Transplanted)	4 - 4.5 month variety 3 - 3.5 " "	Irrigated	3 - 3.5 month variety
Paddy (Non-bunded)	3 - 3.5 month variety 4 - 4.5 " "	Rainfed	
Kurakkan	Rainfed		
Maize & Sorghum	"		
Manioc	"		Irrigated
Sweet Potato	"		"
Greengram, Cowpea & Blackgram			Irrigated and Rainfed
Soyabean	Rainfed		Irrigated
Groundnuts	"		"
Sesame (Gingely)			Rainfed
Cucurbits			Rainfed with supplementary irrigation
Red Onion (Seed onion)			Irrigated
Bombay Onion (Seed plant)			"
Chillies (dried)	Rainfed (Good care against wet damage)		"
Egg Plant			Irrigated
Capsicum			"
Greenbeans			"
Other Vegetables	Rainfed		Irrigated

Note: 1) Cotton & Tobacco: Irrigated cultivation during Yala is possible; much damage in Maha season;

2) Spring Onion: Grows fast (60 days); good for intensive rotational cropping system;

3) Grams Also grow fast (45-60 days varieties);

4) Sugarcane (Permanent): 3 years' rotation (replant) is recommendable.

5.2.2 Cropping Patterns

As discussed in 5.2.1: Possible Crops, the three factors, viz: (i) soils (RBE, LHG, alluvials and their drained conditions), (ii) cultivation season (Maha and Yala), and (iii) type of water supply (rainfed or irrigated) have been taken into consideration before arriving at optimal cropping patterns to be adopted in both the existing fields and the newly reclaimed lands. Consequently, a number of overall cropping patterns which would be applicable to the entire Project Area have been prepared as shown in Fig. 5-2-1.

Other Cropping Patterns:

1) Sugarcane - Kantalai Tank area is suitable for sugarcane production as a permanent crop. Its by-products such as sugarcane tops and molasses are useful as animal feeds. Three years' rotation system is given in Fig. 5-2-2.

    1 st year - New planting
    2nd & 3rd years - Ratoon
    4th year - New planting

2) Upland - Upland rice, pulses, chillies, soyabeans, vegetables, maize, sorghum, manioc, sesame, etc. can be grown under rainfed conditions or supplementary irrigation method (lift irrigation inclusive). Every effort should be made to turn the upland not suitable for crop production into pasture land with Brachiarias and some other improved grasses to encourage animal husbandry. Maize/sorghum - Groundnuts - Vegetable is one of the typical cropping patterns for upland agriculture associated with livestock. (Fig. 5-2-2).

3) Tobacco and Cotton - can be introduced in some limited areas.

Year-round cropping patterns in the existing fields as assumed without Project and proposed under the Project are shown in Table 5-2-1 and those proposed for the new lands, on Table 5-2-2.

5.2.3 Productive Inputs

In determining kinds and quanta of the productive inputs under the Project, the given natural conditions such as topography, climate, soils and cropping seasons have been taken note of side by side with the problems related to the availability of water, the level of farmers' cultivation techniques, the provision of farm equipments, the timeliness and adequacy of input supply under the present circumstances and in the Project future. To raise the current unit production of various crops to the target yields, physical productive inputs like the certified seeds, chemical fertilizers and organic manures, and agro-chemicals (insecticides, fungicides and weedicides) as well as human labour, draught animal power (mainly buffaloes), agricultural machineries(2-wheel and 4-wheel tractors, threshers, rice mills, sprayers and others) should be made available on the farm without delay in accordance with the specific cropping calendars. Otherwise, the improved high yielding varieties of each crop cannot attain their optimal production potentials. The estimated quanta with prices (financial and economic) of the productive inputs involved for planned agricultural production under the Project are summarized in 'Agricultural Inputs' in the Annex VII.

At present, most of the tractors, chemical fertilizers and agro-chemicals are being imported. According to our study, these three productive inputs, if put together, occupy more than 50 per cent of the total production costs (see Annex). Most likely, their costs would be increasing in near future under the pressure of the second oil crisis, and it is imperative to find some alternative ways and means to decrease farmers' dependence on these critical items. Hence the increased supply of organic manures and draught animal power through development of animal husbandry is proposed under the Project. The use of agro-chemicals can also be economized by increasing the plants' resistance to pests and diseases through supply of deficit nutrients.

From these viewpoints of the foreign exchange savings and the maximum use of domestic resources, the following countermeasures are being proposed to deal with the problems regarding chemical fertilizers and agro-chemicals:

(1) More Input of Organic Manures

By organic manures, we mean cattle manure, chicken droppings, cattle urine and composts. It is quite useful to apply 10 tons/ha, especially in case of cultivating chillies, onions, vegetables, maize and other upland crops, because it is recongnized that these organic manures not only supply valuable nutrients like N, P, K and others but also keep soil fertility both in physical and chemical conditions. It has been empirically proved that crop yield will decline through continuous application of chemical fertilizers.

(2) Plants' Resistance to Pests and Diseases

Taking paddy, for instance, application of potassium will help increase the paddy's resistance to pests and diseases. Similarly, crop resistance to pests and diseases can be increased by appropriate replenishment of deficit nutrients in other cases, too. Breeding of new disease resistant variety of each crop should be emphasized.

The problems concerning agricultural machinery would be discussed under 5.2.5. Farm Mechanization.

(3) Total requirements of productive inputs with project is given in the items of Production costs, Labor requirements, Farm mechanizations, Productive inputs in the Annex VII .

5.2.4 Labour Requirements

(1) Background of Labour Problem

Agricultural products are fruits of sweat of farmers; manpower is the basic element of agriculture. Buffaloes and machineries are essentially the aids for human labour. Under the future agricultural development plan, more yield per hectare is expected with each and every crop in return for more inputs including manpower. Farm management requires an assembly of various fields of science and technology which would make input of human labour the more rewarding. At the same time, farm management based on human labour, both mental and manual, needs to be supported by such services as rural credit, input supply, extension, marketing, etc. which would be provided in an integrated manner through relevant agricultural infrastructure. Social amenities including housing, health, education and other community services are also essential for reproduction of human labour.

(2) Average Labour Requirements for Different Cultural Practices

Labour requirements for cultivation of paddy and other crops will be stipulated as follows:

Paddy:

Plowing with mammoty	0.5 acre/day/6 men
Hand tillage of wet land	12 - 15 labour days/ac
Plowing by Baffaloes pair	0.25 ac/day
" (good pair)	0.5 ac/day
Broadcasting seed	approx. 1 labour day/ac
Transplanting	approx. 8 - 10 labour days/ac
Manual weeding	approx. 8 - 10 labour days/ac
Spraying	1 labour day/ac
Water-management	10 - 13 labour days/ac
Top dressing (fertilizer)	1 labour day/ac
Harvesting and processing	approx. 10 - 12 labour days/ac

Other crops:

Hand tillage dry land	approx. 20 labour days/ac
Mammoty weeding	6 - 8 labour days/ac
Manual weeding	10 - 12 labour days/ac
Digging pits (3' x 3')	6 - 8 per labour day
Harvesting & processing (Pulses)	approx. 20 labour days/ac

(3) Labour Requirements

Labour requirements of each crop have been estimated by various agencies as follows:

Labour Requirements (man days/ha)

Crop (Season)	British Victoria Report (1978)	Sogreah (1972)	HTS (1978)	NEDECO (1978)	IBRD (1977)	JICA's F/S Team Estimates (1978)
Sugar Cane	193	-	193	192	- 2/	200
Wetland rice(M)	205	91 1/	205	230	151	190
Wetland rice(Y)	208	91 1/	208	232.5	151	185
Soyabeans(Y)	147	69	147	146.5	89	135
Ground nuts(Y)	138	82	138	137.5	89	133
Cowpeal grams(Y)	118	69	118	117.5	82	115
Maize(Y)	145	49	145	145	111	148
Sorghum(Y)	145	49	145	145	111	148
Chillie(Y)	290	336	290	290	341	328
Red onions(Y)	360	385	360	360	-	328
Bombey onions(Y)	380	497	380	380	-	380
Vegetables(Y)	243	-	243	242.5	235	245

1/: 130 days broadcast in mud 2/: appraisal on Feb. 1977

M : Maha

Y : Yala

JICA's F/S Team has taken into account the growth period of each crop involved in the proposed typical cropping patterns as follows:

Pattern A:	Paddy	135 days (Maha)
	Paddy	105 days (Yala)
	Total	240 days/year
Pattern B-1:	Paddy	135 days (Maha)
	Chillie	150 days (Yala)
	Total	285 days/year
Pattern B-2:	Paddy	105 days (Maha)
	Soyabean	105 days (Yala)
	Vegetables	60 days
	Total	270 days/year

Pattern B-3:	Paddy	135 days (Maha)
	Pulses	75 days (Yala)
	Vegetables	60 days
	Total	270 days/year

(4) Labour Availability

The FAO "Master Plan" assumed that "the total supply" of a farm family was 550 man labour days/year.

Feasibility report of the SOGREA in 1972 said that average labour input per farm family was 194 work days per year for the Stage I area, and 17% of total labour was hired. The average work force/family was estimated as 1.5 unit in case of a young settler and maximum working day during peak season was 45 units in this case.

The Agrarian Research and Training Institute (Research Study No.23) said that total potential of family labour is 2.5 unit/family which resulted by the survey carried on in the Polonnaruwa District.

The following data given by A.R.T.I. have been confirmed as quite reasonable through our field survey:

	Male	Female	Children	Total (man day)
Full time worker	2.2	0.4	0.2	2.4
Part time worker	0.1	0.2	-	0.3
Total				2.5 (Average)

Note: 1. Woman day equivalent to 0.8 man days.

2. Part time worker equivalent to 0.25 man days.

3. Child day equivalent to 0.5 man days.

4. Basic age of adult worker is over 16 years old.

5. Field of works;

Man - land preparation, sowing, irrigation, plant protection, fertilizer application, harvesting, transportation, post harvesting, management, etc.

Woman - transplanting, weeding, harvesting, etc.

Children - only work in the peak seasons.

Assuming 25 working days per month, over a 6 month season (Maha), the total farm labour availability is estimated to 375 units (25 x 6 x 2.5) and if estimated working day per month is 15 days through Yala in average at present, the yearly total Labour Unit per family is approximately 600 units per year under the Project.

(5) Solution of Labour Shortage Problem

The most serious problem for the farmers to adhere to the intensive cropping calendars under the Project is the shortage of labour during peak seasons twice & year, viz., March-April and September-October (the intervals of the plants' growing periods when harvesting of the standing crops and land preparation and planting of the succeeding crops must be completed within the limited time). Labour shortage during these peak seasons would give pressure for increases of draft animals and farm machinery as well as full mobilization of family labour. Under the Project, introduction of group farming on the basis of the Production Unit of 25 ha is proposed to tide over these peaks. The absolute shortage of labour would have to be covered by the hired labour. Details of demand and supply of agricultural labour are taken up in the Annex VII .

5.2.5 Farm Mechanization

(1) Basic Issue

Farm mechanization is a critical problem in Sri Lanka, especially in the Dry Zone, because of labour shortage at peak seasons and scarcity of draft power. Livestock development is strongly advocated under the Project from the dual purpose of foreign exchange saving and stabilization of farm management, as has been referred to elsewhere in this Report. However, livestock development would take longer gestation period and can not be easily synchronized with the proposed agricultural production program which has been worked out to attain the target crop yields within the specific periods of time. For example, ruminants like cattles and buffaloes need pregnancy period of 285 days and 310 days, respectively, on an average and calves would join the work force at 3 - 4 years of age. Moreover, a majority of the indigenous ruminants are poor in their working performance, badly needing improvement through breedings. Only less than 40 per cent of the total buffaloe population is used as draft power, and a pair of them can plough 0.25 ac/day, only when the best buffaloes were made a pair, 0.5 ac/day at the maximum. To tide over the peak season, therefore, regulated introduction and efficient deployment of farm machinery is indispensable in the initial period of planned agricultural production. Of all the farm machinery required, tractors will play the important-most role. Farm mechanization in the Moragahakanda Project area has been studied on the assumption that two-wheel tractors would be most useful for cultivation of both the paddy and the subsidiary crops.

(2) Present Status and Future Requirement of Farm Mechanization

The density of the available draft power and tractors in the existing field of about 38,000 ha is estimated as follows:

Buffaloes (pair)	3,000	(one pair for each 13 ha)
Two-wheel tractors	1,000	(one for each 38 ha)
Four-wheel tractors	400	(one for each 95 ha)

According to the proposed cropping patterns, the maximum cultivation acreage per season would be:

(a)	Paddy/season	48,510 ha
(b)	Subsidiary food crops/season	11,980 ha
(c)	Sugarcane	5,900 ha (including NSE)

The total additional numbers of farm powers required would be assumed as follows:

Buffaloes (pair)	2,821
Two-wheel tractors	2,504
Four-wheel tractors	145

The total amount of initial investment for these additional requirements of farm powers has been estimated as follows:

Buffaloes (Pair)	Rs. 7,052,500
Two-wheel tractor	" 62,600,000
Four-wheel tractor	" 21,750,000
(Total)	Rs. 91,402,500

5.2.6 Projected Crop Yields

(1) General

From the agronomic view-point, paddy is the top priority crop in the Project area because it has the highest production feasibility judging from soils and climates as well as the farmers' proficiency in its cultivation for generations. Subsidiary food crops also have high production potentials. Expansion of the areas under sugarcane has been proposed. A conspicuous labour productivity increase would take place in the existing land through extension of the more intensive farming methods, and the crop yields at modest level to start with would be rapidly raised in the new land by introducing scientific cultivation methods among the newly settling farmers.

(2) Potential Yields of the Possible Crops

Season-wise, soil-wise and irrigation-wise average yields (tons/ha) are estimated as follows:

Season		MAHA				YALA			
Irrigation		Rainfed		Irrigated		Rainfed		Irrigated	
Soils		LHG	RBE	LHG	RBE	LHG	RBE	LHG	RBE
Paddy	Bunded	1.6	0.8	4.6	3.7	-	-	4.2	3.7
	Non Bunded	1.0	0.8	-	-	-	-	-	-
Soyabean		0.6	0.9	0.6	1.1	0.4	0.2	1.2	1.4
Groundnuts (shelled)		0.7	1.0	0.7	1.2	0.4	0.3	1.4	1.5
Cowpeas/grams		0.7	1.0	0.7	1.2	0.4	0.3	1.4	1.5
Maize/sorghum		1.2	1.6	1.2	2.1	0.7	0.5	2.3	2.5
Vegetables/Tomatoes		-	-	-	-	-	-	10.3	11.3
Brinjals		-	-	-	-	-	-	13.6	15.0
Capsicums		-	-	-	-	-	-	4.0	4.4
Chillies (Dried)		0.8	1.1	0.8	1.4	0.5	0.3	1.5	1.7
Bombay Onions		-	-	-	-	-	-	10.3	11.3
Red Onions		5.8	8.1	5.8	10.4	3.5	2.3	11.5	12.7
Sugar Cane (Nucleus Estate)		30-35	45-50	50	75				
Sugar Cane (Out-growers)						20-25	30-35	35	50

(3) Target Yields with the Project

Current crop yields in the existing land and the Project target yields are specified in the below:

Crop	Current Yield (t/ha)	Target /1 Yield (t/ha)
Paddy	1.5	4.2
Soyabean	0.75	1.5
Groundnut	0.75	1.5
Maize	0.80	1.9
Sorghum	0.80	2.0
Cowpeas/grams	0.75	1.5
Chillies (Dried)	0.9	1.6
Red onions	7.0	11.0
Bombay onions	7.0	12.0
Sugarcane (NSE)	40.0	80.0
Sugarcane (Outgrowers)	30.0	60.0
Vegetables (Average)	6.0	11.0

/1: Target yields will be attained not later than the 6th year in the existing land and before the 8th year in the new lands.
These are the safe averages and it is admitted that yield (tons/ha) can be raised higher than the figures given below:

Paddy	5.0
Soyabean	2.0
Maize/sorghum	2.0
Red onion	12.0
Sugarcane	100.0

5.2.7 Projected Crop Areas

(1) The Existing Farming Area

The total farming area existing in Systems G, D1, D2 and A/D, according to the information provided by the Agricultural Instructors, is as shown in Table 4-5-2.

Farming area reported as existing in 1977-78 which has been shown by season (Maha and Yala) and by the pattern of cultivation (authorized and unauthorized), will be as shown in Table 4-5-3 if classified into (a) irrigable area, (b) cropped area, and (c) harvested area.

The projected crop area has been categorically identified and its year-round use for paddy, sugarcane and subsidiary food crops has been determined as per Table 5-2-1.

(2) The Newly Reclaimable Area

The cropping patterns in the newly reclaimable area has been determined primarily on the basis of soils as per Table 5-2-3, and the projected crop area for each specific use has been decided as is shown in Table 5-2-4.

5.2.8 Net Agricultural Benefits

(1) Existing Land

Net agricultural benefit with the Project in the existing land would be estimated as follows: (in thousand rupees)

Year	Paddy	Sugarcane	Upland crops	Total
1986	47,970.0	7,870.5	11,365.2	67,197
1987	109,387.8	10,719.0	29,901.6	150,008
1988	134,959.5	13,617.0	51,847.2	200,424
1989	180,005.4	16,515.0	74,532.6	271,053
1990	209,848.5	19,363.5	105,461.1	334,673
1991	241,117.2	22,261.5	133,487.1	396,866

(2) New Land

Agricultural benefit with the Project in the new land would be estimated as follows: (in thousand rupees)

Year	Systems D1 & A/D	System D2	Total
1987	60,520		60,520
1988	70,442	7,126	77,568
1989	83,794	8,596	92,390
1990	114,249	10,053	124,302
1991	141,898	14,343	156,241
1992	169,684	17,916	187,600
1993	194,375	21,562	215,987
1994	230,781	25,119	255,900
1995	230,781	30,072	260,853

(3) Whole Project Area

The Moragahakanda Project would generate the following agricultural benefits as a whole: (in thousand rupees)

Year	Existing Land	Newly Reclaimed Land Systems D1 & A/D	Newly Reclaimed Land Sustem D2	Whole Project Area
1986	67,197			67,197
1987	150,008	60,520		210,528
1988	200,424	70,442	7,126	277,992
1989	271,053	83,794	8,596	363,443
1990	334,673	114,249	10,053	458,975
1991	396,866	141,898	14,343	553,107
1992	396,866	169,684	17,916	584,466
1993	396,866	194,375	21,562	612,803
1994	396,866	230,781	25,119	652,766
1995	396,866	230,781	30,072	657,719

5.3 Other Agricultural Activities

5.3.1 Rainfed Cropping

(1) Importance of Rainfed Agriculture

Rainfed agriculture has been assumed to be of less importance than irrigated agriculture as its contribution to the gross agricultural production has been rather insignificant. However, it is possible to cultivate some very important cereals and many kinds of useful food items like pulses, vegetables, oil plants, fruits and spices under rainfed conditions without spending much expenditure and wholly utilizing family labour. Rainfed agriculture takes place on highlands and slopes during Maha season. Maha rainfed cropping would be quite beneficial to the growers in terms of self-supply of nutritious diets and cash-income through disposal in the local market. Yala cultivation of the subsidiary food crops in the paddy-field is already proposed under the Project.

(2) Current Rainfed Cropping Practices

(a) Upland rice (mainly 3 - 3-1/2 months HYV and partly traditional varieties)

(b) Annual crops: green gram, blackgram, red onion, groundnut, soya-beans, cowpea, sorghum, maize, sweet potato, kurakkan, gingelly, manioc, chillies, vegetables. (Bombay onion, cotton and tobacco are grown but in negligible acreages.)

(c) Perennial crops: banana, papaw, coconut, mango and other fruit trees.

Note: Cropping areas fluctuate from year to year and exact acreages are not obtainable.

(3) Selection of Suitable Rainfed Crops

(a) Selection Standards:
Crop selection should be made according to the following standards and by taking into consideration the conditions in the Dry Zone:

(i) Drought Tolerance (low water requirements)
A list showing the crops' resistance to drought is given in Annex VII.

(ii) Resistance to high temperature;
(iii) Less fertilizer requirements;
(iv) Easiness of cultivation;
(v) Low production cost;
(vi) Resistance to Pests and Diseases;
(vii) High nutritional values;
(viii) Good market prospects;
(ix) Import substitution, and
(x) Short growth period. /*

/* Growth periods of different crops are given in a list attached to the Annex VII .

(b) Recommended Crops:

(i) Homestead Garden

Coconut, banana, papaw, jak,mango, manioc, sweet potato, yam, kurakkan, red onions, Bombay onions, chillies, capsicum, brinjal, beans, cowpeas, green gram, black gram, bandakka, water melon, spring onion, carrot, beet, radish and other vegetables.

(ii) Slope and Highland

Maha: Manioc, soyabean, pulses (cowpeas/grams), sweet potato, sorghum, kurakkan, maize, upland rice, groundnut, vegetables, pastures and sugarcane.

5.3.2 Animal Husbandry

(1) Introduction

It would be no exaggeration to say that livestock development, its rural base being animal husbandry, is one of the top priority issues worthy for the nationwide attention and the concerted action of the Government and people of Sri Lanka. Apart from the sophisticated livestock industry, the village animal husbandry makes multifarious contributions: it is the source of supply of protein foods to the rural population, draft power in terms of cattles and buffaloes, and the excreta-turned-organic manures for the maintenance of soil fertility. As the supplier of draft power and organic manures, animal husbandry works as antidote for over-dependence on tractors and chemical fertilizers, and helps stabilize the peasant's farm management. From the national economic point-of-view, it serves enormously for saving the foreign exchange.

(2) Present Condition of Animal Husbandry

(a) Average annual growth rate regarding population of Livestocks is as follows. (1946 - 1976) (Poultry included)

Neat Cattle	1.7 %
Buffalo	7.0
Sheep and Goat	7.0
Pig	-1.4
Chicken	13.0

Source: Dept. of Census & Statistics, Sri Lanka (1978)

Note : Unusually high slaughter rate (16 - 18%/year) during food crisis period (around 1973) caused decline of Cattle Population.

(b) Total population of Buffaloes in the existing farm area is estimated at 15,000 heads. Accordingly, only 30 - 35% of paddy field is being plowed with Buffaloes with very poor performance.

(c) 90% of Cattles are indigenous breeds called "Sinhara" (Poor milk producer).

(d) Most of ruminants (Cattle and Buffalo) have been raised by indigenous natural grasses. Brachiaria (improved grass) is only party introduced.

(e) In the Central Livestock Farm, Polonnaruwa, (Government Farm) 7 pints of milk/cow/day is being produced, as raw material for condensed milk factory. Brachiaria mutica have been growing vigorously. (It is estimated that milk/cow/day fed only by natural grasses is 2-3 pints.)

(3) Constraints for Animal Husbandry Development and Their Solution

(a) Breed and reproduction
MURRAH buffalo or improved ZEBU blooded Milch Cow should be increased. In the up-country (above 4000'), temperate breeds of dairy cattle, such as Friesians, Short Horn can be raised. It is a principle of tropical animal husbandry to introduce ZEBU type breeds of cattles (Indian blood). Artificial Insemination system should be expanded. In Japan, A.I. have been practiced as follows:

Dairy Cattle	99 %
Beef Cattle	93 %

It is necessary to prevent the unlawfull and unreasonable slanghtering especially female animals, to maintain regular reproduction.
High mortality ratio of calves should be stopped by improved nursing system. Improvement program by cross breeding should be expandend, including the use of frozen semens of high quality.
In the Philippines, a single buffalo (improved) can perform the job done by a pair of Sri Lanka buffaloes, which means twice as much of the working capacity.

(b) Feeds

Ruminants eat only younger growth stage of grasses and also it is apparent that ruminants require roughages as the fundamental feeds that is source of energy. Production of grasses and fodder crops should be given first priority and it needs to maximize domestic supply of Concentrates for cattles, pig and poultry. By using Brachiaria brizantha or Brachiaria mutica (for imperfectely drained area), the grazing capacity will raise up to one Cow (equivalent) per 1.0 Ac, while it may require 2 - 3 Acs by natural grasses. Problem of tropical grasses is its early maturing, and they get old very quickly with much lignine content which reduce animal's palatability. To prevent this, it would be advisable to introduce the rotational grazing system by about 40 blocks because tropical pastures are better cut within each 40 days. Fodder crops including maize & sorghum should be increased their production as well as legume grasses.
Beside the present Concentrates which are mainly made up of coconut poonac and Rice bran, production of fish meal, gingelly meal, soyabean meal and others should be expanded. Wheat bran produced in Trincomalee Flour Mill is better to be consumed domestically before export.

(c) Animal Health

It is most important to prevent the communicable dangerous diseases by vaccination. In the dry zone, the following diseases are serious at present:

Cattles and Buffaloes

1. Haemorrhagic Septicaemia (H.S.) - Wet season
2. Foot and Mouth Disease (F.M.D.) - Dry season
   (Virus type is "O" and partly "C")
3. Pneumonia (especiably, Polonnaruwa Area)
4. Brucellosis

Note:

1. Vaccines have not been supplied sufficiently and the extension of vaccination methods is not practiced adequately. It is urgently necessary to accelerate the improvement program of vaccines and vaccination.

2. Serious problem is Marek disease of poultry, which gives tremendous damage recently, the vaccines have not been developed in Sri Lanka. Japan almost eradicated this disease by a Special vaccine.

(4) Availability of Feedstuff

(a) Sufficient supply of animal feeds, both roughages and concentrates, is one of the basic requirements for developing animal husbandry as well as livestock industry in a wider sense. The land available for grass herbage production for ruminants in Sri Lanka is approximately 1.985 million acres made up of the following:

		Million ac
a.	Unirrigable highland in the Dry Zone better suited for pasture	0.800
b.	Villu and parklands	0.200
c.	Pasture under coconut (33%)	0.360
d.	Tea farm better suited for pasture	0.096
e.	Lowlying valleys of tea plantation area (5%)	0.010
f.	Patana land (25% of Wet and Dry Zones)	0.440
g.	Herbage on paddyfield bunds (5%)	0.070
h.	Roadsides (50% of natural grass on the roadside)	0.009
		1.985

In addition to the above, over one million acres of paddy land are available for stubble grazing. Furthermore, over two million tons of rice straw is available per annum as roughage for feeding stock.

The domestic concentrates production should also be increased (cereal grains, rice bran, wheat bran, coconut cake, fish meal, groundnut, soyabean and sesame oil cake and others.)

(b) In the Moragahakanda Agricultural Development Project, development of a village-level animal husbandry has been discussed in principle but not yet systematically planned in conjunction with livestock industry including fresh/condenced milk and other dairy products, meat production, egg production, bone processing, leather production, and other processing industries on commercial basis. The potentiality of livestock industry development having been recognized through F/S, it would be desirable to translate such potentials into concrete designing of all these industries on D/D stage.

(c) In the existing farming area, it would be very difficult to find out extra grazing-land or pasture-land for supply of roughages, and animal husbandry there would need to be propelled through additional supply of concentrates.
In the settlement area, however, farmers can cultivate 2.5 ac of farmland under such cropping pattern as shown in 5.2.2, Vol.I. Fig. 5.2.2 is one of the typical patterns for upland cropping under rainfed conditions. This is the reasons why the definite acreage of this pattern has not been calculated as cropping areas would fluctuate from year to year according to the climate and market situations.

In the 0.5 ac homestead area, it is possible to raise poultry, goats or sheep and swines because they are smaller animals or birds. Similarly, larger animals like dairy cattle and buffalo can also be raised in the homestead area but they need more grasses. As mentioned earlier, more concentrates could be supplied in future in addition to pasture grass, indigenous grasses, villu grasses, and other grasses from open parkland, scrub jungle, forest, bank of Tanks, roadside, bunds and around ditches.

To secure the animal feeds especially roughage, however, some kind of "community pastureland" which would be managed by the farmers' organization is necessary besides 3 ac allotment. At the same time, more practical use of handy resources as animal feeds should be encouraged, for instance, rice straw (more than 500,000 MT in the Project area), rice bran (about 25,000 MT), various farm by-products, garbages and residues. It would be advisable to set up a Pilot Project area where an integrated mixed farming (crop and animals) could be practiced for demonstration. Such mixed farming Pilot Project area would harmoniously combine cultivation of paddy and SFC, together with poultry, pig, goat, cattle and buffalo, being replenished by community pasture-land and accompanied by livestock industrial units in the future.

5.3.3 Others

Proposed agricultural production plan would impose upon the resident farmers and the new settlers very intensive and tightly knit cropping calendars which would almost fully mobilize the available family labour all through the year, requiring outside labour at peak seasons. Incorporation of animal husbandry with the irrigated agriculture which is strongly advocated under the Project would mean an additional strain. No doubt there seem to be ample potentials for developing rural industries and fishery in the Project area, and some tentative programs are being worked out. However, under the circumstances to be generated through project implementation, substantiation of extra-farming plans and programs, though they should be organically combined and inter-related with farming itself, would require more careful studies involving number of experiments before officially presented in this Report.

Table 5-2-1 Year-Round Cropping Patterns in the Existing Fields as Assumed w/out Project and Proposed under the Project (ha)

Year		MAHA			YALA										Year-Round Total
		Paddy	Sugar Cane	Total	Paddy	Bombay Onions	Red Onions	Chillies (dried)	Veget-ables/1	Ground-nuts	Pulses	Soya-beans	S.F.C. Total	Total	
Current		33,094	2,890	35,904	30,096	0	70	110	17	20	110	30	357	30,453	66,097
1986	W/out P	33,094	2,890	35,984	29,590	60	175	250	60	68	250		863	30,453	66,097
	With P	35,080	3,400	38,480	33,230	150	300	400	500	150	350		1,850	35,080	73,160
1987	W/out P	33,094	2,890	35,984	29,510	68	190	270	75	75	265		943	30,453	66,097
	With P	35,080	3,400	38,480	31,770	300	550	700	880	280	600		3,310	35,080	73,160
1988	W/out P	33,094	2,890	35,984	29,443	75	205	290		80	280		1,010	30,453	66,097
	With P	35,080	3,400	38,480	30,200	500	780	1,000	1,300	400	900		4,880	35,080	73,160
1989	W/out P	33,094	2,890	35,984	29,362	85	220	310	88	88	300		1,091	30,453	66,097
	With P	35,080	3,400	38,480	28,770	650	1,000	1,300	1,680	500	1,180		6,310	35,080	73,160
1990	W/out P	33,094	2,890	35,984	29,293	90	235	330	95	95	315		1,160	30,453	66,097
	With P	35,080	3,400	38,480	27,030	850	1,280	1,700	2,110	630	1,480		8,050	36,080	73,160
1991	W/out P	33,094	2,890	35,984	29,223	100	250	350	100	100	330		1,230	30,453	66,097
	With P	35,080	3,400	38,480	25,580	1,000	1,500	2,000	2,500	750	1,750		9,500	35,080	73,560

1 : W/out the Project, vegetables will be grown independently; but w/Project, they will be grown as post-crops of groundnuts, pulses and soyabeans. Accordingly, their cropped area will equal to the sum-total of the cropped areas of groundnuts, pulses and soyabeans.

Table 5-2-2 Proposed Cropping Patterns on the Newly Reclaimable Lands (ha) [1]

	System D1						System D2		System A/D					System D1, D2 & A/D			
	Kaudulla		Kantalai				Parakrama Samudra		Kantalai MDB Farm		Newly Reclaimed Land						
	Paddy/ Paddy	Paddy/ Upland crops	Paddy/ Paddy	Sugar Cane NSC	Out-growers	Paddy/ Paddy	Paddy/ Paddy	Paddy/ Upland crops	Paddy/ Paddy	Paddy/ Upland crops	Paddy/ Paddy	Paddy/ Upland crops	Total	Paddy/ Paddy	Sugar Cane	Paddy/ Upland crops	Total
1986	7,650	510	810	2,200	360	90			120	790	820	670	14,020	9,490	2,560	1,970	14,020
87	7,650	510	810	2,200	360	90			120	790	820	670	14,020	9,490	2,560	1,970	14,020
88	7,650	510	810	2,200	360	90			120	790	820	670	14,020	9,490	2,560	1,970	14,020
89	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
99	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
91	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
92	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
93	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
94	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
95	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990
96	7,650	510	810	2,200	360	90	1,460	510	120	790	820	670	15,990	10,950	2,560	2,480	15,990

1 Irrigation reliability is assumed at 90%.

Table 5.2.3 System-wise and Soil-wise Cropping Patterns in the Newly Reclaimable Lands under the Project (ha)

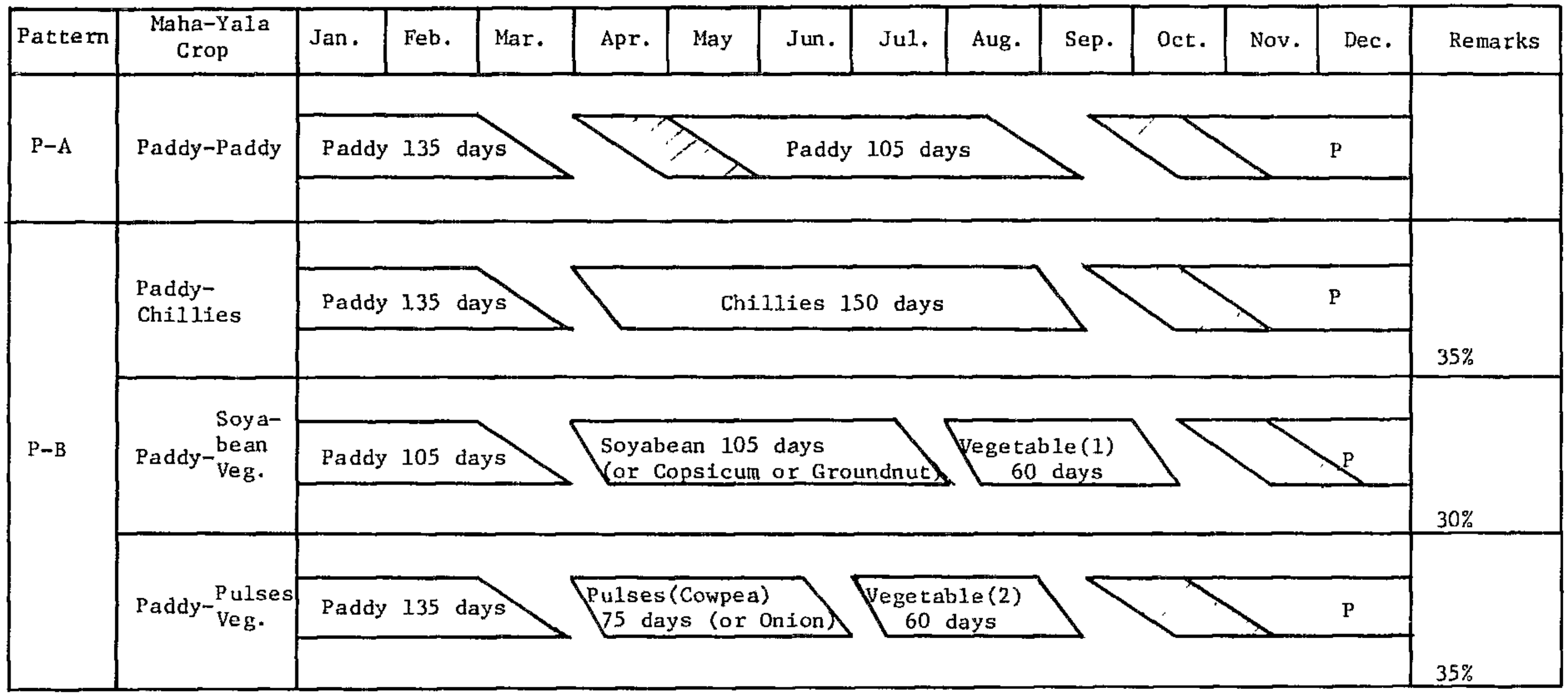
System	Source of Water	Area	Soils				Total
			RBE (improperly/ poorly drained)	LHG	Alluvial (moderately drained)	Alluvial (improperly/poorly drained)	
D_1	Kaudulla Tank	Gross	1,398	20,130	-	1,014	22,542
		Irrigable	562	8,095	-	408	9,065
	Kantalai, Vendarasankulam, Paravipancham	Gross	5,600	1,968	-	-	7,568
		Irrigable	3,245 /1	1,000	-	-	4,245
D_2	Parakrama Samudra	Gross	-	-	1,263	3,593	4,856
		Irrigable	-	-	568	1,617	2,185
A/D	Kantalai MDB Farm	Gross	1,830	274	-	-	2,104
		Irrigable	880	132	-	-	1,012
	Others	Gross	1,675	968	-	1,080	3,723
		Irrigable	747	430	-	483	1,660
	Total	Gross	10,503	23,340	1,263	5,687	40,794
		Irrigable	5,034	9,657	568	2,507	18,168
	Cropping Patterns	MAHA	Paddy	Paddy	Paddy	Paddy	
		YALA	Upland crops	Paddy	Upland crops	Paddy	

/1: This area includes 400 ha which will be turned into sugar plantation under the command of Sri Lanka Sugar Corporation and 2845 ha which will be devoted under the project for sugar cane cultivation through combination of the nucleus sugar estate (NSE) and the outgrowers comprising of new settlers.

Table 5.2.4 Areas under Different Crops in the Newly Reclaimable Lands (ha)

	Kaudulla, Kantalai, MDB Farm and A/D Land											Downstream of Parakrama Samudra										
Year	Paddy	Chillies	Sorghum	Cowpeas/ grams	Red Onions	Bombay Onions	Soya-beans	Ground-nuts	Vegetab-les	S.F.C. Total	Grand Total	Paddy	Chillies	Sorghum	Cowpeas/ grams	Red Onions	Bombay Onions	Soya-beans	Ground-nuts	Vegetab-les	S.F.C. Total	Grand Total
1st year	20,821	20	17	12	6	5	12	8	49	129	20,950	3,398	5	4	3	2	1	3	2	12	32	3,430
2nd year	20,746	30	28	20	10	6	18	13	79	204	20,950	3,373	8	7	6	3	2	5	4	22	57	"
3rd year	20,678	43	37	25	15	10	23	17	102	272	20,950	3,356	10	10	7	4	2	7	5	29	74	"
4th year	20,604	55	47	32	17	12	32	20	131	346	20,950	3,341	14	12	8	4	3	8	6	34	89	"
5th year	20,527	65	57	40	20	14	40	24	161	421	20,950	3,321	17	15	10	5	3	10	7	42	109	"
6th year	20,461	75	67	45	25	15	45	30	187	489	20,950	3,300	20	18	12	6	4	12	8	50	130	"
7th year	20,385	87	77	50	30	18	53	35	215	565	20,950	3,284	23	20	13	7	4	.13	10	56	146	"
8th year	20,303	100	87	60	33	20	60	40	247	647	20,950	3,268	25	22	15	8	5	15	10	62	162	"

Fig. 5.2.1 Proposed Cropping Pattern

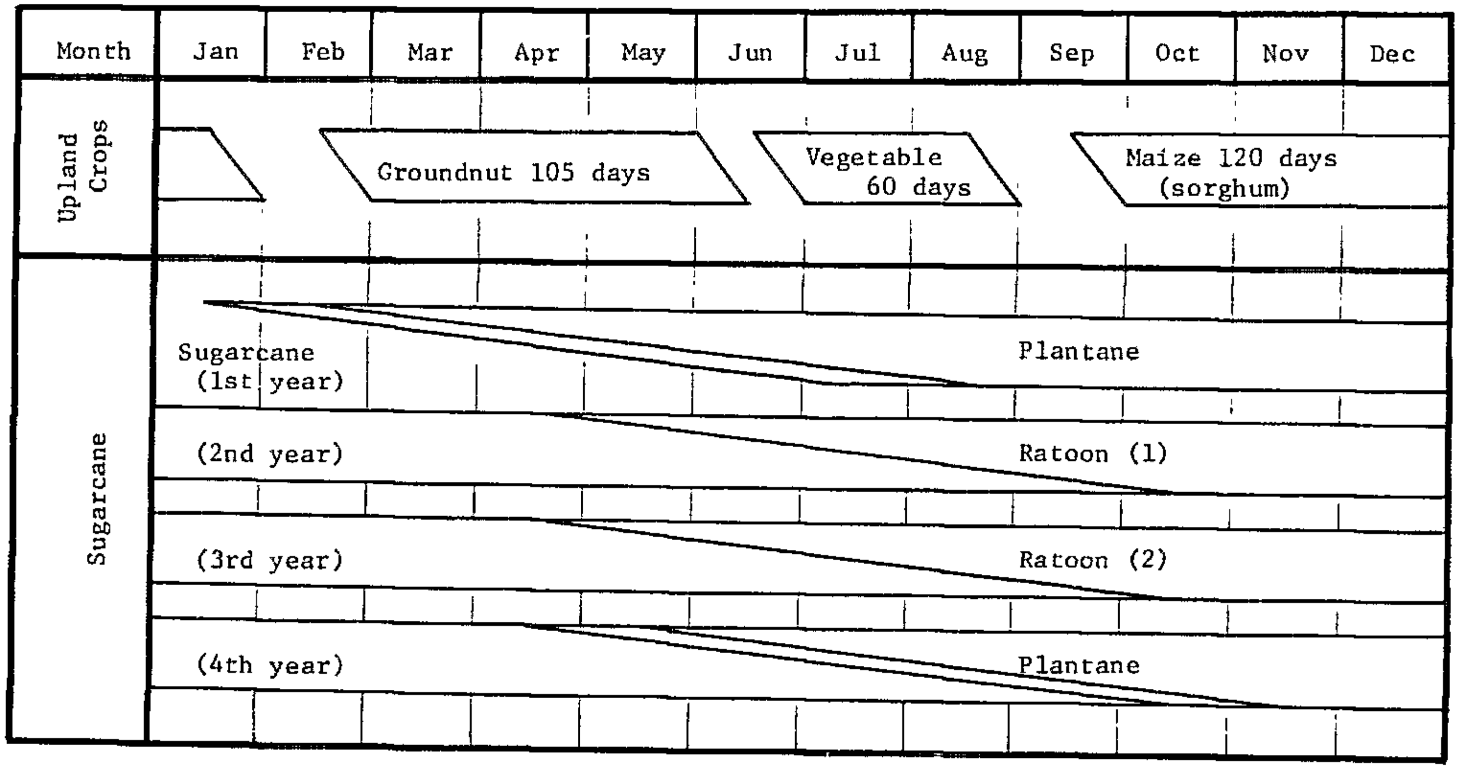


Note: <u>Pattern A:</u> Paddy (Maha) - Paddy (Yala) High yielding varieties (BG11/11 for Maha and BG 34/8 for Yala, for example) are to be used.

<u>Pattern B:</u> Paddy (Maha) - S.F.C (Yala) S.F.C = Subsidiary Food Crops include chillies, soyabeans, vegetable, groundnuts, cowpeas, grams and onions as basic crops. Varieties which have characteristics of short growth period with higher yields and drought resistance should be introduced.

Fig. 5.2.2 Typical Rotational Cropping Pattern of

Upland Crops and Sugarcane



Chapter VI: FARMER SERVICES AND INFRASTRUCTURE

6.1 Organization and Management

6.1.1 Introduction

The Moragahakanda Agricultural Development Project is one of the projects coming under the umbrella of the Accelerated Mahaweli Program and it cannot be implemented in isolation. In fact, from the viewpoint of utilization of the vital most resources, that is, water, all the projects involved have equal concern and respective share which may cause internal conflicts and contradictions unless rationally coordinated through efficient institutional network linking the Central Project Management and the Local Project Management with communication lines serving for a valuable feedback in both directions. Besides such an 'internal' setup, the Program implementation badly needs an 'external' setup which ensures ready cooperation of the Ministries and Departments concerned as the Program itself is an integrated one. All this has been occupying the mind of the Government and as the Program is entering full implementation stage, a renewed attention came to be focused at formation of the most efficient organization and institution as is witnessed by the institutional changes which are taking place nowadays including establishment of a new Authority which may give repercussions to the present role and function of the MDB which has been vested with very comprehensive powers with respect of settlement management and production operations.

The organization to be adopted for the Program implementation is, of course, the matter for the Government decision. The JICA's Feasibility Study Team will simply submit some alternative model of an organization for implementation of the Moragahakanda Project which embraces only four Systems among all those coming under the Accelerated Program by trusting that the Government would eventually establish some such institutional setup to solve all the 'internal' as well as 'external' problems for the ultimate success of the Accelerated Program as a whole.

The Moragahakanda Project area consist of the existing land and the new land which will be developed by additional irrigation water made available through construction of a dam. Thus it may not be wrong to say that the new land which corresponds to one-third of the entire area is an extention of the existing land which will now come to occupy two-thirds of it. Agricultural development efforts towards both the existing and the new lands, therefore, would have to be made by utilizing, by and large, the institutions and facilities which are already existing. As they are meant for the

existing land only, they should, of course, be very much improved and strengthened if they have to extend their coverage towards the new land also. At any rate, project management should be free from any conflicts, frictions and discords which might be caused by unnecessary differentiation between the existing and the new lands.

Nevertheless, it is not implied that agricultural development and farmer services which are being provided in the existing land are well and good and that what is required is their quantitative expansion to look after the new land. The earlier analysis of the existing infrastructure and farmer services as against the current agriculture which is being carried on the basis of the real socio-economic conditions /1 would suggest some radical improvements which are more of qualitative nature than quantitative. JICA's F/S Team, therefore, concentrated its study at the improvement of agricultural development and farmer services at the bottom level and among the 'grass-root' farmers, and proposes a new framework of a 'lower structure' for such services. The Team sincerely hopes that the Government, with full understanding of and best sympathy with the Team's philosophy and strategy towards the Moragahakanda Downstream Development, would take necessary action to improve its 'super structure' so that the proposed 'lower structure' would be enabled to attain its aims and purposes.

In the first few Sections of this Chapter, a hierarchy of agricultural development and farmer service institution designed for project management and its staffing will be discussed, together with the farmers' response to such an approach by the Project Management in terms of active development efforts in an organized manner through their MPCS and others. Then, the problems of agricultural manpower will be answered by establishment of the Rural Development Training Centre (RDTC) which is combined with the Pilot Project and IRDP in order to train the required development staff and village youth. Finally, the issues concerning Settlement will be discussed in the concluding Section.

6.1.2 Supporting Services Reaching 'Grass-Root' Farmers

The Moragahakanda Project area which is made up of some 38,500 ha of the existing land and spprox. 17,750 ha of the new land, totalling 56,250 ha. Because of the special ratio occupied by the existing land thereof, which corresponds to two-third of the total, additional net production-increase

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/1: See Sections 4.5, 4.6 and 4,7 in Chapter IV: Present Conditions of the Project Area.

there should be large enough for economic justification of the entire Project. Therefore, the downstream development strategy would cover the whole Project area, both the existing and the new, and there should be no qualitative difference in its development tactics. It is, however, taken as granted that there are already some devices of farmer services and physical infrastructure in the existing land while they need to be provided altogether in the new land. Hence there would be a difference of intensity between the two.

From the project management view-point, some administrative devices will be required for agricultural development. It would be a pyramidal structure, with the lowest level of the Production Unit (PU) each of 25 ha and an appex of the Project Management Headquarters. In-between, there would be, from the lower to the higher, Production Circle (PC) made of 20 PUU, Production District (PD) of 5 to 6 PCC, and the Production Zone. Their standards will be as shown in Table 6.1.

In the new land, the project management units have been dovetailed with the Settlement hierarchy as adopted by the MDB in Table 6.2.

Eventually, the actual project management units have turned out as shown in Table 6.3.

6.1.3 Intensity of Agricultural Development Services

The Project management staff of lower echelons, whose training and deployment will be discussed in the below, will consist of the Farm Guidance Workers (FGWW) and the Agrarian Service Teams (ASTT) - one Leader and six members, each specializing on (i) Water Management, (ii) Agronomy, (iii) Livestock (and Poultry), (iv) Farm Machinery, (v) Rural Credit, (vi) Input Supplies and Marketing, and (vii) Community Development. Both the FGWW and the ASTT will get their basic training in the Rural Development Training Centre (RDTC) which is combined with the Pilot Project and the Integrated Rural Development Project (IRDP). FGW will be equipped with the capacity which would be equivalent to KVS (or even more), after one year integrated training in RDTC, while AST Members, the capacity equivalent to that of the Agricultural Instructor (if not SMS), TA, etc., after 3.5 years' trainings (1 year integrated training together with FGWW + 6 months' specialized training in RDTC + one year field training in the Pilot Project + one year initiation training in the IRDP). Details of their trainings will be introduced in the following Sections.

In the existing land, one FGW will be attached to a group of 5 PUU (125 ha) and one AST for 2 PCC (1,000 ha), while in the new land, one FGW will look after 2 PUU (50 ha) and one AST per 1 PC (500 ha), as follows:

Project Management Unit	Existing Land	New Land
Production Unit Level	1 FGW for 5 PUU (125 ha)	1 FGW for 2 PUU (50 ha)
Production Circle level	1 AST for 2 PCC (1,000 ha)	1 AST for 1 PC (500 ha)

Thus, in the new land where the project management units are dovetailed with the Settlement hierarchy, 2.5 FGWW per Hamlet and 1 AST per Village Cluster (with the help of 10 FGWW).

Allocation of FGWW and ASTT will be made according to the above standards as per Table 6.4 attached hereto.

6.1.4 Deployment of FGWW and ASTT Members

The planned agricultural production would start in the Project area as it becomes irrigable all through the year in the following order: the existing land, since 1986; the new lands in Systems D1 (Kaudulla, Kantalai, Minneri Oya, Kahambiliya Oya and Wan Ela) and A/D (MDB Farm and the other), since 1987, and the new land in Systems D2 (Parakrama Samudra), since 1988. Assignment of the FGWW and ASTT should accordingly be made as follows:

	By 1985-86		By 1986-87		By 1987-88	
	FGWW	ASTT	FGWW	ASTT	FGWW	ASTT
(1) Existing Land	309	40	-	-	-	-
(2) New lands in Systems D1 & A/D	-	-	260	28	-	-
(3) New land in System D2	-	-	-	-	43	4

In the meanwhile, RDTC would start training about 150 youngmen since 1980 - 81 season and turn out some 70 FGWW per year ever since 1981 - 82 Maha season. Approx. 70 trainees of the first batch would stay on to get intensive, specialized training for another six months in RDTC, and thence transfered to the Pilot Project for field training and, then, to the IRDP for another year's initiation training, before they are sent out in 10 Teams only since 1983. The training periods and assignment schedule of FGWW and ASTT would be as shown in Table 6.5.

Deployment of FGWW and ASTT in the Moragahakanda Project area would be made in the order as shown in Table 6.5.

6.2 Development Efforts by Farmers Themselves

6.2.1 Co-operatives

The co-operative system is fairly well established in the Project area. It assumes a set pattern of the Primary MPCS (Multi-Purpose Co-operative Society) and its Branch-offices, approximately one set per major irrigation scheme. Functionally, MPCS provides such services as credit, input supply and marketing to its members but not in a well co-ordinated manner as discussed earlier. To encourage the organized efforts of the farmers themselves for development, all possible measures should be taken to provide the MPCS with adequate resources and to ensure that they operate efficiently. MPCS in the existing land are generally ill-equipped with warehouses for input supplies (particularly fertilizer) and marketable paddy, vehicles for transport, etc., although the numerical balance between the Primary MPCS and its Branch-offices seem to be appropriate even with Project. It is, however, lacking depots or boutiques through which its members can get the consumer goods for day-to-day use as well as equitable distribution of input supplies. In anticipation of a considerable increase in both input supply and marketable paddy with Project and in order to provide better services to its members, it is recommended that the MPCS in the existing land would have one depot or boutique per hamlet and a set of Village huller and paddy store attached to its Branch per village cluster, under the Primary with improved general stores in each township. The co-operative system to be extended to the new land would have its Primary MPCS in each township with its Branch provided with a village huller, a fertilizer store and a paddy store in each village cluster, and one depot or boutique in each hamlet.

The MPCSS in the Project area should organize themselves into at least one Economic Co-operative Federation which deals with wholesale purchasing and marketing of input supplies and marketable farm products as well as transport and processing services on behalf of the Primary MPCSS which are affiliated to it. It would be advisable to have such Economic Co-op. Federation at the central place where the Project Management HQ. would be located. As for the credit services, the existing Rural Banks and their regional headquarters would function as the Primary

MPCSS' parent banks and appex bank.

With all these and other reinforcements including facilities and institutional arrangements, the MPCS would be in a better position to organically link-up credit, input supply, extension and marketing on behalf of its member-farmers, and eventually enlist the entire farmers in its service-area. This would be accelerated through introduction of co-op or joint farming at least on the basis of Production Unit (a group of farmers who cultivate 25 ha land) and preferably in a wider scale and scope, probably, up to the limit of Production Circle. The more organized the agricultural production, the more timely and adequately the input supply and the marketing of surplus farm products can be arranged through the MPCS and such would naturally enhance the credit-worthiness of the group of farmers who cultivate jointly with their fellow-farmers with the supporting services to be provided by their MPCS. The agricultural development efforts by FGWW and ASTT towards the grass-root farmers would become more effective if they could be channeled through the MPCS and other voluntary farmers' organizations in both the existing and the new lands.

6.2.2 Other Voluntary Farmers' Organizations

Although the rural institutions such as the Cultivation Committee (CC) and the Agricultural Productivity Committee (APC) are virtually disbanded by the new Government, the aims and purposes looked after by these defunct institutions are still waiting to be realized by some ways and means. The CC in the existing lands, that are, the major irrigation scheme areas were mainly functioning, though inefficiently, as the colonists' own water management body. Again, APC was meant for packaging of various farmer supporting services such as rural credit, input supply, extension and marketing into one workable system. Under the Project, it is proposed to strengthen the MPCS system to such institution as was visualized in APC and to let the Primary MPCS fulfill the function which was dreamt by establishing Agricultural Productivity Centre. What remains to be done, then, is reconstruction of ex-CC into a better substitute for the farmers' own water management.

The farmers who are grouped together at each Production Unit level are now encouraged, under the guidance of AST Member (in charge of Water Management), into the Water Management Unit(WMU) consisting of 5 farmers coopted from amongst 25; one of these 5 would be a leader who represents his WMU at the Water Management Group (WMG) which will be established at the Production Circle. The 20-member WMG would elect a Chairman and a Vice-Chairman who represent their WMG at the Water Management Bloc (WMB) at the Production District level. The 12-member WMB would, in turn, be represented by its President and Vice-President at the Water Management Division (WMD) which will be established at each Production Zone level.

Technically speaking, this is not difficult as the project management units which have hierarchical order of PU -PC - PD - PZ are so constituted as to fall within the same irrigation system and it is quite useful to have a parallel water management hierarchy in terms of WMU - WMG - WMB - WMD. In this case, FGW would work as coordinator among WMUU by dealing with the Irrigation Overseers, and AST Member i/c Water Management would coordinate the function among WMG and WMB by dealing with the Irrigation TA. Irrigation Engineer (IE) attached to each Production Zone (being stationed at the headwork of each Tank) would have two venues of water control: the one is the Irrigation Department channel of Overseers - TA, and the other is the farmers' own water management hierarchy of WMU - WMG - WMB - WMG.

Voluntary organization of the owners of draft animals and the private tractors into the 'Draft Animal Owners' Association' and the 'Private Tractor Owners' Association', respectively, is also essential for the success of planned agricultural production under the Project, as discussed under Sub-sections 5.1.2 and 5.1.7 in Chapter V. The rural youngmen and young women in the existing land who are today generally under-employed need to be organized under the guidance of AST Member (i/c Community Development), and given chances to contribute in their own ways for general upliftment of agricultural productivity and farmers' living standards.

6.3 Training of Agricultural Manpower

6.3.1 Introduction

British Victoria Preliminary Feasibility Report[/1] (Main Report pp. 94-95), referring to 'Manpower Supply, Demand and Related Factors' which was written by Messrs I. Asmon and H.G. Duncan who had been sent to Sri Lanka by USAID to prepare and appraise a project to strengthen the Faculty of Agriculture at the University of Sri Lanka at Peradeniya, says as the main conclusions drawn from their review:

/1: Phase I Preliminary Feasibility Report on the Victoria Scheme of the Mahaweli Development Project (November 1978) prepared by Hunting Technical Services Limited, Sir Alexander Gibb and Partners, and Preece, Cardew and Rider, under assignment by the Ministry of Overseas Development, U.K. Government.

(a) Provided that the expansion program for Peradeniya University agricultural faculty goes ahead as planned (- - -), sufficient agricultural graduates and post-graduates should be available for the Mahaweli programs:

(b) The supply of agricultural Diplomates may be critical, with shortages occuring. On the basis of Asmon and Duncan's estimates, a further major expansion at Kundasale School of Agriculture or the Hardy Institute at Amparai appears to be necessary, and

(c) The number of practical farm schools will need to be increased if the country's future requirements for the staff trained by these shcools are to be met. Since the courses involved are of only one year's duration, however, the supply of such staff can be expanded more rapidly than is the case with graduates and diplomates.

6.3.2 Concept of RDTC + PP + IRDP

JICA's F/S Team on the Moragahakanda Project fully agrees with item (c) and takes note of the critical supply of agricultural Diplomates in item (b) of the above conclusions drawn by the British Team on the Victoria Project, and proposes establishment of a Rural Development Training Centre (RDTC) in order to produce skilled agricultural manpower to provide agricultural development and supporting services to the grass-root farmers in the Mahaweli Program area, to start with, in the Moragahakanda Project area.

Rural Development Training Centre will be one of the tripartite scheme being incorporated with the Pilot Project and the Integrated Rural Development Project (IRDP), and is intended for bringing up two kinds of development staff: one is the junior staff with one year integrated training who has been referred to as the Farm Guidance Worker (FGW) and the other is the intermediate staff (members of the Agrarian Service Team or AST) who undergo 2.5 years' training in addition to FGW training.

Some 150 youngmen with the minimum necessary qualifications, preferably from the Mahaweli Program area, Moragahakanda Project area in particular, would be admitted into RDTC for integrated agricultural training for one year. About half of the trainees (approx. 70) would be sent out as so many FGW immediately upon completing this one year course, while the remaining half (approx. 70) would be given additional 6 months' intensive course which is divided into seven different classes, each consisting of 10, of (i) water management, (ii) agronomy, (iii) farm machinery, (iv) livestock (and poultry), (v) rural credit, (vi) input supply and marketing, and (vii) community development. Those who successfully complete these courses would be sent, in 10 batches of 7 - one from each of 7 different classes -, to the Pilot Project for one year field training. Each batch would be consolidated into a Team before being transfered to the IRDP for one year initiation training. Now we shall have 10 Teams of full fledged Agrarian Service staff. The concept of RDTC + PP + IRDP is introduced in the Annex.

JICA's F/S Team is of the opinion that appropriate external assistance would be desirable in establishing RDTC and for steering its training courses, in conjunction with the Pilot Project and the IRDP.

6.4 Settlement

6.4.1 Introduction

The new land which will be developed under the Project would be settled by about 15,160 new farming families as follows:

System	Settlement Location	Settler Families
D1	Downstream of Kaudulla	9,100
"	" " Kantalai	1,260
D2	" " Parakrama Samudra	2,200
A/D	MDB Farm	1,000
"	Along the Mahaweli Ganga	1,600
		15,160

Each settling family would be allocated 1 ha (2.5 ac) farming plot in the lowland and 0.2 ha (0.5 ac) homestead area on the highland. Except about 500 new families who are settling into the downstream of Kantalai colony to devote four-fifth of farming plot (0.8 ha) for outgrowing of sugarcane and one-fifth (0.2 ha) for paddy/paddy,1/ the lowland to be allocated among all other settlers would be used for cultivation of paddy during Maha and paddy-plus-subsidiary food crops during Yala.

1/ See Annex VIII - 5: Alternative Development Plan of the Kantalai Downstream.

6.4.2 Settlement Policies

(a) Settler Selection

With the only exception of System A/D (in the case of MDB Farm and that along the Mahaweli Ganga), all the new lands in other Systems are spreading in the downstream of the existing colonization schemes where substantial numbers of second generation colonists are being accumulated as so many dependants of the original colonists as most of them are under-employed. Under these circumstances, it would be proper to give priority of re-settlement to the surplus population in the existing colonies to the new lands to be developed in their downstreams. If this principle is basically accepted, the likely sources of settlers into the new lands in Kaudulla, Kantalai and Parakrama Samudra would be from the existing colonization scheme in their upstreams.

Among the new lands, Kaudulla is exceptionally large in area and the existing Kaudulla colony in its upstream is relatively underdeveloped. Taking these factors into consideration, it might be possible to allow the surplus population in the existing Giritale and Minneriya Colonies to re-settle into the new Kaudulla, on the ground that Giritale and Minneriya colonies have no extra capacity to accommodate any additional population nor downstream extension unlike the other existing colonies. On the other hand, Kantalai colonization scheme seems to be less congested than Parakrama Samudra. MDB Farm is very thinly populated and the new land along the Mahaweli Ganga in System A/D is a virgin land to which settlers may be selected from any other regions, probably including the neighbouring District of Trincomalee.

Settler selection policy as suggested in the above is along the basic guideline of the Project's downstream development which is chalked out according to the principle of a harmonious inter-relationships between the existing and the new lands which belong to the same irrigation system. This is also being reflected in the formation of project management units as in the case of Production Districts and Production Zones which are lying on the border-line between the existing and the new lands.

(b) The Pattern of Settlement

The MDB standards have been broadly adopted as for the pattern and hierarchy of settlement and the range of facilities at each settlement level.

6.4.3 Settlement Proposals

(a) The phasing of Settlement

The British Victoria Team's recommendation as regards the process and phasing of settlement would be broadly accepted by the JICA's F/S on the Moragahakanda Project, too. Instead of bringing in settlers just three months before the availability of water, a gradual placement of settlers and utilizing them as members of a direct labour group for area development seems to be a wise idea. In the Moragahakanda settlement scheme, from one-half to three-quarters of the selected settlers would be brought into the new land as labour force for land development and preparation of the basic infrastructure of the settlement area; in the meanwhile they will be adequately paid and accommodated in the Village Service Centre and primary school which would have to be completed in the initial stage of settlement. When these works would have been almost completed, the remainder of settlers would arrive probably about three months before the availability of water, and start building temporary houses together with the follow-settlers who came earlier.

(b) Standards of Infrastructure and Facilities

The MDB current policies for the provision of facilities have been generally followed.

6.5 Overall Requirements, Phasing and Costs

Agricultural development in the Moragahakanda project area involving both the existing and the new lands will be administered through a hierarchy project management units which will have the minimum necessary facilities of their own. The network of Production Circle Offices at village level and Production District Office-cum-Agricultural Service Centre at township level, which would be substantiated by the coordinated development efforts among FGWW and AST Members in and out of its mesh, would constitute the 'lower structure' of agricultural development mechanism as aginst the 'super structure' above the Production Zone Office or Zone Branch of the Project Management HQ.

While a full set of agricultural and social infrastructure and facilities would be provided in the new land, a few essential agricultural facilities such as co-op depot or boutique at hamlet level and a village huller and a paddy store at village level would be replenished in the existing land. The standards of agricultural and social infrastructure are shown in the attached Table 6.7.

As has been explained in the above, the planned agricultural production in the Project area will start from 1986 in the existing land, to be followed by the new lands in Systems D1 and A/D, from 1987 onward, and lastly in the new land in System D2, from 1988. Accordingly, the infrastructure construction schedule would be phased in 3 stages of:

Stage I (From mid-83 to mid-85)	Stage II (From mid-85 to mid-87)	Stage III (From end-87 to end-88)
Agricultural Infrastructure in the existing land, and Project Management HQ. and its ancilary.	Agricultural and Social Infrastructure in the new lands in Systems D1 and A/D.	Agricultural and Social Infrastructure in the new land in System D2, and the project management units in some Production Zones.

The kinds and numbers of the facilities to be constructed in each stage are specified in the attached Table 6.8, and their construction costs and disbursement schedule are shown in Table 6.9.

The construction cost has been broken down into: (a) Project management units; (b) non-Project Agricultural Infrastructure, and (c) Social Infrastructure, from the economic analysis' point-of-view. Construction cost of (a) Project management units and one-third of that of (c) Social Infrastructure would be allocated to the Project, but that of (b) Non-Project agricultural infrastructure for processing, marketing, storage, credit, input supply, and others will not be allocated to the Project as these are already taken into account in the derivation of farm-gate input and output prices.

In addition, construction cost of prefabricated building for temporary accommodation of FGWW and AST members who will be assigned to the new land must be allocated to the Project. Their housing in the existing land has not been accounted for as they would face no particular difficulties in finding appropriate accommodation there. Thus, the total construction cost would become:

Total construction cost:	148.971 (LC)	38.914 (FC)
Staff Housing:	8.76	
	157.731 (LC)	38.914 (FC)

All FGWW and Leaders and Members of AST, irrespective of their place of assignment, would be provided with vehicles: bicycle for FGW, Jeep for AST Leader, and motor-cycle for AST Members.

Table 6.1: Standards of Project Management Units

Administrative Unit	Unit Sizes & Combination	Coverage
Project Management Headquarters (HQ)	4 or 5 PZ	15,125 hax4.5=68,000 ha
Production Zone (PZ)	5 or 6 PD	2,750 hax5.5=15,125 ha
Production District (PD)	5 or 6 PC	500 hax5.5= 2,750 ha
Production Circle (PC)	20 PU	25 ha x 20 = 500 ha
Production Unit (PU)	@ 25 ha	25 ha

Table 6.2 Project Management Units as Dovetailed with Settlement Hierarchy

New Settleing Families	Size of Farm-Land	Project Management Unit	Settlement Hierarchy
Each family	1 ha		
25 families	25 ha	Production Unit (PU)	
125 "	125 ha		Hamlet
500 "	500 "	Production Circle (PC)	Village Cluster
3,000 "	3,000 "	Production District (PD)	Township
18,000 "	18,000 "	Production Zone (PZ)	

Table 6.3: Project Management Units in the Moragahakanda Downstream Area

System	Area	Existing Fields				New Lands				Total				Total Area (ha)
		PU	PC	PD	Area (ha)	PU	PC	PD	Area(ha)	PU	PC	PD	PZ	
D1	Giritale	120	6	1	3,000	-	-	-	-	120	6	1	1	10,200
	Minneriya	290	15	2	7,200	-	-	-	-	290	15	2		
	Kaudulla	208	11	2	5,200	358	18	3	9,100	566	29	5	1	14,300
	Kantalai	417	21	4	10,420	56	3	1	1,400	473	24	5	1	14,500
	Others	108	6	1	2,680	-	-	-	-	108	6	1		
A/D	MDB Farm	-	-	-	-	40	2	1	1,000	40	2	1	1	2,640
	Others	-	-	-	-	66	3		1,640	66	3			
D2	Parakrama Samudra	400	20	4	10,000	86	4	1	2,200	486	24	5	1	12,200
	Total	1,543	79	14	38,500	606	30	6	15,340	2,149	109	20	5	53,840

Table 6.4: Allocation of FGWW and ASTT in the Project Area

System	Area	Existing Fields					New Lands					Whole Project Area					
		PU	FGW	PC	AST	PD	PU	FGW	PC	AST	PD	PU	FGW	PC	AST	PD	PZ
D1	Giritale	120	24	6	3	1	-	-	-	-	-	120	24	6	3	1	1
	Minneriya	290	58	15	8	2	-	-	-	-	-	290	58	15	8	2	
	Kaudulla	208	42	11	5	2	358	179	18	18	3	566	223	29	23	5	1
	Kantalai	417	83	21	11	4	56	28	3	3	1	473	112	24	14	5	1
	Others	108	22	6	3	1	-	-	-	-	-	108	22	6	3	1	
A/D	MDB Farm	-	-	-	-	-	40	20	2	4	1	40	20	2	4	1	1
	Others	-	-	-	-	-	66	33	3	3		66	33	3	3		
D2	Parakrama Samudra	400	80	20	10	4	86	43	4	4	1	486	123	24	14	5	1
		1,543	309	79	40	14	606	303	30	32	6	2,149	612	109	72	20	5

Table 6.5: Training Periods and Assignment of FGWW & ASTT

Category	Farm Guidance Worker	Agrarian Service Team Members
Training Period	1 year in RDTC	RDTC+PP+IRDP = 3·1/2 years
Assignment since:		
1981-82 Maha	70	
1982-83 "	70	
1983-84 "	70	70 Members in 10 Teams
1984-85 "	70	- do -
1985-86 "	70	- do -
1986-87 " /1	140 /1	- do -
1987-88 "	140	- do -
1988-89 "	140	- do -
1989-90 "	(140)	- do -
1990-91 "	(140)	- do -
Total Turnout	630	560 Members in 80 Teams
Total Requirement	612	504 Members in 72 Teams
Surplus	18	56 Members in 8 Teams

/1: Another Rural Development Training Centre would need to be established, but with the Regular Course only in 1985.

Table 6.6: Deployment of FGWW and ASTT in the Moragahakanda Project Area

System	Production Zone	Existing Fields: Area (ha)	Existing Fields: Farm Guidance Worker (FGW)	Existing Fields: Agrarian Service Team (AST)	Newly Reclaimable Lands: Area (ha)	Newly Reclaimable Lands: Farm Guidance Worker (FGW)	Newly Reclaimable Lands: Agrarian Service Team (AST)
D1	Giritale	3,000	1982-83 24	1984-85 3	N.A.	N.A.	N.A.
	Minneriya	7,200	1982-83 36 1983-84 22 (58)	1984-85 7 1985-86 1 (8)	N.A.	N.A.	N.A.
	Kaudulla	5,200	1983-84 42	1985-86 5	9,100	1985-86 41 1986-87 (179)	1987-88 5 1988-89 4 1989-90 7 1990-91 2 (18)
	Kantalai	10,420	1983-84 6 1985-86 70 ([illegible])	1985-86 4 1986-87 7 (11)	1,400	1986-87 2 1987-88 26 (28)	1987-88 3 (3)
	Minneri Oya Kahambiri Wan Ela	2,680	1985-86 22/1	1986-87 3	N.A.	N.A.	N.A.
A/D	MDB Farm	N.A.	N.A.	N.A.	1,000	1987-88 20	1987-88 2 1988-89 2 (4) /2
	Others	N.A.	N.A.	N.A.	1,640	1987-88 33	1988-89 2 1989-90 1 (3)
D2	Farakrama Samudra	10,000	1981-82 70 1982-83 10 (80)	1983-84 10	2,200	1987-88 43	1988-89 2 1989-90 2 (4)
	Total	38,500	(1981-82 to) (1985-86: 309)	(1983-84 to) (1986-87: 40)	17,740	(1985-86 to) (1987-88: 303)	(1987-88 to) (1990-91: 32)

/1: Increased by 3 more FGWW because these three colonies are being scattered around;
/2: 2 additional ASTT because of the importance of MDB Farm.

Table 6.7
Standards of Agricultural and Social Infrastructure and Allocation of FGWW and ASTT

Administrative Unit	Production Unit	Agricultural Infrastructure and Supporting Services		Social Infrastructure	
		Existing Fields	New Lands	existing Fields	New Lands
-	Production Unit (@25 ha)		1 FGW for 2 PUU		
Hamlet	5 PUU	Co-op. Depot and 1 FGW	Co-op. Depot and 2.5 FGWW		Primary Education Unit
Village Cluster (4 hamlets or 500 families)	Production Circle (20 PUU or 500 ha)	Village Huller Paddy Store Production Circle Office (4 FGWW)	Village Huller Paddy Store Fertilizer Store Co-op. Branch Production Circle Office 1 AST (10 FGWW)		Village Service Office Senior Secondary Education Unit Village Dispensary Post Box
Township (6 village cluster of 3,000 families)	Production District (6 PCC or 3,000 ha)	Production District Office-cum-Agricultural Service Centre 3 ASTT (1 AST for 1,000 ha) (24 FGWW)	Production District Office-cum-Agricultural Service Centre Primary MPCS (60 FGWW and 6 ASTT)		Town Council Office Township Cultural Centre Central Dispensary/ Maternity Ward Sub Post Office Police Station
Production Zone		Production Zone Office (Zone Branch of P.M.HQ.) Market Area			Post Office
Whole Project Area		Project Management HO Rural Development Training Centre + Pilot Project + Integrated Rural Development Project			

Table 6.8 Agricultural & Social Infrastructure

	STAGE I	STAGE II	STAGE III	Total
1. AGRICULTURAL INFRASTRUCTURE				
Co-op Depot	309	104	17	430
Village Huller	79	26	4	109
Paddy Store	79	26	4	109
Fertilizer Store		26	4	30
Co-op. Branch		26	4	30
Production Circle Office[(a)]	79	26	4	109
Primary MPCS		6	1	7
Production District Office-[(a)] cum-Agricultural Service Centre	14	5	1	20
Production Zone Office[(a)]			4	4
Market Area			4.7/1	4.7/1
Project Management HQ.[(a)]	1			1
Rural Development Training[(a)] Centre + Pilot Training + Integrated Rural Development Project	1			1
II. SOCIAL INFRASTRUCTURE				
Primary Education Unit		104	17	121
Senior Secondary Education Unit		26	4	30
Visiting Dispensary		26	4	30
Central Dispensary				
Central Dispensary/Maternity Ward		6	1	7
Village Service Centre		26	4	30
Town Council Office		5	1	6
Township Cultural Centre		6	1	7
Post Box		26	4	30
Sub Post Office		6	1	7
Post Office			5	5
Police Station		5	1	6

/1: Market Area to be built in System A/D would be of smaller dimension equivalent to 0.7 of the standard Market Area for others.

/(a): Project management units.

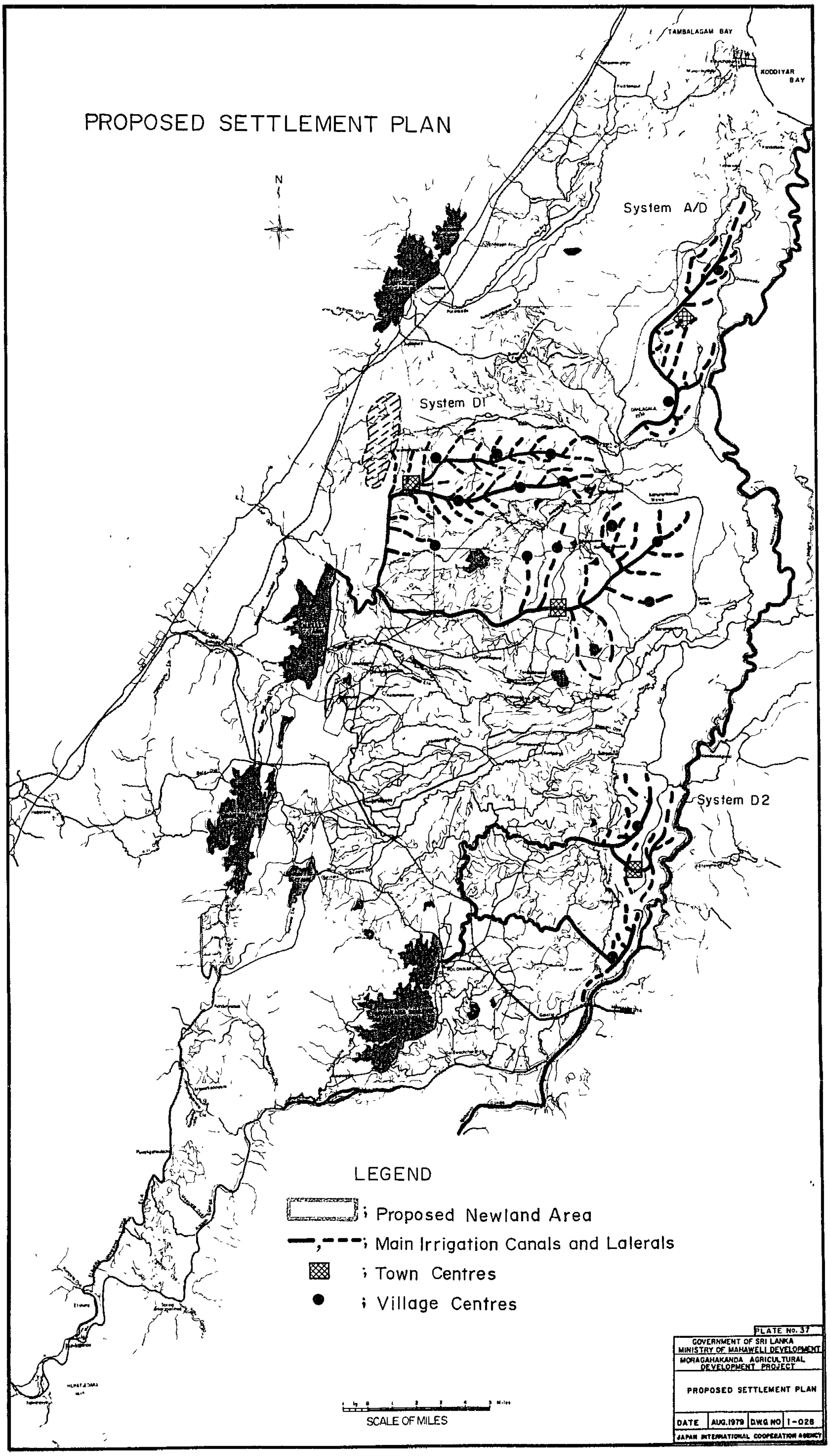
Table 6.9 Summary of Construction Costs and Its Disbursement Schedule of Agricultural and Socail Infrastructure

(Unit in Million Rupees)

Classification	Construction Cost to be Disbursed						Total Construction Cost	
	Stage I		Stage II		Stage III			
	LC	FC	LC	FC	LC	FC	LC	FC
AGRICULTURAL INFRASTRUCTURE								
Co-op. Depot	19.467		6.552		1.071		27.09	
Village Huller	4.035	24.8	1.33	8.16	0.2	1.26	5.565	34.22
Paddy Store	3.37	1.445	1.109	0.476	0.171	0.073	4.65	1.994
Fertilizer Store			3.354		0.516		3.87	
Co-op. Branch			2.028		0.312		2.34	
Production Circle Office[a]	13.43		4.42		0.68		18.53	
Primary MPCS			1.392		0.232		1.624	
Production District Office-cum-Agricultural Service Centre (a)	3.36	0.84	1.2	0.3	0.24	0.06	4.8	1.2
Production Zone Office[a]					1.08		1.08	
Market Area					0.47		0.47	
Project Management HQ[a]	0.28	0.12					0.28	0.12
RDTC + PP + IRDP[a]	1.75	0.75					1.75	0.75
SOCIAL INFRASTRUCTURE								
Primary Education Unit			22.36		3.655		26.015	
Senior Secondary Education Unit			27.69		4.26		31.96	
Visiting Dispensary			1.274	0.546	0.196	0.084	1.47	0.63
Central Dispensary/ Maternity Ward			1.428		0.238		1.666	
Village Service Centre			6.682		1.028		7.71	
Town Council Office			1.000		0.2		1.2	
Township Cultural Centre			1.5		0.25		1.75	
Post Box			0.0026		0.0004		0.003	
Sub Post Office			0.366		0.061		0.427	
Post Office					0.975		0.975	
Police Station			3.13		0.626		3.756	
	45.692	27.955	86.818	9.482	16.461	1.477	148.971	38.914
Project Management Units	(18.82)	(1.71)	(5.62)	(0.3)	(2.0)	(0.06)	(26.44)	(2.07)
Non-Project Agricultural Infrastructure	(26.872)	(26.245)	(15.765)	(8.636)	(2.972)	(1.333)	(45.609)	(36.214)
Social Infrastructure	-	-	(65.433)	(0.546)	(11.489)	(0.084)	(76.922)	(0.63)

/(a): Project management units.

PROPOSED SETTLEMENT PLAN



Chapter VII: THE PROJECT

7.1 General

As mentioned earlier, this Project aims at construction of dams across the Amban Ganga at the site of Moragahakanda to secure the own runoff of the Amban Ganga and the Mahaweli water diverted at Polgolla and flown into the Amban Ganga, and to use the storage water, after regulating in the reservoir, for agricultural development in the downstreams, and also to generate hydro electric power at the foot of the dam.

As the result of water balance calcutlation made on the basis of hydrological data for the last 28 years, it has been concluded that the Moragahakanda reservoir needs to have the effective storage capacity of not less than 606 million m^3 to meet the irrigation requirements for 62,000 ha in its downstream. Six alternative layouts of the dam, five of them incorporating the hydropower development, have been completed to identify the optimal scale of the structure. The eventual choice fell on the scale which involves the high water level (H.W.L) at El. 195 m, with the effective storage capacity of 686 million m^3, and hydropower installation capacity at 26 MW.

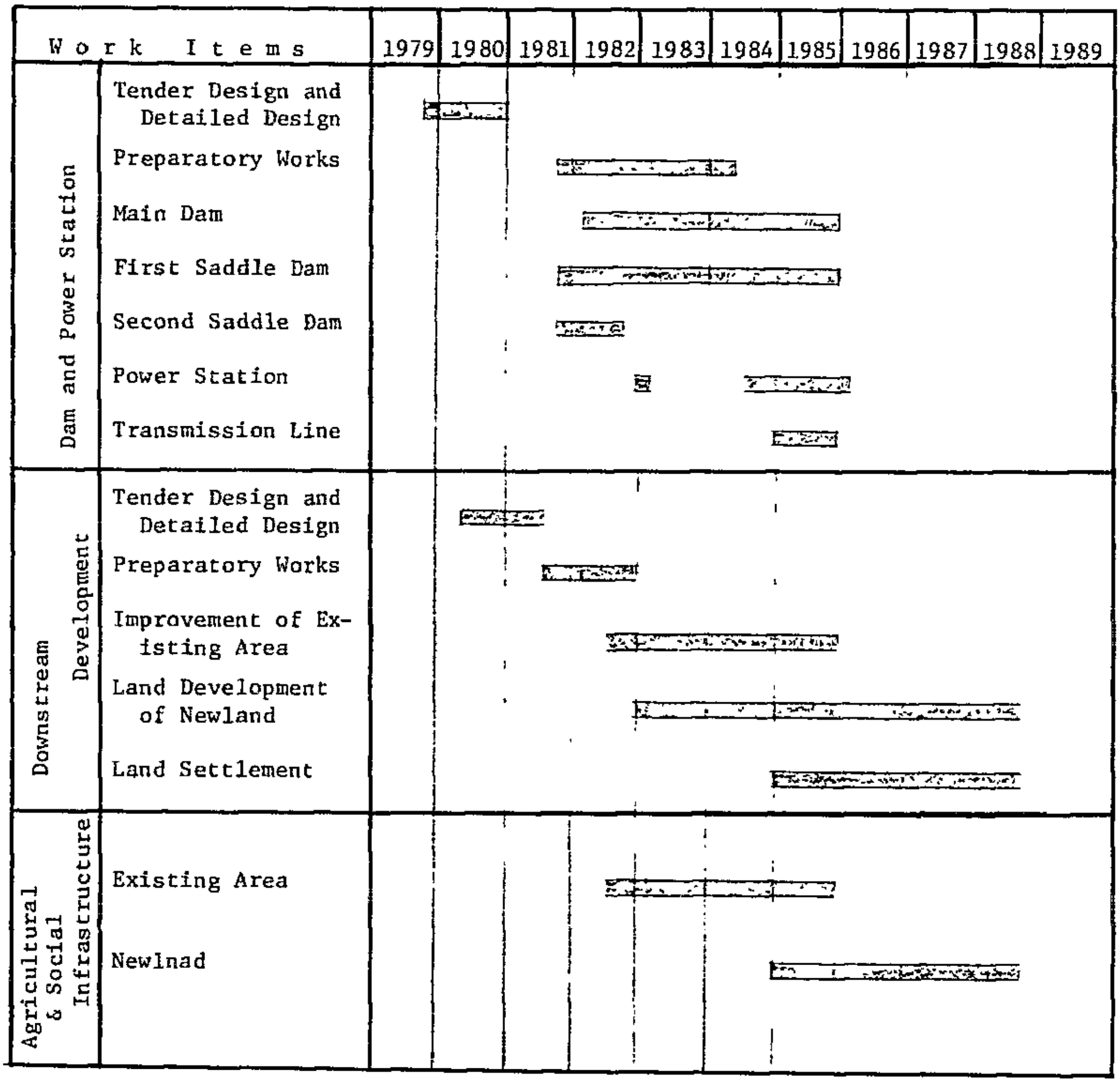
Construction plan of the headwork consisting of the dams and powerhouse has thus been prepared, with their cost estimates. Likewise prepared are the downstream development plan, including rehabilitation/new provision of irrigation/drainage facilities in both the existing and the new lands, land development, settlement and equipment of infrastructure for agricultural development and social services, and their cost estimates.

Construction Schedule

Engineering works for the completion of the Moragahakanda Project would involve the construction of dams and power house, and the downstream development works.

Detailed survey and tender design which takes about one year for both the headwork and downstream development is scheduled between Oct. 1979 and June 1981, so that construciton works can be started from July 1981. Construction period of dam and power house would be about 4.5 years and that of downstream development, about 7 years. Consequently, the former would be completed by the end of 1985 and the latter, the end of 1988. Construction of agricultural and social infrastructure would be started from mid-1982 and completed simultaneously with downstream works in the new lands.

Construction schedule, if illustrated in a bar-chart, would be as follows:



Construction Costs

The construction cost (in financial prices at the end of 1978) of the Headwork has been estimated at US$ 114.4 million, and that of the Downstream Development, at US$ 73.1 million, totalling US$ 187.5 million. They may be tabulated as follows:

Moragahakanda Project Construction Cost

(unit: Million Rupees)

	Foreign Currency Portion	Local Currency Portion	Total
1. Dam and Power-house	1,364.8 (91.0)	350.3 (23.4)	1,715.1 (114.4)
2. Downstream Development	453.4 (30.2)	447.2 (29.8)	900.6 (60.0)
3. Agricultural & Social Infrastructure	38.9 (2.6)	157.7 (10.5)	196.6 (13.1)
4. Grand Total	1,857.1 (123.8)	955.2 (63.7)	2,812.3 (187.5)

(Figure in brackets denote the amounts in US$ @ Rs. 15 = $1)

Disbursement of Investment Costs at Financial Prices

Table shows the expected annual investment costs at financial prices and in terms of estimated current prices in which escalation factors are taken into account. Escalation factors for local component are determined on the basis of indicators given by the Ministry of Planning, while those foreign component are determined by comparing available indicators in OECD as follow.

Assumed Escalation Factors (% p.a.)

	1978	1979	1980	1981	1982	1983 Onwards
Local Component:	12.2	7.9	7.9	6.3		6.25
Foreign Component:	———	———	8.0	———	———	5.50

Table 7.1.1 Cash Flow of Project Investment at Estimated Current Prices/1

(Rs. million)

		HEAD WORK								DOWN STREAM				DEVELOPMENT				Total				
		DAM				Generating Equip. & Transmission				Irrigation Facilities				Social Infrastructure								
		Capital			O & M	Capital			O & M	Capital			O & M	Capital			O & M	Capital			O & M	Total
	Year	F/C	L/C	Total		F/C	L/C	Total		F/C	L/C	Total		F/C	L/C	Total		F/C	L/C	Total		
1.	1980	-	-	-	-	-	-	-	-	12.8	5.3	18.1	-	-	-	-	-	12.8	5.3	18.1	-	18.1
2.	1981	148.8	88.0	236.8	-	-	-	-	-	20.8	7.2	28.0	-	-	-	-	-	169.6	95.2	264.8	-	264.8
3.	1982	380.3	88.3	468.6	-	-	-	-	-	143.0	30.2	173.2	-	-	-	-	-	523.3	118.5	641.8	-	641.8
4.	1983	387.1	90.7	477.8	-	-	-	-	-	189.3	95.6	284.9	-	-	-	-	-	576.4	186.3	762.7	-	762.7
5.	1984	574.5	135.3	709.8	-	116.0	7.1	123.1	-	73.9	144.2	218.1	-	-	-	-	-	764.4	286.6	1,051.0	-	1,051.0
6.	1985	507.9	120.4	628.3	-	51.4	22.0	73.4	-	100.2	182.4	282.6	-	21.2	31.6	52.8	-	680.7	356.4	1,037.1	-	1,037.1
7.	1986	-	-	-	15.1	-	-	-	3.4	51.2	111.3	162.5	36.7	7.1	251.6	258.7	-	58.3	362.9	421.2	55.2	476.4
8.	1987	-	-	-	16.0	-	-	-	3.5	52.8	108.4	161.2	38.9	3.3	33.9	37.2	73.8	56.1	142.3	198.4	132.2	330.6
9.	1988	-	-	-	17.0	-	-	-	3.8	32.6	58.4	91.0	41.1	-	-	-	78.3	32.6	58.4	91.0	140.4	231.4
10.	1989	-	-	-	18.1	-	-	-	4.0	-	-	-	41.8	-	-	-	83.1	-	-	-	149.0	149.0
11.	1990	-	-	-	19.1	-	-	-	4.2	-	-	-	46.5	-	-	-	88.2	-	-	-	158.0	158.0
⋮	⋮				⋮				⋮				⋮				⋮				⋮	⋮
Total		1,998.6	522.7	2,521.3		167.4	29.1	196.5		676.6	743.0	1,419.6		31.6	317.1	348.7		2,874.2	1,611.9	4,486.1		

1/: escalation factors are assumed as follows:

	1978	1979	1980	1981	1982	1983 onwards	
Local Component:	-	12.2	7.9	7.9	6.3	6.25	(%/year)
Foreign Component:	-			8.0		5.50	

escalation factors for O & M are determined based on the assumption that the cost comprises 20 % of F/C and 80 % of L/C.

7.2 WATER BALANCE AND RESERVOIR OPERATION

7.2.1 GENERAL

Available inflow to the Moragahakanda Reservoir consists of the natural runoff from the Amban Ganga basin and the diverted flow from the Mahaweli Ganga at Polgolla Diversion Weir. Upstream of the Reservoir, a part of the flow is diverted from the Bowatenna reservoir to a farm land so called H-area in the other basin. Further diversion is made from the Nalanda reservoir to Dewahuwa area in the other basin. Available inflow to the Reservoir is estimated in a balance among the above-mentioned diversions and the natural runoff.

There exist two irrigation headworks on the Amban Ganga, downstream of the Reservoir: Elahera Anicut for Elahera-Minneriyo Canal linking 4 existing tanks and Angamedilla Anicut to Parakrama Samudra tank. The former is located 1.6 km downstream of the Moragahakanda Dam and the latter, 28 km downstream along the river course of the Amban Ganga. The schematic illustration of the present irrigation systems is given in the attached Fig.-7.2.1.

The required diversion at Elahera Anicut is estimated as a sum of irrigation requirements which are taken directly from the Elahera-Minneriyo Canal and through 4 existing tanks i.e. Giritale, Minneriya, Kaudulla and Kantalai, and those at Angamedilla are calculated according to the irrigation requirements through Parakrama Samudra tank. Required release from the Reservoir is deemed as a sum of both diversion requirements at Elahera and Angamedilla.

A water balance is examined between the available runoff and the irrigation requirements for present farm land for 28 years in a condition without the Reservoir, as the present condition.

The required storage capacity of the Reservoir is studied in a balance between the available flow into the Reservoir and the required release for the irrigation of Project farm land of 62,200 ha. Changing the scale of the reservoir, a series of balance analysis are carried on for 56 cropping seasons until the Reservoir can attain to satisfy the irrigation requirements in a probability more than 80 % or for 45 seasons out of 56. The results show that the required capacity of the Reservoir should be more than 606 mcm.

A series of studies on operation of bigger reservoir than that only for the irrigation are made in a combination with power generation, giving the first priority of release from the Reservoir to the irrigation requirements. An operation rule of the Reservoir is established.

Behavior of the waterlevel of the Reservoir is estimated in a balance between the available inflow and the requirements for the existing farm land of 40,000 ha in a condition that the closure of diversion conduits of the dam will be made in the beginning of October upon the completion of the Dam. It is also checked between the inflow and the requirements for the entire Project area of 62,200 ha.

The analysis mentioned above are made all by electonic computer with a comprehensive program enveloping all such inputs as diverted flow at Polgolla, available runoff on the Amban Ganga and its tributaries and from their own basins of the existing tanks, evaporation losses from the tanks and the Reservoir, conveyance capacity and losses on every canal, storage capacity - waterlevel relation at each tank and the reservoir and irrigation requirements for the commanded area of each tank. The attached Figs - 7.2.2 and - 7.2.3 show the skeleton of the said program.

The evaporation from the water surface of the tanks and the Reservoir is assumed on the basis of records at Kalawewa as follows:

<u>Evaporation from Water Surface</u> (Unit in mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
92	98	123	115	128	136	142	146	148	113	94	90	1,425

The conveyance losses on the canals are estimated according to UNDP/FAO recommendation on unlined canal as follows:

Elahera - Diyabeduma	32 km	6.0 % of flow
Diyabeduma - Giritale	8 km	1.5 %
Diyabeduma - Minneriya	8 km	1.5 %
Minneriya - Kandulla	10 km	1.8 %
Minneriya - Kantalai	51 km	9.6 %
Angamedilla - P. Samudra	5 km	0.9 %

The balance is examined by every cropping season. One year is divided into Yala season of 6 months from April to September and Maha from October to March. The former corresponds to the dry season and the latter to the wet season over the Project Area. The balance of water is checked by every season of 28 years or of 56 cropping seasons.

Further details of the analysis described hereinafter are referred to ANNEX I.

7.2.2 WATER BALANCE IN PRESENT CONDITION

Water balance between the available runoff and the water requirements for existing farm land of 48,300 ha is examined. Monthly requirements are shown in Tables 7.2.1 to 7.2.6. The conditions in which the water requirements are worked out are referred to Section 7.5 IRRIGATION PLAN.

It is assumed in this analysis that available runoff on the Amban Ganga should be taken into the irrigation system to the maximum conveyance capacity of canals until the tanks become full.

The results of the analysis are summarized in Table 7.2.7. As seen in the Table, the deficit of water would occur so frequently as much as 23 times out of 28 Yala seasons, while that in the Maha crop appears only 5 times. This means that a reservoir shall be indispensable even to satisfy the present requirements for 48,300 ha in the Yala season.

7.2.3 REQUIRED CAPACITY OF RESERVOIR

To secure the water required for irrigable area of 62,200 ha envisaged in the Project, the Moragahakanda Reservoir is considered.

A series of water balance study are made between the requirements for 62,200 ha and the possible release from the reservoir of assumed scales. The water requirements for the Project area of 62,200 ha are estimated according to the recommendable cropping pattern on the farm land commanded by each tank for 28 years, as summarized in Tables-7.2.8 to -7.2.13.

In order to estimate the diversion requirements at the Elahera and the Angamedilla Anicuts, the operation rule at each existing Tank is studied. The concept in which the operation rule is prepared is to obtain enough water for the irrigation with the minimum scale of the Reservoir as much as possible.

As the results, the following are made clear:

i. Minneriya Tank should be kept always full so far runoff are available, and

ii. Other four tanks should be operated according to the rule curves as shown in Fig. 7.2.4.

The details of the study are referred to ANNEX-I.

The assumed Reservoir is operated to release to the water requirements through the tanks, so far the stored water in the Reservoir are available. After the Reservoir has been evacuated, the available runoff is released without regulation when the requirements exceed the runoff. Such operation of the Reservoir is always started from the H.W.L at the beginning point of the analysis in January 1950, and continuous operation is kept in the balance between the available inflow and the required release for 28 years.

A series of the balance studies are made in various scales of the Reservoir in 56 cropping seasons. The results in the selected reservoir are summarized in Table-7.2.14.

As the result, required capacity of the Moragahakanda Reservoir is estimated at 606 mcm for the irrigation requirements for 62,200 ha of the Project area. By this capacity, the irrigation requirements would be satisfied in a successfulness more than 80 % in the occurrence or eventually more than 90 % in the quantity.

Main parameters of the Reservoir only for the irrigation are as follows:

High waterlevel (H.W.L)	El. 188 m
Low waterlevel (L.W.L)	El. 154 m
Effective	606 mcm
Dead storage	42 mcm
Gross capacity	648 mcm

The dead storage below L.W.L will provide a space for sedimentation for more than 100 years.

7.2.4 OPERATION OF RESERVOIR WITH POWER SCHEME

In determination of the optiomal scale of the Reservoir, the hydro-power development is introduced. The schemes taken up in the optimization study are as follows:

Scheme No.1 : No power development is envisaged, the IRRIGATION DAM of the H.W.L at El. 188 m and the L.W.L at El. 154 m,

Scheme No.2 : Power unit to generate with the release for the irrigation and the head available in the Irrigation Dam,

Scheme No.3 : The H.W.L is heightened to El. 195 m and the L.W.L to El. 170 m, and 686 mcm in the available storage is utilized for irrigation and power generation.

Scheme No.4 : Development of peak powerstation in the Reservoir scale same as in the Scheme No.3 above.

Scheme No.5 : The H.W.L is raised to El. 200 m and the L.W.L, set at El. 175. Available storage capacity of 802 mcm is utilized for irrigation and power generation.

Scheme No.6 : Development of peak power station in the Reservoir scale same as in Scheme No.5 above.

To operate the Reservoirs listed above the following rules are applied:

a. Release from Irrigation Dam (Schemes No.1 and No.2)

So far the waterlevel is above the L.W.L, the water is released to meet the irrigation requirements. When the waterlevel reaches the L.W.L. the available inflow is released without regulation when the requirements exceed the inflow.

b. Release from Bigger Reservoir (Schemes Nos.3 to No.6)

The first priority of the release is given to the irrigation requirements in case the waterlevel is above the operation waterlevel. When the irrigation requirements are less than the required water to keep the firm power potential, the required water is released in case the reservoir water level is above the operation waterlevel. The first priority of the release of water below the operation level is given to the power requirements. In case the waterlevel reaches the L.W.L, the available inflow is discharged without regulation until the inflow becomes bigger than the requirement.

Firm power potential is the maximum potential which can be kept to be generated constantly and continuously without any obstruction against the successfulness of the irrigation requirements.

The operation waterlevels are set at the waterlevel above which a storage capacity of 606 mcm is secured under the H.W.L. The operation waterlevel in Schemes No.3 and No.4 is taken at El. 174.4 m and it in Schemes No.5 and No.6 is at El. 182.8 m. In other words, the release is governed above the operation waterlevel so as to satisfy the bigger requirements for the irrigation or the firm power generation. The release below the operation waterlevel is governed principally to keep the firm power generation.

A series of water balance studies are made in each Scheme abovelisted among the irrigation requirements for beneficial farm land of 62,200 ha, the requirement for power generation and the available inflow for 28 years. The outputs of the said analysis are summarized in Table-7.2.15.

The firm power potential is worked out in every scale of the Reservoir as follows:

Scale of Reservoir	Firm power potential	Applicable Schemes
H.W.L 200 m	10,000 kW	Schemes No.5 & 6
H.W.L 195 m	6,000 kW	No.3 & 4
H.W.L 188 m	0 kW	No.2

The attached drawings No. D-010 and -011 show the main features of Reservoir operation in case of the recommended scale of Reservoir with the H.W.L at El. 195 and hydropower unit of 26 MW.

7.2.5 BEHAVIOR OF RESERVOIR WATERLEVEL IN IMPOUNDING

In order to estimate the required time until the benefit envisaged under the Project can be expected, the behaviors of the Reservoir water level are examined in conditions that impounding of the Reservoir will be commenced in the beginning of October upon the completion of the Dam by releasing the water to meet the irrigation requirements downstream.

The analysis are made in two cases of feeding the existing farm land of 40,000 ha and the full beneficial area of the Project of 62,200 ha. The water requirements for the existing farm land are estimated on the basis of cropping pattern presently prevailing over the area, while the requirements for the beneficial area are taken same as the values mentioned in previous Sub-section 7.2.3. The Reservoir operation in this case is made to release on satisfying the irrigation requirements until the waterlevel reaches the L.W.L and after that to obey the operation rule established in the previous subsection.

The results of the analyses are summarized in Tables 7.2.16 and 7.2.17 and show the following:

i. Impounding by feeding the existing land would take 3 to 73 months until the waterlevel reaches the H.W.L and 1 to 25 months until it reaches very the L.W.L. The average period is 5.5 months to reach the L.W.L and 19.3 months to the H.W.L The average, when the worst case is excluded is 17.3 months.

ii. Impounding by releasing the water for all the beneficial area would take 28 months in an average until the water level attains to the H.W.L.

According to the results, it is recommended that the target of completion of reclamation of new land should be delayed to a time 18 months or three cropping seasons after the completion of the Dam, otherwise the benefit would not be raised as planned. As the power generation would be started when the waterlevel reaches the L.W.L, the target of the completion is considered same as the Dam.

7.3 MORAGAHAKANDA DAM

7.3.1 General

The purpose of construction of the Moragahakanda Dam is principally to provide a storage reservoir enough to secure the irrigation water for farmland of 62,300 ha extending downstream and additionally to harness the hydro-power with the potential incidental to the construction of the Dam.

The damsite is chosen in a gorge on the Amban Ganga 1.6 km upstream of the existing Elahera Anicut (head works) of the Elahera-Minneriya Canal. The Canal has fed mainly four existing tanks, from which the water has been distributed to the existing farm land amounting to about 40,000 ha. The anicut Canal System is estimated to convey the water of 56.6 m^3/s (2,000 cusec) at the maximum. UNDP/FAO's Masterplan had proposed an agricultural development in the North Central Province (NCP) with the water diverted from the Moragahakanda Reservoir in the future when the present Project areas G, D1, D2 and A/D2 would have come to be fed with the water from the main Mahaweli Ganga. An irrigation canal so called NCP Canal had been proposed for conveying the release from the Moragahakanda Reservoir to the said NCP area in a gravity flow with the intake waterlevel at El.143.3m (470') downstream of the Dam. Although the Government of Sri Lanka has not taken up the NCP development in the present Accelerated Mahaweli Development Program, considerations are given to the idea of NCP headworks for the time being to such extent that the realization of the idea is not restricted or hampered in future by construction of the present Dam. In consequence, the water turbine to be installed is designed to stand with a rise of tailwater level by about 4 m in the future.

As stated in the preceding section, the water requirements for irrigable farm land of 62,300 ha need the Moragahakanda Reservoir to have the effective storage not less than 606 million cubic meters (mcm) in order to satisfy the requirements in a probable successfulness not less than 80% in the occurrence or not less than 90% in the quantity. The scale of the Reservoir to meet the above requirements is to have the H.W.L. at El.188 m and the L.W.L. at El.154 m.

In incorporating into the Project the hydropower development, it is considered that the water release from the Reservoir is so governed as to meet the irrigation requirements in the first priority and consequently, the power sector should bear only the incremental cost from it of the irrigation dam. Five alternative power schemes are taken up and checked their viability. A stage development of the powerstation is also studied in the case of the optimal height of the Dam.

7.3.2 Damsite

The damsite proposed in the Master Plan seems most appropriately selected in every respect. No any competitive sites can be found.

The Amban Ganga at the damsite has the water level around El.138 m (452') during dry season and is 60 to 70 m (220') in the width. The slope of the right abutment of the main dam is gentle as 1:6 up to El.160 m (525') and as 1: 2 on the upper part to the top of the ridge at El.250 m (820'). The slope on the left abutment is about 1:2.5 to the top of the ridge at El.209 m. On this damsite there are two cols where the saddle dams are required. The first saddle dam is contacted directly to the main dam, the elevation of the col here being at El.152 m (500'). The second saddle dam is situated on the col beyond a ridge providing the left abutment of the first saddle dam, the height of the second col being El.182 m. The valleys are generally wide, open with gentle slopes.

The Amban Ganga at the damsite has the drainage basin of 782 km^2. As stated in the previous section, the 200-year flood is estimated at 3,878 m^3/s at the peak and 290 mcm in the total runoff upon which the design flood for the spillway of the Dam is worked out at 4.654 m^3/s at the peak and 348 mcm in the volume. The sedimentation at the damsite is estimated at 15 mcm in the total on 100 year basis.

Foundation rocks in the damsite can be classified principally into two: gneissic rock group and calcareous rock group. The gneissic rock group consists of quartz-feldspar gneiss, charnockite, granulite etc. and the calcareous rock group is composed of crystalline limestone and calc gneiss. The boundary between them is sometimes not distinguished clearly because of gradual and continuous variations.

Geological structure of foundation rocks is homocline, has bedding generally of NS/10°-20° W. The foundation rocks are formed of alternation of the above groups of rock. Foundation of the main dam consists of the gneissic rock group, the first saddle dam mostly of calcareous rock group and the second saddle dam of both groups.

Geological condition shows fairly hard, solid and water tight in fresh rocks under the overburden of 6 to 12 m thick. The only problem is possibility of cavity or opening in the calcareous rock. The cavities are observed in several drill holes and a test adit on the left abutment of the first saddle dam. The cavities observed were measured at 4 - 5 m in the length of drill holes at the maximum. Further details of mechanism of the cavities shall be ascertained by aditting in the investigation for the detailed design. However, it is fairly probable that such cavities are rather local and of limited scale without long continuity, taking into account the high groundwater tables in the drill holes and absence of karst topography in the vicinity.

Strength of foundation rock was tested in the adit No.5. The insitu rock tests show that cohesive strength can be taken at more than 25 kg/cm^2, friction angle more than 50° and elasticity more than 80,000 kg/cm^2 on the excavation line as shown in the DWG No.D-002. Permeability in the fresh zone of more than 20 to 30 m underneath the surface is generally less than 1 Lugeon. Further details of the geological conditions are referred to the ANNEX- II.

The present investigation reveals that all the embankment materials for dams are available in a close distance from the dams. The material for impervious embankment is available on a flat land about 1.3 km downstream of the dams, the materials for rock embankment at the proposed Quarry-I and those for filter and fine aggregate of concrete from the deposit on the Amban Ganga. As the result of laboratory test, the Quarry-I is chosen as the quarry for coarse aggregate of concrete. Further details of the investigation and the engineering properties of the materials are referred to the ANNEX-II.

The land to be inundated in the Moragahakanda Reservoir is covered mostly with jungle and few flat valleys along the Amban Ganga and its tributaries are now cultivated into paddy, upland field, plantation and house garden. Correlation between reservoir waterlevel and storage capacity of the Reservoir is given in the attached DWG No. D-003.

The geology in the Reservoir area consists of gneissic rock group and calcareous rock group as the damsite does. Overlying the above basal rock groups are the Quaternary deposits such as residual, talus and river bed deposits. Thick or massive deposit, however, is not found. Some faults are assumed in the area, but the existence of any significant faults of which some special care should be taken in the reservoir creation is not recognized. Since the Reservoir is surrounded by flat mountains with the gentle slope, leakage from the Reservoir and potentiality of massive landslide are hardly conceivable. General distribution of rock groups and location of faults are referred to in the ANNEX-II

7.3.3 Layout of dams and main structures

To decide the most suitable layout of the dams and other main structures, a comparative study is made among four alternatives all to keep the H.W.L. at El.195 m and to comply with the common design criteria, the details being referred to the ANNEX-III. As the result the Alternative No.2 is taken as the best.

The Alternative No.2 consists of the main dam in rock-fill type, the first saddle dam in concrete gravity and the second saddle dam in the rock fill type, the spillway on the first saddle dam and the powerhouse at the foot of the first saddle dam. A diversion canal is dug along the valley of the first saddle dam for care-of-river during the construction. The principal features of the layout is referred to the attached drawings Nos.D-004 and -005.

The type and the axis of the second saddle dam proposed in the Master plan are reviewed and decided to be the rock fill type and to be placed on a straight axis about 200 m upstream of the Master plans, as the result of a comparative study on three alternative axes. The details are referred to the ANNEX-III.

Upon the basis of the layout chosen hereabove the study on the optimal height of the dam is made in comparison of cost-benefit among three scales of the H.W.L. of the Reservoir: El.188 m, 195 m and 200 m.

7.3.4 Optimal height of dam

With the water released for irrigation requirements and the head created by the dam, certain power can be generated. Further, if more effective storage is provided by a higher dam, the higher dam will produce more power because of higher head and more discharge available, though more cost is entailed naturally.

A study is made to find out the optimal dam height incorporating power generation. One irrigation dam and 5 power schemes taken up in the study are summarized in the attached Table -7.3.1.

Schemes No.4 and No.6 are designed as peak powerstation to be operated for more than 4 hours and shall be accompanied with afterbay to regulate peak discharge down to the maximum coveyance capacity of the existing Elahera-Minneriya Canal at 56.6 m^3/s, in order to save any waste of released water. The site of afterbay weir is selected immediately downstream of the existing Elahera Headworks.

Construction cost is estimated as shown in the attached Table 7.3.2 in every case. The cost increment in every power scheme is worked out by deducting the cost of Irrigation Dam from the power scheme.

Power benefit is estimated assuming an alternative oil-furnace power plant which costs US$660 per kw of the installation, and on the basis of fuel cost at US$0.073 per litre (present market price 0.062 plus subsidy by the Government). The alternative thermal plant has an installed capacity equal to the dependable peak output which is estimated to be the peak capacity of the hydroplant with a dependability of 93% or dependable for 26 years in 28 years period. It generates the same amount of energy as the hydroplant. Cost and benefit are capitalized for 50 years assuming a discount rate at 10%. Other conditions set in the cost-benefit analysis are given in the attached Table 7.3.3.

The results of the study are summarized in the Table 7.3.3. The optimal scale of the Reservoir and the power station is estimated to be represented by the Scheme No.3 having the H.W.L. at El.195m and an installation of one unit of 26 MW.

Further details of the study are referred to the ANNEX-III.

7.3.5 Stage Development of Powerstation

Further study to the optimal scale of the reservoir and power installation is made whether a stage development of the powerstation is viable or not.

As seen in the cost-benefit analysis summarized in Table 7.3.3, what worsens the balance in the Schemes No.4 and No.6 is a comparatively heavy imposition of the afterbay. When the peak powerstation is constructed with the Dam, the construction of the afterbay is indispensable, and the afterbay weir site is limited around the existing Elahera Anicut for the topographical reason.

In the future, there is a plan to construct an irrigation canal to convey the water released from the Reservoir to the NCP area. About 5 km downstream of the Dam along the route of the Canal, a topographically suitable weir site is found. The site is located immediately upstream of the estuary of the Kongetta Oya to the Elahera-Minneriya Canal.

When an afterbay weir of about 1.8 km long and 14 m high at the maximum is built on the site, the necessary regulation capacity of 2.45 mcm will be got with a drawdown of 1.7 m from H.W.L. at El.141.5 m. By the construction of the afterbay, the length of the Canal will be reduced by about 3 km, while a widened canal to carry the peak discharge from the powerstation to the Kongetta Oya afterbay will be required. The cost increase entailed by construction of the afterbay and the widened canal is worked out by deducting the construction cost of new NCP headworks and canal to the Kongetta Oya from the cost for the NCP headworks, widened canal and afterbay. The cost increment is estimated at about US$ 6 million. The details of the study are referred to the ANNEX-III.

The power installation is planned as two units of 26 MW each: one is set in the first stage and the other one will be installed in the future when the NCP canal is constructed. At the first stage, the intake, penstock and space in powerhouse will be provided for the future unit.

Cost - benefit analysis is made in two cases: one that the future unit will be installed 5 years after the first unit is put in service and the other that the future unit will not be installed within a period of 50 years. The results of the analysis are summarized in Table 7.3.4.

The conclusion from the study is that the stage development is fairly promising and, therefore, provision to accommodate an additional unit of 26 MW is recommended to be made at the first stage. The cost increase for the provision is estimated at about US$2.0 million.

In addition, it is noted that the study is still at a preliminary level and therefore, further investigations are inevitably required to consolidate the above conclusion before the detail design of the Dam and Powerstation is undertaken.

7.3.6 Description of Proposed Dam and Powerstation

The proposed layout of main, first saddle and second saddle dams, spillway, powerstation, diversion canal, primary cofferdams, main cofferdam and access roads is shown in the attache DWG No. D-004.

The proposed reservoir will provide an effective storage capacity of 686 mcm between the low water level (H.W.L.) at 170 m and the high water level (H.W.L.) at El.195 m. The dead storage below the L.W.L. will be 217 mcm. A surcharge of 0.6 m above the H.W.L. will detain about 22 mcm of flood when the design flood passes over the Dam. The reservoir area will be about 40 km^2 at the flood water level (F.W.L.) of El.195.6 m.

Three dams will be built. The main dam on the Amban Ganga will be of central-cored rock fill type of 72 m in the height, 490 m in the crest length and 2.43 mcm in the volume. The dam crest will be at El.199 m. The slope of the embankment will be 1:1.8 in the upstream side and 1:1.6 downstream. The width of the crest is taken at 10 m.

The first saddle dam will be of concrete gravity type of 62 m in the height, 396 m in the crest length and 376,000 m^3 in the volume. The dam crest will be at El.197.5 m and 6 m in the width, the slope being 1:0.05 in the upstream side and 1:0.75 downstream. Spillway, river outlet facilities and power intakes will be provided on the dam.

The second saddle dam will be of central-cored rockfill of 42 m in the height, 490 m in the crest length and 430,000 m^3 in the volume. The crest will be at El.199 m and 10 m in the width, the slope being 1:1.8 upstream and 1:1.6 downstream.

Regarding the foundation treatment of the dams, the following are taken into consideration:

i. Thorough excavation of cavity zones apparently developing within 30 m of depth in the calcareous rock beds on the left abutment of the first saddle dam,

ii. consolidation grouting under the gravity dam and blanket grouting under the core zone of rock-fill dams, both at 5 m intervals and in a depth up to 5 m, to unify loosened rock by filling all the cracks and opening,

iii. curtain grouting along axes of the dams in two rows, grout holes being arranged in an interval of 2 m on each row and in a depth up to 30 m.

Proposed river diversion arrangement composed of diversion chanel, diversion conduits provided in the first saddle dam and the main cofferdam are to stand with an attach of 50-year flood with the peak of 3,000 m^3/s and the total volume of 217 mcm with some allowance, provided that concrete placing in the spillway section of first saddle dam should be limited to not more than El.152m, until the embankment of the main dam progresses beyond the height of the main cofferdam.

The spillway capable of 3,400 m^3/s resulted from routing the design flood of 4,650 m^3/s at the peak with the surcharge above the H.W.L., will be located in the middle of the first saddle dam in the direction of the diversion canal. Four sets of radial gate with a height of 8 m and a width of 17.5 m will be installed on the overflow creat at El.187 m, each gate being operated by a motor-driven hoist which will be installed atop the concrete pier. The chuteway will be the downstream face of the dam guided by the concrete side walls. The stilling basin will be provided downstream of the dam with a sub-dam of 8.1 m high at the end of the basin of 68 m long, in order to kill the energy of jet flow. The width of the stilling basin will be 79 m between the sidewalls of 16 m high.

Three sets of river outlet facilities will be furnished in the spillway section of the first saddle dam. Total discharge through these river outlets will be more than 56.6 m^3/s at the L.W.L. The facilities are designed to be operated when the operation of the powerstation is stopped for some reason or the release is needed more than the maximum discharge of the power unit. Each set will have a fixed trash rack of 3.5 m square at the inlet, a ring follower valve and a jet flow valve both of 1.5 m in the diameter. The center line of the outlet will be El.165 m. A steel pipe of 1.5 m inside diameter will be embedded in the dam and bent in the direction of downstream slope of the dam at the outlet. The operation will be made by motor-driven hydraulic system installed in a gallery in the dam body.

Two sets of power intake will be provided on the upstream face of the next blocks to the left side of the spillway. The maximum discharge at each intake will be 56.6 m^3/s. A fixed steel trashrack will be installed at the bell mouthed inlet, 6 m high and 6 m wide, on each intake, while one intake gate of 3.9 m square in the clear span will only be installed on the intake for the first unit in this stage. The center line of the intakes will be at El.164 m. Concrete structures for the intake including gate hoist deck will be done all in the first stage.

Two lanes of steel penstock will be installed in the first stage. The diameter of the penstock is decided on the basis of cost-benefit analysis. The diameter will be at 3.9 m in the upper portion and reduced to 3.2 m at the powerhouse. Total length of each penstock will be 87 m along the center line.

The powerhouse will be located about 84 m downstream from the axis of the first saddle dam and next to the left side of the stilling basin. It will be of reinforced concrete and of 32 m in the height, 27.8 m in the breadth and 41 m in the length. The space will be provided in the powerhouse enough to house two units of generating equipment each of 26 MW. One unit will be installed in the first stage, leaving the other unit for future, except for the draft tube. A complete set consisting of vertical shaft Francis turbine of 26 MW at the rated head of 54.8 m and the maximum discharge of 56.6 m^3/s, an alterating generator of 30 MVA, the control gears and the auxiliary equipment will be installed in the powerhouse, while a unit of main transformer capable of 30 MVA will be installed behind the power house. The switch gears will be installed on the outdoor switch yard. A single circuit transmission line rated at 132 kVA will be constructed to the junction with the existing line at the Bowatenna Powerstation for a distance of 16km. The generating unit will produce 145 GWh of energy output in an average per year. Tailrace channel will be located next to the stilling basin and protected by a guide wall from violent flood flow protruding from the end of the left guide wall of stilling basin. Two sets of roller gate, each with a height of 3.5 m and a width of 3.6 m, will be provided at the end of draft tube and operated by a gantry crane installed on the platform in front of the powerhouse.

7.3.7 Construction Schedule and Cost Estimate

A construction schedule of the dams and the powerstation at the first stage is proposed as shown in the attached DWG No D-009, with an assumption that the construction will be contracted with a contractor by May 1981.

An international engineering consultant firm will be appointed for further detailed survey, tender design, assistance for tender and contract, and construction supervision in collaboration with local supervisory staff.

All of the works will be constructed on the international contract basis, excepting for the relocation of high way, construction of administrator's quarter and compensation of the submerged area and work sites, which are considered to be undertaken by the Government.

During the early two years of 1981 and 1982, the contractor will concentrate their efforts into construction of their quarter, installation of the construction facilities, excavation of the diversion canal and placement of concrete on the first saddle dam.

Following completion of diversion canal targeted at the beginning of dry season i.e. the end of March, 1983, the Amban Ganga will be diverted in the diversion canal and the river bed under the main dam will be dried with primary cofferdams. The hastiest operation of excavation of river bed and embankment of the main cofferdam will be required during this dry season up to October 1983. The impounding of the Reservoir will be commenced at the beginning of October 1985, releasing the water required for the existing farmland of 40,000 ha. The dams and spillway will be completed at the end of the year 1985 and the powerstation will be commissioned a few months later the completion of the dams with the irrigation release.

More details of the construction plan are referred to the ANNEX - .III. The lists of major construction equipment and plants and main materials for the construction are referred to the attached Tables 7.3.5 and 7.3.6 respectively

The investment cost of the reservoir, dam and powerstation in the first stage comprises the direct construction cost, engineering and administration costs, and compensation cost. In the estimating the investment cost all costs are based on the price levels at the end of 1978. A physical contingency of 10 % for civil and hydro-mechanical works are added.

The direct construction cost is estimated on the unit price basis assuming that almost all the construction will be done by the international contractor, the import taxes and duties on materials and equipment brought into the site by the contractors being exempted. Detailed breakdown of the direct construction cost is referred to the ANNEX III.

The investment costs are broken down into foreign and local currency components with the assumption that locally available resources were utilized to the maximum extent.

The total investment cost at the 1978 price level is estimated at US$114.34 million equivalent for the reservoir, dam, powerstation with the first set of generating equipment and transmission line to the Bowatenna, out of which amount the local currency component is expected about 310 million Rupees or 18 % of the total cost, as shown in the attached Table 7.3.7.

Based upon the construction time schedule and aforementioned, the disbursement schedule estimated by year is shown in the attached Table 7.3.8.

7.4 POWER GENERATION

7.4.1 General Aspects of Electric Power System in Sri Lanka

The entire public power supply system in the country is managed and operated by the Ceylon Electricity Board (CEB). The design and construction of new power facilities are also under the CEB's management, while design and construction of reservoirs and dams are under management of the Central Engineering Consultancy Bureau (CECB).

In 1977, the total energy generated was 1217 GWH and the peak demand was 261 MW. The records of energy generation and consumption for 1968 through 1977 are shown in Table 7.4.1.

The 132 kV transmission voltage is employed for trunk transmission lines, 33 kV voltage is mainly employed for local transmission and 66 kV voltage is employed for short distance only. All of the power stations and substations are interconnected each other by transmission lines and are united into one electric power system as referred to Fig. 7.4.1 and Fig. 7.4.2.

About 80 per cent length of the transmission lines are rated at 132 kV and about 20 per cent of which are rated at both 66 kV and 33 kV.

The generating facilities in the CEB system as of the end of 1978 are 402.06 MW in installed capacity and consist of hydropower plants of 332.19 MW, a steam power plant of 50 MW and diesel power plants of 19.87 MW. The shares of the hydro, steam and diesel power installations in capacity are 83 %, 12 % and 5 % respectively.

The installed capacity of each power station is listed in Table 7.4.2 for hydropower stations and Table 7.4.3 for thermal power stations.

The power stations currently under construction or under planning are listed in Table 7.4.4 and Table 7.4.5.

Other sites than under planning as promising at present for hydropower development are listed in Table 7.4.6; the capacity of which being 93.5 MW in total.

7.4.2 Power Demand Forecast

For the purpose of future power projection, two regression analysis methods are employed; one is the total power consumption related to the Gross Domestic Product (GDP) and the other related to the value added in manufacturing and mining.

The mean values of the above two regression analyses are assumed as most probable and employed for the succeeding studies.

The future growth rates of the GDP and value added in manufacturing and mining are assumed to be 6.09 % and 8.50 % respectively and to remain constant during the period of the forecast. The forecasted power demand upto 1995 is tabulated in Table 7.4.7. The peak power demand. 261 MW in 1977, will become 548 MW in 1985 and reach 1293 MW in 1995. The details of the forecast process including calculation formulae are referred to ANNEX-IV.

The result of the power demand forecast is compared with those performed by other organizations, the Perera Committies, CEB and NEDECO, as shown in Fig. 7.4.3. The power demand forecast in this report is almost simillar to that of the Perera Committee.

7.4.3 Relation between Future Power Demand and Supply

(a) Relation between Maximum Demand and Firm Peak Output

The firm peak capacity of all the hydropower station as of 1978 was 295 MW as listed in Table 7.4.2 and the total firm peak capacity of the entire CEB system is estimated to be 364 MW including the thermal power output of 69 MW.

The required generating capacity is usually obtained as sum of the forecasted peak demand and certain reserve capacity. CEB usually decide the reserve capacity from the 15 per cent of the system peak demand or the largest unit in the system whichever is the larger.

The relation between the forcasted required generating capacity and the estimated firm peak capacity of the system is shown in Table 7.4.8 assuming that the development projects which are envisaged at present are realized as scheduled. The commissioning dates of Bowatenna, Canyon and Samanalawewa power stations are scheduled at the ends of the years 1979, 1980 and 1983 respectively and other power stations as shown in Table 7.4.8.

It is clear from Table 7.4.8 that the power supply shortage will begin in 1981 and will increase to 96 MW in 1983. In order to fill up such shortage, a new thermal power station of around 100 MW in capacity should be built by the end of 1982.

As the power shortage in 1981 is only 4 MW and is very small compared with the reserve capacity, it is necessary that the first unit of 50 MW capacity should be built toward the end of 1981 and the other unit of 50 MW capacity by the end of 1982.

Fig. 7.4.4 shows the relation between the forecasted peak demand, required generating capacity and power supply capacity assuming the construction of the new thermal station with two units of 50 MW capacity as mentioned above. The power supply will satisfy the power demand until the year of 1989.

In order to meet the power demand after 1989, another new thermal power station will be required to be built by the end of 1989. There will be no suitable site for large hydropower development. Thus after 1989, the share of thermal power will become greater year by year.

(b) Relation between Annual Energy Demand and Firm Energy Supply

Available annual energy generation of the Kelanitissa steam power station, diesel power stations and the new thermal power station are assumed to be 210 GWH, 10 GWH and 300 GWH x 2, respectively.

Table 7.4.9 shows the relation between the forecasted energy demand and available energy generation. It is clear from the table that the available energy will be adequate until the year of 1990.

Fig. 7.4.5 shows the relation between the available annual mean and firm energy output and forecasted annual energy demand by means of a graphical explanation.

(c) Relation between Annual Energy Demand and Mean Energy Supply

Table 7.4.10 shows the relation between the forecasted annual energy demand and available energy generation of the years with the mean annual river flow.

After commissioning of the Moragahakanda power station in 1986, support by thermal energy will become necessary in 1990. The mean generated energy of hydropower stations including the Moragahakanda power station will be fully utilized in 1990 and thereafter.

7.4.4 Moragahakanda Powerstation

The Moragahakanda Powerstation is planned to be located at the toe of the Moragahakanda Dam. Principal purpose of the Dam is to secure necessary water to satisfy the irrigation requirements for the farmland of 62,200 ha.

In order to decide the optimal height of the Dam, 6 alternative schemes are taken up for the comparative study, as descrived in the previous Section 7.3 MORAGAHAKANDA DAM. Preliminary design and cost estimated of generating equipment matching with the above alternative schemes are made for the study's.

Scheme No.2: One unit of 22.5 MW, designed with the maximum discharge of 56.6 m^3/s at H.W.L. of El. 188 m. The operation will be limited within a range of water level above El. 165 m.

Scheme No.3: One unit of 26 MW with the maximum discharge of 56.6 m^3/s at H.W.L. of El. 195. Designed so as to be able to discharge 56.6 m^3/s at the operation level of El. 174.4 m.

Scheme No.4: Two units each of 20 MW with the maximum discharge of 57 m^3/s at the water level of El. 181.8 m. Four hour peak station with afterbay.

Scheme No.5:	One unit of 28.5 MW with the maximum discharge of 56.6 m^3/s at H.W.L. El. 200, and designed to be able to release the maximum discharge at the operation water level of El. 182.8 m.
Scheme No.6:	Two units each of 33 MW with the maximum discharge of 82.5 m^3/s at the waterlevel of El. 187.8 m. Four-hour peak station with afterbay.

As stated in the previous Section 7.3, Scheme No.3 is selected as the best alternative. A detailed explanation is given below to the generating equipment envisaged to suit with the optimal Dam. The main parameters of 26 MW unit are summarized in Table 7.4.11.

The turbine discharge is limited to 56.6 m^3/s and the maximum output of 26 MW is available when the Reservoir is at the H.W.L. of El. 195 m. The conditions in which the maximum output is obtained are as follows:

H.W.L.	El. 195 m
T.W.L.	El. 139.3 m
Gross head	55.7 m
Loss of head in waterway	0.9 m
Effective head	54.8 m
Turbine efficiency	0.879
Generator efficiency	0.97

$$\text{Output} \doteq 9.8 \times 54.8 \times 56.6 \times 0.879 \times 0.97$$
$$= 25{,}917 \text{ kW} \doteqdot \underline{26 \text{ MW}}$$

Other than the main generating equipment, an overhead crane of 120 ton capacity, storage batteries, power line carrier telephone for communication with Bowatenna etc. are to be installed. One set of diesel-engine driven generator of 150 kVA (120 kW) will also be installed for emergency power supply.

The connection diagram and the general arrangement of the power-station are shown on DWGs No. P-001, P-002 and P-003.

A plan of stage development is recommended in a promise that the NCP canal is built in near future, as described in the previous Section 7.3. One complete set of power facilities such as the intake, penstock and generating equipment will be provided in the first stage, according to the proposed plan. Some part of the intake, penstock and space in the power house will be also built together with the draft tube of the future unit as the provisional work for the future installation.

As the future unit, 26 MW unit of same design as the first unit, is preferred in view of easier operation and maintenance.

The estimated cost of the first unit covers the provisional works as mentioned above.

7.4.5 Power Benefit

It is generally accepted that the benefit of a hydropower plant is evaluated from the cost of the least-cost alternative to produce an equivalent power and energy to those of the planned plant. The most likely competitive means in Sri Lanka will be oil-fired steam plant.

The installation cost of the steam plant of a scale from 50 to 66 MW is estimated to be US$660/kW. The capacity adjustment factor of the hydropower plant to the steam plant is estimated to be 1.118.

The kW benefit is obtained as sum of capital cost, being 11.02 % of the construction cost assuming a discount rate of 10 % per annum over the economic useful life of 25 years, and annual operation and maintenance cost, being 3.65 % of the construction cost.

The kWh benefit is obtained as sum of lubricant cost and fuel cost assuming the fuel price of US$0.073/litter and overall operating efficiency of 27 %.

The kW and kWh benefits of the Moragahakanda power station obtained as above are US$108/kW and US$0.02575/kWh. The details of calculation are referred to ANNEX-IV.

Regarding the dependable peak power and energy for economic evaluation, the following definition is employed. The dependable annual energy output at the power station is worked out as a sum of monthly product which can be expected in a dependability of more than 90 % (energy output which can be secured for 26 months out of total months of 28 under study from 1950 to 1977; such study is conducted for each month as referred to ANNEX-IV,4.4) and dependable output is obtained as the yearly average of power output in 12 months in which the dependable energy product is counted. The secondary energy is defined as an energy given at a balance between the annual average output during 28 years and the dependable energy output. The dependable output, dependable energy product and the average available energy in each alternative are worked out from the outputs of reservoir operation study as referred to ANNEX-I, and summarized in Table 7.3.1 of Section 7.3.

7.4.6 Transmission Line

A single circuit 132 kV transmission line with one earth wire of 16 km length is to be erected between Bowatenna and Moragahakanda power stations.

The line will be connected directly to the Bowatenna Ukuwela line near the Bowatenna power station.

The neutral point of the 132 kV power system will be directly earthed.

The line route is shown on the Fig. 7.4.6. This route may be slightly changed as a result of detailed survey of the line route.

Table 7.4.12 shows the main parameters of this line.

7.4.7 Construction Schedule and Cost

(a) Power Station

The length of time from the tender opening to the completion of the power station equipment is about 39 months (See Fig. 7.6.2).

The tender opening should be at the end of December 1982, at the latest.

The cost estimate of the equipment and its installation is as follows:

1. Turbine	38	(10^6Rs)
2. Generator	26	"
3. Transformers	5.46	"
4. Switch gear	9.38	"
5. Ancillary Equip.	10.46	"
6. Miscellaneous	4.08	"
7. Freight & insurance	3.77	"
8. Inland transportation	1.84	"
9. Installation	19.7	"
Total	118.69	(10^6Rs)

Table 7.4.13 shows annual disbursement of the cost of the equipment and its installation.

(b) Transmission Line

It takes about 22 months to complete the transmission line after the tender opening date (See Fig. 7.4.8). The tender should be opened at the end of January 1984 at the latest.

The completion date shall be the end of December 1985 to coinside with the trial operation of the power station.

The breakdown of the construction cost is as follows.

Towers	2.15	(10^6Rs)
Conductor, earth wire, insulators	2.03	"
Survey and design	1.15	"
Erection	2.48	"
Total	7.81	(10^6Rs)

Table 7.7.4 shows the annual disbursement of the transmission line cost.

(c) An Equipment Steam Power Station

Table 7.7.5 shows the disbursement schedule of the 26 MW steam power station needed to study the economic feasibility of the Moragahakanda power station.

The construction period of the steam power station is estimated three years, and the construction cost amount to 660 US$/kW that is 9,900 Rs/kW.

7.5 Irrigation and Drainage Plan

7.5.1 Basic Policy

Being one of the projects put under the umbrella of the Mahaweli Ganga Development Program, the irrigation plan of the Moragahakanda Agricultural Development Project needs to be worked out by taking into consideration an overall water balance to be maintained among all the projects involved. Presumably, the study on the overall water balance and allocation of water resources among the Systems belonging to each project should have been taken up by NEDECO under its Mahaweli Program Implementation Strategy Study, but the final findings agreeable to the Government of Sri Lanka were not available before this Section was in the drafting stage. Under these circumstances, the irrigation plan of the Moragahakanda Project has been based on the following criteria:

(1) The Mahaweli water to be diverted at Polgolla:- the volume of water to be released down below Polgolla along the Mahaweli Ganga shall not be less than 150 cusec (4.2 m^3/sec) from the riparian management point-of-view; after assuring this, the Mahaweli water may be diverted towards the Amban Ganga within the maximum limit of 2,000 cusec (56.6 m^3/sec);

(2) The volume of the Mahaweli water to be diverted at Polgolla-based on the calculated annual average discharge for the last 28 years - will not be more than 1,250 TAF (1,542 x $10^6 m^3$) as is specified in the UNDP/FAO Report;

(3) The Mahaweli water diverted at Polgolla will be subsequently diverted at Bowatenne to System H to the extent of 518 x $10^6 m^3$ which corresponds to the total water requirements, as estimated by NEDECO, in Systems H, I(H), and M(H);

(4) The remainder of the Mahaweli water and the own discharge of the Amban Ganga, after being stored and regulated by the Moragahakanda Reservoir, will be used for agricultural development of both the existing fields and the new lands, totalling 153,800 ac (62,200 ha) in Systems G, D1, D2 and A/D, and

(5) The existing fields in the Moragahakanda downstream will be assured with stabilized year-round supply of irrigation water, while the new lands will enjoy equally assured year-round supply of water allowing the settlers there to engage at full irrigated agriculture.

7.5.2 Irrigable Area

The irrigable area which has been identified by the JICA's F/S Team is shown, System-wise as well as Tank-wise, in comparison with the relevant figures given in the UNDP/FAO Report (1968) and the MDB Report (1977) in Table 7.5.1. Irrigation Plan has been worked out, on the basis of our recent-most survey result, toward the area specified in the below:

a) The entire existing field: 40,000 ha (98,900 ac)

b) The area which was proposed for new development in conjunction with the Polgolla-Bowatenne Complex but has been left undone: (Other Schemes)

in System G	4,100 ha (10,000 ac)
in System D1	3,800 ha (9,500 ac)
(Kantalai Sugar corporation are)	400 ha (1,000 ac)
	8,300 ha (20,500 ac)

c) New lands which can be developed by additional water made available through construction of the Reservoir: (in Systems D1, D2 & A/D) 13,900 ha (34,400 ac)

62,200 ha (153,800 ac)

The irrigable area under this Project is larger than that proposed in the MDB Report by 5,800 ha (14,400 ac). As the topographic maps used for the survey were both old and incomplete, the acreage thus obtained cannot claim full accuracy; it is therefore necessary to re-confirm the irrigable acreage by using more dependable maps at detail design stage.

7.5.3 Water Requirements

Irrigation plan is meant for the optimal satisfaction of the water requirements which are primarily made up of the Crop Water Consumption Requirement (Evapo-transpiration) = ET. ET is a coefficient of the Reference or Potential Evapotranspiration = ETo, and the Crop Factor, to be stipulated month by month corresponding to the growth period of the crops grown under specific cropping pattern(s). ETo values have been obtained by the modified Penman Method which is usually used by the Land Use Division, Irrigation Department, on the basis of the recent meteorological data which have been collected at Maha-Illuppallama.

Data available at rainfall observation posts at Kantalai, Hingrakgoda, Polonnaruwa and Elahera have been used to determine Effective Rainfall, separately for paddy and upland crops. Effective rainfalls for upland crops have been calculated by USDA SCS Method and that for paddy has been determined according to the following formula:

Effective rainfall = (Rainfall - 1" or 25.4mm) x 0.67
Maximum effective rainfall = 9" or 228.6mm
Rainfall less/than 1" or 25.4mm = 0

Water requirements for land preparation have been determined at 7" (177.8mm) for puddling of the paddyfield, and 1.5" (38.1mm) for upland ploughing, each per season. Percolation loss in the paddyfield has been estimated at 6" (152.4mm) per month, and 50 per cent irrigation efficiency will be applied to the upland crops. Distribution loss between the outlets and the peripheral farms have been estimated at 30 per cent of the irrigation requirement. Conveyance loss along Yoda Ela between Elahera/Angamedilla headworks and the five existing tanks has been assumed at 0.3 per cent of the irrigation requirement per mile (1.6 km).

Based on the above-mentioned assumptions and principles, the System/ tank-wise monthly diversion requirements have been estimated as per Table 7.5.2. The diversion requirement per unit acreage will be 1.91 l/sec/ha and the total diversion requirements in Systems D1, D2, G and A/D would amount to 1,788 x $10^6 m^3$ (1,450 x 10^3 ac.ft), in terms of mean value for the last 28 years.

7.5.4 Designed Water Requirement

Monthly water requirement is the highest during July, when calculated on the basis of the proposed cropping patterns. Water requirement for each 400 ha (1,000 ac) is 2,183,295 m^3 (1,700 ac. ft) under Cropping Pattern A, and 1,618,352 m^3 (1,312 ac.ft) under Cropping Pattern B. Designed water requirements have to be identified to determine the dimensions of irrigation facilities and structures, and effective rainfall needs not to be taken into account. The ratio between Cropping Patterns A and B being 4:1, unit water requirement would be 1.91 l/sec/ha (36.6 ac/cusec).

7.5.5 Water Balance

Water balance calculation based on the individual Tank's water requirement as regulated through its operation, on one hand, and the hydrological/ meteorological data for the last 28 years (1950-1977), on the other, the

Moragahakanda Reservoir would promise a high success percentage of crop cultivation in its downstream at 90.5% on an average. Assuming that the Polgolla-Bowatenne Complex project could have been complemented by innovation/ new provision of irrigation/drainage facilities in the existing fields (and new lands might have been thereby brought under cultivation), an average success percentage might have been in the neighborhood of 84.2%. According to the opinions held by the resident farmers in the region, the most favorable success percentage of crop cultivation in the post-Polgolla years has been around 84.2%.

Success percentage of the irrigable area in each different case referred to in the above are given in Table 7.5.3.

7.5.6 Irrigation Plan

Gravity irrigation is the rule; no pump-irrigation nor lift-irrigation is taken into consideration. In the existing fields, the canals would be utilized as they are as far as possible but with necessary improvements and repairs, together with new provision of irrigation/drainage facilities toward the improvised farms to prevent wastage of irrigation water. The nature of the work involved in the 'acreage under specification' would be the repair of distributory canals and facilities, and that in the 'acreage under unauthorized cultivation' would be consolidation of farms, new provision of irrigation/drainage channels and other facilities indispensable for proper distribution of irrigation water.

19,500 ac whose development was originally planned under the Polgolla-Bowatenne project and in fact partially undertaken at places and 1,000 ac Kantalai sugar-cane area would be exempted from this Irrigation Plan. For irrigation of the new lands, the present Yoda Ela will be utilized as it is equipped with enough flow capacity to irrigate the new lands on and above the existing fields. To recover its original flow capacity, however, it is necessary to remove grasses and shrubs left growing on its inner bands and sedimentation on its bed, side by side, with restoration of its original crossing.

System D1

The existing main canal running down from the intake on the left bank of Kaudulla Tank would be utilized but a new canal (Branch No. 2) will be constructed to convey water to Stage III. Conveyance of water to Stage IV will be effected through the existing branch canal (Branch No. 1) but upon proper widening and lining works. A new canal will have to be constructed to send water further downstream. As a rule, the existing canals would be lined and widened, as necessary. Distribution of water to each Tract will be done by providing distribution channels.

System D2

For conveyance of water to the newly reclaimable area, the existing main canal starting from Dl Intake of Parakrama Samudra will be utilized and thence by two routes of the existing Dl - North canal and Dl - East canal. The advantage between the one-route method and the two-routes method was compared but in vain as both canals are almost equally in advance stage of deterioration and neither be used without repairing. Moreover, distribution of conveyance water into two canals would make the widening work either unnecessary or of a limited scale.

System A/D

Originally, it was planned to utilize the existing right bank canal of Kantalai Tank, but a new conveyance method was hinted upon during the field survey and eventully adopted because of its multiple advantages. It is to construct a new Tank in the upstream of the Kalu Ganga to collect the surplus water of the Gal Oya and Aluth Oya. This Tank would be useful for flood-control of the Kalu Ganga itself, diminishing waste water and securing irrigation water for Yala cultivation. It will be replenished with additional irrigation water through diversion from Minneriya-Kantalai Yoda Ela. Diversion weir will be built at about 7.5 miles downstream of the Tank and water will be lead to System A/D by a newly built canal.

The area currently fed by Heen Ganga Tank would correspond to the projected new land in System Dl, and its discharge would become much less in future, particularly during Yala season. Hence it has not been involved in the irrigation plan under the Project.

Irrigation Network of the new land in each System is diagrammed in Fig. 7.5.1 to Fig. 7.5.3. The construction plan of the irrigation facilities is outlined in Summary.

7.5.7 Drainage Plan

The drainage water flowing into the Mahaweli Ganga through the natural rivers which are currently used as the drainage system in the Project area would flood over their banks and extensively innundate farmlands along their courses in every monsoon season. They sought to be turned into the main drainage canals being linked with the field drainage channels and System-wise drainage canals to be constructed under the Project.

The drainage improvement plan has been based on 5 year design floods and involve excavation, embankment, river-bed restoration, etc. along the specific length of the under-mentioned rivers:

Rivers	Irrigation System	Length (miles)
Kalu Ganga	D1	11.5
Thimbri Ela	"	7.5
Ambagaha Oya	"	8.4
Periya Aru	D2	11.2
Sinna Ganga	"	9.0
Uppu Aru	A/D	4.8
Karappankadawela Aru	"	4.4
		56.8

7.5.8 Land Reclamation

Almost all the new lands to be reclaimed are covered by jungle which is rated as 'common' in density, except in System A/D where jungle density is a little coaser, that is, 'medium'. Terrain is generally flat (particularly in System D2) or sloped by 1/500 - 1/1,000. Land reclamation will be done on the standards of 2.5 ac (1 ha) farm-plot and 0.5 ac (0.2 ha) house-plot but of cluster type.

Farmland would be consolidated into a unit of 310' x 70'. Field irrigation/drainage channels would be provided for free manipulation by the cultivating farmers themselves. Roads of different dimensions would conveniently link the farmland area and settlement area. Irrigation/drainage channels and farm roads would be proportionated to the farmland as follows:

Irrigation channel	93 ft/ac	(70 m/ha)
Drainage channel	80 "	(60 ")
Farm Road	87 "	(50 ")

7.5.9 Downstream Development Schedule and Cost Estimate

Improvement and new provision of irrigation/drainage facilities and structures in the existing land would be completed by the end of 1985 when the headwork would have been constructed. Assuming that storage of irrigation water to benefit the new land would take about 1.5 years after completion of the dam, development of new lands in Systems D1 and A/D would be completed by about April 1987, and that in the new land in System D2, after it would become flood-free upon completion of a group of dams and reservoirs in the upstream of the Mahaweli Ganga.

Detailed survey and tender design would take about one year from mid-1980 to mid-1981, and the construction period would be seven years from 1982 to 1988. Construction Time schedule of Downstream Development is shown in the attached Fig. 7.5.5.

Machinery and equipment required for downstream development construction work and their prices (cif. Colombo or Trincomalee, December 1978) are shown in Table 7.5.6. Summary of Construction Cost and its annual disbursement schedule are given in Tables 7.5.4 and 7.5.5 respectively.