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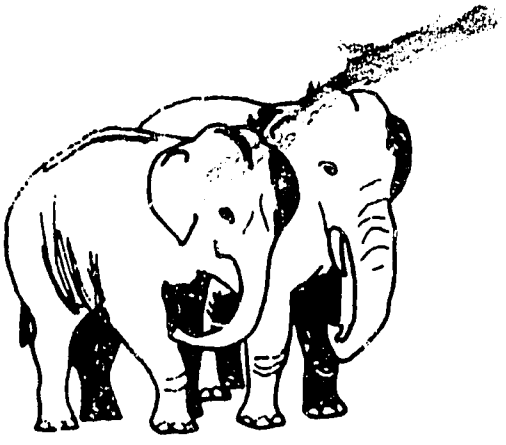


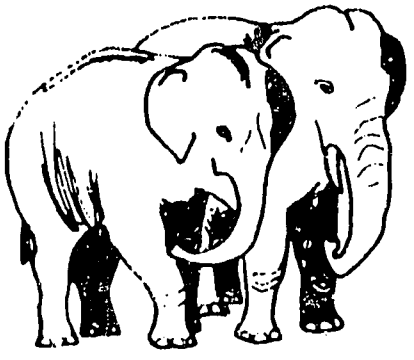
ENVIRONMENTAL ASSESSMENT
ACCELERATED MAHAWELI DEVELOPMENT PROGRAM

Funded by United States Agency for International Development

OCTOBER 1980

VOLUME II
TERRESTRIAL ENVIRONMENT

Democratic Socialist Republic of Sri Lanka
Ministry of Mahaweli Development



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VOLUME II
TERRESTRIAL ENVIRONMENT

TAMS TIPPETTS-ABBETT-McCARTHY-STRATTON
NEW YORK, NEW YORK

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CLIMATE

EXISTING CONDITIONS

The climatic conditions in the project area are largely influenced by two monsoon systems of the Indian Ocean. From December to February, the area is generally under the dominance of the northeast monsoon, known as maha; while from May to September, it is under the dominance of the southwest monsoon, known as yala.

The climatic elements which are pertinent to this study are discussed in the following paragraphs under appropriate headings.

Rainfall

The mean annual rainfalls in the project area range from 1,650 millimeters in the downstream areas to 5,300 millimeters in the mountains, as shown on Figure A-1. The seasonal distribution of rainfall in the project area is closely associated with the monsoon systems. Although the rainfall during October and November is of convectional and cyclonic origin, it is ordinarily considered together with the northeast monsoon (maha) season. Most of the hill country generally receives abundant rainfall during both monsoon seasons, but the downstream area receives significant rainfall only during the maha season. The typical monthly distribution of rainfall at various locations of the project area is also illustrated in Figure A-1. Information regarding monthly rainfall totals and number of rainy days can be obtained from the annual reports published by the Sri Lankan Department of Meteorology.

Previous study (NEDECO 1979) has shown that there is no definite long-term trend preserved in the annual rainfall series. In other words, the rainfall occurrence in the project area can be assumed as a stationary process. Furthermore, there is no specific evidence for dry years to follow dry years. The rainfall amount in each year seems to be independent from those in the preceding years.

Temperature

The annual temperature variations are small (usually less than 5°C) throughout the project area. According to the annual statistics published by the Department of Meteorology, the mean annual temperature in the downstream area varies very little from 27°C.

However, it decreases with the increase of ground elevation. For example, the average monthly temperatures at Kandy (elevation about 490 meters above sea level) range between 23°C and 26°C; the approximate range at Diyatalawa (1,220 meters) is from 18°C to 22°C; and that at Nuwara Eliya (1,860 meters) is from 14°C to 17°C.

Relative Humidity

Relative humidity is a measure of the amount of water vapour in the air as compared with the maximum amount that can be contained at a certain temperature. The diurnal variation of relative humidity is always inversely related to temperature. In the morning, when the temperature is low the realtive humidity is usually high. This relationship is generally reversed in the afternoon.

During the maha season, the daily maximum relative humidity reaches between 80 and 90%; and the daily minimum varies between 70 and 80% throughout the project area. During the yala season, however, the daily maximum is generally below 80% and the daily minimum ranges between 60 and 70%.

Evaporation and Evapotranspiration

Evaporation rates in Sri Lanka have been widely measured by means of the U.S. Weather Bureau Class A pans since the 1950's. However, most of the pans with long-term records are located in the downstream area; only one station, Kande Ela (about six km south of Nuwara Eliya with an elevation of 1,850 m), is situated in the highlands. The mean annual and mean monthly evaporation rates at selected stations within the project area are indicated in Table A-1.

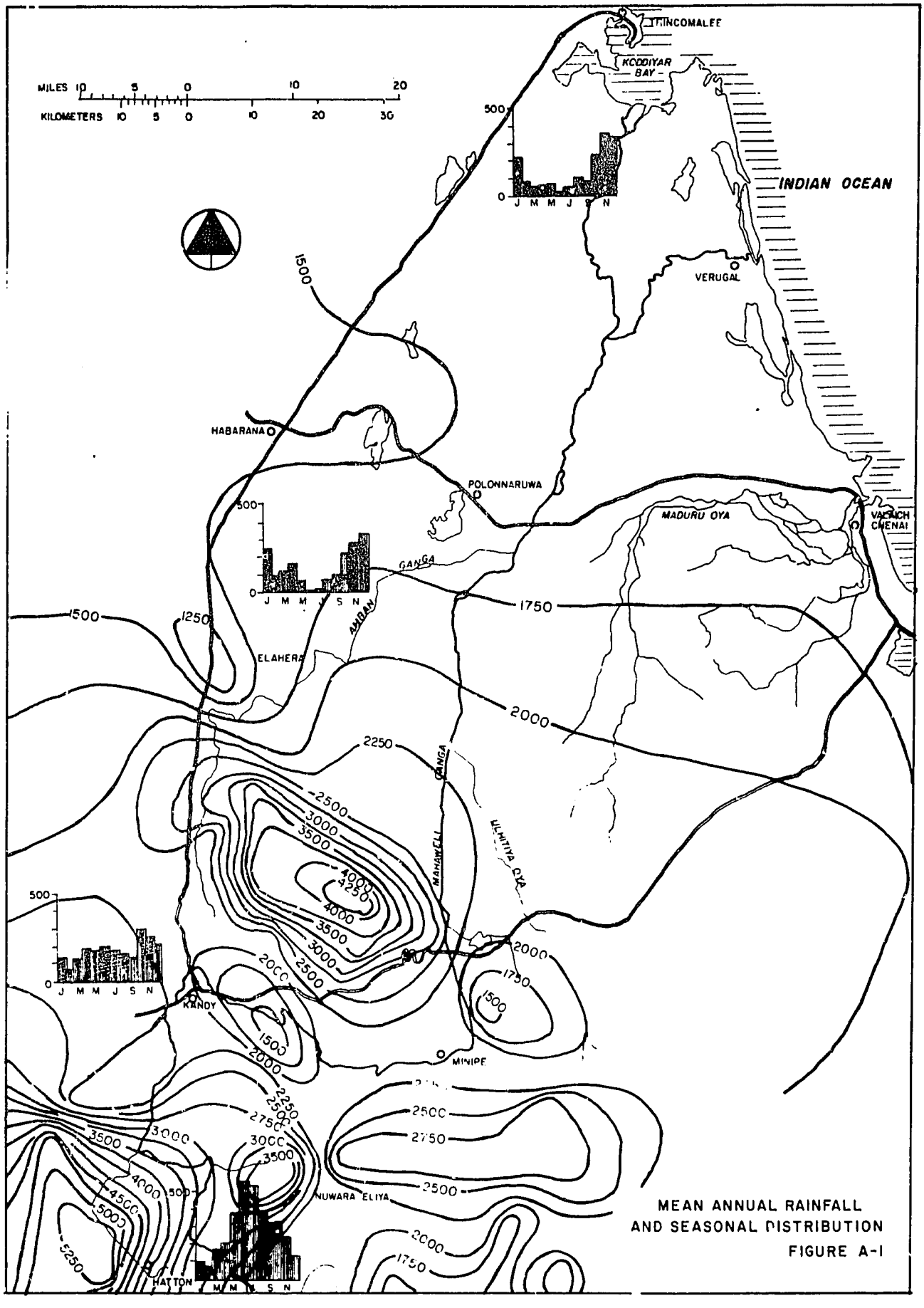
Evapotranspiration, sometimes called consumptive use, represents the total water removed from an area by transpiration through plants as well as by evaporation from soil and water surfaces. It depends on net radiation, temperature, relative humidity, wind speed and altitude. Long-term climatological records in the vicinity of the project area are available only at Anuradhapura, Maha Illuppallama and Trincomalee. Using the recently obtained solar radiation data, the Department of Irrigation has calculated the evapotranspiration at Maha Illuppallama by means of the modified Penman method. NEDECO (1979), on the other hand calculated the evapotranspiration, also based on the modified Penman method, for Anuradhapura by estimating the net radiation from cloudiness observations and sunshine hours. Their results are compared in Table A-2.

IMPACT ANALYSIS

Perhaps the only noticeable impact on climate in the future will be due to the change of land use patterns in the project area. A portion of the existing forest will be cleared and thousands of hectares of land will be developed for agricultural uses. The impact of land use changes on climate are discussed below.

Evaporation and Evapotranspiration

Theoretically, the evapotranspiration rates in the project area



MEAN ANNUAL RAINFALL
AND SEASONAL DISTRIBUTION
FIGURE A-1

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will decrease with the reduction of forest. But the decrease of evapotranspiration will probably be exceeded by the increase of surface water due to irrigation on the proposed agricultural land, especially on the proposed rice paddies. The net effect is difficult to be quantified. Nevertheless, this impact is expected to be a localized phenomenon.

Temperature

An increase of evapotranspiration from land surface may result in changes in radiation and air temperature. But the incremental change of air temperature will be too small to cause any significant impact on human populations, livestock, wildlife or crops. However, it may have a side effect on local storm events (see next subsection).

Rainfall

It was formerly believed that a land use practice that increased evaporation could cause rainfall on nearby areas to increase appreciably. This view has now been almost entirely abandoned by meteorologists (Gilman 1964). Since the rainfall in Sri Lanka is mainly dominated by the monsoon systems, the moisture added to the atmosphere is ordinarily transported some hundreds of miles away before it falls again to the earth as rainfall. Therefore, the increased evapotranspiration will not cause a significant increase of moisture in the same locality.

However, in March, April, September and October, many of the storm events in the project area are associated with convectional origins. The formation of a convective storm generally requires three conditions: 1) the presence of a warm, moist air; 2) atmospheric instability in the zone overlying this body of air; and 3) an initial lifting agent. The initial lifting agent is most commonly a local thermal convection. When the local evapotranspiration rate increases, the air temperature increases correspondingly. The humid surface air over a heated land area becomes warmer than the surrounding air and causes an unstable condition on which the warm air rises. If this unstable convective condition continues, towering cumulus clouds will form and thundershowers will occur.

As the net evapotranspiration will increase in the future, the thunderstorm activities are expected to increase within the project area. However, the storm locations will be shifted with the alteration of land use patterns. The influence of land use changes on spatial distribution of rainfall seems to be unavoidable. But it may be considered as a beneficial impact to crops as the convectional movements tend to bring the evaporated moisture back to the cultivated areas.

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Table A - 1

Pan Evaporation at Selected Stations

Location	Mean Monthly Evaporation												Mean Annual Evaporation	Years of Observation
	J	F	M	A	M	J	J	A	S	O	N	D		
Kantalai	102	98	131	122	153	182	183	182	169	140	95	95	1653	9
Kalawewa	124	127	162	151	176	176	185	189	200	154	123	118	1885	14
Kande Ela	82	93	114	91	92	75	79	80	87	82	80	76	1031	20
Maha Illuppallama	132	142	180	173	178	183	190	203	208	150	117	114	1971	N/A

Notes : 1. Data are expressed in millimeters; obtained by means of U. S. Class A Pans.

2. Source of information : Department of Irrigation ; complied by Domros (1974).

3. Data at Maha Illuppallama are from the Agricultural Research Institute.

Table A - 2

Estimated Evapotranspiration

Location	Monthly Figures (mm)												Annual Total (mm)
	J	F	M	A	M	J	J	A	S	O	N	D	
Maha Illuppallama [1]	119	152	157	150	163	175	191	193	191	157	109	114	1,871
Anuradhapura [2]	124	136	168	152	168	187	191	197	188	139	108	108	1,866

Notes : 1. Estimated by Department of Irrigation

2. Estimated by NEDECO (1979)

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SURFACE WATER

EXISTING CONDITIONS

River Basin

The Mahaweli Ganga is the largest river in Sri Lanka. Its drainage area is about 10,300 square kilometers, approximately one-sixth of the island's area. The river originates from the high hill country near Hatton and runs northerly and easterly to Koddiyar Bay at Trincomalee. The major tributary is the Amban Ganga which joins the main river near Manampitiya. Numerous smaller tributaries in the upland area comprise the major source of flows for the Mahaweli Ganga.

The Maduru Oya is a much smaller river flowing northerly, adjacent to the east boundary of the Mahaweli basin. It turns easterly at Welikanda and discharges into the Indian Ocean near Valaichchenai. The drainage area at Welikanda is about 1,000 square kilometers.

Streamflow

Based on the 28-year gauging records (1950-1977), the mean annual flow of the Mahaweli Ganga at Manampitiya is approximately 8,300 million cubic meters; the Maduru Oya average at Welikanda is approximately 620 million cubic meters. The mean monthly flows estimated by NEDECO (1979) at some key stations are shown in Table A-3.

As mentioned in the previous section on CLIMATE, the downstream area receives significant rainfall only during the maha season, but the upper catchment area receives abundant rainfall during both monsoon seasons. Therefore, the seasonal range of streamflow is not as large as that of rainfall in the lowland area. For example, the average flow during the dry season (March to September) at Manampitiya is approximately 46% of that during the wet season (October to February), but the dry season rainfall is only equal to 27% of the wet season rainfall.

In view of the 28-year data processed by NEDECO, the 1955/1956 water year appeared to be the most critical period. At Manampitiya, as shown in Figure A-2, the total flow in that water year was only equal to 53% of its mean annual flow.

Existing Water Resources Development

The existing major development of water resources in the project area includes the Polgolla Barrage which diverts flow from the Mahaweli Ganga through a tunnel to the Sudu Ganga; the Minipe Anicut which diverts flow to Hasalaka Irrigation Subdivision; the Bowatenna Diversion Dam which provides water to System H; and the Elahera Anicut which diverts water for

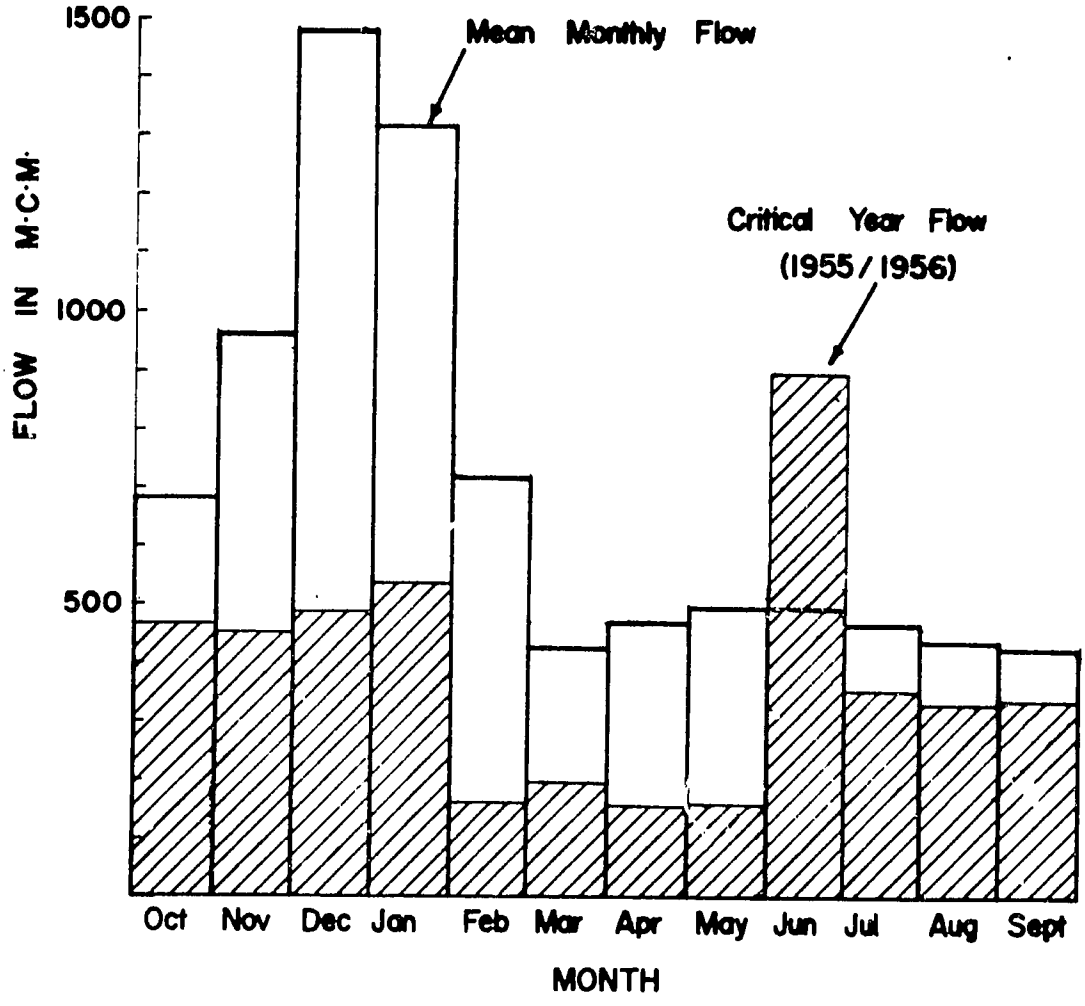
Table A - 3

Mean Monthly Flows at Selected Key Sites

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mahaweli Ganga													
Polgolla	116	70	64	107	199	299	273	249	239	321	284	218	2438
Minipe	408	264	172	247	334	415	400	368	349	501	528	538	4524
Manampitiya	1203	709	422	471	508	502	478	442	435	694	966	1459	8289
Elahera	151	93	55	49	46	27	25	22	21	57	104	178	829
Maduru Oya													
Damsite	95	48	20	14	13	4	3	4	4	45	50	112	381
Welikanda	158	76	35	22	20	6	4	6	6	25	80	184	622

Notes : 1. Flows are expressed in million cubic meters.

2. Source of information : NEDECO (1979).



VIRGIN FLOWS OF MAHAWELI GANGA AT MANAMPITIYA
FIGURE A-2

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irrigation in Systems G and D.

The capacity of the Polgolla Tunnel is 2,000 cubic feet per second (cusecs), of which a maximum of 1,000 cusecs is diverted through the Bowatenna Tunnel to the headwaters of the Kala Oya, while the remainder flows via the Elahera Canal to Systems G and D (World Bank 1977). The size of the development area to which the water is diverted from the Minipe Anicut has been increased from 1,600 ha in 1950 to 5,200 ha in 1979 (NEDECO 1979). The actual diversion rate is unknown.

There are hundreds of irrigation tanks in the project area. Some of them are very small and some of them are no longer in service. The characteristics of the major existing tanks are presented in Table A-4. The locations of the tanks are shown in Figure A-3. These tanks are generally controlled by sluice gates without any definite operation schedules. However, their influence on streamflow pattern is usually insignificant as the storage capacities of these tanks are generally small, compared with the total flow in the Mahaweli Ganga. In addition, the impact on water quality is not expected to be significant because the tanks are relatively shallow (between three and eight meters), thus stratification is unlikely to occur. The impact of irrigation tanks on fisheries is discussed in TOPIC REPORT G: FISHERIES.

There are a number of villus in the lowland area that are important to livestock, fisheries and wildlife. The locations of the major villus are shown on Figure A-3. The details of villus are discussed in TOPIC REPORT H: WETLANDS.

FUTURE CONDITIONS

Proposed Development

The proposed development is defined by the Accelerated Mahaweli Program which consists of the Kotmale, Victoria, Randenigala, Ulhitiya Oya (including Ratkinda Oya) and Maduru Oya Reservoirs and their respective catchments as well as the proposed irrigation systems A, B, C and D.

In addition, the development of the Rotalawela and Moragahakanda Reservoirs may also become alternative parts of the Accelerated Program in the future.

Proposed Reservoirs and Related Structures

The proposed reservoirs and related structures for the Accelerated Program are discussed in the following paragraphs. The locations of the reservoirs and structures are shown on Figure A-4. A summary of the reservoir characteristics is presented in Table A-5.

In addition to the proposed dams and reservoirs, the Minipe Right

Table A - 4

Characteristics of Existing Major Irrigation Tanks

Tank	Storage (m cu-m)	Surface Area (ha)	Average Depth (m)
System A			
Allai	--	1,360	--
System B			
Vakaneri	13.8	454	3
Pimburettewa	--	1,020	--
System C			
Dambarawa	15.9	344	4.6
Mapakada	8.2	186	4.4
Horabora	--	434	--
System D			
Giritale	21.5	308	7.0
Kantalai	135.3	2,025	6.7
Kaudulla	127.9	1,664	7.7
Minneriya	135.3	2,552	5.3
Parakrama Samudra	--	2,528	--
Vendarasan Kulam	24.6	416	5.9

Notes : Above figures are based on full storage levels.

Source: S. Arumugam (1962)

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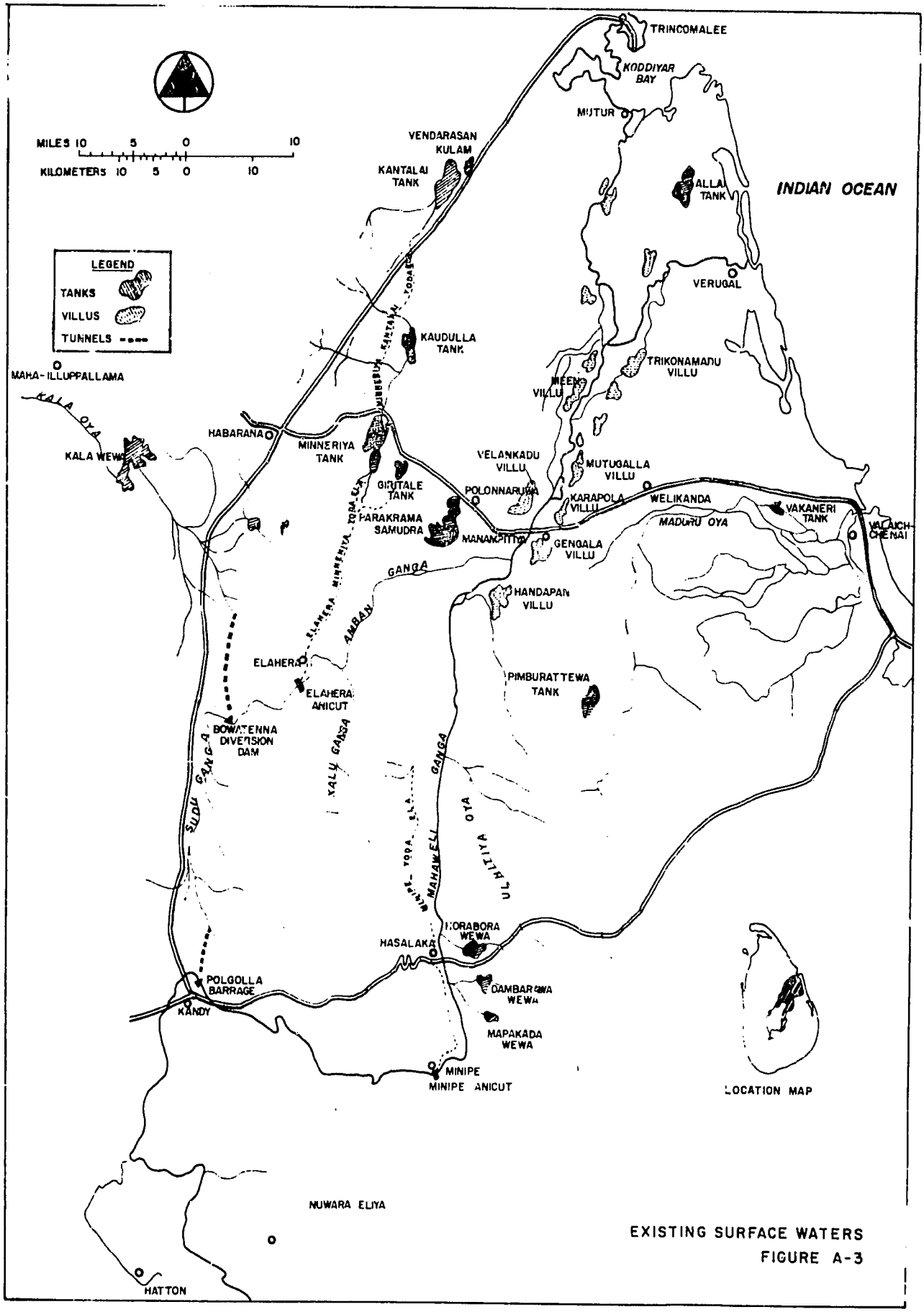

EXISTING SURFACE WATERS
FIGURE A-3

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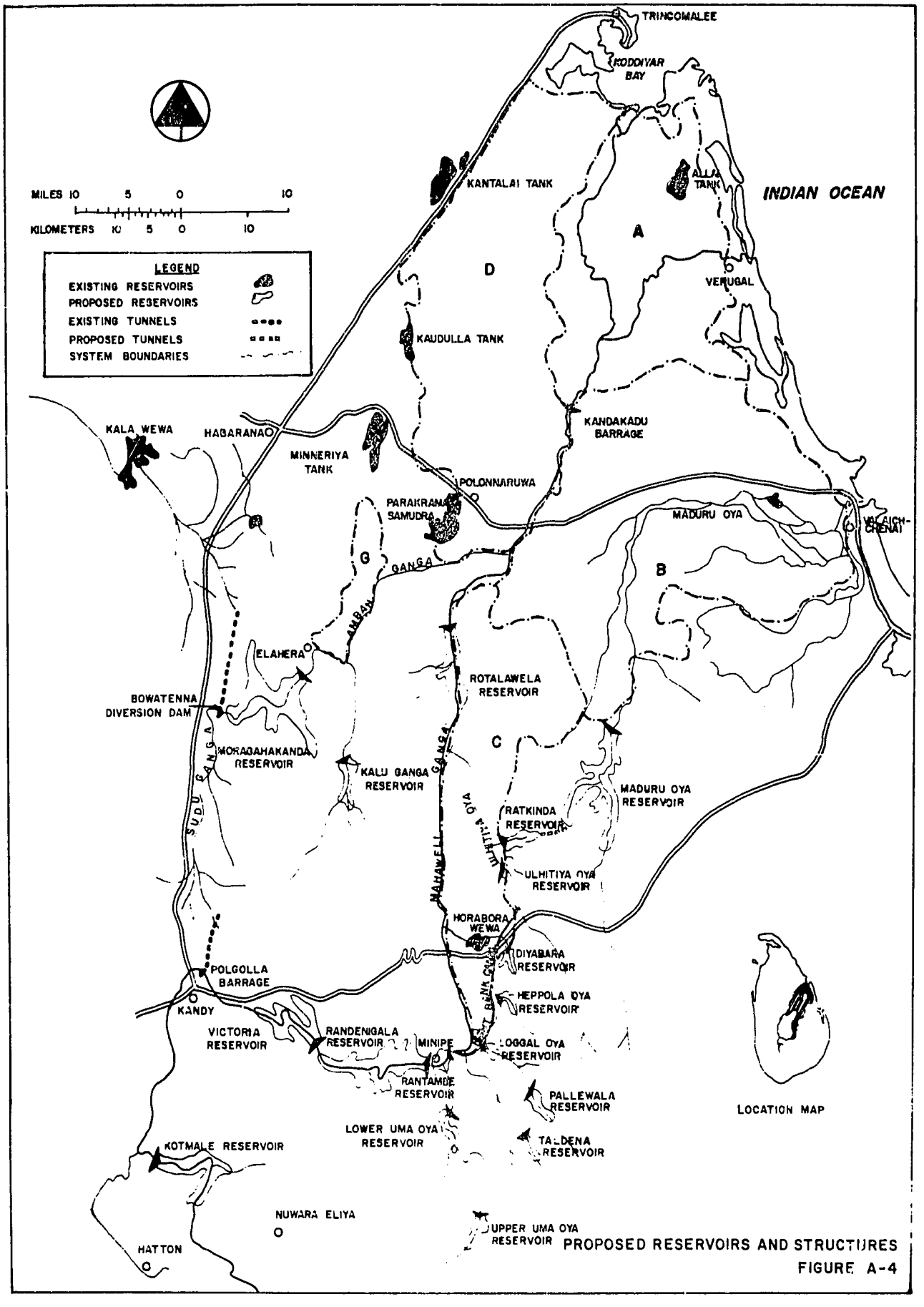

PROPOSED RESERVOIRS AND STRUCTURES
FIGURE A-4

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Bank Canal and a tunnel will be provided to divert water from the Mahaweli Ganga at Minipe to the Maduru Oya Basin. Also a barrage (Kandakadu Barrage) is proposed to be built in the Mahaweli Ganga near Manampitiya to provide enough head for irrigation in System A.

A number of minor reservoirs have also been proposed in the project area. These reservoirs include the Upper and Lower Uma Oya, Taldena, Pallewala, Loggala, Hepola, Diyabana, Heen Ganga and Kalu Ganga.

Under the Accelerated Program, the total storage capacity for the major reservoirs listed in Table A-5 is 2,555 million cubic meters (m cu-m). However, a large portion of that will be reserved for power generation. The net capacity of storage for existing irrigation tanks and other proposed reservoirs is estimated to exceed 3,000 m cu-m, which will be available for irrigation in the project area (NEDECO 1979).

Diversion Requirements

The diversion requirements for irrigation flow in various systems have been discussed by different reports in the past (World Bank 1979; NEDECO 1979; Fernando 1979; Acres 1979; Hunting Technical Services Ltd. 1979; and JICA 1979). In each report, however, the number of hectares to be developed and irrigated is often different from that appearing in other reports, because the areas of the proposed development in many systems have been revised several times during the past twelve months.

Based upon the monthly diversion requirements derived from the figures estimated by NEDECO (1979) and updated according to the reports prepared by Acres (1979) and Hunting Technical Services Ltd. (1979) and by recent interviews with the consultants, the total diversion requirements for the Accelerated Program were calculated as shown in Table A-6.

IMPACT ANALYSIS

Water Availability

NEDECO (1979) has derived the virgin flows at various points along the Mahaweli Ganga and Amban Ganga on the basis of the 28-year gauging records and the actual or estimated diversion flows. The mean monthly virgin flows at Manampitiya, which is located just upstream of the proposed Kandakadu Barrage, represent the total flow available for diversions in each month. As shown in Table A-6, the available flows in the Mahaweli Ganga are enough to meet the irrigation requirements for the Accelerated Program.

Based on the mean monthly virgin flows on the Mahaweli Ganga at Manampitiya, as shown in Table A-6, the total deficit between May and July is 252 million cubic meters. The annual flow surplus available for storage is estimated to exceed 3,000 million cubic meters, not even counting the storage of the proposed Rotalawela and Moragahakanda Reservoirs. Therefore,

Table A - 5

Characteristics of Proposed Major Reservoirs

Reservoir [1]	Height of Dam (m)	Approx. FSL Surface Area (ha)	Net Storage Capacity (m cu-m)	Irrigation Potential (ha)
Kotmale	107	970	408	22,000
Victoria	110	2,270	690	53,000
Randenigala [2]	93	2,750	860	-
Rantembe [2]	43	-	21	-
Ulhitiya Oya [3]	26	2,270	146	-
Ratkinda Oya	25			
Maduru Oya [4]	40	6,280	430	50,000
Rotalawela	78	15,000	850	-
Moragahakanda [5]	72	4,050	686	20,000

Source : 1) NEDECO (1979); unless noted otherwise
2) Joint Venture Randenigala (1980)
3) Hunting Technical Service Ltd.(1979)
4) Acres (1979)
5) Japan International Cooperation Agency (1979)

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Table A-6

Flow Availability (Million Cubic Meters)

Month	Mean Monthly Flow Available At Manampitiya	Accelerated Program		
		Diversion Requirement	Flow Surplus	Flow Deficit
January	1,203	251	952	-
February	709	316	393	-
March	422	272	150	-
April	471	372	99	-
May	508	525	-	17
June	502	669	-	167
July	478	546	-	68
August	442	316	126	-
September	435	327	108	-
October	694	304	390	-
November	966	306	660	-
December	1,459	186	1,273	-
Annual	8,289	4,390	4,151	252

Note: Application rate used is 3 ac-ft/year.

SOURCE: NEDECO (1979); ACRES (1979); HUNTING TECHNICAL SERVICES (1979).

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it is apparent that there will be sufficient water for irrigation of the proposed Accelerated Program.

River Flows

The impacts of the proposed reservoirs on river flows can be summarized in three aspects: volume, stage and frequency.

Under the Accelerated Program, the mean annual diversion of irrigation water will be 4,390 m cu-m, of which 519 m cu-m will be delivered to System H and not return to the Mahaweli Ganga. Of the remainder perhaps only 20% is likely to re-enter the Mahaweli as irrigation return flow. Therefore, the volume of flow in the Mahaweli will be reduced by about 50%, especially if water application rates actually exceed eight acre-feet/year.

Although the objectives of the proposed reservoirs are not for flood control, the flood peaks would still be reduced considerably by the surcharge storage in the reservoirs. However, the percentage of reduction is difficult to be quantified before the reservoir operation policies are finalized.

The river stage in the Mahaweli Ganga will not only be reduced during the maha season due to the reservoir regulation scheme, but also will be lowered during dry months, because a large portion of the existing flow will be diverted to other drainage basins and not return to the Mahaweli Ganga.

For the Maduru Oya, however, the future flow during the dry months will be increased due to the transbasin diversion at Minipe. Thus, the river stage will be raised.

Another impact on the river flows is that the frequency of flood occurrence will be reduced as a result of the controlled outflows from the proposed reservoirs. Again, the degree of reduction is not possible to estimate at the present time.

Effect of River Basin Development on Villus

Villus are vegetated land areas saturated with water seasonally. Most of the villus in the project area have direct connections to the Mahaweli Ganga or its tributaries by means of small channels. When the river is low, much, but usually not all, of the villu water will flow out through these channels. On the contrary, when the river is high, the flow will be reversed.

The surface area of a villu generally consists of two portions. One portion is the ponding area which is more or less constantly filled with water; and the other is the floodplain which is inundated by water only during the flood period.

The water level of a villu is a function of the volume contained in the villu, and the change of volume is governed by the rates of inflow

and outflow of the villu. Usually, the inflow of a villu has three sources: direct rainfall on the villu surface; runoff from watershed areas; and river water which enters during high river stages. The outflow, on the other hand, is mainly the result of losses due to evaporation and seepage. However, the subsurface layer under the ponding area is constantly saturated with water, and hence the seepage rate is probably negligible. Therefore, water is lost mainly through evaporation from the surface of the ponding area.

The magnitude of rainfall or evaporation in a water-balance equation is determined by the climatic condition of the project area. Since the climatic trend is found to be stationary in the past, and it is unlikely to have any noticeable change in the future, the mean annual, or mean monthly, rainfall and evaporation can be treated as constants. Therefore, the primary factors which will affect the water level of a villu are the river stage and surface runoff.

During the flood seasons, the portion of river water that flows into a villu is a function of the peak stages in the river and the villu geometry. As mentioned in the previous section, the peak stages of the Mahaweli Ganga will be reduced due to the regulation of the upstream reservoirs. Therefore, the inundated area of the villu, especially the portion on the floodplain, would be reduced. The area of reduction on the floodplain could be up to 50% of its original size.

Another impact from the river flow on villus is that the duration of inundation of flood water in the villus will be shortened, because the frequency of flood occurrence will be reduced. Also, the grazing value of villus will be decreased since the water-level in villus will be less fluctuating due to the relatively stabilized river stage in the Mahaweli Ganga.

In an effort to assess the impact of surface runoff on villus, a typical villu in System A was examined in this study. As shown in Figure A-5, the size of the ponding area of the villu is about 600 hectares. The vegetation cover is fairly dense and uniformly distributed in the drainage area. Since the downstream area received significant rainfall only during the maha season, the average amount of rainfall in the months from October through January was used in the estimation of runoff.

The volume of the mean annual rainfall on the ponding surface is approximately 3.2 m cu-m, while the mean annual evaporation, based on the information from the Agricultural Research Institute at Maha Illuppallama, is about 3.6 m cu-m. According to the runoff-curve-number method developed by the U.S. Soil Conservation Service, the annual runoff (into the villu) is estimated to be 0.7 m cu-m. The sum of the rainfall and runoff is almost balanced by the evaporation loss. Consequently, the chief factor affecting inflow volume is the river stage.

Since runoff is collected from the watershed, any changes of watershed characteristics will affect the quantity of runoff produced by storm rainfall. The type of vegetation in the villus is usually related to the

hydroperiod and the depth of flooding. When villu area and inundation duration are changed, the type of vegetation cover in the watershed will be altered. The existing vegetation cover on the margins of villus is primarily creeping grass. Instead, bushes and trees are expected to grow in the future, and hence the runoff volume is likely to be reduced. However, the impact on the villus resulting from the change of runoff volume will be insignificant because water contributed from surface runoff is small, compared with rainfall and river flow.

Effect of Land Use Changes on Surface Water

The effects of various land uses on surface runoff can be evaluated by several methods, depending on the watershed conditions and available data. In this study, the runoff-curve-number procedure is used for an evaluation of the effects. The runoff curve numbers, as developed by the U.S. Soil Conservation Service (1957), indicate the relative value of the hydrologic soil-cover complexes in producing direct runoff. The basic equation for runoff estimation in terms of runoff curve number and rainfall is:

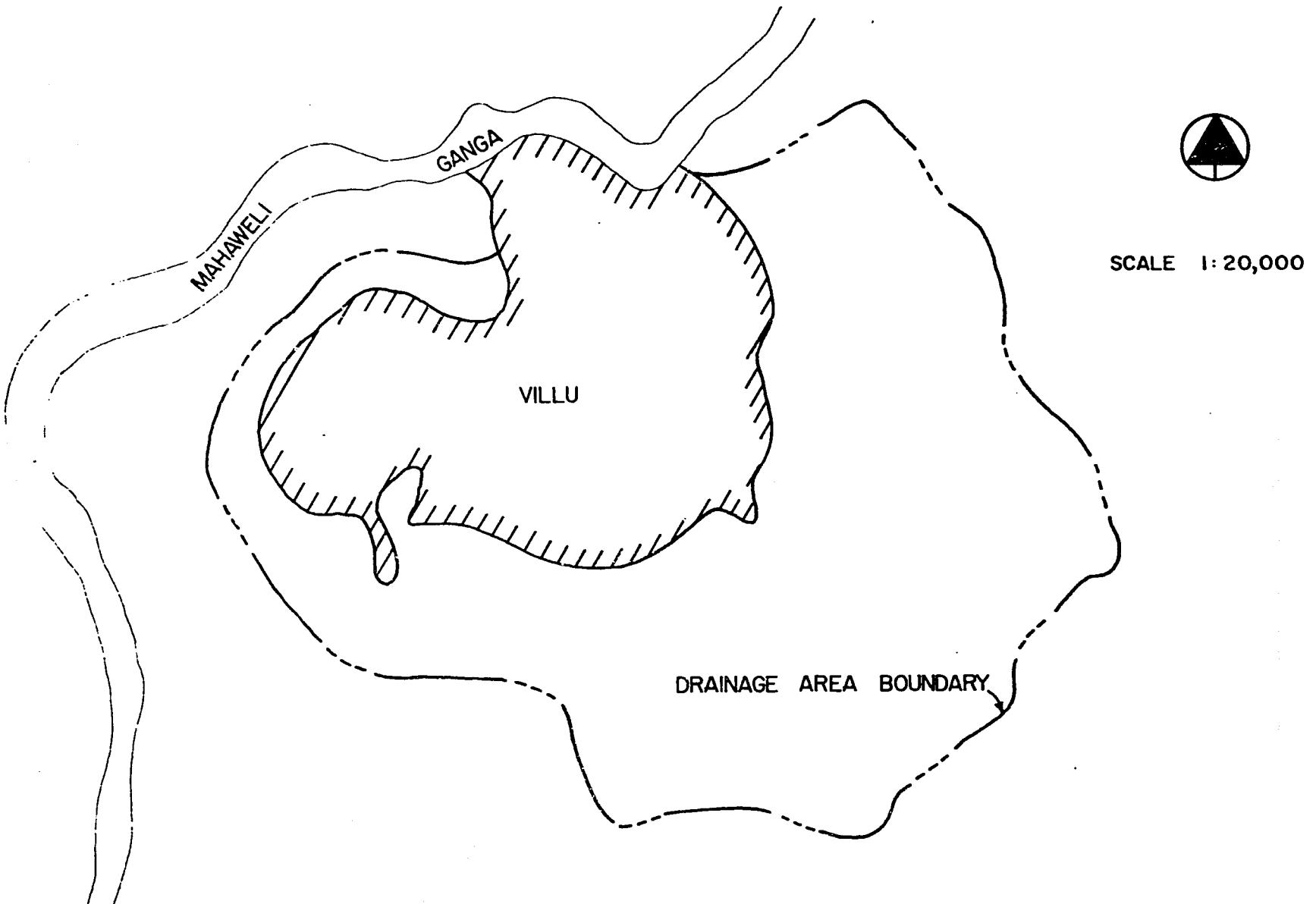
$$Q = \frac{P - \dfrac{50(100-C_N)^2}{C_N}}{P + \dfrac{200(100-C_N)}{C_N}}$$

where Q is the storm runoff and P is the area-wide storm rainfall, both in millimeters, and C_N is the runoff curve number. For the same input of rainfall, any change of land uses on runoff will be reflected by the different values of runoff curve number. A large runoff curve number will produce more surface runoff.

As mentioned earlier, the runoff curve number is a function of soil permeability, land use, and the condition of vegetation cover. Usually, these three factors are classified separately. Soils are classified into four basic groups according to their water transmission properties:

Group A: These soils have a high rate of water transmission and low runoff potential. They consist mainly of sands or gravel that are deep and well to excessively drained. Infiltration rates are high even when soils are thoroughly wetted.

Group B: These soils have a moderate rate of water transmission. They have moderately fine to moderately coarse textures and are moderately deep to deep and moderately well to well drained.



A TYPICAL VILLU IN SYSTEM A
FIGURE A-5

Group C: These soils have a slow rate of water transmission. They have moderately fine to fine textures with a slow rate of downward movement of water.

Group D: These soils have a very slow rate of water transmission and high runoff potential. This group contains clay soils with a high swelling potential, soils with a high permanent water table, soils with a clay layer at or near the surface, and shallow soils with nearly impervious materials.

The condition of vegetation cover for forest land is determined on the basis of humus depth and compactness. As observed in the field, the average humus depth of the forest land in the project area is about one inch thick and is in loose condition. According to the U.S. Soil Conservation Service, therefore, the appropriate runoff curve numbers for the forest land of the project area are as follows:

Soil Group	Runoff Curve Number
A	36
B	60
C	70
D	76

On the other hand, the runoff curve numbers for rice paddies in this area are:

Soil Group	Runoff Curve Number
A	62
B	71
C	78
D	81

When these two tables are compared, it is obvious that the runoff volume will be increased by a range of 10 to 20% if the forest land is converted to agricultural land. However, the actual impact on streamflows is not expected to be significant, because the area of the forest land to be cleared for agricultural uses is relatively small, as compared to the total drainage area of Mahaweli basin. In addition, the increased volume of runoff will be retained by the rice paddies and eventually lost through evapotranspiration.

Salinity Intrusion

Salinity intrusions at the mouths of the rivers are caused by the

difference in densities of the ocean salt water and fresh water river flows. The common boundary between salt and fresh water is usually referred to as the interface. The shape and location of the interface depend on the tidal characteristics, river geometry, as well as the quantity and quality of the fresh water runoff entering the tidal estuary.

Currently, there is no available information describing the nature and extent of tidal intrusions in the lower Maduru Oya and Mahaweli Ganga estuaries. Based on the observations from a helicopter and the analysis of the aerial photographs, the geomorphology at the delta areas of both the Mahaweli Ganga and Maduru Oya indicated that the tidal influence in these areas is generally within six kilometers from the coast. Also, during a field reconnaissance, it was found that the surface water at Verugal (approximately five river kilometers upstream from the mouth of the Verugal Aru) was not appreciably saline. But the surface water at Mutur (about two river kilometers from the Koddiyar Bay) was saline. Since the proposed reservoir regulations and diversions will result in a reduction of downstream flows in the Mahaweli Ganga, there may be an increase in the extent of the tidal wedges. In addition, the quality of water in the lower river sections will be affected by the irrigation return flows. The change of density in the fresh water due to increased salt concentrations may slightly alter the salinity regime.

The situation of salinity intrusion in the Maduru Oya will probably be improved since the increased flow from the transbasin diversion at Minipe will push the salt water further toward the coast.

As there is no previous baseline study on the estuarine waters, a program is needed to examine the existing nature and extent of tidal intrusions in the lower Mahaweli Ganga and Maduru Oya. The proposed program is discussed under the section of RECOMMENDED ACTIONS.

Public Health

Since the flow rate and stage in the Mahaweli Ganga will likely be reduced in the future, a significant increase in both water-borne and insect vector (especially malaria) disease can be expected in the project area. The method of mitigation is discussed in the section of RECOMMENDED ACTIONS.

The similar impact related to malaria is not expected to occur in the Maduru Oya because the future flow in the river will be increased due to the transbasin diversion at Minipe. This increased flow is likely to flush out the larvae in the puddles of the river.

RECOMMENDED ACTIONS

Water Management and Control

As discussed previously the annual flow surplus in the Mahaweli Ganga is sufficient to meet the irrigation requirements for the Accelerated Program,

if the water is properly managed and controlled.

There will be some irrigation return flows available in addition to the virgin flows. However, a large portion of the irrigation return flows will be offset by the release of flood water and the losses through seepage and evaporation in the reservoirs. In addition, when irrigation water is applied in excess of the field requirements, a number of undesirable effects will occur. First of all, the excess water may flow across the field and be wasted as surface runoff at the downslope side. Secondly, a larger quantity of nutrients may be leached out through the soil profile. Thirdly, it may cause potential drainage problems over the field. Therefore, it is important to establish a management program which will control and regulate the application of irrigation water effectively. The management program should include not only the installation of more accurate flow measurement facilities, but also the administrative capabilities, such as manpower training and irrigation scheduling, to implement the program efficiently.

Mitigation of Impacts on Villus

As pointed out earlier, the inundated area of villus, especially the portion on the floodplain, will be reduced as a result of the reservoir regulations and transbasin diversions.

From an engineering point of view, the original area of a villu can be restored by two commonly accepted methods. One method is to build a weir or barrage at the outlet of the villu or in the river just downstream of the villu to raise the water to a constant level. By doing this, however, the villu will lose its grazing value because the water-level fluctuations in the villu will be very small. The other method is to alter the alignment of the river, similar to straightening a river meander, to let it flow through the villu. In other words, the villu will be a part of the realigned river. Nevertheless, the villu will still lose part of its original area as the river stage will be lowered by the upstream regulations. Practically, therefore, the loss of an appreciable amount of grazing value on villus seems to be unavoidable.

Baseline Survey of Salinity Intrusions

The recommended program for a baseline survey of salinity intrusions in the lower Mahaweli Ganga and Maduru Oya estuaries consists of data collection and analysis of tidal currents, river profiles and cross sections, and salinity concentrations.

Tides should be measured simultaneously at several sections along the rivers as far upstream as possible so that the limit of estuarial conditions can be established. The upstream river flows should be measured at existing or provisional gauging stations during the same period.

The elevations of about 20 cross sections along the rivers will be needed for this program. These cross-sectional elevations can be obtained

by means of echosounding or other conventional methods. The slope of the thalweg can be obtained from these cross sections.

Salinity measurements should be made every two months throughout a period of one year. Each time, observations should be made for at least two consecutive days. Measurements should be referred to an upstream fresh water discharge. A boat should be used to follow the propagation of high water slack toward upstream and to obtain as close a synoptic distribution as possible. Frequent vertical profile measurements should be made in terms of salinity and temperature so that the stratification conditions can be determined.

The conditions of salinity intrusion in the lower Mahaweli Ganga and Maduru Oya estuaries can be analyzed mathematically on the basis of the collected data.

Malaria

The proposed development program will result in a reduction of flow in the Mahaweli Ganga. This could increase mosquito breeding sites in the river channel and cause potential malaria increases in the project area. One of the mitigation measures for this kind of impact is the periodic flushing of breeding puddles that may remain in the river channel during low-flow periods.

In order to flush out the larvae in the puddles, a minimum flow depth of 0.2 meters should be maintained in the river channel. The average slope of the Mahaweli Ganga downstream of the Minipe Anicut is approximately 0.0007 and the average width is about 200 meters. The discharge required to maintain a depth of 0.2 meters would be approximately six cumecs. If the process of flushing is conducted once a week with a duration of two hours each time, the total volume of flow required for river-bed flushing would be equal to 172,800 cubic meters per month. There should be more than sufficient reservoir storage in most areas to permit this weekly flushing. Alternatively, a conservation flow of 10 cumecs as suggested by the Hydrology Division of the Irrigation Department would also limit pool formation, while simultaneously conserving the riverine habitat for aquatic life.

Other mitigation measures on malaria are discussed in TOPIC REPORT K: PUBLIC HEALTH.

SUBSURFACE WATER

INTRODUCTION

In general, there are two basic zones below the ground surface: the zone of aeration and the zone of saturation. In the zone of aeration, water is held by capillary force and drawn up by plants in the process of transpiration. The water in the zone of saturation is called the ground water. The plane separating these two zones is called the water table. The soil-water relationship in the zone of aeration is covered in TOPIC REPORT B: LAND USE AND SOILS. The existing conditions, impacts and mitigation measures of groundwater in the project area are discussed in this section.

EXISTING CONDITIONS

The existing information on groundwater resources in the project area is very limited. A contour map of the water table in the project area is not available at the present time. Based on observations of the existing dug wells in Systems A, B, C and D during April 1980, the water tables are generally two meters below the ground surface.

In the System C area, groundwater is reported to occur within the soil, the weathered rock and the fractured rock zones (Hunting Technical Services Ltd. 1979). At the Ratkinda and Ulhitiya Oya dam sites, the depths of soil layer, weathered rock and fractured rock zones are respectively three, eight and twenty-four meters, as shown in Figure A-6. The average permeability in these three zones are 0.86, 0.86 and 0.30 meters per day, respectively. Aquifer characteristics in other irrigation systems are presently unknown.

Based on the hydrogeological map prepared by Fernando (1973), potential of groundwater development in the project area appears to be available only in the lower reach and the delta region of the Mahaweli Ganga because the geological nature of that area is composed of alluvium and miocene limestone.

IMPACT ANALYSIS

Effect of Irrigation

When irrigation water is applied to a soil surface, both gravity and capillary forces cause its downward movement by infiltration. If the water table is close to the ground surface and sufficient water is applied, the moisture will reach the water table and add to the groundwater. If the rate of groundwater movement is less than the infiltration rate, the water table will rise and salt will be accumulated in the root zone. This will create a problem since most crops do not prosper with their roots in a saturated zone, especially with high salt concentrations.

The infiltration rate varies with the types of soils, and the rate of groundwater movement is a function of soil permeability and the slope of the water table. According to Darcy's Law, the flow rate (volume per unit time) through a cross-sectional area of an aquifer may be estimated by the following equation:

$$Q = AKS$$

where Q is the flow rate in cu-m/day; A is the cross-sectional area in sq.m; K is the coefficient of permeability in m/day; and S is the slope of the water table.

As the information on aquifer parameters is not available except for System C, figures obtained from System C are used for the computation of groundwater movement in all the proposed irrigation systems. Assuming that the slope of the water table is parallel to the ground slope, the estimated rate of groundwater movement per unit width of aquifer in each irrigation system is tabulated in Table A-7.

The actual amount of water adding to the aquifer through infiltration is unknown at the present time. A very conservative value of 0.3 meter per year is assumed in this study. Even so, the infiltration rates are far greater than the groundwater movement rates in Systems A, B, C and D. Therefore, drainage ditches will be required to remove the excess water from infiltration.

Effect of Land Use Changes

With the proposed development in the project area, much of the existing forests will be cleared and converted to agricultural land. The existing type of trees in the project area are mainly wira, satin, ebony and milla. Some of their roots are likely to penetrate into the saturation zone. As a result, a portion of the groundwater is removed by the roots in the process of transpiration. But if the forest land is converted into rice paddies, that portion of groundwater will remain in the zone of saturation, and the water table will rise consequently. Nevertheless, this slight raise in water table will be overshadowed by the significant raise due to irrigation.

Salt Water Intrusion

Salt water intrusion may be defined as the increase in the salinity of the groundwater at a given location and depth produced by acts of man. Intrusion can result from a variety of degrading influences; however, a unique groundwater problem is that of intrusion in coastal aquifers.

Under normal conditions, a natural equilibrium between fresh and salt groundwater develops along coastlines. The common boundary between salt and fresh water is usually referred to as the interface. The location of the interface, as sketched in Figure A-7, can be approximated by the Ghyben-Herzberg relation. The specific gravity of seawater is about 1.025 times that of fresh water, thus $Z = 40\ H$.

Table A - 7

Groundwater Movement Rates

Irrigation System	Approx. Length of Aquifer (m)	Average Slope of Water Table (m/m)	Groundwater Movement (cu-m/m/yr)
A	10,000	0.0010	6
B	8,000	0.0020	12
C	7,000	0.0025	15
D	5,000	0.0035	21

where Z and H are as shown in Figure A-7. This equation implies that it requires a head of one meter of fresh water above sea level to maintain each 40 meters below sea level.

The extent to which salt water is intruding into groundwater should be determined. Saline groundwater may lead to several problems: well water may no longer be fit for human consumption, and, if used for irrigation, the contaminated water will lead to salt accumulation in the upper layers of the soil, thus affecting crop yields. In addition, complications may arise where groundwater flows into a stream bed, a phenomenon which may occur as a result of upstream reservoir operations and diversions of the Mahaweli Ganga. Specifically, the river stage declines, leading to changing head gradients; groundwater may then discharge into the stream bed, causing potential salt water intrusion due to water table depletion in the delta area. Finally, if the influent groundwater is already saline, fresh surface water becomes contaminated. Thus, salt water intrusion may cause deterioration of both ground and surface waters.

The problem of salt water intrusion is not expected to occur in the Maduru Oya delta because the river stage will be raised as a result of the transbasin diversion from the Mahaweli Ganga.

RECOMMENDED ACTIONS

Drainage Facilities

It has been demonstrated that the infiltration rates, as an effect of field irrigation, will be far greater that the groundwater movement rates in Systems A, B, C and D. Therefore, drainage ditches will be required to remove the excess water from infiltration. The spacing between drainage ditches should range between 20 and 80 meters, depending on the detailed information of soil characteristics in each area.

Mitigation of Salt Water Intrusion

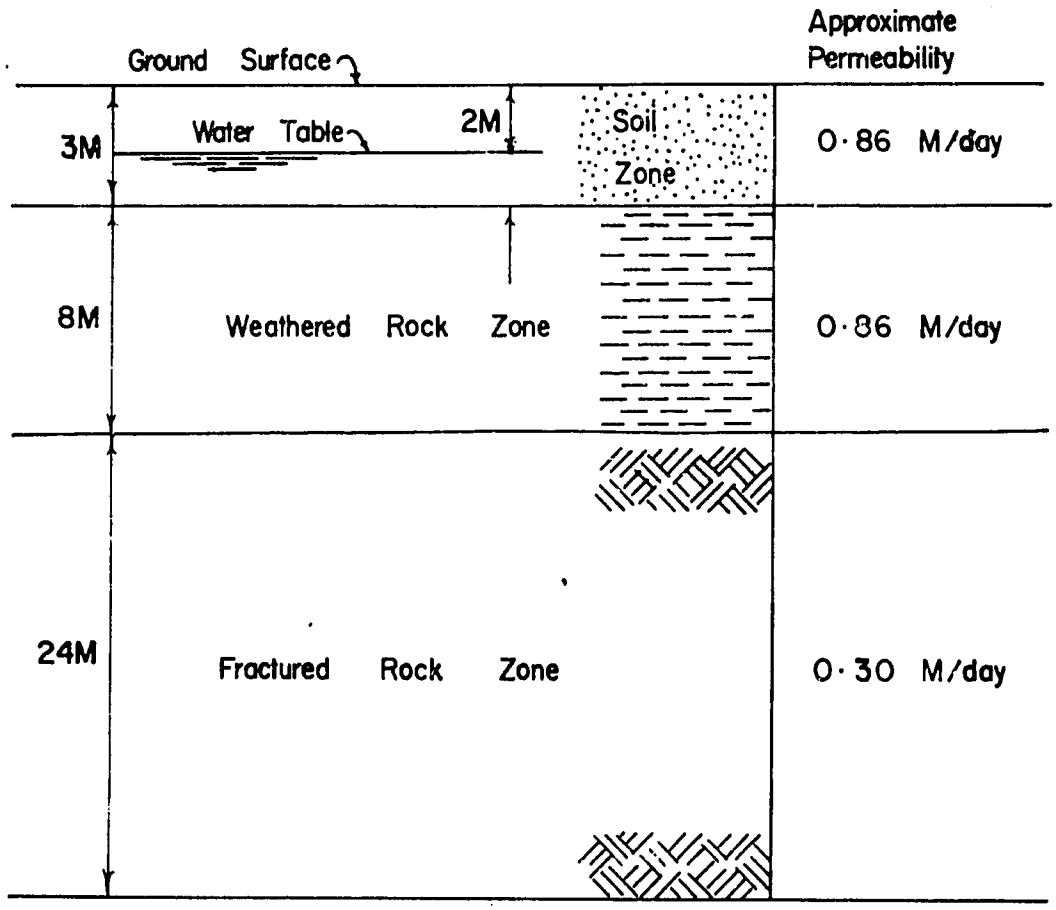
The potential problem of salt water intrusion into the coastal aquifers can be mitigated in two ways. One is to maintain a positive (above sea level) head of the water table in the lower Mahaweli Ganga with irrigation return flows. However, the application rate should be properly controlled to avoid accumulation of salt in the root zone from a rising groundwater table.

The other measure is careful management of the future groundwater withdrawal rates from the Mahaweli Ganga delta area. If pumping is required in the future, horizontal collectors or radial wells, which operate with a small drawdown and need not extend below sea level, should be used to avoid inducing salt water intrusion to the aquifer.

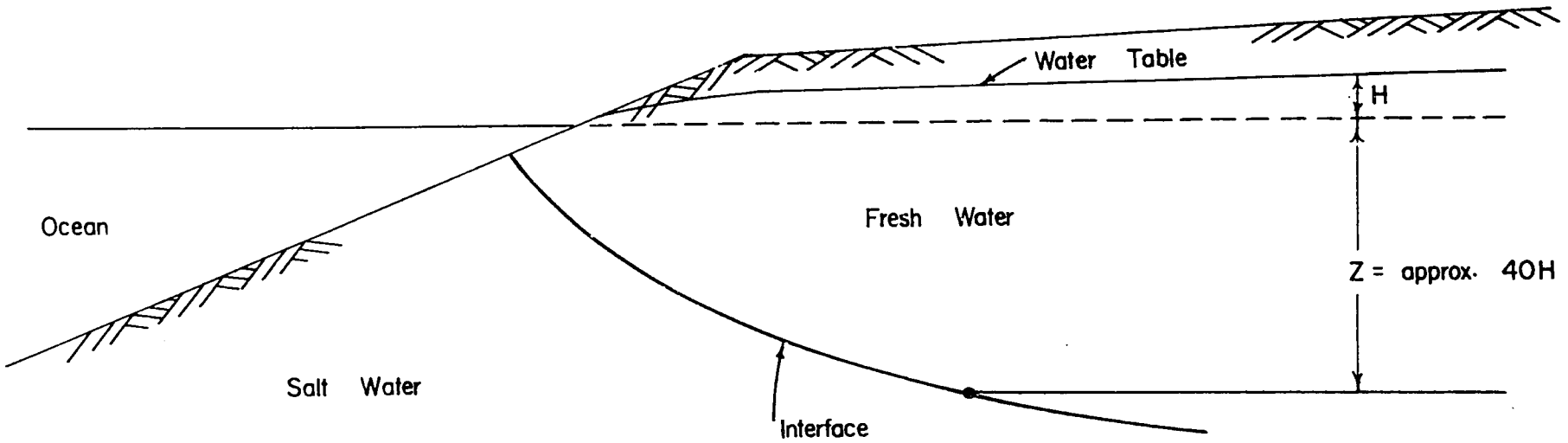
Monitoring Program

To ensure the quantity and quality of groundwater in the project

area, a monitoring program should be implemented as soon as possible. The most practical way to monitor groundwater quality for both salt and other potential contaminants is to install staff meters in the existing dug wells, preferably one well per village. At least one water table reading should be taken and recorded during both wet and dry seasons each year. The monitoring program for groundwater quality is discussed in TOPIC REPORT F: WATER QUALITY.



AQUIFER CHARACTERISTICS IN SYSTEM C
FIGURE A-6



SALT AND FRESH GROUNDWATER
NEAR A COASTLINE

FIGURE A-7

SEDIMENTATION

EXISTING CONDITIONS

Sediment load in most streams consists of two major parts: suspended load and bed load. Suspended load is finer material which the flow can easily carry in large quantities, while bed load is a coarser material which is more difficult to move by flowing water. Suspended load is generally governed by its availability in the watershed and bed load by the transporting ability of the stream.

Sediment Yield

The primary source of sediment yield in the project area is soil erosion in the Upper Catchment, because the slope in that area is relatively steep and rainfall is ample. A detailed estimation of sediment yield in the upper catchment is presented in TOPIC REPORT C: WATERSHED MANAGEMENT.

Sediment Transport

According to the observations from a helicopter and the interpretation of aerial photographs, a large amount of sediment currently deposits in the Mahaweli Ganga between Minipe and Manampitiya, especially near the confluence of the Amban Ganga. Less sediment has been observed in the river downstream of Manampitiya. Also, the shape of the delta indicates that the sediment transport is not very active in the lower Mahaweli Ganga. This is probably because the slope of the river changes from 0.7% to 0.07% downstream of Minipe. In addition, near the confluence with the Amban Ganga, the river bed is about two times wider than its upstream sections. The abrupt reduction of flow velocity causes the deposit of sediment in this reach.

The existing sediment load is insignificant in the Maduru Oya.

IMPACT ANALYSIS

With the construction of the Kotmale, Victoria and Randenigala Reservoirs, the main portion of the sediment transported from the Upper Catchment will be trapped in these reservoirs. The impact of the settled sediment on reservoirs is discussed in TOPIC REPORT C: WATERSHED MANAGEMENT.

If the Mahaweli Ganga is denied its normal sediment load in the downstream reaches, it could tend to scour its bed or cave its banks. However, the situation of scouring is not expected to be a serious problem because the flood flows will be reduced considerably due to the surcharge storage in the upstream reservoirs.

RECOMMENDED ACTIONS

The reduction of sediment load to reservoirs can be achieved by means of soil conservation methods within the Upper Catchment. Terraces, strip cropping, contour plowing, and similar techniques can retard overland flow and reduce erosion. Check dams in gullies can retain some sediment and prevent it from entering the streams. Vegetation cover on land can reduce the impact force of raindrops and minimize erosion. The detailed discussion on the mitigation of erosion and sediment load is covered in TOPIC REPORT C: WATERSHED MANAGEMENT.

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INTRODUCTION

Land use and soils concerns are of paramount importance to the Accelerated Mahaweli Development Program, since a more effective land use without undue depletion of the soils is a primary objective of the Program. The Program encompasses two relatively distinct areas: the upper catchment or watershed above the proposed dams and the downstream irrigation systems, namely Systems A,B, C and D. Land use and soils concerns in these two areas focus on different goals. In the upper catchment the aim of land use planning is towards development of forest and upland crops which are the most effective, given the topographic and soils conditions, for minimizing the extensive problems of erosion. In the downstream systems, the goal is for achieving the most effective use of areas suitable for irrigation balanced against the need for areas for forests, settlements and related infrastructure. The difference in focus is sufficient to suggest a division in the discussion of land use and soils. Therefore, this TOPIC REPORT B: LAND USE AND SOILS addresses the downstream systems while TOPIC REPORT C: WATERSHED MANAGEMENT deals with the upper catchment.

Although there are feasibility reports for each system (Joint Venture Randenigala 1980; ACRES 1979; Hunting Technical Services Limited 1979; JICA 1979), these reports employ different land use, land capability and soils terms and classification methodologies (i.e. land classification and land capability or land suitability implies categorizing areas of land as to their capability for growing certain crops such as upland crops and wetland rice as well as noting the limitations of the areas such as poor drainage, poor soils, etc.). In order to provide a uniform and concise summary of existing conditions, the EXISTING CONDITIONS section of this report discusses the systems using common definitions and classifications which resulted from TAMS applying uniform land use and land capability classification methodologies. Having consistent classifications among the four systems is essential for assessment of impacts and for recommending rational land use plans which mitigate the impacts of the irrigation projects.

Although TAMS has developed a uniform land use and land classification data base, the assessment of impacts is made difficult by the fact that the boundaries of the irrigation projects at this feasibility level are not well defined, nor is there a detailed description of the layout of the projects or the land and water management schemes for the four systems. However, in as much detail as possible, this report identifies the impacts of the Accelerated Program in terms of changes in land use; effects on the physical and chemical properties of soils (e.g. soil salinity, nutrient and mineral depletion, waterlogging); losses from erosion; and finally, the use of lands in relation to their land capabilities.

In order to mitigate these impacts, the RECOMMENDED ACTIONS section of this report suggests certain changes in land use, concepts for land and water management, methods of erosion control during construction and production, programs for monitoring the success of these measures and methodologies for uniform, more detailed land use planning which will be required during the final design stage of the Accelerated Program.

EXISTING CONDITIONS

EXISTING LAND USE

Methodology of Existing Land Use Survey

Prior to the initiation of the Mahaweli Environmental Assessment, a land use survey with a uniform map scale and with standard symbols had not been implemented to cover the Accelerated Program area. There was little definite knowledge as to the location and extent of forested areas, chena areas, current paddy areas, scrubland, grasslands, improved pasture areas, and other land uses. In order that integrated land use planning may be properly implemented throughout the Mahaweli Accelerated Program area, a uniform inventory of existing land use is essential.

The need for this concise knowledge prompted TAMS to develop maps of present land use for Systems A,B,C and D of the Accelerated Program. These have been prepared from recent 1979 aerial mosaics of 1:20,000 scale, and the mosaics were used to map the land use classes through aerial photo interpretation in conjunction with field verification. Several(usually four) mosaics were used together for integral base maps and the land use drafted from the mosaics using a plastic map overlay at the same scale of 1:20,000. Figure B-1 shows the map index of the resulting land use maps which cover the entire area of Systems A,B, C and D.

In this report, the present land use has been identified on the 1:20,000 land use map using categories as defined by the Commission on World Land Use Survey which has been widely accepted as a workable categorization scheme. Table B-1 defines the land use categories.

The results of the land use mapping are documented in this report and are depicted in the 1:50,000 scale land use maps contained in the Map Addendum.

A summary of the extent and percentages of various land use categories in each of the Systems A,B, C and D and the totals for the four systems are presented in Table B-2. These have been measured by the grid-dot method and the extent of each land use category is recorded in hectares. Figures B-2, B-3, B-4 and B-5 show a generalized land use for chena, permanent cropland and forest for the four systems.

System A Land Use

Settlements and homesteads cover 1,300 hectares or only 1.4% of System A. Total cropland accounts for 37,700 hectares, or 40.7% of System A, which is the lowest of the four systems. The sugar cane of Kantalai along with paddy and chena represent a large proportion of the cropland. Figure B-2 maps the locations of large areas of chena and permanent cropland.

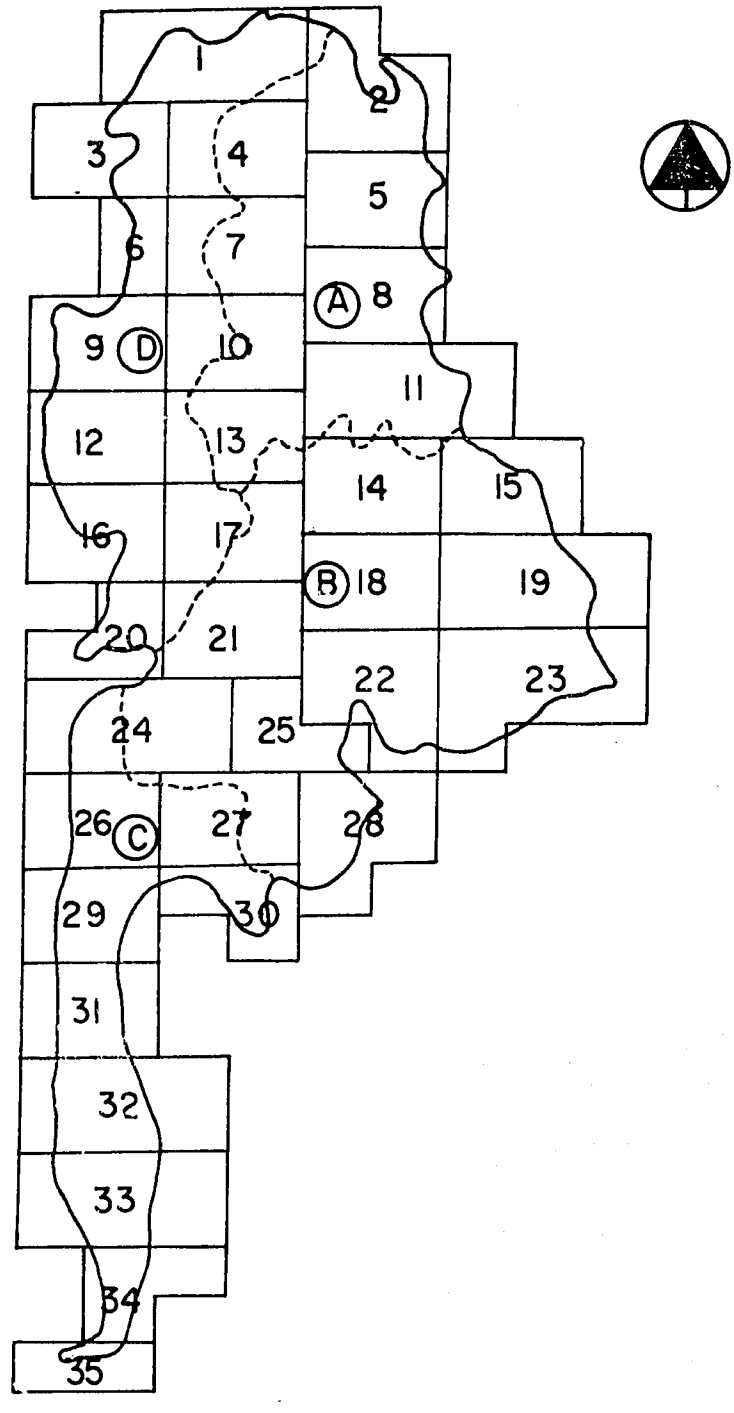
Extending over 10,000 hectares, the total permanent pasture and grassland is comparable with the total of this category in System B, but both Systems A and B have considerably larger pasture and grassland areas than Systems C and D.

Table B-1

Land Use Categories Mapped In The Accelerated Program Area

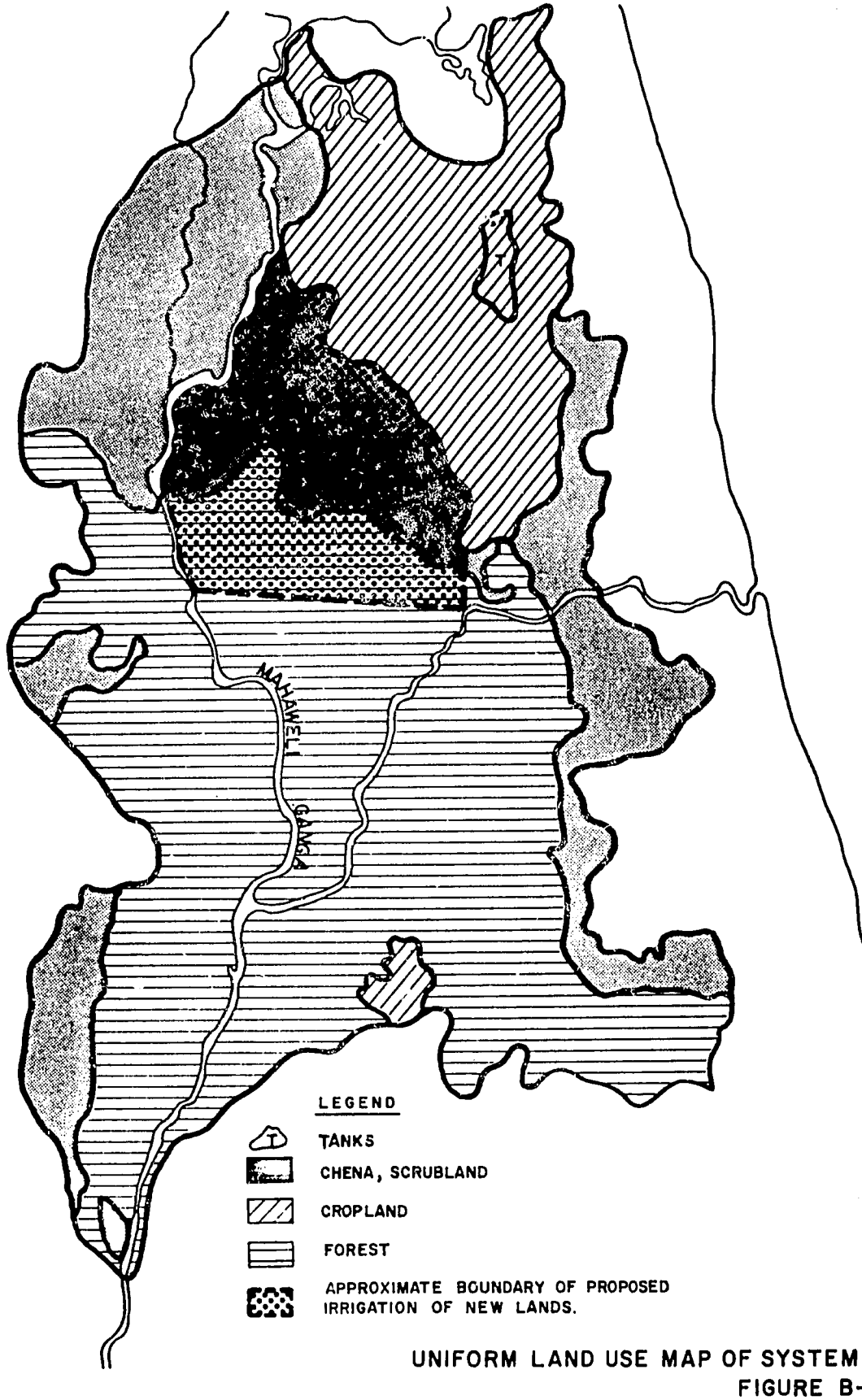
General Division	Map Symbol [1]	LAND USE CATEGORY
1	1	Settlement and Associated Non-Agricultural Lands
2	2	Horticulture
	2H	Homestead Garden
3	3	Tree and Other Perennial Crops
	3C	Coconut
	3Ca	Cocoa
	3O	Orchard
	3R	Rubber
	3T	Tea
	3Tm	Tea in need of Renovation
	3Tx	Poor or Abandoned Tea
4	4	Cropland
	4C	Sugarcane
	4D	Land Under Developed
	4P	Paddy
	4Pd	Permanent Dry Cropping
	4S	Chena - (shifting cultivation)
	4T	Tobacco
5	5	Improved Permanent Pasture
6	6	Grassland and Scrubland
	6D	Damana Grassland
	6V	Villu Grassland
	6Sc	Scrubland
7	7	Woodland or Forest
	7ND	Non-Productive Forest
	7LD	Low Yield Forest
	7MD	Medium Yield Forest
	7HD	High Yield Forest
	7P	Plantation
8	8	Swamp and Marsh
9	9	Unused Land

1/ Categories of Land Use are those derived from the land use classification adopted by the Commission on World Land Use Survey, Internation. Geo. Union.



THE MAP ORIGINALS (SCALE 1:20,000) NUMBERED FROM 1-35 ARE ON FILE WITH THE SURVEY DEPARTMENT AND ARE THE BASIC DATA FROM WHICH THE LAND USE SUMMARY TABLE B-2 AND THE 1:50,000 SCALE LAND USE MAPS OF THE ACCELERATED PROGRAM AREA WERE DEVELOPED (SEE MAP ADDENDUM)

INDEX OF MAPS FOR UNIFORM LAND USE STUDY
FIGURE B-1



UNIFORM LAND USE MAP OF SYSTEM A
FIGURE B-2

Table B-2
EXTENT AND PERCENTAGES OF VARIOUS LAND USE CATEGORIES

Land Use Symbol	LAND USE	System A Sub Total	System A Hectares	System A %	System B Sub Total	System B Hectares	System B %	System C Sub Total	System C Hectares	System C %	System D Sub Total	System D Hectares	System D %	Total Sub Total	Total Hectares	Total %
1	Settlement		100	0.1		400	0.3		–	*		1,200	1.1		1,700	0.4
2H	Homestead Gardens		1,200	1.3		900	0.6		2,000	2.9		15,000	13.9		19,100	4.5
3C	Coconut		–	–		–	–		–	–		100	0.1		100	*
3O	Orchard		–	–		–	–		–	–		100	0.1		100	*
4C	Sugarcane		–	–		–	–		–	–		6,500	6.0		6,500	1.5
4D	Land Under Development		1,300	1.4		8,000	5.3		11,000	15.7		–	*		20,300	4.8
4P	Paddy		10,000	10.8		23,000	15.2		6,000	8.6		44,000	40.7		83,000	19.7
4PD	Permanent Dry Croping		100	0.1		1000	0.7		2,700	3.9		300	0.3		4,100	1.0
4S	Chena		26,000	28.1		38,000	25.8		22,000	31.4		9,600	9.1		96,800	23.0
4T	Tobacco		300	0.3		–	–		–	–		–	–		300	0.1
4	Total Cropland	37,700		40.7	71,000		47.0	41,700		59.6	60,800		56.1	211,000		50.1
5	Improved Permanent Pasture		1,200	1.3		700	0.5		–	–		1,000	0.9		2,900	0.7
6D	Damana Grassland		400	0.4		8,000	5.3		400	0.6		700	0.6		9,500	2.3
6V	Villu Grassland		9,000	9.7		2,000	1.3		100	0.1		1,700	1.6		12,800	3.0
	Total Pasture and Grassland	10,600		11.4	10,700			500		0.7	3,400		3.1	25,200		6.0
6Sc	Scrubland		6,000	6.5		17,000	11.3		1,200	1.7		11,000	10.2		35,200	8.3
7ND	Non-Productive Forest		30,000	32.5		41,000	27.1		7,000	10.0		15,000	13.9		93,000	22.1
7LD	Low Yield Forest		3,000	3.2		1,000	0.7		16,000	22.9		–	–		20,000	4.7
7MD	Medium Yield Forest		1,700	1.8		–	–		–	–		–	–		1,700	0.4
7P	Plantation		100	0.1		3,000	2.0		–	–		–	*		3,100	0.7
7	Total Woodland and Forest	34,800		37.6	45,000		29.8	23,000		32.9	15,000		13.9	117,800		27.9
8	Swamp and Marsh		–	–		–	–		–	–		–	–		–	–
9	Unused Land		100	0.1		2,000	1.3		300	0.4		–	–		2,400	0.6
	Tanks		1,400	1.5		4,000	2.6		1,300	1.8		900	0.8		7,600	1.8
	Rivers		700	0.8		–	–					800	0.7		1,500	0.4
	GRAND TOTAL		92,600	100		151,000	100		70,000	100		108,100	100		421,700	100

* Less than 0.1%

Source: TAMS Calculations, 1980

Woodland and forest make up a total of 34,800 hectares of which the predominant non-productive forest areas amount to 30,000 hectares or 32.5% of System A. Forest cover of all categories including the Somawathie Chaitiya Game Sanctuary amounts to 37.6% of the present land use (see Figure B-2 for location of forest areas).

The System A consultants state that because this system lies within three districts and because the exact boundaries have not yet been defined, there is yet no statistical information specified in System A (Joint Venture Randenigala 1980). Therefore, in this report it was necessary to make some assumptions when assessing numbers pertinent to the inventory of forest and land use. This may account in part for the differences between the Joint Venture's total land use figures of 106,000 hectares and that of 92,600 hectares shown here. This TOPIC REPORT was also concluded before a final decision has been made on the precise boundary between Systems A and B.

System B Land Use

Covering 151,000 hectares, System B is the largest of the four systems, and accounts for more than one-third of the total. The areas attributed to each land use category show approximately the same percentage distribution as in System A.

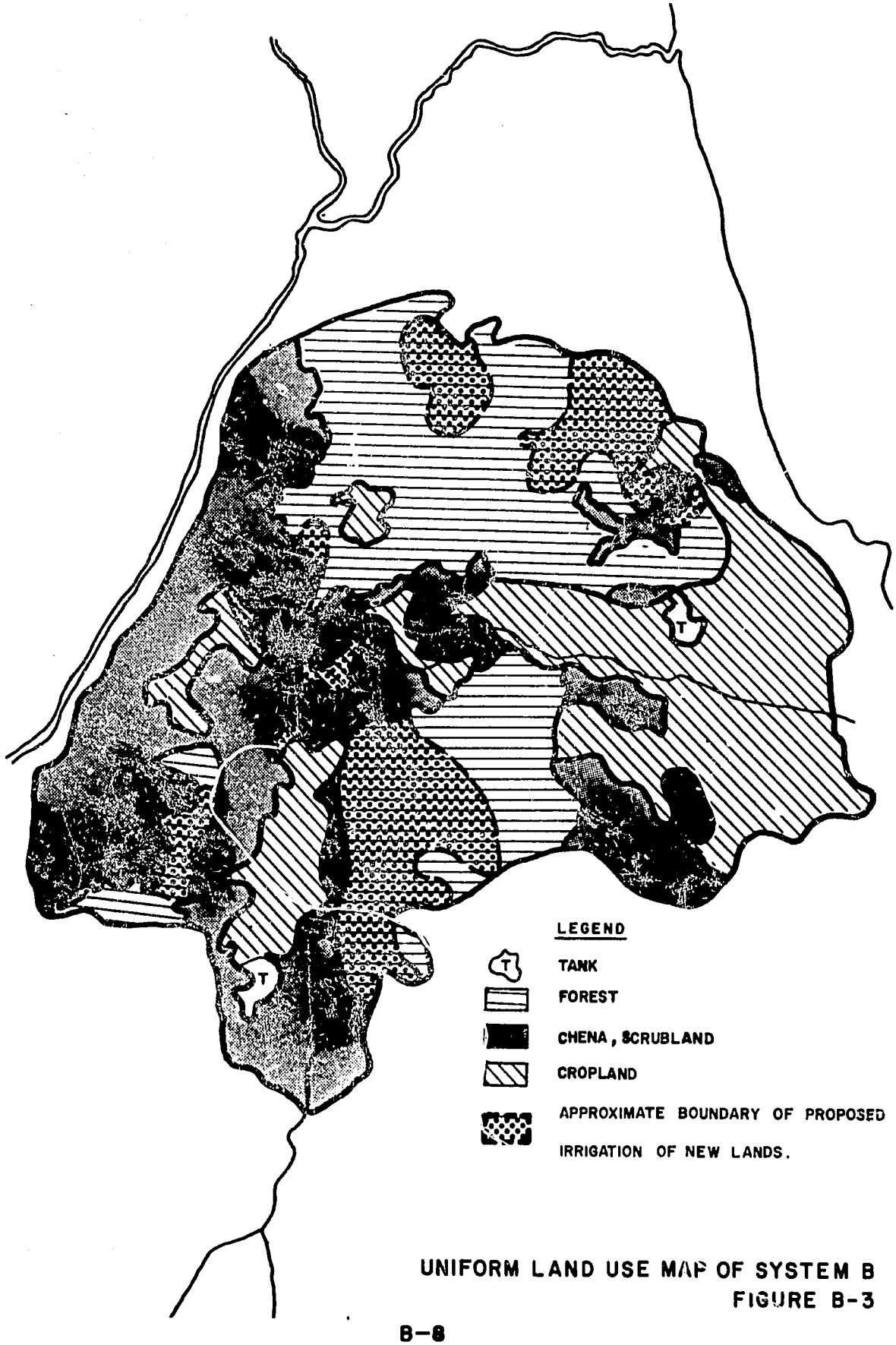
Although as a percentage, chena encroachment is about the same as in System A, chena lands in System B cover 39,000 hectares which is considerably larger than chena coverage in the other systems. Present paddy lands in System B of 23,000 hectares are second only to System D which has 44,000 hectares. System B has the largest extent of total cropland (71,000 hectares) with System D being the next highest with 60,000 hectares. Both Systems C and D have a higher percentage of total cropland than does System B (see Figure B-3 for the location of chena, cropland and forest).

Scrubland in System B is of the largest extent, 17,000 hectares. In addition, System B has the largest concentration of non-productive forest which extends over 41,000 hectares. However, System B is the only system with a substantial amount of plantation forest with 2,000 hectares.

In System B total land use area compared favorably with the System B feasibility report summary, since the Vakaneri and Punani paddy schemes were not included in their total land use study area, and the eastern boundary has been measured somewhat west of the consultant's easternmost boundary for System B(see Figure B-1) (ACRES 1979).

System C Land Use

The 70,000 hectares of System C is the smallest in extent of the four systems. System C has a slightly different distribution of land use than the other systems since it has a higher proportion of cropland and a lower proportion of pasture. More than 93% of the area is either cropland or woodlands.



UNIFORM LAND USE MAP OF SYSTEM B
FIGURE B-3

Of the 41,700 hectares of cropland, 11,000 are lands under development which is considerably higher than in other systems; however, only 6,000 hectares are paddy, which is the lowest in absolute and percentage terms of the four systems. Chena accounts for almost one-third of the area which is the highest percentage of the four systems.

Pasture and scrubland are insignificant, but woodland and forest extend over the top third of the system (see Figure B-4).

System D Land Use

The second largest system, System D covers 108,100 hectares. The distribution of land use is much like that of System C, since a little more than 56% of the land is cropland except that D has more homestead gardens and less woodland and forest than in System C.

Settlements and homestead gardens cover 1,200 and 15,000 hectares, respectively,which are largest of all the systems. Also System D has the largest concentration of sugarcane and paddy. Paddy alone accounts for 40.7% of the area. Chena land occupies only 9,800 hectares which is considerably lower than other systems (see Figure B-5).

As in System C,pasture and grassland accounts for a small percentage of area. However, unlike System C scrubland exists on about 10% of the land. Forest lands are the smallest of all four systems.

Summary of Land Use for the Accelerated Program Area

The total land use area covered in this survey of the Accelerated Program area is nearly 422,000 hectares. Chena lands occupy the largest portion of the total areas since they cover 96,800 hectares or 23%. Non-productive forest is next with 93,000 hectares. Together, these two land uses take up 45% of the total area. The third largest land use is for paddy which extends over 83,000 hectares. Scrubland, although fourth in extent, is far less extensive than the first three largest land uses, since it covers 35,200 hectares or less than 10% of the total areas. Of similar size are the land under development (20,300 ha.), low yield forests (20,000 ha.) and homestead gardens (19,100 ha.). Villu grassland (12,800 ha.) and damana grasslands (9,500 ha.) individually account for more than 2% of the total areas. Other land uses generally account for less than 1% of the total area.

SOILS IN THE ACCELERATED PROGRAM AREA

Introduction and Background of Soil Classification

The history of the development of soil classifications for Sri Lanka in general and the Accelerated Program area in particular, began as early as 1935 and requires a rather lengthy discussion to clarify the differences among the various classification systems and to define the characteristics of the soil types. For the reader interested in this technical discussion, Appendix B-I documents the history of soil classification, the soil surveys, and presents lists of the soil groups and series which occur in the Accelerated Program area. Tables in the

Appendix provide a general description of the soil series as well as indications of their land classification and suitability for irrigation.

A brief discussion of the results of soil classifications from the Systems A,B,C and D feasibility reports (Joint Venture Randenigala 1980; ACRES 1979; Hunting Technical Services Ltd 1979; and Japan International Cooperation Agency Ltd. 1979) is presented below. For further details as to the survey methods, laboratory and field techniques, the reader should consult the appropriate feasibility reports.

Semi-detailed soil classification maps are not included in this TOPIC REPORT but may also be found in the feasibility reports.

Before summarizing the information concerning soils of the four systems, an overview of the influence of geology and climate on soils of the area is presented.

Influence of Geology on Soils

The geologic origin of the parent rock material of many of the soils of the Accelerated Program area is well summarized in the ACRES International Ltd. Interim Report to the Ministry of Mahaweli (ACRES 1979) in which the major rock types are identified.

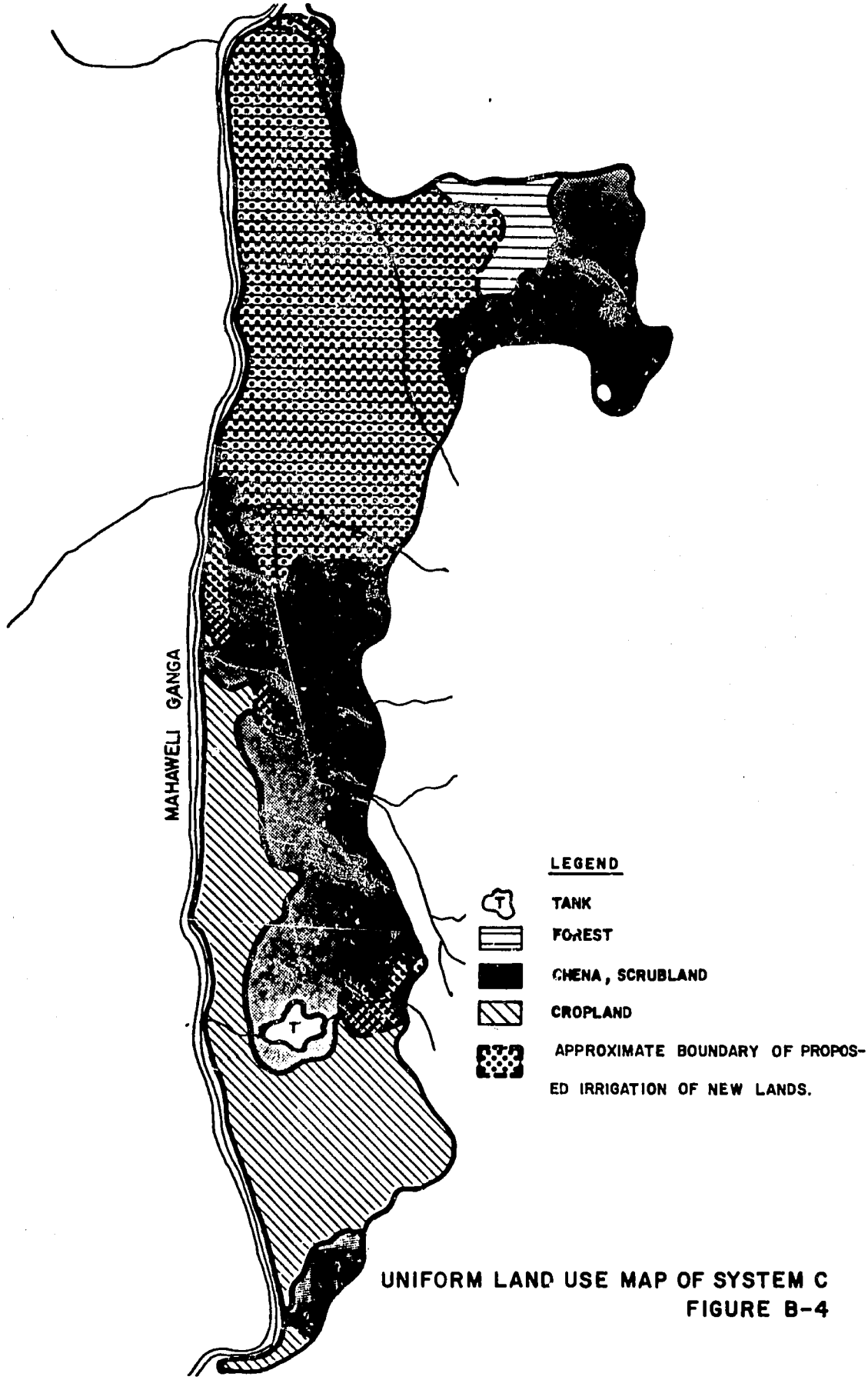
The geology of the area is characterized by Pre-Cambrian rock which can be separated into the following two groups:

- The Vijayan series of hornblende gneiss, biotite gneiss and hornblende biotite gneiss with the associated pegamitites and migmatities which dominate the project area; and

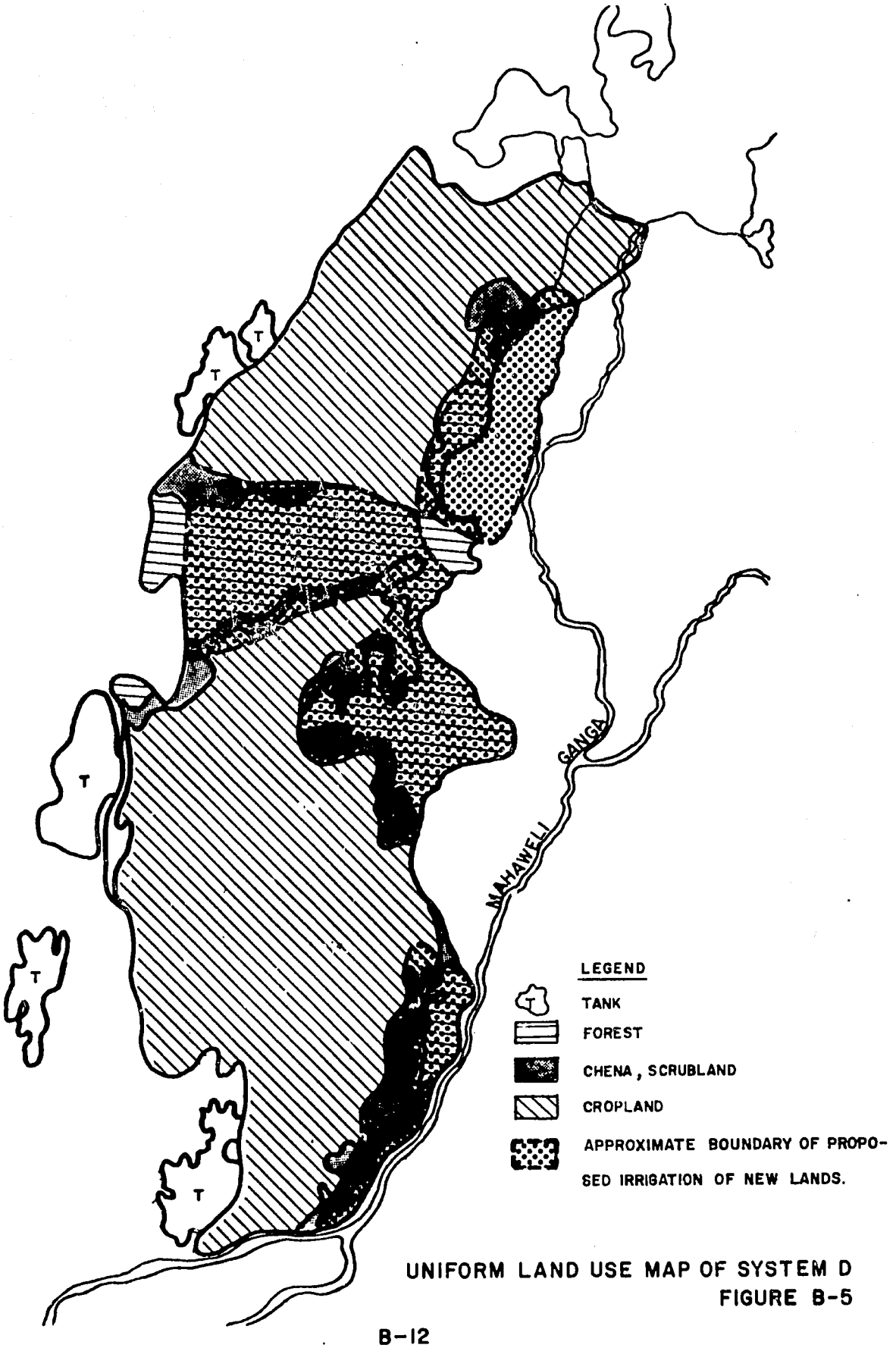
- A transitional zone of rocks between the Vijayan Series and the Khondalite series made of Hornblende biotite gneiss, charnokites, biotite gneiss and thin calc-silicate lenses which are found mainly in the south-western portion of the project area.

The geologic degradation of these very ancient rocks has resulted in the formation of a mature, mantled peneplain. This peneplain surface is contrasted by the Pleistocene and Miocene sediments of the coastal plain to the north-northwest. The peneplain is broken by numerous, large, prominent erosional remnants of rock outcrops and rock ridges that rise to heights of several hundred meters. The most prominent of these is Gunner's Quoin which rises to over 500 meters above the gently undulating surrounding plain.

The thickness of the soil mantle on the peneplain is often thin (less than one meter) and sometimes, non-existent in the case of areas of flat rock outcrops or rock knobs. Two very different groups of soils have developed on these Pre-Cambrian Rocks. On those rocks rich in ferromagnesium minerals, shallow to moderately deep reddish brown sandy clay loam soils have developed. These soils occur on slopes of 0-4%. Some small areas exceed 4% and occur in association with prominent rock outcrops. On those rocks relatively poor in ferromagnesium minerals, but rich in quartz, moderately deep to shallow grey brown sandy soils have developed. These soils occur on



UNIFORM LAND USE MAP OF SYSTEM C
FIGURE B-4



UNIFORM LAND USE MAP OF SYSTEM D
FIGURE B-5

60

nearly level slopes and overlie impermeable rock. Associated with these prominent soils are imperfectly and poorly drained lowland and alluvial soils, and better drained alluvial soils along the Mahaweli and Maduru Oya floodplains (ACRES 1979).

Influence of Climate on Soils

The TOPIC REPORT A: HYDROLOGY/CLIMATE covers all the principal aspects of climate in this environmental assessment study, but there are several items that need to be emphasized in relation to the soil resources.

The temperatures of the Accelerated Program area are uniformly high throughout the year. The rainfall is strongly seasonal since most of the rain occurs during the Northeast monsoon (Maha) from October until April, although the heavy rains slacken in January and rainfall is slight until April. The area is typically dry during the Southwest monsoon(Yala) from May to September due to the topographic wind-shadow effect of the Central Highlands.

The strongly fluctuating climate has a marked effect on the soils and vegetation of the project area, and potentially affects the future land use. During the intensive and extensive precipitation that occurs during the Maha season the imperfectly drained lowland and alluvial soils become exceeding wet. Even much of the upland sandy, shallow quartz soils over impermeable bedrock quickly reach field capacity and remain waterlogged throughout this monsoon season. The reddish brown sandy clay loam soils usually occurring on side slopes readily shed water. This runoff which is hindered further by limited surface drainage aggravates the wetness of the lowlands of the Accelerated Program area during Maha. Controlled drainage is a basic requirement to remove excess water during the Maha. Application of irrigation water during the Yala season must be carefully managed to avoid undesirable wetness presently associated with the Maha season.

System A Soils

A reconnaissance soil survey of System A to furnish initial basic soils data for the land classification was carried out by three teams of soil surveyors of the Land Use Division (LUD) and TAMS during the months of September and October, 1979. An area of 86,300 ha. was covered, including 1,300 ha. for tanks, etc. The purpose of the survey was to supplement soils information given by the 1966 FAO map and its revised edition compiled by LUD in 1978. This soil map became the source of the basic soils data needed for the land suitability map which was prepared. This additional information made it possible to demarcate areas which have required further study during the second phase survey, carried out between January and May, 1980.

Located in the low lying coastal zone, System A has a very subdued relief and a general gradient to the north of less than 0.5%. It can be sub-divided into several main physiographic units; the central floodplain of the meandering Mahaweli Ganga and Verugal Aru; the eastern and western peneplains developed on Pre-Cambrian granitic gneisses which can be further differentiated into old alluvial terraces (OAL), and the nearly level plain; and the gently undulating plain, and the valley bottoms. The types of soils series occupying each unit are discussed below. Table B-14 of Appendix B-I presents a summary of the characteristics of the soils series found in System A.

The Central Floodplain - The soils fringing the Mahaweli and Verugal Aru are all recent alluvial deposits (i.e. Fluvisols according to Soil Taxonomy, see Table B-12 in Appendix B-I). In the northern part of the floodplain the soils are rather uniform and heavily textured, but in the south, particularly on the right bank of the Mahaweli Ganga, soils are highly stratified and often light textured. The area is characterized by numerous old river channels which have light textured soils on the levee banks. After silting up the river channel the levee materials have often been buried by finer textured sediments which has led to a very complicated and variable soil pattern.

Table B-3 shows the approximate extent of the various soil series throughout System A (and also B, C and D). Since LUD compiled these figures prior to the more detailed soil surveys for the feasibility reports, the values are only approximate but are useful for understanding the relative extent of the soil types. The dominant soils which occupy the floodplains are the Henbarawa (Hm) and the Handapanwila (Ha) Series. These two series cover half of the area of System A. Both are fine textured (clay loam) soils, generally with a clay content ranging from 40-60% with 20-30% silt. They are imperfectly drained, and mottled, with gleying at depths greater than 75 centimeters.

Less common fine textured soils (i.e. clay loams and clays) are the Hewampitiyavillu (Uh) and the Katuwanwila (Kt) Series. These are generally very fine textured and occupy the lowest part of the landscape. These soils are dark grey to grey in color, poorly to very poorly drained and exhibit gleying throughout the profile.

Aluthnuwara (A) and the Kalinga Ela (KA) Series are the soils fringing the river courses and old stream beds. These are deep, moderately well drained recent alluvial soils and are slightly raised topographically and are therefore less subject to flooding than the claying villu soils. The Aluthnuwara soil has a sandy clay loam texture; the Kalinga Ela is sandy.

The Old Alluvial River Terraces and Nearly Level Plain - The soils of the"Old Alluvial River Terraces" and the nearly level floodplain are medium textured and overlay weathered rock materials and/or granite gneiss at a depth of one to three meters. The most characteristic feature of these soils is the sandy overburden. The topography of the landscape is nearly flat. The natural drainage system particularly of the "Old Alluvial Terraces" is characterized by a dendritic pattern of dense, shallow drainage lines - usually less than one meter deep. After the monsoon rains the area is very wet, since the sandy topsoil gets temporarily saturated. However, due to the high hydraulic conductivitiy of the coarse textured soil and dense drainage pattern, drainage water is discharged to lower topographic levels within a short period and little water percolates into the subsoil. These tend to be very droughty after a brief wet period.

Covering 20% of System A, the Arasanagar (Ar) and the Ulpothawea (Up) Series are the dominant series of the eastern and western peneplain. The most typical characteristic of both series is the coarse textured sandy topsoil. The sandy material in the Arasanagar is deep and ranges from 70 to 100 cm. in depth, and in most cases makes a nonarable land use area. The subsoil clay content increases with depth and may range from 15 to 30%.

The Gently Undulating Plain - The soils of this physiographic unit occupy slightly more than 10% of System A and are located on the more elevated part of the survey area. They consist of well drained and imperfectly drained brown and reddish soils. The well drained reddish brown soils are the Wilayaya (W), Ulhitiya (U) and Manampitiya (Mn) Series. The imperfectly drained soils, mostly situated in the middle and lower slopes are Alawakumbura (Aa) and Horaborawewa (H) Series. These are yellowish brown to dark brown with subsoil mottlings. Textures of these five series are mostly textures of sandy loams with a clay content range of 20 to 35%. The pH of both topsoils and subsoils is about 6.

Derived from more acid rock in the same landscape, soils with lower base status occur. These are soils of rather major extent - the Welikanda (We), the Boatte Wewa (Bo) and the Galwewa (G) Series. Colors are greyish brown to brown. Welikanda is a moderately well drained, moderately deep soil usually associated with the Manampitiya (Mn) Series. It has light sandy loam textures. The Galwewa is an imperfectly drained moderately deep sandy clay loam which is acidic. Boatte Wewa is also imperfectly drained. These three soils belong to the Non-Calcic Brown Great Soil Group and are marginal for agriculture, especially the coarser textured soils. High infiltration rates and low water holding capacity restricts the use of these soils for paddy production.

Since these soils have not been extensively cultivated in the past, plans are currently being developed for a research program to establish the most beneficial use for these soils. With proper management which would include fertilizer and careful water management some of these soils could be used for limited upland crops, particularly where the Welikanda Series are found.

The Valley Bottom Soils - The soils occupying the lower parts of peneplain are almost identical with the poorly drained soils of the "Old Alluvial Terraces."

The Kuda Oya (K) Series is the most common soil. It is poorly drained, deep and has greyish or bluish greyed sands and sandy loams. It lacks the sandy topsoil of the Moogamana Ela (M) Series but is otherwise similar in characteristics and in land use.

Miscellaneous Soils - A very minor part of System A is occupied by shallow and stony soils, rock outcrops and saline soils bordering lagoons. All these soils have little agricultural potential, but may be used for wildlife habitat, settlement and other non-arable uses.

Systems B and C Soils

The soils in these two areas are described together since most of the soils are common with the exception of the Great Soil Group of Non-Calcic Brown Soils which are found in a sizeable area of System B.

System B, or the Maduru Oya project area, soils can be grouped into two major physiographic positions: the upland soils consist of the well to moderately drained Reddish Brown Earths (RBE) and Non-Calcic Brown (NCB)

soils, and the Levee Recent Alluvial (RAL) soils on the Maduru Oya flood-plain. These soils make up about 15% of the irrigable area. The other major physiographic group consists of the imperfectly to very poorly drained RAL, OAL (Old Alluvial), Low Humid Gley (LHG) and Solodized Solenetz (SS) soils. Included in these physiographic groups are small areas of imperfectly drained RBE and NCB soils, adjacent to the upland, but on lower slopes. Lowland paddy soils, soils imperfectly to very poorly drained, will make up a high percentage of the irrigable area.

Much of System C consists of undulating to rolling plain with isolated erosional remnants or monadocks and rock knob plains. The area is characterized by parallel ridges with intervening valleys with north-south trend which follows the geological strike. The Mahaweli Ganga follows this strike trend through most of its length and is the west boundary of System C. Along its banks there is a relatively wide band of recent alluvium characterized by undulating relief and low levee formations. Most of the tributary valleys are characterized by small flood plain areas floored with alluvial deposits. These occur along the Ulhitiya Oya, and the Hungamola Ela.

Well drained soils are the same Reddish Brown Earths of System B. The imperfectly drained Reddish Brown Earths of the lower landscapes, the poorly drained low humid gleys and imperfectly drained RAL's of the flood-plain areas are similar to those found in System B. Figure B-22 in Appendix B-I shows the catenary sequence of soils in the typical valley area in System C (south), which range from well drained RBE's to poorly drained LHG's, dark grey soils with gley horizons.

Some of the most important and extensive of the soil series that occur commonly in Systems B and C are briefly described herein. Also Table B-15 of Appendix B-I briefly describes the soil series found in Systems B and C. A detailed description can be found in the Soils and Land Classification Sections of the consultant's Feasibility Report of 1979.

In the upland areas the following soils are predominant: The Ulhitiya Series of the Reddish Brown Earths consists of well drained moderately deep to deep, dark reddish brown to dark red sandy clay loams which cover about 40% of System C and occur mostly in upland areas. The Wilayaya Series, well drained, moderately deep, dark brown clay loam, often gravelly below 30-60 cm depth belongs to the brown subgroup of the Reddish Brown Earths, and covers large areas in Systems of A, B and C. Another Reddish Brown Earth which is usually associated with the two above upland soil series, is the Manampitiya Series. Finally there is the Alawakumbura Series, an imperfectly drained moderately deep to deep yellowish brown, sandy clay loam which is common to Systems A and B. In the lowlands occur the Moogamana Ela, Horaborawewa. Kuda Oya and Ulpothawewa Series. The Moogamana Ela Series belongs to the old Alluvium Great Soil group and is made up of imperfectly drained, moderately deep, very dark grey to olive sandy soils underlain by calcareous sandy clays. This soil occurs in a very limited area in System C, in a moderate extent in System B. Covering a major portion of the lowlands of System C and a moderate area of the lowlands of System B is the association of the Horaborawewa and Kuda Oya Series. The Ulpothawewa Series covers major areas of the lowland areas of System B and some limited areas in System C. This soil is an imperfectly drained Old Alluvium, which belongs to the Solodized Solenetz.

Table B - 3

Extent of Different Soils in Systems A, B, C And D

Map Unit	Soil Series	Hectares per System A	B	C	AD	Crops* that can be grown on each soil during the two seasons MAHA	YALA
1	Ulhitiya Series	-	2,800	29,500	1,240	All upland crops of the dry zone e.g. Chillies, Onion, Groundnuts, Soya bean, Cowpea, Turdhal, Green gram, Cotton, Sugar cane, Tobacco, Maize, Sorghum, Upland rice, Fruit crops etc.	All upland crops of the dry zone.
2	Moogamana Ela Series	-	50	190	-	Lowland rice, Sugar cane, Pastures.	Upland rice, Sugar cane, Pastures, Groundnut.
3	Wilayaya-Ulhitiya-Alawakumbura Association						
	i. Wilayaya Series	3,140	17,400	2,460	660	Same as soil unit 1	Same as soil unit 1.
	ii. Ulhitiya Series	1,570	8,680	1,230	330	Same as soil unit 1	Same as soil unit 1.
	iii. Alawakumbura Series	1,570	8,680	1,230	330	Upland rice	Upland rice
4	Maduru Oya Series	850	24,200	120	-	Sugar cane, Upland rice, Maize, Sorghum, Cowpea, Green gram, Turdhal, Kenaf, Castor, Citrus, and Other fruit crops.	Sugar cane, Chillies, Onion, Vegetables, Citrus and Other fruit crops, Groundnut.
5	Kathiraveli Series	280	2,490	-	-	Unirrigated coconut.	Unirrigated coconut
6	Malwattekulam Series	340	2,970	-	-	Forestry for provision of fuel wood and timber and for settlements (unirrigated)	
7	Horaborawewa-Kuda Oya-Alluttarama Association						
	i. Horaborawewa Series	3,490	1,380	15,420	1,780	Lowland rice	Upland rice
	ii. Kuda Oya Series	1,000	390	4,520	510	Lowland rice	Lowland rice
	iii. Aluttarama Series	500	200	2,260	250		
8	Ulpothawewa-Kuda Oya Association						
	i. Ulpothawewa Series	4,990	12,570	230	-	Same as soil unit 2	Same as soil unit 2
	ii. Kuda Oya Series	2,140	5,380	100	-	Lowland rice	Lowland rice
9	Ulpothawewa-Vakaneri Association						
	i. Ulpothawewa Series	18,570	10,460	-	-	Same as soil unit 2.	Same as soil unit 2.
	ii. Vakaneri Series	3,280	1,840	-	-	Lowland rice	Lowland rice
10	Aluthmuwara Series	-	-	1,880	-	Tobacco, Chillies, Onion, Ground nut	Tobacco, Chillies, Onion, Ground nut.
11	Hembarawa Series	41,500	20,700	1,490	1,270	Lowland rice, pastures	Lowland rice, pastures
12	Handapanwila Series	4,750	410	-	-	Lowland rice, pastures	Lowland rice, pastures
13	Hungamala Series	-	250	460	-	Lowland rice, pastures	Lowland rice, pastures
14	Panichchankerni Series	670	-	-	-	Lowland rice.	Lowland rice.
15	Rock Knob Plain	1,620	10,670	8,590	870	Settlements, homesteads & building sites	Settlements, homesteads & building sites
16	Erosional Renants	80	5,000	3,570	-		
	TOTAL	90,340	136,520	73,240	7,240		

* Specific crops could be selected according to depths of soil & rooting depths

SOURCE: LUD-IRRIGATION DEPARTMENT, JULY 1978, REVISED

The Arasanagar Series of the Old Alluvium Great Soil Group extends over moderate areas of the north and eastern area of System B.

Two land types, namely the Rock Knob Plains and Erosional Remnants are common to all the Systems, but lie mainly above command irrigable areas and are unsuited for arable cropping. They are non-arable but can be used for settlements, building sites, or rougher areas for wildlife habitat.

System D Soils

The only soils data is the reconnaissance level soil survey jointly produced by FAO-Land Use Division in the late 1960's. Series and soil types were not mapped; only the Great Soil Group designations were. Table B-4 gives a summary of the soils of this soil classification for the various sub-units within System D, i.e. D-1, D-2, A/D and G, adapted from the Japan International Cooperation Agency Feasibility Report (1979).

LAND CLASSIFICATION

General

A complete description of existing conditions requires a discussion of the capability or suitability of the land to produce certain crops. The assignment of a capability rating to an area is called land classification and entails the consideration of many factors including soil properties, topography, water requirements, crop type, costs and others.

The results of land classification for the Systems A,B,C and D are reviewed in the following sections. Consultants for each of these Systems have utilized the basic soil classification data furnished by LUD (i.e. semi-detailed maps, laboratory data, field data for permeability and infiltration, and descriptions of soil series and types). Consultants for System D used the soils information made available from the Land Use Division from the reconnaissance level FAO/LUD soil survey which was completed in the late 1960's. No land classification was available for System D. In order to fill this gap in land classification, this report presents the results of TAMS preliminary classification of land in System D using the criteria developed by the U.S. Bureau of Reclamation (USBR 1967) for lands considered for irrigation. This method considers the major relevant factors and has been widely accepted.

The present land classifications for the individual systems are not uniform, but are variable in style, technique, standards, criteria, map symbols and assumptions. An objective of this report is to assess these differences and to suggest methods for improving and focusing on a technique of land classification that will be standardized and make classification simpler and more efficient. Each method of land classification is reviewed in Appendix B-II, and a uniform method is proposed.

To achieve an understanding of existing conditions it is useful to present the land use inventory with the land classification at the same scale. Consistent with existing land use maps, TAMS has developed

Table B-4

SOIL AND LAND CLASSIFICATION
SUMMARY FOR SYSTEM D (UNIT HECTARES)

LAND[1] CLASS	SOIL TYPE	A/D	D_1	D_2	G	TOTAL	CROPPING POTENTIAL MAHA	YALA
1U	R.B.E. Well drained	2230	10 650	50	2980	15 920	All upland crops	
2U	Alluvial moderately well drained	0	390	1480	230	2100	Cash crops, Tobacco, Vegetables Etc.	
1R	R.B.E. imperfectly poorly drained	2110	6480	0	2210	10800	Lowland Rice Sugarcane	Upland Rice Sugarcane
1R	L.H.G. imperfectly poorly drained	510	12230	0	830	13970	Pasture and Lowland Rice	
2R	Alluvial imperfectly poorly drained	1520	1790	4270	0	7580	Lowland Rice	
	SUB TOTAL	6370	31940	5800	6250	50570		
6	Solonetz	0	1140	0	0	1140	Not suitable except if soil can be improved.	
6	Shallow, Rocky	870	2350	150	3100	6470	Homesteads Settlement Forest Plantations	
	SUB TOTAL	870	3490	150	3100	7640		
	TOTAL	7240	35430	5950	9350	58010		

Notes: R·B·E·— Reddish Brown Earths
L·H·G·— Low Humic Gley
Alluvial, Solonetz
] Great Soil Groups

[1]LAND CLASS ASSIGNED BY TAMS

Adapted From Japan International Cooperation Agency, Feasibility Report October, 1979

a uniform mapping of land classification for the entire Accelerated Program area covering Systems A, B, C and D at a scale of 1:50,000 (see the Map Addendum). In addition, summary maps showing areas of arable and non-arable land for the four systems appear in Figures B-6,B-7,B-8 and B-9, respectively. The land classification has been simplified in order to attain more uniformity in mapping land classes for the Accelerated Program area. These uniform land use and land classification maps furnish the basic data from which recommendations are made for future land use.

As discussed in more detail in Appendix B-II, the following land class criteria were established to be used in these maps for five arable classes: 1U, 2U (Upland Classes); 3 an Upland Marginal Class; 1R, 2R (Wetland Rice Classes) and Class 6, a non-arable class. These classes are further defined below:

- 1U, Lands with minor limitations for moderately well to well-drained soils of upper slopes capable of producing good yields of upland crops with minor expenditure;

- 2U, Lands with moderately severe limitations for moderately well to well-drained soils of upper slopes capable of producing reasonable yields with acceptable levels of expenditure;

- 1R, Lands with minor limitations for paddy production in lowland areas capable of producing reasonable paddy yields with minor levels of expenditure, with imperfectly to poorly drained soils which minimize water requirements;

- 2R, Lands with moderately severe limitations for paddy production in lowland areas capable of producing reasonable paddy yields with acceptable levels of expenditure; poorly drained to very poorly drained soils, or very sandy soils with high water requirements;

- 3 , Lands with topographic, or soil deficiencies or both which would require higher land development costs or higher inputs of water, fertilizer or other management practices than those of Classes 1 or 2 and for which returns would be appreciably lower; and

- 6 , All lands that do not meet criteria for Classes 1,2, or 3. Includes both arable and nonarable lands, i.e., rockland, roads, tank bunds, tanks and stream courses.

It is important to emphasize that the term "arable" denotes lands which can be plowed and also can be irrigated. Thus, arable can include upland as well as lowland as long as the upland can be irrigated. "Non-arable", then, means not able to be plowed and not able to be irrigated. Nonarable land can be utilized for forests, woodlots, pastures, etc. and is, therefore, not unproductive from an agricultural point of view. Certainly, nonarable lands can be utilized for settlements and related infrastructure which are of primary importance for the success of the agricultural projects.

Results of Land Classification for System A

Table B-5 presents a tentative summary of the System A Consultant's land classification for three types of irrigated land use: upland crops, intermediate crops which tolerate periodic wetness on the surface (e.g. sugarcane on ridges) and wetland rice. Their classification covered 85,500 hectares of the approximately 95,600 hectares of System A.

Table B-6, although not covering the entire System because of lack of adequate soil maps, shows the uniform land classification applied by TAMS. The upland areas are generally marginal (Land Class 3) and these areas cover almost 30% of System A. Of rice land, fully a third of the System has a high ranking of suitability. Total arable land extends over 89% of the area, leaving about 11% as non-arable or tanks (see Figure B-6). The non-arable land, however, is of considerable importance for the location of settlements, forest and wildlife areas all of which are essential for successful development of System A.

Results of Land Classification for System B

Showing the land classification of the full extent of System B, Table B-7 summarizes the results of System B Feasibility report. About 14% has ratings of 1 or 2 for upland crops; 20% has a rating of 1 for rice; 37% has a rating of 1 or 2 for rice; and more than half the system is suitable as arable land.

The uniform land classification shows approximately the same percentage distribution of land classes as discussed above. Although the lands classified as Class 6 are extensive (as shown in Table B-8 and Figure B-7), some areas of cropland have been included which due to their position or location above command are designated 6U or 6R but may or may not have agricultural potential depending on the severity of limitations. More detailed studies are required to determine the full extent of areas within Class 6 lands which could be used for forest, pastures and other agricultural uses.

Results of Land Classification for System C

The System Consultant's land classification is shown in Table B-9. Of the total 66,830 hectares, there is a sizeable Class 5 area of 11,830 hectares (see Appendix B-II for this land class specification) which needs further study before a final irrigated land use can be designated. Further study of the drainage requirements would be necessary, since zonal areas reported indicate that it would be the northern sectors that would be the most questionable. It is understood that the World Bank has requested a review of the land classification, but the resulting information is not generally available.

Table B-10 presents the uniform land classification, and Figure B-8 shows the location of arable and nonarable areas. About one-quarter of the area is suitable for upland crops while almost 42% is suitable for rice. One third, then, is nonarable being comprised of rock outcrops, erosional remnants, roads, tanks, tank bunds and water courses.

Results of Land Classification for System D

As discussed above, the System D feasibility report did not contain a land classification. TAMS applied the uniform land classifications method to rate lands with adequately detailed soils maps (i.e. subareas A/D, D_1 D_2, G and the Kantalai sugarcane fields). This land classification was done only with the limited available data and not from criteria set up for a feasibility study with all of the field checks that would usually be needed.

The total 1R and 2R classifications as presented in Table B-11 indicates that land suitable for rice production covers about 60% of the area, or 30,610 hectares. Upland crop areas cover 27.9% or 13,680 hectares Total irrigable area adds to 44,290 hectares so that 88% of the areas under consideration are arable. The remaining area is Class 6 and as shown in Figure B-9 acounts for only small,scattered patches.

PRESENT AGRICULTURAL PRACTICES

Agricultural practices in all the System areas where lands have been cleared follow the centuries-old dry zone pattern. Rice is grown on irrigated land from stream diversion or from the thousands of tank areas distributed over the accelerated Program area and the rest of the dry zone. Slash and burn or chena agricultural cultivation as it is known in Sri Lanka is used for annuals, mainly cereal and root crops. When conditions and area available permit, perennials and vegetables are grown in homestead plots along with bananas, pineapples, mangoes, papaya and other tropical fruits. Because of limited input requirements, these practices are relatively satisfactory, but the shifting cultivation does result in permanent damage to forest and soil resources.

In traditional villages in the project area, farmers operate usually a 0.2 to 0.6 hectare plot on lowland below the village tank, a small rainfed homestead plot with mainly tree crops and an area of rainfed shifting chena cultivation for pulses, millets, vegetables, tobacco and sometimes rainfed paddy.

On the irrigated lowland, the staple food of the family, is the main crop. On well drained parts of these lowlands, chillies, onions and vegetables are also grown. The traditional system minimizes cash resources needed and the risks of farming and allows for a greater income from the limited labor and draught power available.

Roughly two million hectares of land are cultivated in Sri Lanka. Of this total about 45% is in paddy, 22% in coconuts, 12% in tea, 11% in rubber, and 10% in chillies, manioc, kurakkan, maize, sweet potatoes,onions and potatoes (Dept.of Census and Statistics 1979). From 1968 to 1978 the trends in areas under paddy, tea, rubber, coconut, jurakkan, red onions, chillies and potatoes showed no significant increases, although area in paddy did increase slightly from 1976 through 1978. Taken over the entire period the areas under the other crops (i.e. maize, manioc and sweet potatoes) remained steady but there were large increases in areas cultivated during 1974, 1975 and 1976. Trends in yields do not appear to show significant changes.

Table B-5

Land Classification Summary From System A Feasibility Report

	Area Extent (hectares)		
Suitability Class	Upland Crops	Intermediate Crops	Wetland Rice
1	11,863	11,868	34,550
2	1,720	24,796	8,015
2-3	-	6,633	10,407
3	33,337	10,252	16,128
6	38,450	31,826	16,275

Notes: Total hectares mapped (in rounded figures) = 85,400 ha. not including 1300 ha.of swamp, lagoon and tanks.

Summary figures for each suitability class and for each corresponding land use area are not in rounded figures. It will also be noted that because of the overlap of suitability classes from Upland, Intermediate, or Wetland Rice Areas, it is not possible to have sub-totals for each suitability class and land use area to give the total of 85,000 hectares.

See TAMS simplified land classification summary System A under the Land Classification Section of this report and the Land Classification Map of System A in the Map Addendum.

Source: Joint Venture Randenigala (1980).

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Table B-6

Summary of Uniform Land Classification of System B

LAND CLASSES	HECTARES	SUBTOTALS	PERCENTAGE
1U	1,800	--	2.9
2U	1,040	--	1.7
3	18,070	--	29.5
Total Upland	--	20,910	34.1
1R	19,980	--	32.6
2R	13,350	--	21.8
Total Rice land	--	33,330	54.4
Total Arable	--	54,240	88.5
Total Class 6 (Non-Arable	--	6,180	10.1
Tanks		890	
Gross Total Area Classified		61,310	100.0

Source: TAMS (1980)

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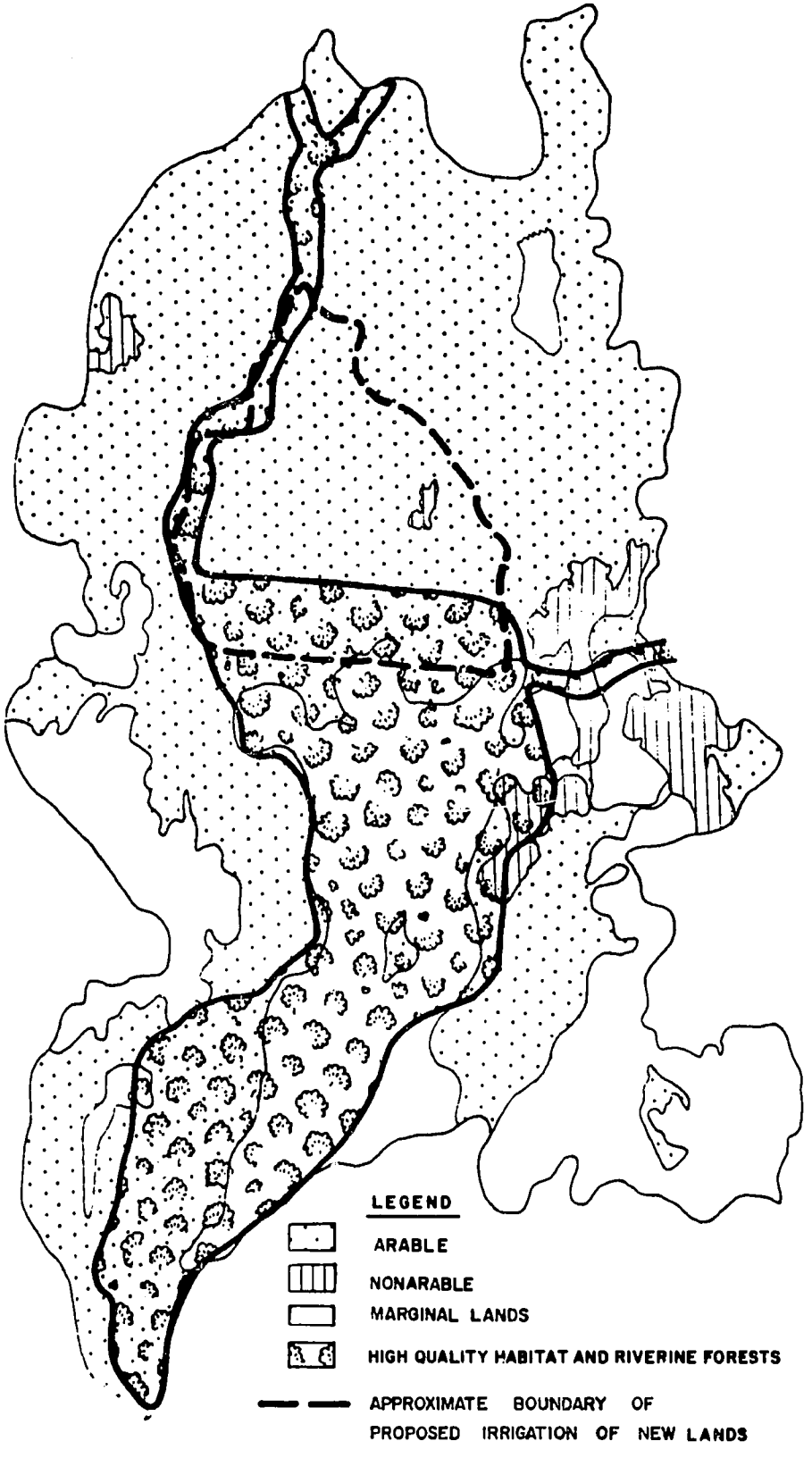

UNIFORM LAND CLASSIFICATION MAP OF SYSTEM A
FIGURE B-6

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Table B-7

Land Classification Summary From System B Feasibility Report

MAP AREAS	LAND CLASS	AREA	ARABLE SUBTOTAL	CLASS 6 SUBTOTAL
Map Areas 1,2,3B and 4 (completed in 1979)		ha	ha	ha
	1U	5,360	--	--
	2U	7,291	--	--
	Total Upland		12,650	--
	1R	14,450	--	--
	2R	17,060		
	Total Riceland	--	31,510	--
	Class 6	--	--	42,570
Map Areas, Balance 3&5 (completed in 1980)				
	1U	1,390	--	--
	2U	6,870	--	--
	Total Upland	--	8,260	--
	1R	15,690	--	--
	2R	8,750	--	--
	Total Riceland	--	24,440	--
	Class 6	--	--	30,680
Grand Total - Arable		--	76,860	--
Grand Total - Non Arable Class 6		--	--	73,250

SYSTEM SUMMARY TOTALS CLASS	ha	TOTALS	%
1U	6,750		4.5
2U	14,160		9.4
Total Upland Classes		20,910	13.9
1R	30,140		20.1
2R	25,810		17.2
Total Riceland Classes		55,950	37.3
Total Arable Area		76,860	51.2
Total Non-Arable (Class 6)		73,250	48.8
Total Area Classified		150,110	100.0
Area not Classified		370	
Total Gross Area, System B		150,480	

Source: ACRES (1980)

Table B-8

Summary of Uniform Land Classification[1]
of System B

LAND CLASSES	HECTARES	SUBTOTALS	PERCENTAGE
1U	5,250	--	6.1
2U	7,000	--	3.1
Total Upland	--	12,250	14.2
1R	14,720	--	17.0
2R	16,460	--	19.0
Total Riceland	--	31,180	36.0
Total Arable	--	43,430	50.2
Total Class 6 (Non-Arable)	--	38,500	44.5
Tanks	--	1,980	2.3
Flood plain	--	2,600	3.0
Gross Total Area Classified	--	86,510	100.0
Not Classified	--	540	--
Gross Area	--	87,050	--

1 Does not include Map Areas 3A, 3C and 5 which were to be completed in early 1980, but Consultant (Acres) Land Class Maps were not completed in time to be summarized in TAMS Final Report.

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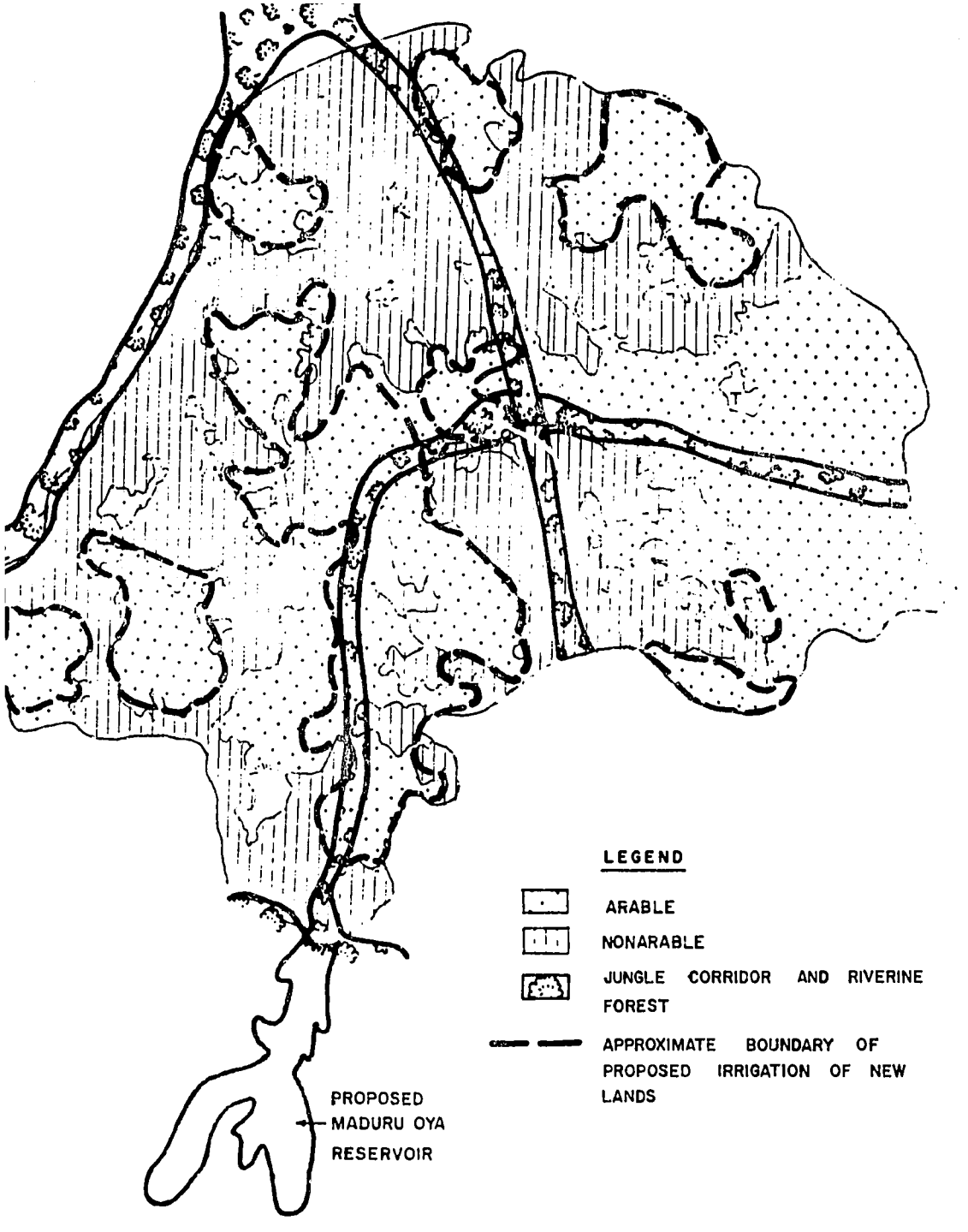

UNIFORM LAND CLASSIFICATION MAP OF SYSTEM B
FIGURE B-7

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Table B-9
Summary from System C Feasibility Report

Zone	Type	Wetland Rice Classes 1	2	3	5	6	Common Rock	Villus & Tanks	Zone Total
1	Total	1,100	1,250	1,250	2,930	2,460	2,900	1,100	13,000
2	Commanded	3,100	1,690	1,010	1,110	1,450	300	-	8,660
	Non-Comm.	250	760	490	2,490	1,970	1,950	-	7,910
	Total	3,350	2,450	1,500	3,600	3,420	2,250	200	16,570
	Lost to	10-630	260	110	140	100	-		1,240
	Rotalawela	20-1780	970	480	760	310	-		4,300
3	Commanded	1,180	1,170	620	560	280	-	-	3,810
	Non-Comm.	20	100	100	280	70	200	-	770
	Total	1,200	1,280	720	840	360	200	-	4,580
	Lost to 10	30	30	-	-	-	-	-	60
	Rotalawela 20	300	240	60	20	70		-	690
4	Commanded	5,560	5,190	2,450	1,080	840	180	-	15,300
	Non-Comm.	160	1,050	1,150	1,010	510	400	-	4,280
	Total	5,720	6,240	3,600	2,090	1,350	580	-	19,580
	Lost to 10	1,700	820	200	100	510	-	-	3,330
	Rotalawela 20	1,970	1,430	410	260	620	-	-	4,690
	230	50	70	50	20	20	70	-	280
5	Commanded	1,810	1,070	410	330	30	30	-	3,680
	Non-Comm.	100	210	190	460	240	70	-	1,270
	Total	1,910	1,280	600	790	260	100	-	4,950
6	Commanded	630	1,120	830	640	150	240	-	3,610
	Non-Comm.	80	660	750	940	810	1,300	-	4,540
	Total	710	1,780	1,580	1,580	960	1,540	-	8,150
CLASS TOTAL		13,990	14,280	9,250	11,830	8,810	7,570	1,300	66,830

1 - 70 M Contour
2 - 76 M Contour
Above 76M Contour

Source: Hunting Technical Services Ltd. (1980).

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Table B-10

Summary of Uniform Land Classification of System C

LAND CLASSES	HECTARES	SUBTOTALS	PERCENTAGE
1U	3,600	--	5.2
2U	12,000	--	17.2
Total Upland	--	15,600	22.4
1R	11,000	--	15.8
2R	18,800	--	27.0
Total Rice Land	--	29,800	42.8
Total Arable	--	45,400	65.2
Total Class 6 (Non-Arable)	--	23,800	34.2
Tanks	--	360	0.6
Gross Total Area Classified	--	69,560	100.0

Source: TAMS (1980)

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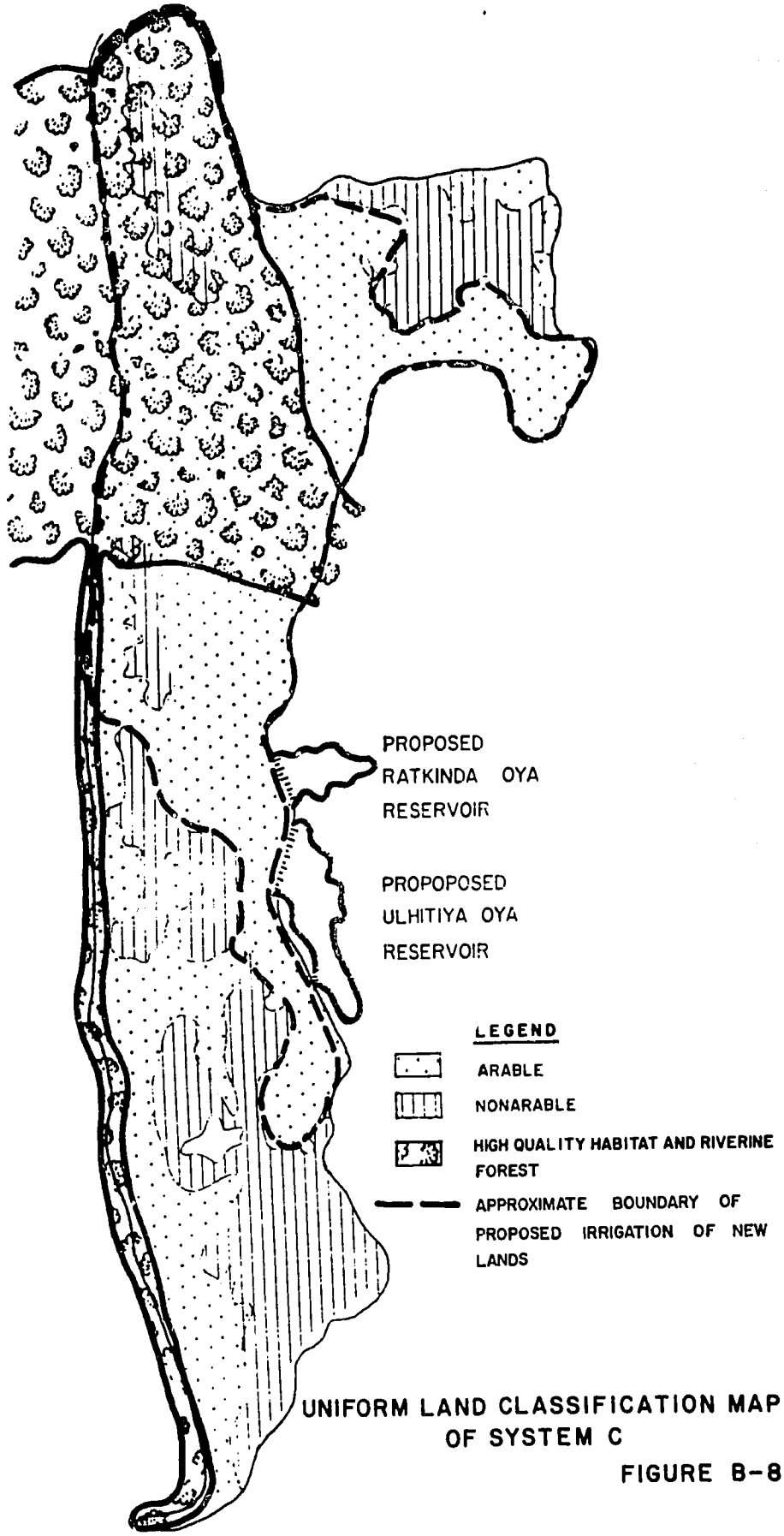


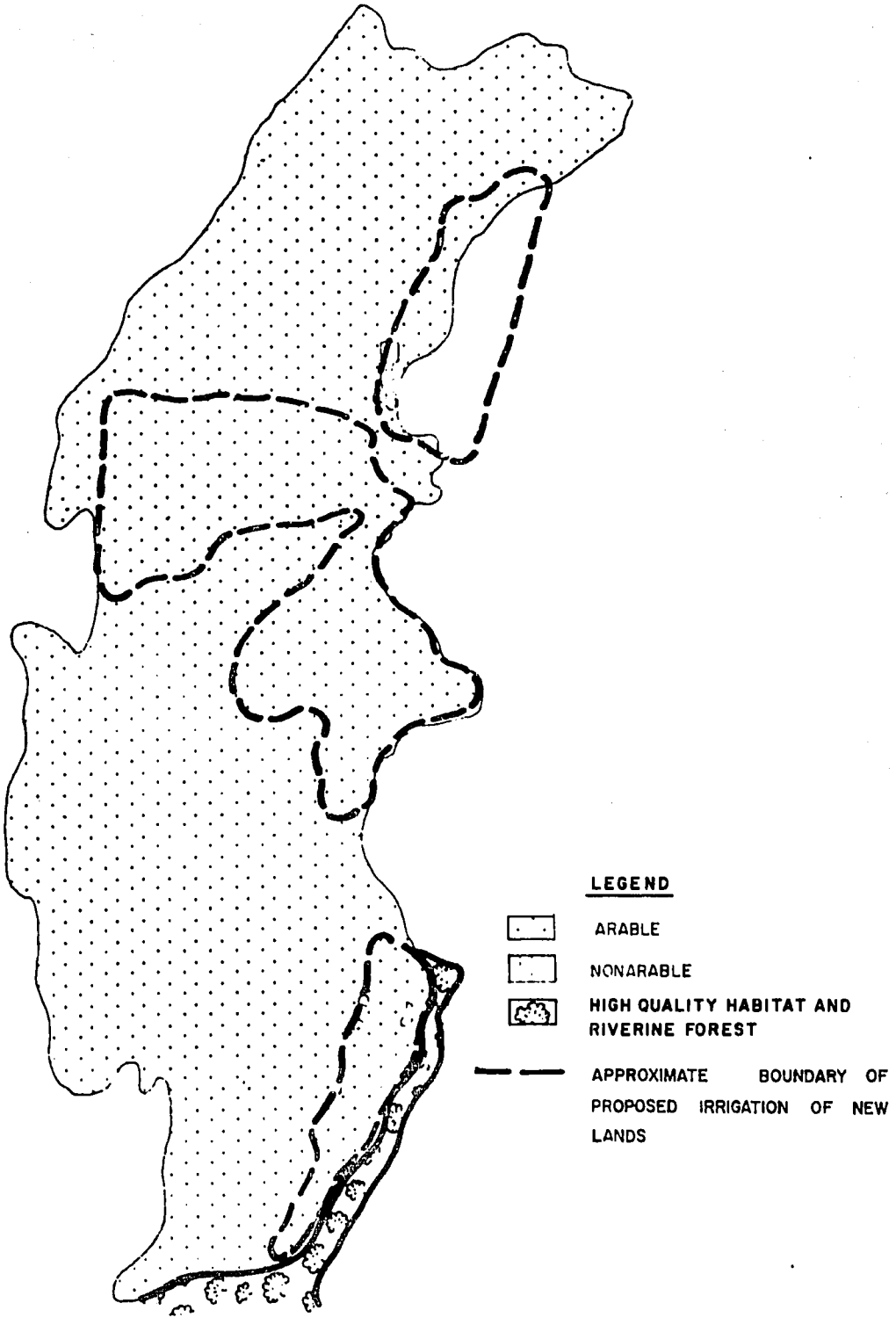
UNIFORM LAND CLASSIFICATION MAP
OF SYSTEM C

FIGURE B-8

Table B-11

Summary of Land Classification for System D

LAND CLASS	HECTARES	SUBTOTALS	PERCENTAGE
1U	10,620		21.1
2U	3,060		6.0
Total Upland		13,680	27.1
1R	22,720		45.2
2R	7,890		15.7
Total Rice Land		30,610	60.9
Total Arable Land		44,290	88.0
Total Class 6 (non arable)	6,080	6,080	12.0
Tanks & Others		-	-
Total Area Classified		50,370	100.0



UNIFORM LAND CLASSIFICATION MAP OF SYSTEM D
FIGURE B-9

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REGULATING AGENCIES

A number of principal regulating and program oriented agencies of the GSL are directly involved in providing technical expertise to land use and natural resource development programs in the project area.

The Survey Department

Created in 1800, the Survey Department is one of the oldest Civil State Departments. The Department maintains and operates a modern Photogrammetic Laboratory equipped with precision plotting instruments to systematically produce maps and plans from aerial photography. A new air survey aircraft equipped for aerial photography has arrived and will be used to train Air Force Pilots in aerial photography. This has been funded under USAID for the Agricultural Base Mapping Project.

Additional assistance is being made available through USAID for modernization and improvement of the cartographic facilities, which includes the installation of a recently arrived large scale copy camera which is adjustable for enlargements and reductions. A new two-color map printing machine will be secured also under the USAID funded program to be installed in the map reproduction department. The Cartographic Unit has been operating with old equipment, which has been a major constraint in the issue of up-to-date maps and plans to the other government departments and the public. These facilities are manned by a number of well qualified officers who have been trained here and abroad.

A training program is underway to provide both field surveyors and cartographic personnel to meet the great demand for the Accelerated Mahaweli Development Program and other national programs.

The Agricultural Base Mapping Project is of prime importance to the country in assisting with the Accelerated Program. The first objective of this project is to produce up-to-date color maps of the country on a scale of 1:50,000 to replace the one inch to one mile topographic series. Because the Department has not been able to systematically revise the old maps due to staff being diverted to urgent development surveys and due to outdated printing and cartographic equipment, the old map series need to be replaced by the new metric scale series.

The second objective of this project is to produce more detailed topographic and thematic maps of the entire island on a scale of 1:10,000. These maps will show one, two or five meter contours depending on the terrain, and in the future will be the base maps for information concerning land use, soils, forestry, etc.

The Irrigation Department

The Irrigation Department has been entrusted with a part of the irrigation engineering for the Accelerated Mahaweli Development Program. In addition, they are still carrying out the normal irrigation development

work on the island; the design of the 30.8 km long R.B. Canal from the Minipe Anicut; the planning design and construction of System D1, involving about 10,100 hectares in the Kandulla extension scheme; and the planning and design of System A including the 20,200 ha of new land and 7,000 ha of existing land.

The Land Use Division of the Irrigation Department has been charged with the responsibility of conducting semi-detailed soil surveys at all the Accelerated Program Area Systems, while they are completed in cooperation with consultants for Systems A,B and C. No feasibility level survey was performed in System D except to up-date and improved in part the original reconnaissance soil survey made in cooperation with FAO in the late 1960's. Soil laboratory support for sampling in the various scheme soil surveys has also been maintained by the Land Use Division, which has capability of continuing technical support for future detailed soil surveys. Soil survey team personnel have also been responsible for making infiltration and permeability field determinations required by the Consultants.

It is presumed that the soil survey teams employed in the feasibility level studies will also be utilized in the soil surveys necessary to implement the design stage in the next phase of development in the Accelerated Program area.

During late 1979 at a Sri Lankan Soil Science Society Meeting held at the Association for Advancement of Science, it was indicated that a Land Use Planning Department would be organized as an entity in the government. This could enlarge the technical responsibility and work load of the present Land Use Division of the Irrigation Department, which presently is charged with the following responsibilities:

- Inventorying the soil resources of Sri Lanka to help in planning and location of project areas;
- Carrying out soil surveys and land classification studies of proposed projects for the preparation of feasibility reports to be submitted to financing agencies;
- Recommending suitable cropping patterns for different areas;
- Selecting suitable methods of irrigation for each area and planning farm irrigation and drainage design;
- Predicting and correcting problems of salinity and alkalinity in soils;
- Monitoring the quality of irrigation water;
- Making recommendations regarding soil management practices for each kind of soil, including fertilizer application, tillage, moisture, conservation, soil conservation, etc;
- Preparing land use plans and farm layout plans; and
- Interpreting the suitability of soils for forestry, engineering uses (roads, sewers, buildings, pipelines), tourism, recreation, wildlife habitat, etc.

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IMPACT ANALYSIS

POTENTIAL LAND USE CONFLICTS

General

Since an assessment of impacts requires a clear understanding of the project, it is worthwhile to briefly review the characteristics of the project as they relate to the downstream irrigation system. (The MAIN REPORT presents a more detailed definition of the overall project). The Accelerated Program encompasses four irrigation systems: System A will comprise approximately 17,500 hectares of improved or new paddy; System B will provide 40,150 hectares of new and improved paddy as well as some upland cropland; System C will be primarily 19,550 hectares of new and improved paddy and upland cropland. As a consequence of building dams to provide water for irrigation, the flow of the Mahaweli Ganga will be reduced by approximately 50% (see TOPIC REPORT A: HYDROLOGY AND CLIMATE) which in turn will reduce the area of wetlands by approximately 50% (see TOPIC REPORT H: WETLANDS). The impacts of these actions are addressed below for each System. It should be noted that potential land use conflicts which arise due to project development involve replacing present uses with cropping or generally prime agricultural lands.

System A

Since Figure B-2 shows a composite of existing land use and the approximate boundaries of the proposed irrigated area, it is possible to identify changes in land use and potential conflict areas. The term "conflict" is used here to denote land use changes which, although desirable from one viewpoint such as development of irrigated agriculture, may be undesirable according to other goals such as conservation of wildlife, provision of fuelwood, protection of existing settlements and infrastructure.

The northern portion of area to be developed covers chena or scrub land so that there is not a significant impact since the land will be more productive with irrigated agriculture. However, the southern portion of the area to be developed for new riceland extends over approximately 5,600 hectares of the Somawathie Sancutary which TOPIC REPORT E: WILDLIFE has identified as high quality wildlife habitat so that there is a conflict between development and wildlife conservation. TOPIC REPORT M: ECONOMICS shows the results of determining the cost of foregoing the development of this 5,600 hectare portion and leaving it as wildlife habitat, TOPIC REPORT E: WILDLIFE documents the importance of this area for wildlife.

It should also be noted that almost 30% of System A is rated as Class 3 lands or lands which are marginal for development. A large portion of Class 3 land lies on the southern half of System A so that it is unlikely these areas will be developed.

System B

As shown in Figure B-3 the two northern sectors of development as well as the portion south of the river and parts of the southeast sectors will replace forest and therefore have a significant impact. These proposed developments will eliminate 10,000 hectares of forest lands in System B.

The other areas for new ricelands are primarily chena or scrublands so that they do not cause an appreciable impact. Likewise, improvement of existing paddy does not present a conflict with other potential users.

Areas within System B which are part of wildlife reserves which have potential for development include about 2,500 hectares of the existing Nelugala Corridor. The System B feasibility Consultant will calculate the cost of not developing these portions of the corridor (see also the Appendix of TOPIC REPORT M: ECONOMICS).

Other areas which TOPIC REPORT E: WILDLIFE has identified as important wildlife habitats are strips about 200 meters on either side of the Maduru Oya. The floodplain area along the Mahaweli Ganga is not slated for development, but it has been identified as a high quality wildlife habitat. These protective bands account for roughly 2,800 hectares of land.

System C

Figure B-4 shows the proposed areas for new ricelands, the existing land use and the high quality wildlife habitat. The northeastern wedge, known as Zone 4 is forested and also high quality habitat but is scheduled for development. The high quality habitat is about one-third of the forested areas of System C or roughly 15,000 hectares (8,000 net irrigable). This wedge forms an important connection between Wasgamuwa Wildlife Reserve (recommended for a National Park) and Maduru Oya National Park (see TOPIC REPORT E: WILDLIFE).

The development in Zones 5 and 6 of System C will cover roughly 5,000 hectares of forest. The rest is chena or scrublands. The new ricelands in the southern portion of System C will eliminate mostly chena and scrubland. Except for the 200 meters of riverine forest on either side of the Mahaweli Ganga, this southern development will not have a significant impact.

System D

Of the three areas for new riceland shown in Figure B-5, the northern two do not present a conflict with existing land use as these areas are chena, scrubland or non-productive forest. The lower section is mostly on chena land, and the only conflict may arise if the project extends into the floodplain of the Mahaweli Ganga which has been identified as a high quality wildlife.

EFFECTS OF IRRIGATION AND DRAINAGE

Summary

The impacts of irrigation and drainage on specific soil series are discussed in the following sections under the headings of impacts on physical and chemical properties, potential waterlogging, and erosion. To summarize the general impacts, this section presents a brief discussion of each system in terms of its soil classifications.

System A - As shown in Figure B-6, the area to be developed for irrigation is a triangular shape located north of the Somawathie Sanctuary on lands which are classed as primarily arable. Here, the distribution of Classes 1U,2U,1R,2R and 6 is different from the distribution of the entire System A (see Table B-6 for statistics on System A and Classes). Approximately two-thirds of the proposed new irrigation area is composed of lands classified as 1R. The soil properties, topography and economic considerations of these 1R lands make them highly suitable for paddy production. The impacts of irrigation and drainage on these soils will be minor.

About one-sixth of the proposed irrigated area is Class 2R lands which although suitable for irrigation, usually are sandy soils with large water requirements. However, the impacts of irrigation on the soils themselves will be minor.

Only about 7% of the lands are classed 1U which implies good productively, with little negative impact on the soils. However, since upland areas have steeper slopes, the potential for erosion is greater than in the riceland areas, but the losses due to erosion in 1U lands are not expected to be significant especially if the land is properly managed. A more severe problem with erosion may be encountered with the lands classified 2U, since these lands have steeper slopes and more erodable soils than 1U lands. Less than 5% of the proposed irrigated area is composed of 2U lands so that in terms of absolute extent, any losses due to erosion, although higher in degree than other lands, will be minor.

The arable lands account for almost 95% of the proposed irrigated lands, while the remaining lands are Class 6, on non-arable. If these lands are not cleared but left in forest, woodlots or pasture where the land is suitable, the impacts on soils will be minor.

System B - Figure B-7 shows that, unlike System A, the System B project area is spread out over the entire System and separated by Class 6 or non-arable lands. The arable areas account for about half the System B area. Of the arable half, about 30% of the arable lands are 2R which will have a higher water requirement than the 1R but will not show appreciable impacts from irrigation.

The remaining 30% of the arable lands are suitable for upland crops. The land classified as 2U accounts for about 15% of the arable lands (or half of the uplands croplands), and these lands will have the most potential of all the arable lands to be degraded by erosion. However, since these lands are such a minor portion of the lands to be developed in System B, the overall impact should not be significant.

System C - Of the land proposed for development for irrigation in System C, only about one-quarter is classified as 1R land, while roughly 40% is 2R. System C has one of the highest levels of 2R land of the four systems (see Figure B-8).

Also, System C has a higher proportion of 2U lands with about one-quarter of arable lands for development in this least suitable category. The remaining 10% is rated 1U.

System D - Figure B-9 shows the layout of arable and non-arable lands in System D. About 90% of the lands stated for development are arable lands. Half of the arable land is rated 1R the most suitable for paddy. Another 20% is classified as 2R. About one-quarter of the arable land is Class 1U areas and therefore not suitable for upland crops. Only about 5% of System D's area is 2U so that impact from erosion will not be significant as it is confined to a small area.

Impacts on Physical Properties of Soils

The physical characteristics of soils often change when they are placed under irrigation. From a favorable virgin condition, the soils become more coherent and resistant to root penetration especially in the part of the profile subjected to wetting and drying. The effect is likely to be more marked if the organic matter is low. It also depends on the clearing operations and the leveling of the land. If the fallen trees, brush and debris are bulldozed into windrows often much organic matter is removed as well as some of the topsoil. Consequently, the organic matter percentage in the topsoil and subsoil exposed is decreased.

The Reddish Brown Earths have a relatively high bulk density (1.5 to 1.6 gm/cm^3) and a moderate to low water holding capacity. The surface textures are sandy clay loams and the long term infiltration rates are moderate Due to this moderate infiltration rate and low water holding capacity, under irrigated paddy, the water use and lateral percolation losses would be high.

The Non-Calcic (NCB) soils which are found mostly in System B occur in association with the LHG and RBE soils. These soils typically consist of moderately deep loamy sand and light sandy clay loam to sandy loam underlain by a composing bedrock. These NCB soils have a low to moderate available water holding capacity and a moderate to a rapid long-term infiltration rate. The high infiltration rates and low water holding capacity restrict the use of these soils for paddy production. The suitability for irrigated agriculture is marginal especially for the coarser textured soils; although with proper management including fertilization and careful water management these soils may be used for limited upland crops.

Low Humic Gley (LHG) soils have a moderate available water holding capacity and moderately slow to slow long term infiltration rates. These characteristics are closely associated with fine textures in surface and subsoil. They have proven to be excellent paddy soils in areas within the Accelerated Program area where paddy is already being produced on them.

The Recent Alluvium (RAL) soils which are found within both the Mahaweli Ganga and Maduru Oya floodplains are found in association with adjacent upland NCB, RBE and terrace Old Alluvial (OAL) soils. These soils occur in a topographic sequence of levee, backslope and basin soils. The RAL soils are especially susceptible to erosion along the river levees, and will probably be even more so under sustained irrigation. The backslope

soils found at the foot of the levee, unless good drainages is provided, will tend to become waterlogged. Because of the topographic position, the basin RAL's will continue to be poorly drained. Flood control will be necessary to minimize flood damage. Until flood control measures can be implemented, special management may be necessary to minimize flood damages by the planting of paddy after January 15th to ensure sustained productive agriculture.

The Old Alluvial (OAL) soils occur both in Systems A and B and are found in association with NCB and RBE soils. OAL soils are typically moderately deep, but the physical characteristics of their profiles will limit their productive capacity under irrigation. These soils consist of imperfectly drained sands and sandy loams overlying discontinuous sandy clay loams to sandy clays of residual origin. The sandy surface will be permeable creating impeded drainage and waterlogging. The Ulpothewewa, Moogamana, and Arasanagar series are typical to these OAL soils, and in many instances because of these particular properties, will be classified as marginal irrigable soils and in some cases even Class 6 or non-arable land. These soils have moderately rapid long term surface infiltration rates and low available water holding capacities due to their coarse textures. With the fine textured substratum which prevents rapid deep percolation, the Ulpothawewa and Moogamana series are best suited for double-crop paddy cultivation.

Solodized Solonetz (SS) soils occur on river terraces where they are found in association with OAL soils. The SS soils are typically sandy surface soils overlying a bleached, strongly sodic subsoil which is fine textured and has a strong columnar structure. The strongly clayly subsoil underlying the shallow sandy soils limits vertical water movement and root penetration. Without adequate drainage and costly reclamation, the SS soils are unsuitable for upland crops. However, with a sandy surface soil underlain by a slowly permeable subsoil and with proper management, the SS soils will be suitable for paddy cultivation under most circumstances. These soils occur in relatively small blocks and are intricately mixed with OAL soils. The extent is not great, but irrigated agriculture could cause an extension of affected area if drainage is not improved in the surrounding areas and associated cropland soils.

One physical property which can cause difficulty in irrigated agricultural development from new virgin lands is the tendency for upland soil to form a hard crust after it dries out following irrigation. This can affect seedling emergence and can seriously affect the stand of planted crops. It is more serious when soils are calcareous, or there is lack of sufficient organic matter in the topsoil. It is not likely that many of the soils of the Accelerated Program area will be thus affected.

Impacts on Chemical Properties of Soils

Clearing land and leveling it for irrigation will reduce the organic matter content of the surface soil unless special care is taken to preserve clearing debris.

Irrigation water further reduces the available nitrates by leaching. In normal rainfed agriculture in freely drained soils, oxygen distribution in the soil air produces an environment which encourages oxidation of soil minerals, but under an irrigated regime and particularly a conversion of land to paddy production creates a reducing atmosphere with the excess water. This is fine for paddy since soil nitrogen is taken up in the reduced form by the rice plants.

Nitrates are highly water soluble. When the initial organic matter from the land clearing operation is depleted after one or two crop years, nitrate in the form of mineral fertilizers will be needed to sustain crop yields. Although most local soils appear to have sufficient potassium from normal soil mineral sources, crops under sustained irrigation will require potassium fertilizers. Laboratory soil tests indicate that the normal soluble phosphorus content of virgin soils is low and phosphate fertilizers will be required from the very beginning.

Sustained irrigation year round will cause depletion of soluble nutrients if low water application efficiency becomes the rule. There is a high risk involved in the potential loss of nutrients when excessive water is used for irrigation. Water management with high efficiency in water application wastes the least amount of the nutritional elements required for high yields.

Insufficient drainage facilities can promote soil salinity problems, especially in the intermediate topographic areas between the upland soil areas and the lowland areas. Any upland soil area where the downward movement of drainage water through the soil profile is restricted is an area where the risk of a soil salinity problem created is relatively high, especially when long term year around irrigation is considered.

The most drastic impact on chemical properties will come in the flooding of the first lowland soils for paddy. Besides the change from a soil environment of oxidation to one of reduction, it produces a change in the biological microflora of the soil as well.

Impacts of Potential Waterlogging

Insufficient substrata data are available to properly assess the drainage characteristics and potential drainage requirements throughout the Accelerated Program area upland soils areas which are deeper than 150 centimeters. Full development of double cropping paddy as currently planned on the imperfectly drained and poorly drained lowlands would greatly restrict natural drainage from well drained upland soils and may cause extensive waterlogging unless required drainage facilities are constructed.

There are areas of soils in Systems B and C which are relatively shallow over bedrock or quartz gravel which need to be further investigated before development of irrigated cropping on these soils can be justified, without risk of waterlogging them and the other intermediate upland soils topographically below them.

IMPACTS OF EROSION

Generally, erosion in the downstream irrigation project area is mininal in contrast to erosion in the upper catchment where slopes are steeper and rainfall is greater than in the irrigation projects. The clearing in the irrigation areas is confined predominantly to the lowlands which have insignificant slopes in terms of erosion. In addition to low erosion potential because of little slope and low rainfall, a dense ground cover will grow up quickly after clearing which will protect the soils from erosion.

According to the Systems A and C Consultant's reports (Joint Venture Randenigala 1980; Hunting Technical Services Limited 1979) no upland clearing should occur in Systems A and C, and, therefore, no additional erosion from uplands should occur because of the project. Systems B and D Consultants propose clearing about 5,000 hectares of uplands in each System (ACRES 1979; JICA 1979). These upland clearings account for less than 5% of the area of these large systems and the small amounts of losses from the new upland cropland should be insignificant.

RECOMMENDED ACTIONS

RECOMMENDED LAND USE

System A

A generalized map of the land use recommendations for System A is shown in Figure B-10. The new riceland overlaps high quality habitat in the northern part of the Somawathie Sanctuary; however, the feasibility study for System A is not completed to date. If possible, this conflicting area should remain part of the Sanctuary (see TOPIC REPORT E:WILDLIFE). The new cropland to the northeast is discussed in System D. The lands of existing agriculture in the northeast retain their present use. However, along the Mahaweli Ganga is shown the riverine forest on either side of the river. As explained in TOPIC REPORT E, this band is considered high quality habitat and it is recommended it be developed as a park.

The lands to the east and west of the Somawathie are shown as possible for park expansion for those portions which are not already developed. The southeastern portion of System A is marginal for agriculture and should be forest, pasture and park extension as found appropriate. This area could perhaps provide a trade-off for developing the Nelugala Corridor (see TOPIC REPORT E.)

System B

As shown on Figure B-11, recommended land use for System B is built around a network of wildlife and forest conservation parks. The central branch is the Nelugala Corridor, which is shown extending to the south to the Forest Reserve and the Maduru Oya National Park, and may be only a temporary designation. This southern extension covers land of Class 6, although some of the existing corridor crosses prime agricultural lands.

Extending along both sides of the Maduru Oya is the recommended band of riverine forest. Along the Mahaweli Ganga floodplain, which is high quality wildlife habitat, is recommended that a Conservation Park which leaves existing development but prohibits further development be created.

Cropland and forest areas are shown throughout system. Unlike System A, System B contains large areas of Class 6 or non-arable land which can be used, not only for forests and woodlots, but also for settlements.

System C

The generalized land use recommendations for System C are shown in Figure B-12. Large portions of the southern half of System C are shown as cropland which includes a central spine of forest and/or settlement areas. The northern segment known as Zones 4,5, and 6 also has a large area of cropland with some localized areas slated for forest. The riverine forest in the western edge of System C is recommended for inclusion within the Wasgomua Reserve to the extent possible.

System D

Of all the Systems, System D has the least changes in land use. Figure B-13 shows areas allocated to cropland which is basically the same as shown in System D's Feasibility Report (JICA 1979). The Conservation Park within the floodplain is also shown as a recommended land use.

CONSIDERATIONS FOR INTEGRATED LAND USE PLANNING

Develop Soil Classification According to Soil Taxonomy and Soils Maps on a Standard Scale

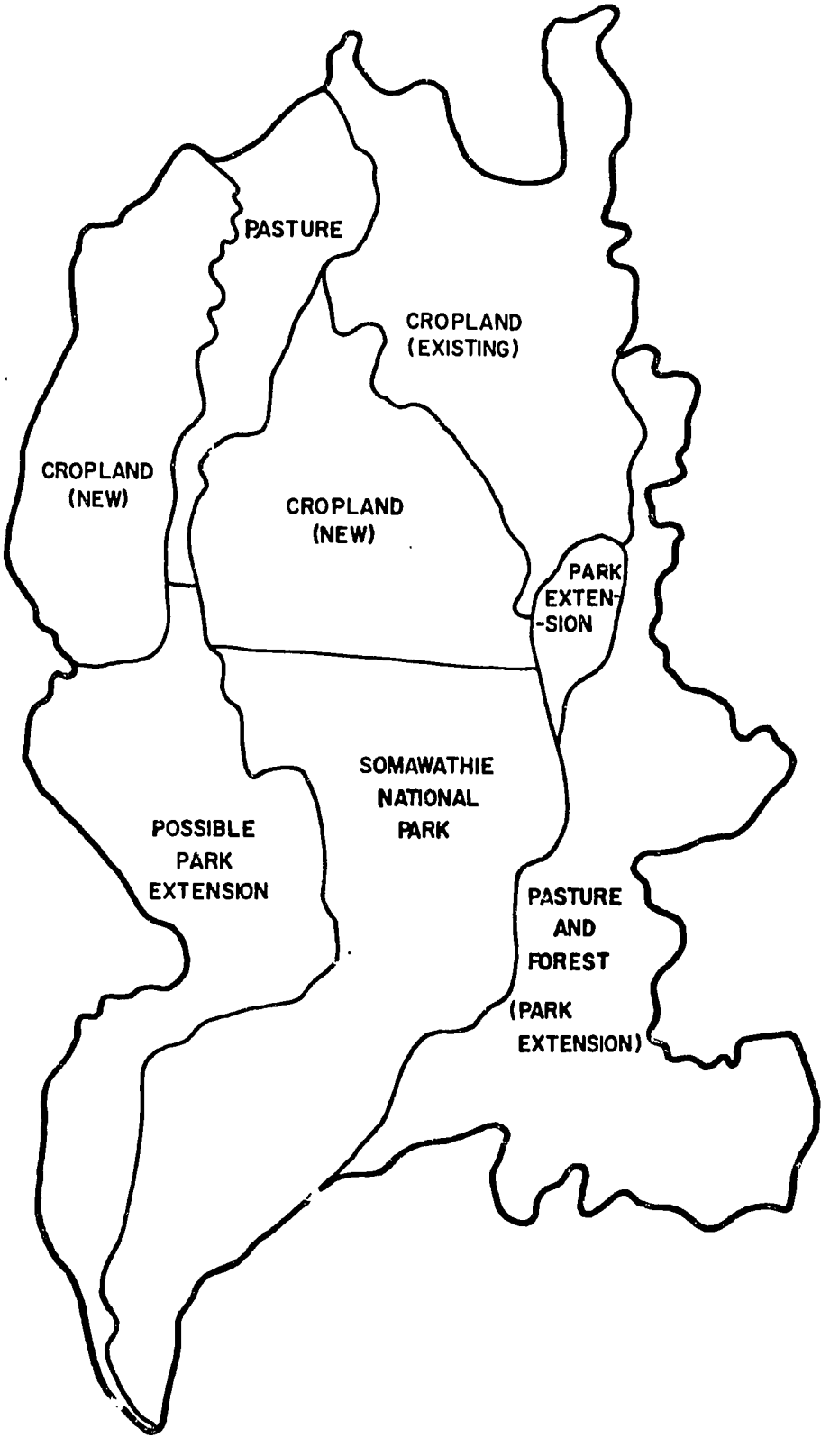
The Land Use Division, Irrigation Department, expressed the need of a more extensive and complete system of soil classification than has been available for use to date. This report recommends the adoption of the Soil Taxonomy of the United States Department of Agriculture, Soil Conservation Service which has recently received renewed emphasis and consideration. Through a series of discussions, correspondence and experience in Europe and other continents this system has developed into one that can be used world-wide. Its flexibility in classification of tropical soils in Sri Lanka presents a special challenge for attaining proficiency in the Soil Taxonomy Classification.

The Land Use Division anticipates a preliminary draft map of Soil Taxonomy at the Great Soil Group level about August 1, 1980. Assistance is being sought in the technical aspects necessary in correlating this system into the continuing classification of Sri Lankan soils for future field and laboratory work for their soil survey program.

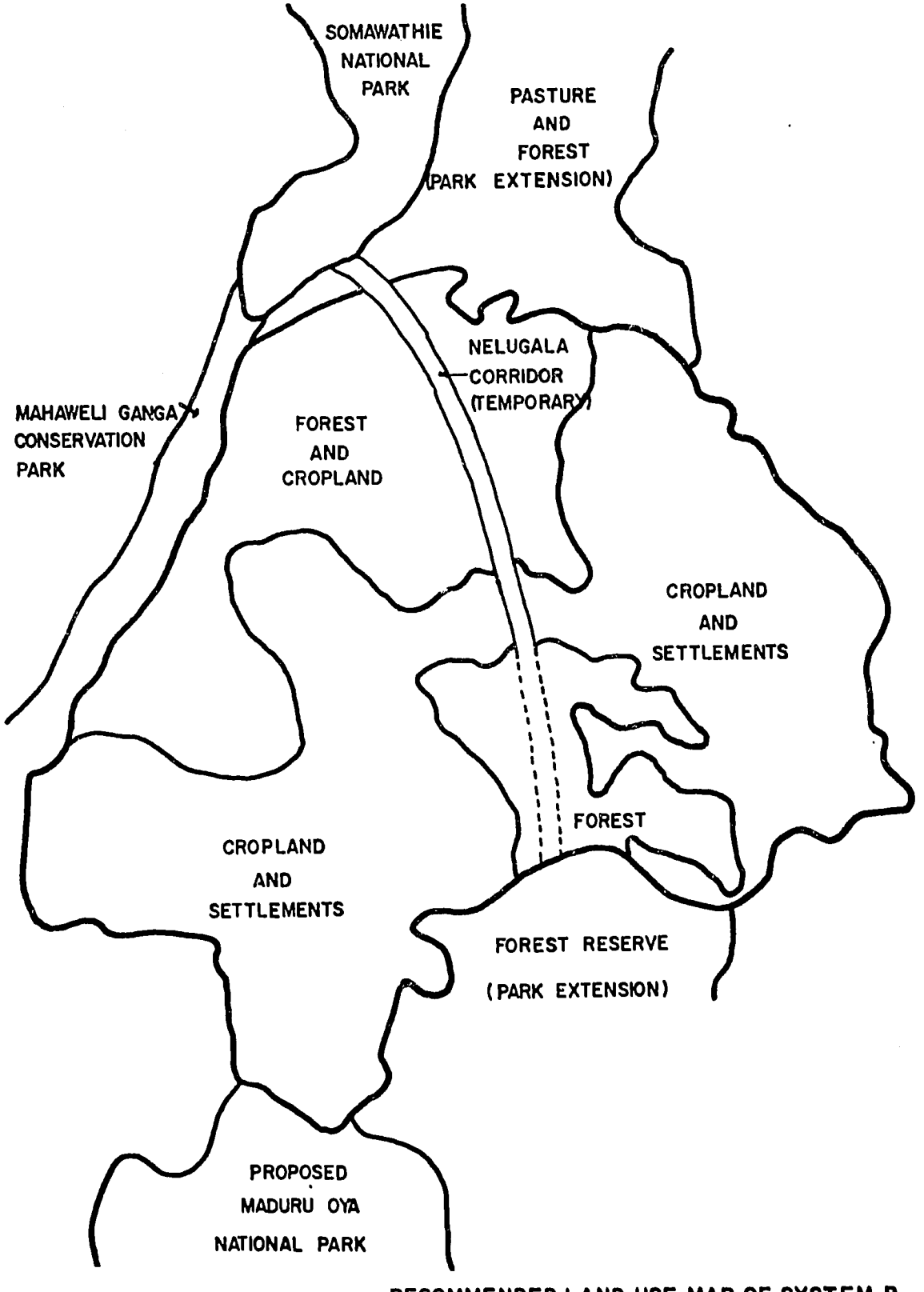
It is recommended that a standard mapping scale be developed so that all soils, topography and other maps can be used together without the cumbersome process of accounting for different map scales. For feasibility studies, a scale of 1:20,000 and/or 1:50,000 is suggested as being the most workable convenient scale. For final design, a different set of maps at a scale of 1:500 is more appropriate for designing paddy areas and settlements where areas of a fraction of a hectare are being considered.

Complete the Uniform Land Use Mapping for Areas Outside the Accelerated Mahaweli Development Program

In order to expand the basis for rational land use planning and for allocation of natural resources, it is recommended that the land use mapping started by TAMS be continued with priority placed on mapping areas which may be feasible for development. This project should be carried out by the Land Use Division and would require aerial photography at the 1:20,000 scale for appropriate areas. The mapping requires a person trained in interpretation of aerial photography and would require about two man-years of effort for every one million hectares. Land classification would require two to three man-years for every one million hectares depending on the level of detail (i.e. whether Class 6 areas were subdivided into finer classification as suggested below). All mapping should be at standard scales.



RECOMMENDED LAND USE MAP OF SYSTEM A
FIGURE B-10



RECOMMENDED LAND USE MAP OF SYSTEM B
FIGURE B-11

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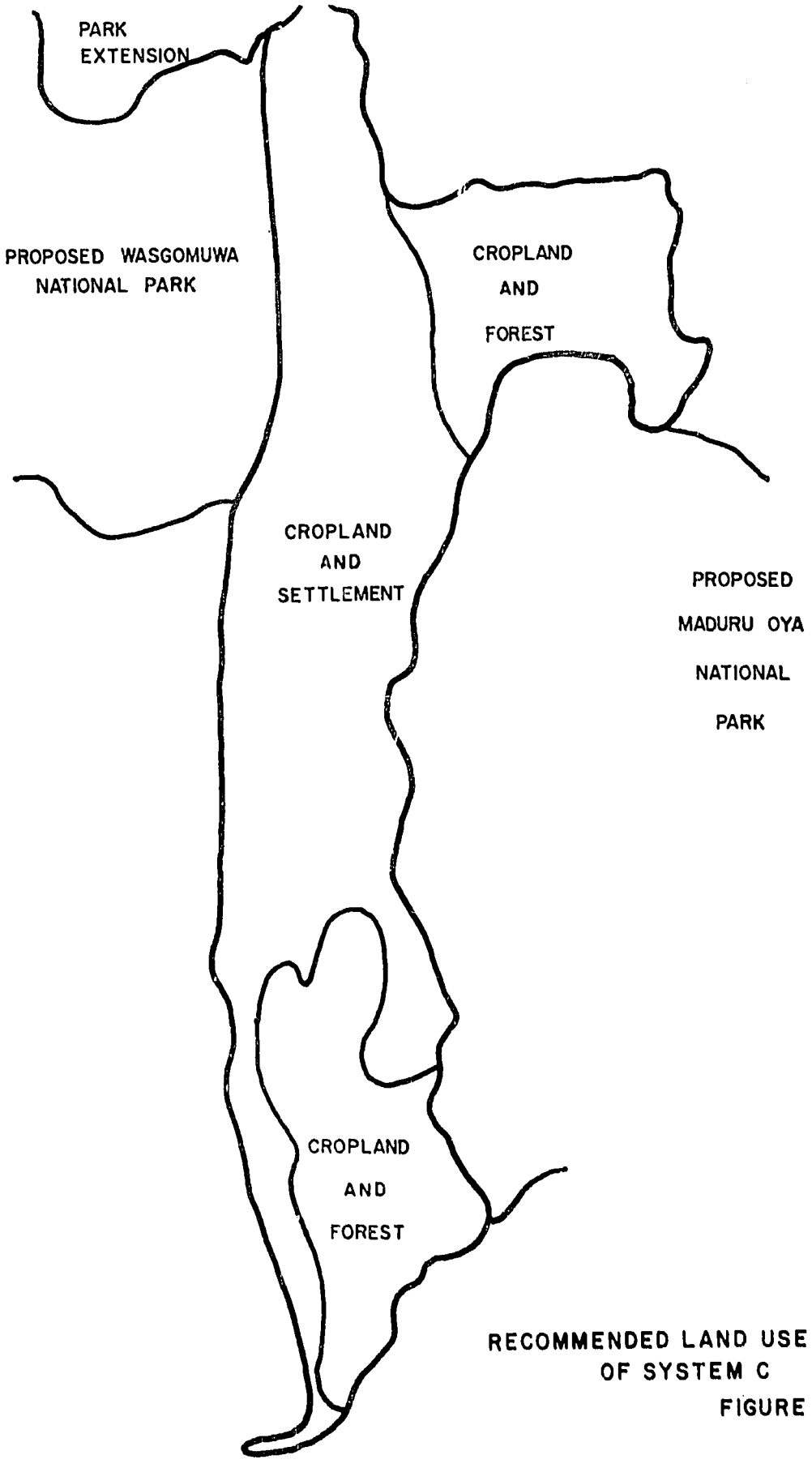
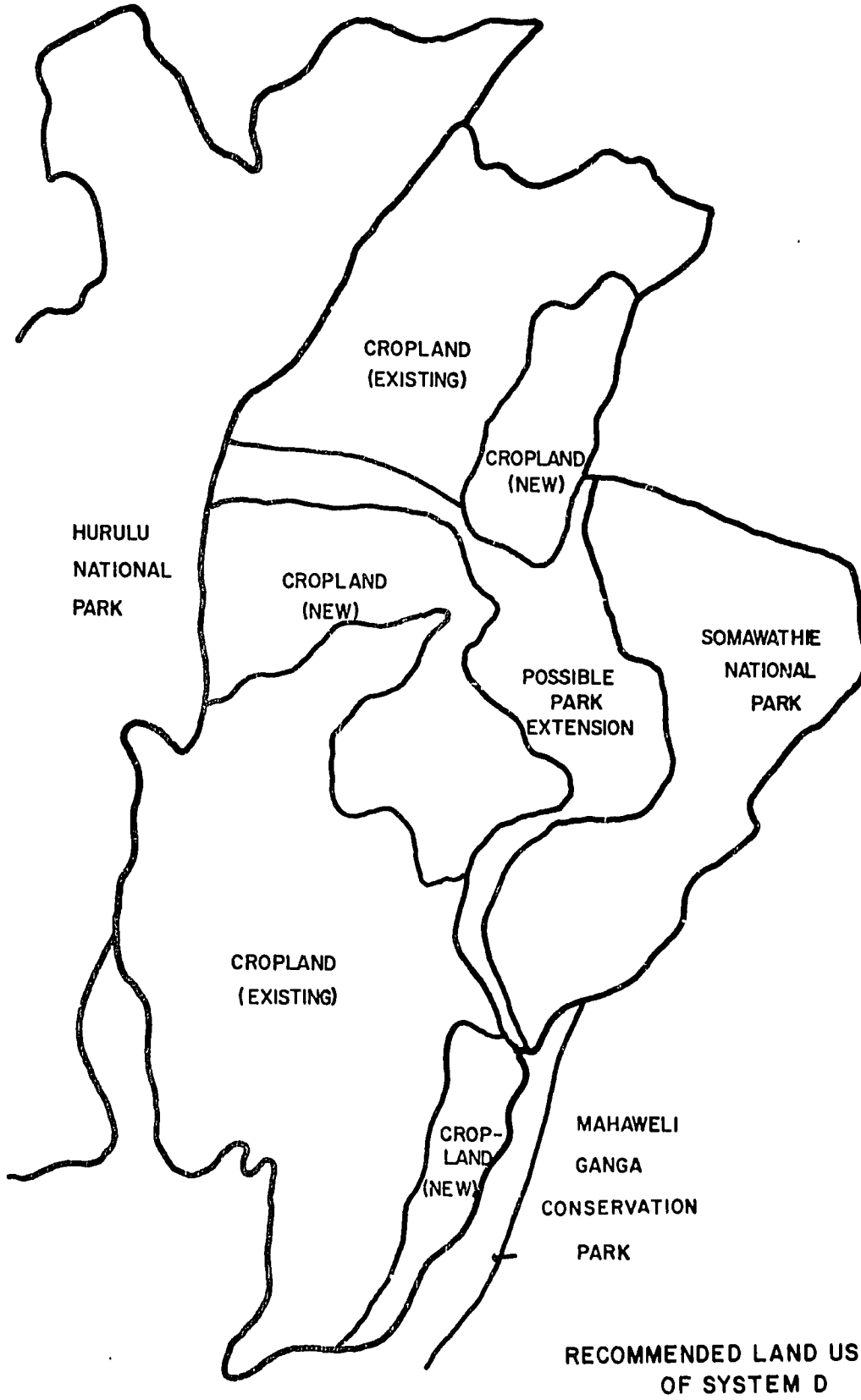


RECOMMENDED LAND USE MAP
OF SYSTEM C
FIGURE B-12

95



RECOMMENDED LAND USE MAP
OF SYSTEM D

FIGURE B-13

Complete Uniform Land Classification of Accelerated
Program Areas According to the U.S. Bureau of Reclamation System

It is recommended that use for irrigated agriculture follow the land classification standards recommended in this report in the preceding section of Land Classification, to fulfill the requirements for a detailed design stage soil survey and land classification. A standardized land classification should be formulated for universal use in any part of the country for evaluating irrigable lands. It would be advisable to use the land classification standards which the United States Bureau of Reclamation designed for use in Southeast Asia (USBR 1967), where paddy rice predominates as the predominant crop. In this modified system, there are two basic upland crop classes and two basic wetland rice classes used to distinguish arable lands according to their suitability for irrigated agriculture together with one class to identify non-arable or Class 6 lands.

The mapping symbols would need to be different and should take the form as recorded in the Land Classification Section of this report, with some minor changes. The basic land class mapping symbols would remain as shown in Appendix B-II but the land use code could be changed to:

- Homestead Garden (H)
- Settlement (V)
- Chillies (C)
- Paddy Rice (R)
- Tobacco (T)
- Groundnut (G)
- Soybean (S)
- Maize; Sorghum (M)
- Dhal grain crops, grams, cowpeas (D)
- Onions (O)
- Fiber Crop (F)
- Vegetables (V)
- Manioc (M)
- Woodlot Plantation (W)

The codes for relative productivity, relative land development cost, farm water requirement, land internal drainability and others should remain the same as shown in Appendix B-II.

The system of land classification and the standards and criteria should be agreed upon jointly by the Land Use Division, each consultant group involved and the MDB before future feasibility studies or design soil and land classification studies are begun in the field.

Carry Out Detailed Mapping and
Refined Classification of Class 6 Lands

In order to provide integrated planning of all lands for development as riceland and especially for forest, woodlots, pasture and settlements, it is necessary to have detailed mapping not only of ricelands but also of areas outside of command or land classified as Class 6. The Class 6 designation needs a further refinement. It is recommended that these lands be mapped in detail and given land use capability classifications

similar to that used by the Soil Conservation Service of the United States. This would be a great aid in formulating overall land use policy which provides guidelines for the noncultivable lands as well as the agricultural crop lands, or both irrigated and non-irrigated areas.

All out-of-command areas with soils not suited for cultivation within each irrigation system could be given land capability classifications according to the following guidelines:

Class V - Soils in Class V should be kept in permanent vegetation. They should be used for pasture or forestry; they have few or no permanent limitations and not more than slight hazards. Cultivation is not feasible, however, because of excessive wetness, stoniness, shallow soils, or other limitations. The land may be nearly level. It is subject to only slight erosion by wind or water, if properly managed. Grazing should be regulated to keep from destroying plant cover.

Class VI - Class VI soils should be used for pasture and forestry, and may have moderate hazards when in this use. They are subejct to moderate permanent limitations and are unsuited for cultivation. They are steep or shallow. Grazing should not be permitted to destroy plant cover. This land is capable of producing forage or woodland (forest or forest plantations), when properly managed. If plant cover is destroyed, the soils use should be restricted until plant cover is restored. Class VI land is steeper and is more subject to water erosion than Class V land.

Class VII - Soils in Class VII are subject to severe permanent limitations or hazards when used for grazing or forestry. They are steep, eroded, rough, shallow, droughty or swampy. They are fair to poor for grazing or forestry and must be managed with care. Where rainfall is high, Class VII land should be used for woodland or grazing. In either case, strict land management should be applied.

Class VIII - Soils in Class VIII are too rough for woodland or grazing. They should be used for wildlife refuges, recreation or maintained as an undisturbed watershed area. These would include the Erosional Remnants and the Rock Knob Plains areas (Stallings 1957).

Class 6 areas in the project area are presently measured in terms of extent, but subclasses are not shown on the Consultant's land classification maps, and even Class 6 lands are not labelled on the land classification maps. It is suggested that these designations be developed in the near future, when the design stage, detailed soil surveys and land classification are conducted on irrigable lands. A comparative land capability classification should be made on all adjoining, out of command areas in each of the Systems in order that these lands may be an integral part of the land use planning.

Recommended Considerations for Final Design

In addition to the standardized, detailed mapping recommended above, it is essential for successful design of the project that the following concerns be stressed in the final design of the proposed development areas.

There should be a follow-up of the drainage recommendations made by the U.S. Bureau of Reclamation Consultants who conducted an initial drainage investigation for System C. The final drainage designs to parallel the designed irrigation systems should be carefully revised and appraised before embarking on the construction of the downstream irrigation works of any of the System areas. For further discussion of drainage, refer to TOPIC REPORT A: CLIMATE AND HYDROLOGY.

Final design of bunds should carefully consider the types of soils and topography since the spacing and size of the bunds is a function of soil type and contours. Major bunds should be oriented along the contour while smaller bunds should be for water distribution only. Bunds constructed of erosion resistant LHE soils can be smaller than the normal design size but bunds of erodable soils such as RBE soils must be larger than usual. (see TOPIC REPORT A for further discussion of irrigation design considerations).

RECOMMENDATIONS FOR LAND AND WATER MANAGEMENT AND MONITORING PROGRAMS

Adopt Standard Procedure for Land Clearing

Before major clearing takes place the contractors should be given a standard set of procedures to follow when clearing to reduce loss of topsoil, nutrients and to minimize erosion after clearing. Certain conservation practices should be observed and incorporated in land clearing, rough leveling and preliminary cultivation operations to assure protective land use:

- Where bulldozers are used for forest clearance, windrows of tree trunks and brush should be formed along the contour;
- Scraping of topsoil should be minimized;
- Where ripping of heavy tree cover is necessary, a single pass should be made along the contour, and cross ripping should be done only to extricate large stumps;
- The use of heavy desk harrows is recommended for clearing light forest and regrowth. Trash mixed in with the topsoil forms an erosion resistant surface layer and helps to retain the nutrient level of the soil;
- The closure of gulleys should commence at the gulley head and proceed down slope; and
- Plowing and harrowing should be done in long runs along the contour.

Monitor Groundwater Levels in the Project Area

In order to provide efficient water management to protect soils from waterlogging it is recommended that a groundwater monitoring program be established (see TOPIC REPORT A for details).

Establish Soil Testing Program

The above program should parallel the monitoring program for water quality (see TOPIC REPORT F: WATER QUALITY). The critical parameters for soil monitoring will be salinity and exchangeable sodium percentage of lower river area soils and agricultural areas adjacent to Mahaweli Ganga and Maduru Oya channels affected by salt water intrusion. In areas where large amounts of pesticides are being used, drainage waters, soils and plant material will need to be monitored for level of contamination. Levels of deficiencies for the major nutrient elements, N, P, K, will need to be established for new agricultural lands for both upland crops and paddy.

Deficiency level samples should be taken on first priority of each System area existing producing land areas once per year starting next year and again when new lands begin to be brought into production and then twice a year, for both deficiency level samples and pesticide agricultrual products and soil contamination samples. Initially, there should be about 250 samples per System being developed, with this amount increased as required as the development progress increases.

Staff at the Land Use Soils Laboratory or the soils laboratory at Peradeniya could be increased by two initially and later to four soil chemists when more field samples were being obtained. This would coincide with additional soils laboratory work required for detailed design stage soil surveys in the Accelerated Program area that will be implemented shortly. A revised budget would be needed for the additional personnel plus additional chemicals, equipment and supplies required.

Encourage Erosion Control Practices

On upland areas, contour plantings should be initiated from the very beginning with properly spaced bunds to retain and distribute the runoff without causing erosion. Of the highest priorty, would be the stabilization of the Upper Watershed Areas of the Mahaweli Ganga and the Maduru Oya with the reforestation projects which are presently being implemented through the assistance of various donor agencies. During the land development phase of the Accelerated Program, and especially during the land clearing for irrigated agriculture, it would be recommended that consultant expertise be employed from sources that would furnish technical guidance to initiate soil conservation control measures right from the beginning. This would also provide an opportunity for training counterpart Sri Lankans in fundamentals of an effective Soil Conservation program and a more effective national organization.

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Institute Water Use and Management Recommendations

TAMS would endorse the full functional project presently being established by USAID for On Farm Water Management for System H. Techniques and results of this project in System H can be applied to the Systems of the Acclerated Program area as well, as an expanded program.

RECOMMENDED INSTITUTIONAL MEASURES

Expand Soil Conservation Service

The Soil Conservation Division of the Ministry of Agriculture has insufficient budget and equipment to accomplish any field soil conservation action programs in support of the reforestation programs being implemented. One soil conservation officer with a limited small office force at the Botanical Gardens, Perandeniya, Kandy is all that remains of the more than 60 who at one time had training in soil conservation.

It is recommended that a new cadre of trained personnel be established through a training program in soil conservation at the university level at Peradeniya which would be near to the eroded areas of the Upper Catchment. These personnel could implement coordinated programs that bring together reforestation and required soil conservation measures that will prevent further destructive erosion of the watershed, and repair the extensive areas already damaged from deforstation and erosion.

Establish a New Land Use Planning Division

FAO has been requested by the GSL to assist in the planning and the organizational structuring necessary in the establishment of a new Land Use Planning Division in the Ministry of Lands and Land Development. Included in the project planning should be improved and expanded cartographic and soil laboratory facilities which have been very much in need with the increased work load. All encouragement and assistance is recommended in the re-organizational structure of this unit.

Produce a Movie on "Conservation of Natural Resources in Sri Lanka"

The public in general is not aware of the waste in natural resources that is beginning to escalate in all sectors and all areas of the country. Before really effective government programs can be initiated to foster the conservation of natural resources a concerted effort must be made to inform the public. Some of the major critical issues that should help formulate public opinion to request government action toward conservation should be graphically portrayed on film. The "March for Conservation" activity recently sponsored in Colombo and to be implemented at Polonnaruwa is a good beginning toward educating the public for support.

The film could cover all aspects of conservation in Sri Lanka which would include: wildlife; endemic species of flora and fauna; forests; soils; water resources; historic and religious sites; coastal coral resources; fisheries; and mineral and gem resources.

This film could be produced into at least a 30 minute feature film for viewing in theatres throughout the island with the provision to produce 10 or more 16 millimeter prints for use in extension education with Tamil and Sinhalese subtitles and commentary. The script would need to be prepared from a committee chosen from people working closely in the natural resource categories mentioned above and from university, public or private sectors. The actual filming of this production could be coordinated by a cooperative arrangement between the State Film Corporation and the Photography Section of Ministry of Agriculture Information Division. A previous 15 minute B.W film on Soil Conservation has been completed, and a new 15 minute B/W film on "Water Management" has recently been completed and is soon to be previewed.

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APPENDIX B-1

CLASSIFICATION OF SOILS

BACKGROUND OF CLASSIFICATION METHODS

Mapping and classification of Sri Lankan soils is one of the basic prerequisites to formulating a national land use plan. These fundamental studies which have taken place during the last two decades are indispensible to the understanding and efficient management and use of the lands which are to come under irrigation development as well as adjoining non-arable lands within the Accelerated Mahaweli Development Project and for the improved land use management of the Upper Catchment areas of the Mahaweli Ganga.

The first systematic studies of the soil of Sri Lanka were those of Dr. A. W. Joachim and his colleagues during the period from 1935-1945. Considering the state of the development of soil science in the tropics of that period, Dr. Joachim's work was a significant contribution to the knowledge of Sri Lankan soils. However, there has been a vast improvement in recent years in the use of soil and land classification as well as land capability classifications to plan for better land use in tropical areas of the world. Application of these guiding principles for developing the Accelerated Program needs to be carefully considered, by using soil maps and data from soil surveys to supply the land resource technical information required.

The soil survey of the fifteen river basins covering an extent of almost two million hectares (7,500 square miles) which was carried out by the Canada-Colombo Plan Resources Survey in collaboration with the Land Use Division was the beginning of modern organized and systematic surveys of Sri Lankan soils. The important end product that resulted from these surveys was the joint publication of the "Soils of Ceylon" in the January-March 1961 issue of the Tropical Agriculturist (Moorman and Panabokke 1961). This was a new approach to the identification and classification of the most important soil groups of Sri Lanka. This study was based on the morphological characteristics of the soil classification, in which the inherent morphological characteristics of the soil units were identified and studied in the field, while their chemical and some physical properties were determined in the laboratory. The Great Soil Groups of Sri Lanka which are found in both the Accelerated Program area and the Upper Catchment zone of the Mahaweli Ganga are well described in this publication.

Of greatest value to the future soil studies in Sri Lanka was the reconnaissance soils map compiled and published in January 1967 by the Soil Survey Staff of the Land Use Division of the Irrigation Department, using information derived from soil surveys conducted under the "National Soil Survey" programme. The entire dry zone and intermediate zone, respectively, have been covered by systematic soil surveys; and this also includes the earlier soil survey data of a northwestern portion of the island which was carried out by the Hunting Survey Corporation in collaboration with the Land Use Division. The wet zone has been studied and surveyed at a more generalized level and the soil boundaries of this region do not have the same degree of accuracy as the rest of the island.

The soils of Systems A, B, C and A/D of the Mahaweli Development Program were previously studied and mapped at low intensity by the Land Use Division and a soil consultant of the UNDP in 1968 (FAO-Irrigation Department 1968). The mapping was carried out by means of airphoto interpreation of 1:40,000 air photographs combined with field checking on accessible roads, foot paths and cleared traverses.

In late 1977, the available soil data was combined with additional field studies and reinterpreted by the Land Use Division to demarcate and characterize the main soil series occurring in Systems A, B, C and A/D. A series of maps showing the distribution of these series and association of series of these systems were also assembled on 1 inch = 0.5 mile toposheets of the area and then reduced to a scale of 1 inch = 2 miles.

The main soil units in these areas consisted of soil series and associations of these soil series (see Table B-3). In order to give a more basic approach to the gneiss and morphological aspects of soils, importance was given to the geomorphology of the soils as shown in Figures B-14 through B-20 which were taken from the Land Use Irrigation Department's Report of 1978 (July 1978 revised). In addition, two landform units with low arable cropping potential were also identified and recommendations made based on experience for the range of crops that can be successfully grown during Maha and Yala monsoon seasons. Records on crop production in dry zone experimental stations and on farms was also given, as well as agronomic and irrigation practices recommended for each of these soil units to achieve sustained productivity.

Concurrently, a publication of the International Rice Research Institute showed the relationship between the rice soils of Sri Lanka and classifications for Soil Taxonomy (Panabokke 1978). Table B-12 presents the equivalency. However, when the need arose to rapidly classify soils for the Accelerated Mahaweli Development Program, there was not sufficient time to organize the soil classifications on the basis of the system defined in Soil Taxonomy. The soil classification proceeded on the basis of work carried out in cooperation with FAO. Therefore, a program of detailed soils mapping was begun by the Land Use Division in early 1979. It was necessary that the land classification for potential irrigation development would require soil maps of sufficient detail to separate the Great Soil Groups into soil series, depth and drainage phases combined with accurate topographic mapping. These soil maps combined with the 1:31,680 or 1:50,000 topographic map prepared by the Survey Department provided the basis for the land classifications maps developed for these feasibility studies in all Systems of the Accelerated Program area.

Details of the soil surveys and land classifications of the various project area schemes which follow in this Appendix have important implications in the irrigation development of the arable lands and the associated upland non-arable land areas for use as forest land, woodlots, wildlife reserves, recreational or settlement areas.

Table B-12

Correlation of the Principal Rice-Growing Great Soil Groups of Sri Lanka* With The Equivalent Great Groups of Soils Taxonomy (USDA 1975)

Order	Suborder	Great Group	Rice-growing great soil groups of Sri Lanka*	Location
Alfisols	Aqualfs	Tropaqualfs	Low Humic Gley Soils	(DZ)
	Ustalfs	Rhodustalfs	Reddish Brown Earth	(DZ)
		Haplustalfs	Noncalcic Brown Soils	(DZ)
Ultisols	Aquults	Plinthaquults	Low Humic Gley Soils of low base status	(DZ)
Entisols	Fluvents	Tropaquents	Alluvial Soils	(DZ)
		Udifluvents	Alluvial Soils	(DZ and IZ)
		Tropofluvents	Alluvial Soils	(WZ and DZ)
		Ustifluvents	Alluvial Soils	(DZ)
Inceptisols	Aquepts	Tropaquepts	Alluvial Soils	(DZ,IZ and WZ)
			Half Bog Soils	(WZ)
	Tropepts	Dystropepts	Immature Brown Loams	(WZ)
Vertisols	Usterts	Pellusterts	Grumusols	(DZ)
Aridisols	Orthids	Solorthids	Solonchaks	(DZ)
Mollisols	Rendolis	Rendolis	Rendzina	(DZ and IZ)

DZ = Dry Zone, IZ = Intermediate Zone, WZ = Wet Zone.
* With emphasis on the Dry Zone

SOURCE: Panabokke, (1978).

GREAT SOIL GROUPS OF THE FAO SURVEY

In the UNDP/FAO Report of 1969, the reconnaissance soil survey identified 15 Great Soil Groups within Sri Lanka. In the Accelerated Program area six great soil groups occur:

- the Reddish Brown Earth (RBE) generally situated in the highly lying, upper parts of the catchment basins (uplands) and extending towards the bottoms of the valleys;
- the Non-Calcic Brown (NCB) also associated with uplands but developed from a different substratum;
- the Low Humic Gley (LHG) found in the valley bottoms;
- the Recent Alluvial (RAL) found in narrow stretches on the floodplain of the Mahaweli Ganga and the Maduru Oya; and
- the Solidized-Solonetz (SS) found in association with the OAL snd LHG soils, in Systems A and B.

Thirty-five major and minor soil series have been established in the project area to date and are representative within these six Great Soil Groups. Table B-13 summarizes the occurrence and distribution of these series that have been established, but not entirely correlated for the Systems A, B and C. In this Appendix, the major series which are common in the Accelerated Area are briefly described.

Field observations of the following soil physical properties which are required for good irrigation land classification were carried out in the field by LUD soils personnel in all System areas where applicable:

- Slope designations were not made in the soil survey. Topographic maps developed by the Survey Department were used in establishing and identifying USBR land classes by consultant personnel;
- Drainage classes were established as follows:

  WD - Well drained-no gleying or mottling in profile
  MWD - Moderately well drained-no gleying, but mottling at depth of 75 cm.
  ID - Imperfectly drained-gleying at 125 cm and mottling at 75 cm or gleying at 75-125 cm.
  PD - Poorly drained-gleying 20-75 cm
  VPD - Very poorly drained gleying, 0-20 cm;
- Notes were made of areas where flood hazard is of short or long duration during Maha;

Soil permeability classes were established for each series by field testing with double ring permeameters according to the following standard determinations; for both surface and subsurface.

R - rapid 15 cm/hr.
MR - Moderately rapid, 1.5-5 cm/hr.
M - moderate, 1.5-5 cm/hr.
S - slow, 0.15-0.5 cm/hr.
VS - very slow, 0.15 cm/hr

Texture was observed for both surface and sub soil;

- Notation was made of relative percentage of surface rock for each mapped area where this problem was evident;

- Depth to bedrock was noted in centimeters according to the following standards:

  S - shallow 60 centimeters
  MS - moderately shallow 30-90 centimeters
  MD - moderately deep 90-120 centimeters
  D - deep - 120 centimeters;

- Available water holding capacity and bulk density for each soil series was determined on soil samples taken in the field by use of pressure plate and bulk density measurements in the laboratory;

- Soil color was observed and recorded by use of Munsell Color Charts; and

- The physiographic sub-unit of the landscape was noted for each of the soil series.

Soil Samples were taken during the soil survey for analysis in the laboratory from samples taken in the various survey areas and the following analyses made in the LUD Soils Laboratory:

pH - 1:1 soil: water ration using pH meter

Electrical Conductivity - 1:5 soil: water ration using EC bridge and expressed in micromhos/cm

Cation Exchange Capacity - Saturation of soil with Sodium Acetate (pH 8.2) followed by saturation with Ammonium Acetate at pH 7.0 and then determining in leachate.

Exchange Cations - Leaching with N. Ammonium Acetate at pH 7 and then determining the cations in the leachate. Na and K by flame photometer. Ca and Mg by Atomic Absorption Spectrophotometer.

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Organic Carbon (C) - Walkley and Black's method of oxidation of organic C using Potassium Dichromate and Sulphuric Acid.

Particle size distribution - Wet sieving of the soil followed by pipette sampling for clay and silt.

Overall supervison of the field work was by Soil Scientist Dr. Kingsley A. De Alwis, Head of the Land Use Division who was assisted in various supervisory capacities by Soil Scientists W.D.Joshua, N.S.Jayawarden, S. Somasiri, and others.

SOIL CLASSIFICATIONS FOR ACCELERATED PROGRAM AREA

Tables B-14 - B-16 document the soil series found in Systems A, B and C, respectively. For each series these Tables provide general description, indication of land form and summary information concerning highest land class, suitability for irrigation and limitations or required improvements. Figure B-21 shows the catenary sequence of soils in the typical valley area of System C. Since only a reconnaissance level soil survey was undertaken for System D, a summary table showing the soils in System D is contained in the main body of this report (Table B-4).

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Table B-13

The Occurrence and Distribution of Soil Series by LUD in Systems A, B and C

	Soil Series*	Systems		
		A	B	C
1.	Aluthnuwara	x	x	x
2.	AlawaKumbura	x	x	-
3.	Arasanagar	x	x	x
4.	Beliannevala	-	x	-
5.	Boatte Wewa	x	x	-
6.	Bulatiebb	-	x	-
7.	Dehiyatakandiya	x	-	-
8.	Galwewa	x	x	-
9.	Horaborawewa	x	x	x
10.	Handapanwila	x	x	x
11.	Hembarawa	x	x	x
12.	Hewampitiyavillu	x	x	x
13.	Kekuluwela	-	x	-
14.	Kumarapuragama	-	x	x
15.	Kuda Oya	x	x	-
16.	Kangaswela	x	x	-
17.	Kalinga Ela	x	x	-
18.	Katuwanwila	x	x	-
19.	Mawa Kulam	-	x	x
20.	Mailadeniya	-	x	-
21.	Moogamana Ela	x	x	x
22.	Maduru	x	x	-

Table B-13
(cont'd)

	Soil Series*	Systems		
		A	B	C
23.	Manampitiya	x	x	x
24.	Muthugalla	x	x	-
25.	Odigar	-	x	-
26.	Panichchankerni	x	-	-
27.	Pochchakadu	-	x	-
28.	Padumundam Kulam	-	x	x
29.	Perillaveli	-	x	-
30.	Timbiri Aru	-	x	x
31.	Ulhitiya	x	x	x
32.	Ulpothawewa	x	x	x
33.	Vakeneri	x	x	-
34.	Wilayaya	x	x	x
35.	Welikanda	x	x	-

* With future LUD Soil Series Correlation, with properties and variations considered allowable within each series, quite a number of these may be eliminated or absorbed into other series.

Table B-14

Brief Soil Descriptions With Land Classes For Irrigation Development For System A

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wet-land	
A	Aluthnuwara	1U	Moderately well drained, dark brown and reddish brown sandy clay loam, imperfectly drained sandy clay loams have been included for this survey	Levee in	high	high	marg.	Good internal drainage renders this soil less suitable for wetland rice, flood control required
A st	Aluthnuwara	2R(2F)	As above, with a sandy sub-soil within 1 metre from the surface	Levee in Recent Alluvial plain	high	high	un-suit	Sandy subsoil renders this soil unsuitable for wetland rice; flood control required
Aa	Alawakumbura	2R	Imperfectly drained, brown yellowish brown, mottled sandy clay loam containing manganese nodules; commonly overlying weathering rock at ± 120 cm	Middle and lower slopes of Gently Undulating Plain	marg.	mod.	marg.	Periodically too wet for most upland and crops; drainage required; somewhat too permeable for wetland rice
Aa 2	Alawakumbura (Sloping)	2R	As above with slopes of 1.5 to 3%	As above	marg.	mod.	marg.	As above.
Ar	Arasangar	6	Imperfectly to poorly drained, pale brown coarse sand, abruptly overlying grey to brown mottled sandy clay loam at 70 to 120 cm depth	Old Alluvial Terrace	unsuit.	unsuit.	unsuit	Collapsing sands with very low fertility and moisture retention capacity, water drains away very rapidly over the subsoil to depressed sites

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Table B-14
(continued)

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wetland	
Bo	Boatte Wewa	2R	Imperfectly drained, greyish brown to yellowish brown, mottled light sandy clay loam and sandy loam	Gently Undulating Plain	marg.	mod.	marg.	Periodically too wet for most upland crops;drainage required;somewhat too permeable for wetland rice
D	Dehiyatukandiya	6	Shallow sandy clay loam to clay loam overlying calcareous weathering rock	Gently Undulating Plain	unsuit.	unsuit.	unsuit.	Too shallow for irrigation
G	Galwewa	6	Imperfectly drained, brown to yellowish brown, mottled coarse sand and loamy coarse sand; commonly overlying weathering rock at ± 100	Gently Undulating Plain	unsuit.	unsuit.	unsuit.	Very low fertility and moisture retention capacity; very high infiltration rate; only small scattered areas occur in places above command of canal
G2	Galwewa	6	As above with slopes of 1.5 to 3%	Gently Undulating	unsuit.	unsuit.	unsuit.	As above
H	Horaborawea	2R	Imperfectly drained, dark greyish brown to yellowish brown, mottled sandy clay loam with quartz gravel (dominant),feldspar and mica in subsoil	Middle and lower slopes of Gently Undulating Plain	marg.	mod.	marg.	Periodically too wet for most upland crops;drainage required; somewhat too permeable for wetland rice

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Table B-14
(continued)

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wetland	
Ha	Handapanwila	1R	Imperfectly drained, dark colored, mottled, dense clay	Recent Alluvial Plain, low lying areas above the basins	unsuit.	mod.to	high	Denser than Hembarawa (Hm) Series and consequently well suited to wetland rice but too slowly permeable for most upland crops; only surface drainage feasible flood control required
Hm	Hembarawa	1R	Imperfectly drained, dark colored, mottled clay loams	Recent Alluvial Plain; adjacent to the levees	marg.	mod.	high	Physically more favorable than the very dense Handapanwila (Ha) Series more permeable; somewhat too wet for most upland crops; surface drainage required, flood control required
Hm st	Hembarawa (Stratified)	1R	As above, with a lighter textured, sometimes sandy subsoil within 1 metre from the surface	As above	marg.	mod.	high	Similar to Hembarawa series above, but this soil will also benefit from subsurface drainage and then become more suitable for upland crops

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Table B-14
(continued)

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wetland	
Hw	Hewampitiya villu	2R(2F)	Poorly drained, dark greyish brown to grey, mottled clay and clay loam	Recent Alluvial Plain	unsuit.	unsuit.	mod.	Too wet for upland crops; only suitable for rice but requires extra protection from flooding by run-off from surrounding ground
[illegible]	Kuda Oya	1R	Poorly drained, dark greyish brown to grey mottled sandy clay loam	Valley Bottoms	unsuit.	unsuit.	high	Only suitable for wetland rice due to wetness; some drainage required to prevent build-up of salinity
Ka	Kanngaswela	1R	Poorly drained, dark greyish brown to grey mottled clay	Valley Bottoms	unsuit.	unsuit.	high	Only suitable for wetland rice due to wetness; some drainage required to prevent build-up of salinity
Ka	Kalinga Ela	2U	Well drained, brown to yellowish brown sands to sandy loams; sometimes stratified	Levee in Recent Alluvial Plain	mod.	mod.	unsuit.	Water retention capacity somewhat low for most upland crops; too permeable for wetland
Kt	Katuwanwila	2R(2F)	Very poorly drained, grey clay and clay loam	Recent Alluvial	unsuit.	unsuit.	mod.	Too wet for upland crops; only suitable for rice but requires extra protection from flooding by run- off from surrounding ground; extra drainage required.

Table B 14
(continued)

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wetland	
M	Moogamana Ela	1R	Poorly drained, dark greyish brown to grey, mottled sandy clay loam to sandy clay; may have a sandy topsoil of less than 30 cm depth	Valley Bottoms and areas on Old Alluvial Terrace	unsuit.	unsuit.	high.	Only suitable for wetland rice due to wetness; some drainage required to prevent build-up of salinity
M imp	Moogama Ela(imper-	2R	Imperfectly drained,dark colored,mottled sandy clay loam;may have a thin sandy topsoil	Valley Bottoms and low areas on Old Alluvial Terrace	marg.	mod.	mod.	Periodically too wet for most upland crops; drainage required
Ma	Maduru	6	Moderately well drained, brown coarse sand and loamy coarse sand; commonly overlying weathering rock at ≥ 100 cm	Gently Undulating Plain	unsuit.	unsuit.	unsuit.	Very low fertility and moisture retention capacity very high infiltration rate; only small scattered areas
Mn	Manampitiya	2U	Well drained, dark reddish brown sandy clay loam with feldspar (dominant) and quartz gravel; weathering rock at ± 100 cm		high	high	mod.	Too permeable for wetland rice
Mn 2	Manampitiya (sloping)	2U	As above with slopes of 1.5 to 3%	Upper	mod.	mod.	marg.	Too permeable for wetland rice; in places above command of canal; fairly uneven topography

Table B-14
(continued)

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wetland	
Mu2	Muthugalla (sloping)	1U	Well to moderately well drained, brown to reddish brown sandy clay loam with slopes of more than 1.5%	Gently Undulating Plain	marg.	marg.	marg.	Too permeable for wetland rice; in places above command of canal; fairly uneven topography with many stony patches
Pk	Panichchan-kerni	6	Poorly drained, grey, mottled, saline sandy clay loam	Fringing Lagoons	unsuit.	unsuit.	marg.	Too saline for most crops
U	Ulhitiya	1U	Well drained, dark reddish brown sandy clay loam with a gravelly subsoil containing quartz gravel (dominant) and feldspar; weathering rock at ± 100 cm	Upper slopes of Gently Undulating Plain	high	high	marg.	Too permeable for wetland rice
U2	Ulhitiya (sloping)	2U	As above with slopes of 1.5 to 3%	Upper slopes of Gently Undulating Plain	mod.	mod.	marg.	Too permeable for wetland rice; in places above command of canal; fairly uneven topography
Up	Ulpothawewa	2R	Imperfectly drained brown to pale coloured coarse sand to loamy coarse sand, abruptly overlying grey or brown, mottled sandy loam to sandy clay loam at 20 to 50 cm depth; in places this soil is poorly drained; in places the subsoil is sodic and/or saline	Old Alluvial Terrace	marg.	marg.	mod. to marg.	The sandy topsoil has a low fertility; the slowly permeable subsoil is unfavourable for most upland crops; due to high sodium content in places, the subsoil can become harder and more dense under irrigation; fairly high lateral water loss will occur under wet land rice

Table B-14
(continued)

Map Symbol	Soil Series	Highest Land Class	General Description	Land Form	Suitability for Irrigation			Limitations and Required Improvements
					Upland	Intermed.	Wetland	
V	Vakaneri	6	Poorly drained, brown to pale brown, coarse sand to loamy coarse sand, abruptly overlying grey or brown mottled sandy clay loam at 15 to 30 cm depth; the subsoil is sodic and has a columnar structure and albic capping	Nearly Level Plain	unsuit.	unsuit.	marg.	The subsoil is too slowly permeable for upland crops; marginal for rice to the sandy topsoil and sodic subsoil
W	Wilayaya	1U	Moderately well drained, dark brown sandy clam loam containing many manganese nodules; weathering rock at ± 100 cm	Upper slopes of Gently Undulating Plain	high	high	marg.	Too permeable for wetland rice
W	Wilayaya (sloping)	2U	As above with slopes of 1.5 to 3%	Upper slopes of Gently Undulating Plain	mod.	mod.	marg.	Too permeable for wetland rice; in places above command of canal; fairly uneven topography
We	Welikande	1U	Moderately well drained, greyish brown to yellowish brown light sandy clay loam; weathering rock at ± 100 cm	Upper slopes of Gently Undulating Plain	high	high	marg.	Too permeable for wetland rice
We2	Welikande (sloping)	2U	As above with slopes of 1.5 to 3%	Upper slopes of Gently Undulating Plain	mod.	mod.	marg.	Too permeable for wetland rice; in places above command of canal; fairly uneven topography

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Table B-14
(continued)

	Highest Land Class	Accessary Symbols and Miscellaneous Land Units	
md	3	Moderately deep; weathering rock at 90 to 120 cm or gravel at 60 to 90 cm	
RKp	6	Rock knob plain I :	25 to 50% of the surface covered by rock
505	6	Rock knob plain II :	more than 50% of the surface covered by rock
ER	6	Steep land	more than 50% of the surface covered by rock

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Table D-15

Summary of Major Soil Series, Properties and Land Classes for System B

Great Group Soil Series	Soil Mapping Unit/Phase	Textures Surface	Textures Sub-Soil	Depth to Bedrock	Drainage Class	Hydraulic Conductivity Surface	Hydraulic Conductivity Subsoil	Available Water Holding Capacity	Sali-nity	Alka-linity	Cation Exchange Capacity	Extent of Soil	Physiographic Sub Unit	Land Classificat-ion USBR (Adapted)
				cm.					EC-mmhos	ESP				
RBE (Upland)														
Wilayaya	W	SL/SCL	SCL/DPM	> 120	MWD	M-FR	S	Mod	< 1	< 5	8.9/85.10	Moderate	Convex Slope	1U (2Us)
Muthugala	Mu/d	Gr	SCL/DPM	> 120	MWD	M	M	Mod	-	-	-	Minor	Convex Slope	1U
Manampitiya	Mn/d	SCL	gr.SCL/DPM	> 120	WD	M-FR	M	Mod	< 1	< 5	10-12/11-12	Moderate	Crest Convex Slope	1U
Ulhitiya	U/md	SCL	gr.SCL/DPM	90-120	WD	M	M	Mod	< 1	< 5	- -	Major	Crest Convex Slope	1U
RBE (Lowland)														
AlawaKumbura	Aa/md	SL-SCL	SCL/DPM	90-120	ID	M	M	Mod	< 1	< 5	8-10/13	Moderate	Lower Concave Slope	1R
MawaKulam	Mw/md	SL-SCL	SCL-CL	90-120	ID	M	MS	Mod	-	-	-	V. Minor	Lower Concave Slope	1R
PadummdaKulam	Pa/d	SCL	gr.SCL/DPM	> 120	ID	M	M	Mod	< 1	< 5	6-17/8-17	Minor	Lower Concave Slope	1R
Horabarawewa	H/d	SCL	gr.SCL/DPM	> 120	ID	M	M	Mod	< 1	< 5	25/19	Minor	Lower Concave Slope	1R
NCB (Upland)														
Maduru	Md/md	S-SL	S-SL/DPM	90-120	MWD	FR-R	R-MR	V.Low	< 1	< 5	3.5/4.5	Moderate	Crest Convex Slope	6S (Upland)
Welikanda	We/md	SCL	SCL/DPM	90-120	MWD	M	M	Low-Mod	< 1	< 5	3.5/7.5	Major	Crest Convex Slope	2U
NCB (Lowland)														
Galwewa	G/md	LS/SL	S/DPM	90-120	ID	FR	FR	V.Low	< 1	<10	1.5/0.5	Major	Lower Concave Slope	6S (Lowland)
Boattewewa	Bo/md	SCL	SCL/DPM	90-120	ID	M	M	L-Mod	-	-	-	Major	Lower Concave Slope	2R

Table R-15
(Continued)

Great Group Soil Series	Soil/Mapping Unit/Phase	Textures Surface	Textures Sub-soil	Depth to Bedrock cm.	Drainage Class	Hydraulic Conductivity Surface	Hydraulic Conductivity Subsoil	Available Water Holding Capacity	Sali-nity EC-mmhos	Alka-linity ESP	Cation Exchange Capacity	Extent of Soil	Physiographic Sub Unit	Land Classificat-ion USBR (Adapted)
RAL (Maduru Oya)														
Bulatiebbe	B/b	LS-SL	SL	> 120	MWD	FR	FR	Low-Med	< 1	< 5	4.5-5.5/8.0	V.Minor	Levee	2U
Timbiri Aru	T	CL	SCL	> 120	ID	MS	M	Mod-Hi	< 1	< 5	18/17	Moderate	Back Slope	1R
Odigar Villu	O	SICL-CL	CL	> 120	ID	S	S	High	-	-	-	V.Minor	Basin	1R
Bellanewala	Be	LS-SL	LS-SL	> 120	PD	FR	FR	Low	< 1	10/25-40	4.5/4.7	V.Minor	Fan	1R (2Rs)
QAL_4														
Ulpothawewa	Up	LS-S	SC	> 90	PD	M	S	Mod	< 1	<10	4.0-7-8 8.5	Major	Almost dry Elev. Area	2RS
Moogamana Ela	M	SL-SC	SC	> 90	PD	M-MS	-	High	1-1-4	10-30	10-14/10-11	Moderate	Depression	1R
Kumurapuragama	Ku	S	S	> 120	MWD	R	-	V.Low	-	-	-	V.Minor	Almost dry Elev. Area	6 (6Rs)
Arasanagar	Ar	S-IS	S	> 90	ID	R	-	V.Low	-	< 5	4.5/3.0	Moderate	Depression	6 (6Rs)
Solodized Solonetz														
PochchaKadu	P	S	SCL	> 90	ID	M	S	Low-Mod	< 1/1	25/35	5.0/3.0	V.Minor	Micro-Mound	2Rs
Valneri	V	S	SCL-SC	> 90	PD	FR	S	Low-Mod	-	-	-	V.Minor	Flat	2Rs (6Rs)
LHG														
Mailadeniya	Ma	S-LS	S-LS/DPM	> 120	PD	MR	MR	Low	< 1	< 5	3.5/4.5	V.Minor	Gently Sloping	2Rs
Kuda Oya	K	SL-SCL	SCL	> 120	PD	MS	MS	Mod	-	-	-	Moderate	Gently Sloping	1R
Duminnewela	D	SL-SCL	SCL-SC	> 120	PD	M	S	Mod-Hi	-	-	-	V.Minor	Gently Sloping	1R

Table B-16

Brief Soil Descriptions with Series and Land Classes for Irrigation Development

For Systems B and C

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS B	HIGHEST LAND CLASS C	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASE
A. VALLEY OF THE MAHAWELI	1U	-	Levee	Ke KALINGA ELA SERIES Well drained, deep, yellowish red. fine sandy loams
	1U	1U		A ALUTNUWARA SERIES Well to moderately well drained, brownish black to dark brown, deep sandy, loam to sandy clay loam underlained by dark reddish brown, sandy clay loam, usually containing many fine mica and mn concretions.
	1R	1R	Back slope	Hm HEMBARAWA SERIES Imperfectly drained, deep brown to yellowish brown, mottled, clay loams, sometimes gleyed at depths greater than 75 cm.
	1R	1R	Basin Slope	Ha HANDAPANWILA SERIES Imperfectly drained, deep dark brown, clay loams underlained by mottled, sandy loams sometimes gleyed at depths greater than 75 cm.
	1R	1R	Depression (Upper)	Hw HEWAMPITIYAVILLU SERIES Poorly drained, deep, dark gray to gray, gleyed, clay loams and clays. Grazing in Yala. Left abandoned in Maha.
	2R(F)*		Depression (Lower)	Kt KATUWANWILA SERIES Very poorly drained, deep, dark gray to gray, gleyed, clay loams and clays. Back swamp area - subject to flooding.

* Subject to Periodic Flooding during monsoon season.

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(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS B	HIGHEST LAND CLASS C	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
B. VALLEY OF THE MADURU OYA	$2U_s$	-	Levee	B. BULATIEBB SERIES Moderately well drained, deep brown to yellowish brown, loamy sand and sany loams. Soil deficiency - high permeability.
	1R	-	Back slope	T. TIMBIRI ARU SERIES Imperfectly drained, black to dark brown, clay loams underlain by mottled sandy clay loams, sometimes gleyed at depths greater than 75 cm.
	1R	-	Basin	O. ODIGAR VILLU SERIES Poorly drained, deep (need further studies for detail description)
	2R	-	Fan	Be. BELIANNEVALA SERIES Poorly drained, deep, dark grayish brown to gray, gleyed, loamy sand to sandy loams. Soil deficiency - high permeability.
C. VALLEY OF THE OLD RIVER TRIBUTERIES			Partly dry Stream plain	
	$2R_s$	2R	Elevated area	Up. ULPOTHANEWA SERIES Imperfectly drained, moderately deep to deep, pale brown to grayish brown, loamy aandy and sand underlain by grayish, mottled,sandy clay, sometimes gleyed at depths greater than 75 cm
	1R	1R	Depression	Ma. MOOGAMANA ELE SERIES Poorly drained, moderately deep to deep, gray to dark gray, gleyed, sandy clays, occasionally with a thin sand layer at the surface.

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Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS		PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASE
	B	C	Elevated area	Ku. KUMARAPURAGAMA SERIES Moderately well drained, deep, sandy soils (need further studies).
	6(5)	-		
	6(5)	-	Depression	Ar. ARASANAGAR SERIES Imperfectly drained, deep, sandy soils (need further studies)
D. NEARLY LEVEL PLAIN	6	-	Micro-Mount	P. POCHCHAKADU SERIES Imperfectly drained, moderately deep, light brownish, grayish or whitish, sand abruptly underlain by gray to olive gray, mottled, alkaline, sandy clay loam, sometimes gleyed at depth greater than 75 cm. Solodized Solmetz - not recommended for rice culture.
	6	-	Flat	V. VAKENERI SERIES Poorly drained, light brownish, grayish or whitish thin sandy layer abruptly underlain by gray to olive gray gleyed, alkaline, sandy clay, sometimes showing marked columnar structures. Not recommended for Rice.
E. GENTLY UNDULATING PLAIN (UPLAND)	1U	1U	Convex slope	W. WILAYAYA SERIES (RBE) Moderately well drained, moderately deep to deep, dark brown, sandy clay loam containing many manganese nodules, underlain by whitish D.P.M.
			Crest	W.r - WILAYAYA, rocky phase W.s. - WILAYAYA, shallow phase W.ms - WILAYAYA, moderately shallow phase
			Upper slope	W.md - WILAYAYA, moderately deep phase W.d - WILAYAYA, deep phase.

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Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS B	HIGHEST LAND CLASS C	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
	1U	-	Convex slope	Mu. MUTHUGALLA SERIES (RBE) Well to moderately well drained, deep brownish black to dark brown, heavy sandy clay loam to clay loam, occasionally with sub-angular pebbles and cobbles of quartz at the surface.
			Crest	Mu.r - MUTHUGALA, rocky phase Mu.s - MUTHUGALA, shallow phase Mums - MUTHUGALA, moderately shallow phase
			Upper slope	Mu.md- MUTHUGALA, moderately deep phase Mu.d - MUTHUGALA, deep phase
	2R	-	Concave lower slope	Aa. ALAWAKUMBURA SERIES (RBE) Imperfectly drained, moderately deep to deep, yellowish brown, mottled, sandy clay loams, containing many manganese modules and sometime gleyed at depth greater than 75 underlain by whitish D.P.M. Aa.r - ALAWAKUMBURA, rocky phase Aa.w - ALAWAKUMBURA, shallow phase Aa.ms - ALAWAKUMBURA, moderately shallow phase Aa.md - ALAWAKUMBURA, moderately deep phase Aa.d - ALAWAKUMBURA, deep phase
	1R	-		Mu. MAWA KULAM SERIES (RBE) Imperfectly drained, moderately deep to deep, dark brown to yellowish brown, mottled, heavy sandy clay loam to clay loam, containing manganese nodules and sometimes gleyed at depths greater than 75 cms.

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Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASSES B	C	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
				Mw.r - MAWA KULAM, rocky phase Mw.s - MAWA KULAM, shallow phase Mw.ms - MAWA KULAM, moderately shallow phase Mw.md - MAWA KULAM, moderately deep phase Mw.d - MAWA KULAM, deep phase
F. UNDULATING PLAIN (UPLAND)	1U, 1U		Convex slope	Mn. MANAMPITIYA SERIES (RBE) Well drained, moderately deep, dark reddish brown to dark red, sandy clay loams with gravelly sub-soil containing quartz and feldspar gravel and mica, underlain by reddish or yellowish D.P.M.
			Crest	Mn.r - MANAMPITIYA, rocky phase Mn.s - MANAMPITIYA, shallow phase Mn.ms- MANAMPITIYA, moderately shallow phase
			Upper slope	Mn.md- MANAMPITIYA, moderately deep phase Mn.d - MANAMPITIYA, deep phase
	1U, 1U		Convex slope	U. ULHITIYA SERIES (RBE) Well drained, moderately deep, dark reddish brown to dark red sandy clay laoms with gravelly sub-soil containing quartz gravel (dominent), feldspar and mic underlain by reddish or yellowish D.P.M.
			Crest	U.r - ULHITIYA, rocky phase U.s - ULHITIYA, shallow phase U.ms - ULHITIYA, moderately shallow phase
			Upper slope	U.md - ULHITIYA, moderately deep phase U.d. - ULHITIYA, deep phase

Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	LAND CLASS B C	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
	$2R_t, 2R_t$	Concave lower slope	Pa. PADUMUNDA KULAM SERIES (REE) W/topographic deficiency better classed as $2R_t$ Imperfectly drained, deep, dark greyish brown to yellowish brown mottled, sandy clay loam with quartz and feldspar gravel and mica in sub-soil, sometimes gleyed at depth greater than 75 cm. Pa.r - PADUMUNDA KULAM, rocky phase Pa.s - PADUMUNDA KULAM, shallow phase Pa.ms - PADUMUNDA KULAM, moderately shallow phase Pa.md - PADUMUNDA KULAM, moderately deep phase Pa.d - PADUMUNDA KULAM, deep phase.
	$2R_t, 2R_t$		H. HORABORAWEWA SERIES (REE) W/topographic deficiency better classed as R_t Imperfectly drained, deep dark greyish brown to yellowish brown, mottled, sandy clay loam with quartz gravel, (dominant) feldspar and mica in sub-soil, sometimes gleyed at depth greater than 75 cm. H.r. - HORABORAWEWA, rocky phase H.s - HORABORAWEWA, shallow phase H.ms - HORABORAWEWA, moderately shallow phase H.md - HORABORAWEWA, moderately deep phase H.d - HORABORAWEWA, deep phase

Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS B	C	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
G. DISSECTED UNDULATING PLAIN (UPLAND	6(5)	-	Convex slope	Ma. MADURU SERIES (NCB) Moderately well drained, moderately deep, brown to yellowish brown, loamy sands and sandy loams, underlain by whitish D.P.M. Needs more study as upland soil.
			Crest	Md.r - MADURU, rocky phase Md.s - MADURU, moderately shallow phase Md.md - MADURU, moderately deep phase Md.d - MADURU, deep phase
	$2U_s$	-	Convex slope	We. WELIKANDA SERIES (NCB) Moderately well drained, moderately deep, brown to yellowish brown, light sandy clay loams, underlain by whitish D.P.M.
			Crest	We.r - WELIKANDA, rocky phase We.s - WELIKANDA, shallow phase We.ms - WELIKANDA, moderately shallow phase We.md - WELIKANDA, moderately deep phase We.d - WELIKANDA, deep phase
	$2R_s$	-	Concave lower slope	G. GALWEWA SERIES (NCB) Imperfectly drained, moderately deep, brown yellowish brown, mottled, loamy sands and sandy loams, sometimes gleyed at depth greater than 75 cm. G.r - GALWEWA, rocky phase G.s - GALWEWA, shallow phase G.ms - GALWEWA, moderately shallow phase G.md - GALWEWA, moderately deep phase G.d - GALWEWA, deep phase

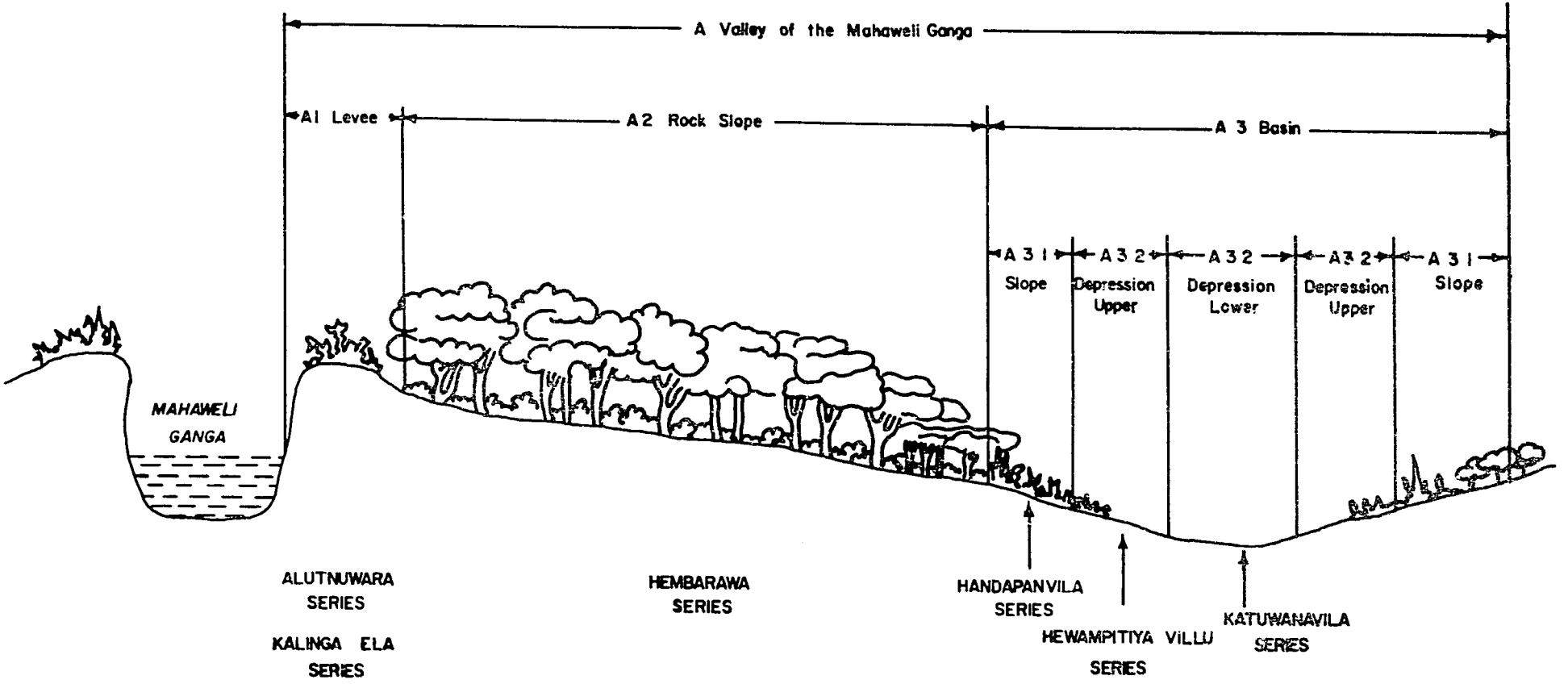
Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS		PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
	B	C		
	$2R_s$	-		Bo. BOATTE WEWA (NCB) Imperfectly drained, moderately deep, brown to yellowish brown, mottled, light sandy clay loams, sometimes gleyed at depth greater than 75 cm. Bo.r - BOATTEWEWA, rocky phase Bo.s - BOATTEWEWA, shallow phase Bo.ms - BOATTEWEWA, moderately shallow phase Bo.md - BOATTEWEWA, moderately deep phase Bo.d - BOATTEWEWA, deep phase
H. VALLEY BOTTOMS OF UNDULATING PLAIN	2R	-	Gently sloping	Ma. MAILADENIYA SERIES (LHG) Poorly drained, deep greyish or bluish, gleyed, sands and sandy loams.
	1R	-		K. KUDA OYA SERIES (LHG) Poorly drained, deep, dreyish or bluish, gleyed, sandy clay loams and clay loams.
	1R	-		Ka. KANNGASWELA SERIES (LHG) Poorly drained, deep, greyish or bluish, gleyed heavy clay loam or clays.
	$2R_s$	-		Pe. PERILLAVELI SERIES (LHG) Poorly drained, deep, greyish or bluish, gleyed, sands or sandy loams of thickness less than 5¼ cm, underlain by clay.
	$2R_s$	-		Ke. KEKULUWELA SERIES (LHG) Poorly drained, deep greyish or bluish, gleyed sands or sandy loams and sandy loam of thickness of 50-100 cm underlain by clay.

Table B-16
(Continued)

MAJOR PHYSIOGRAPHIC UNIT	HIGHEST LAND CLASS	PHYSIOGRAPHIC SUB-UNIT	DESCRIPTION OF SOIL SERIES AND PHASES
	B C 1R,1R		D. DAMMINNEWELA SERIES Very poorly drained, deep, greyish or bluish gleyed, sandy clay loam, usually with carbonate (Depth phases indicating depths to carbonate layer which is inpenetrable to roots have to be mapped).
I. ROCK KNOB PLAIN	6, 6	RKP 1 (very rocky)	25 to 50% of the surface area covered by rock exposures.
		RKP 2 (Extremely rocky)	More than 50% of the surface area covered by rock exposures.
J. EROSIONAL REMNANTS	6, 6	ER	Steep land with more than 50% of the surface area covered by rock exposures.

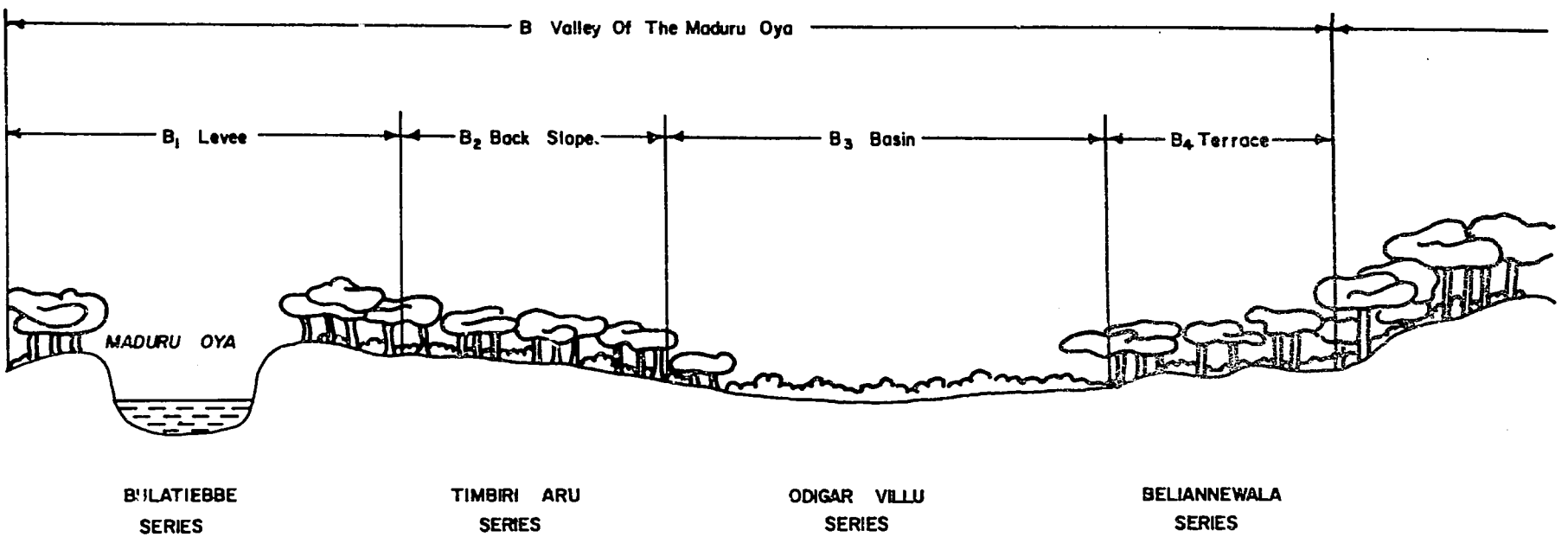
SOURCE : LUD (1979)



ALLUVIAL VALLEY OF THE MAHAWELI GANGA
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS

SOURCE: LUD-APRIL 1979

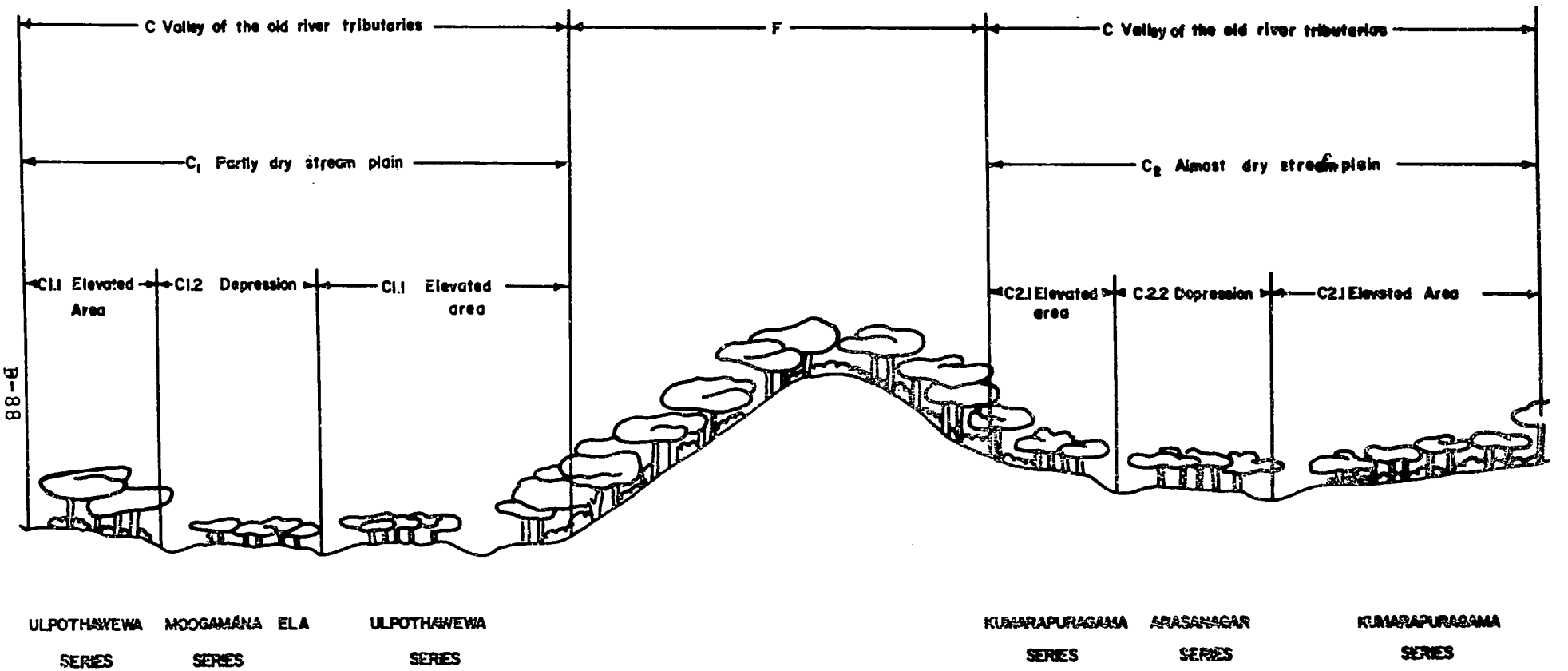
FIGURE B-14



ALLUVIAL VALLEY OF THE MADURU OYA
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS

SOURCE: LUD-APRIL 1979

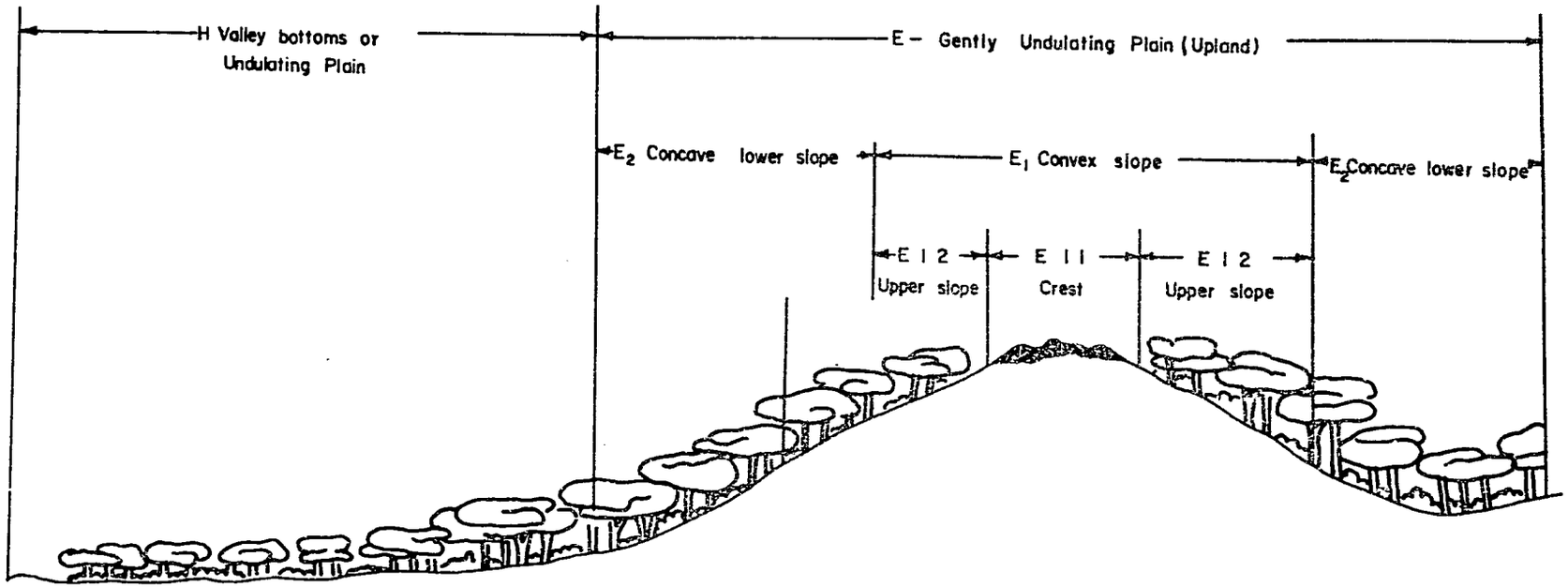
FIGURE B-15



ALLUVIAL VALLEY OF THE OLD RIVER TRIBUTARIES
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS

SOURCE: LUD-APRIL 1979

FIGURE B-16



MAILADENIYA SERIES
KUDA OYA SERIES
KANNGASWELA SERIES
PERILLAVELI SERIES
KEKULUWELA SERIES
DAMMINNEWELA SERIES

ALAWAKUMBURA SERIES

WILAYAYA SERIES

SHALLOW PHASE OF WILAYAYA & MUTHUGALLA SERIES

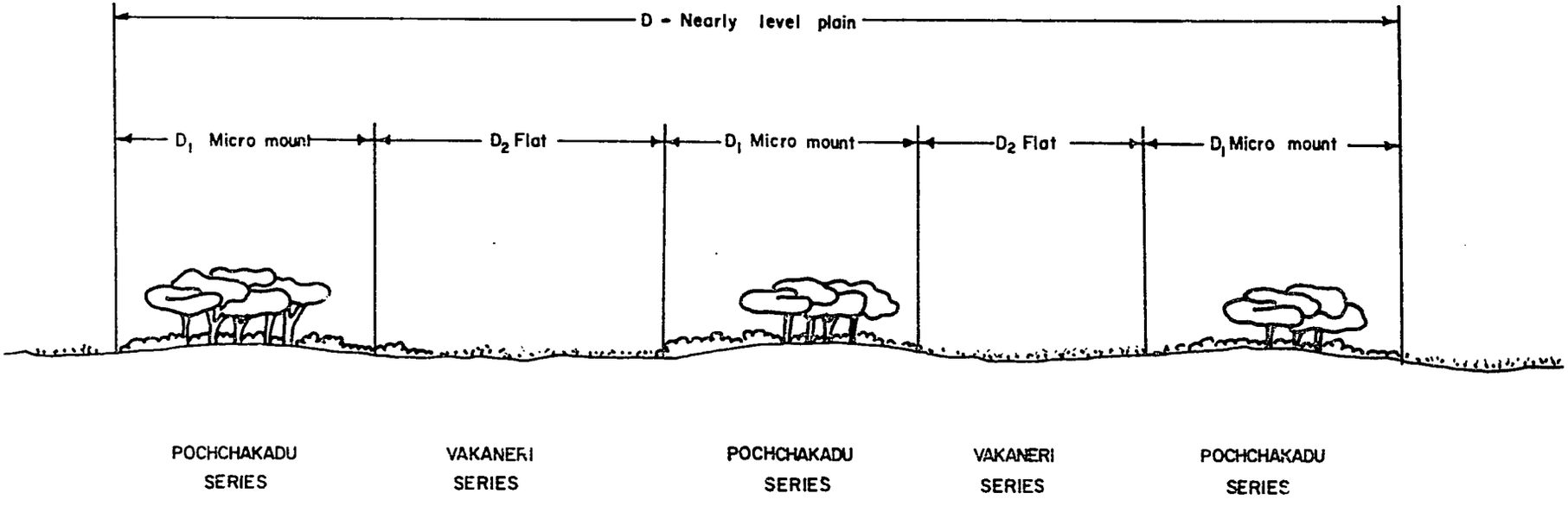
MUTHUGALLA SERIES

MAWA KULAM SERIES

GENTLY UNDULATING PLAIN (UPLAND)
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS

SOURCE: LUD-APRIL 1979

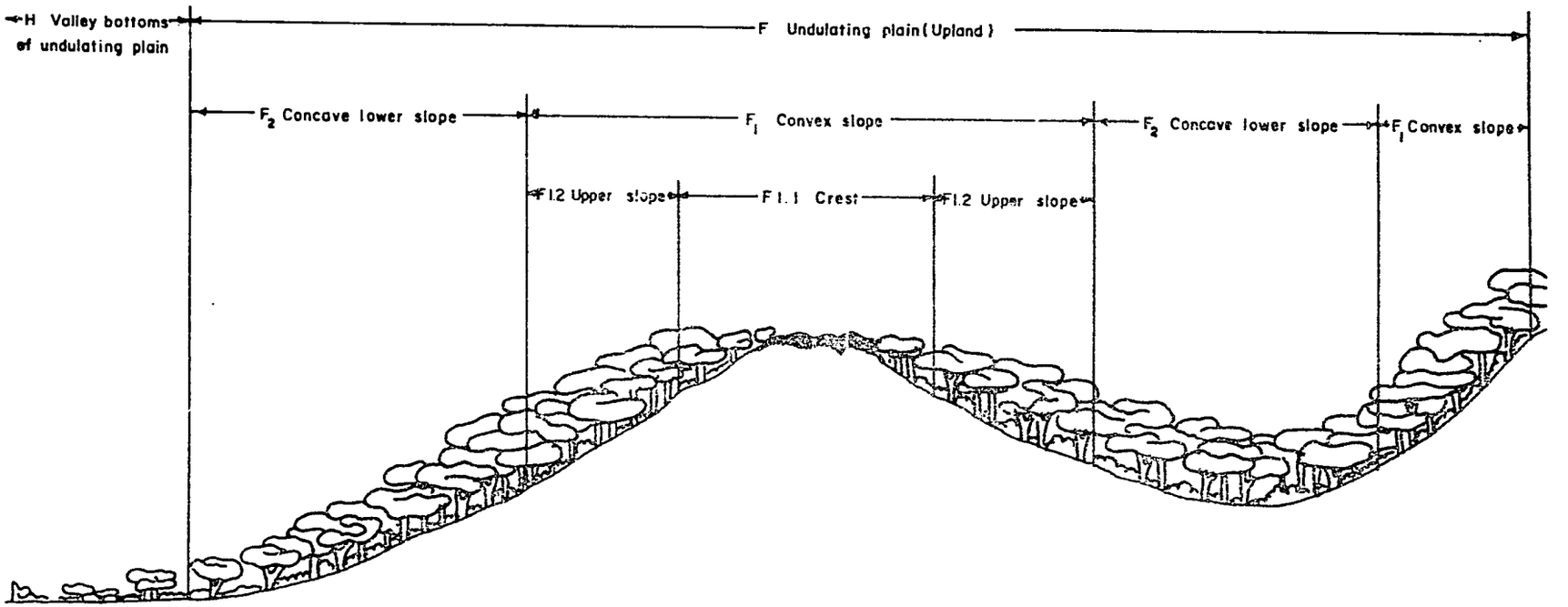
FIGURE B-17



NEARLY LEVEL PLAIN
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS

SOURCE: LUD-APRIL 1979

FIGURE B-18



MAILADENIYA SERIES
KUDA OYA SERIES
KANNGASWELA SERIES
PERILLAVELI SERIES
KEKULUWELA SERIES
DAMMINNEWELA SERIES

PADUMUNDA KULAM SERIES

MANAMPITIYA SERIES

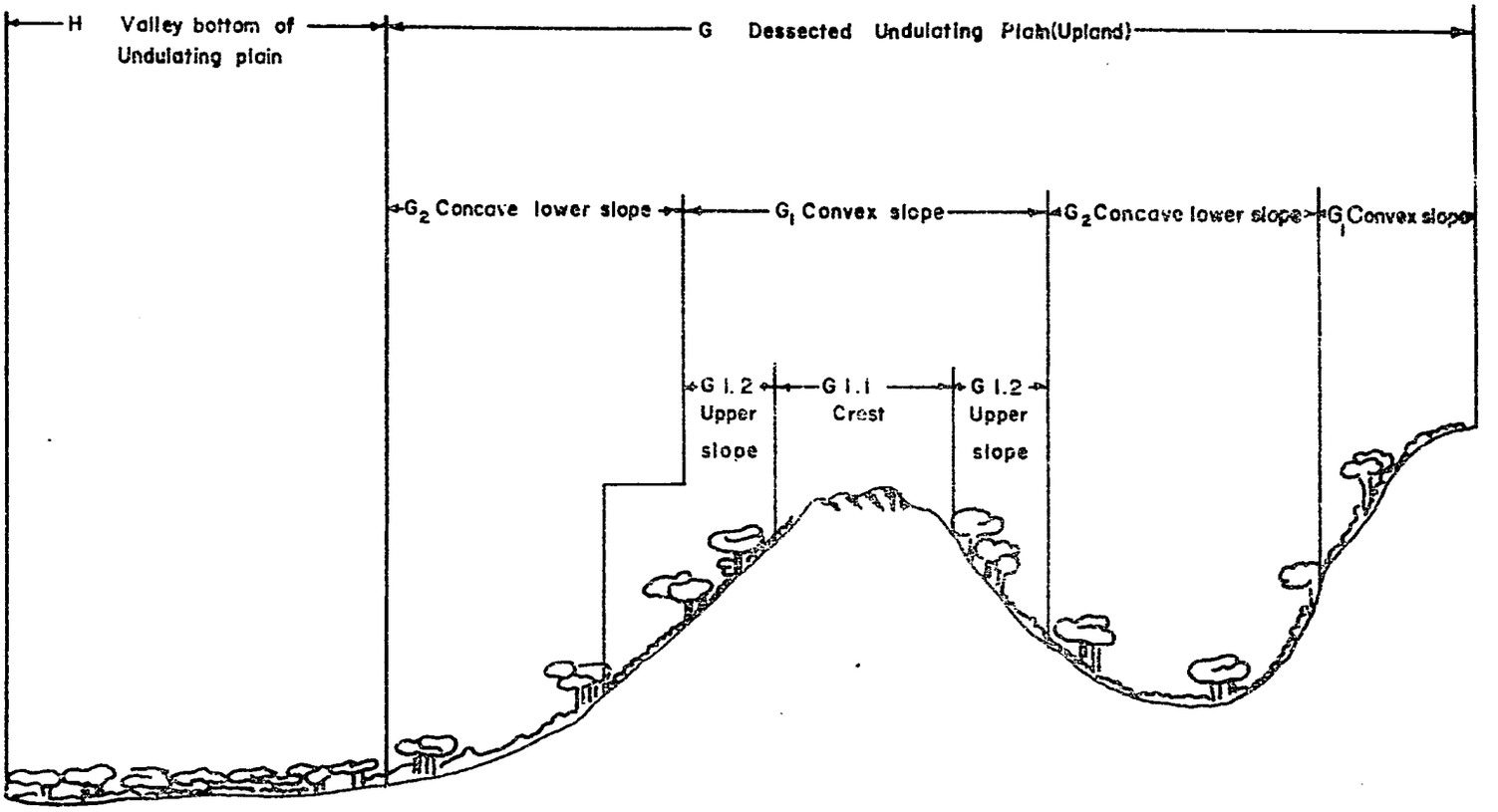
SHALLOW PHASE OF MANAMPITIYA & ULHITIYA SERIES

ULHITIYA SERIES

HORABORAWEWA SERIES

UNDULATING PLAIN (UPLAND)
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS
FIGURE B-19

SOURCE: LUD-APRIL 1979



MAILADENIYA SERIES
KUDA OYA SERIES
KANNGASWELA SERIES
PERILLAVELI SERIES
KAKULUWELA SERIES
DAMMINNEWELA SERIES

GALWEWA SERIES

MADURU SERIES

SHALLOW PHASE OF MADURU & WELIKANDA SERIES

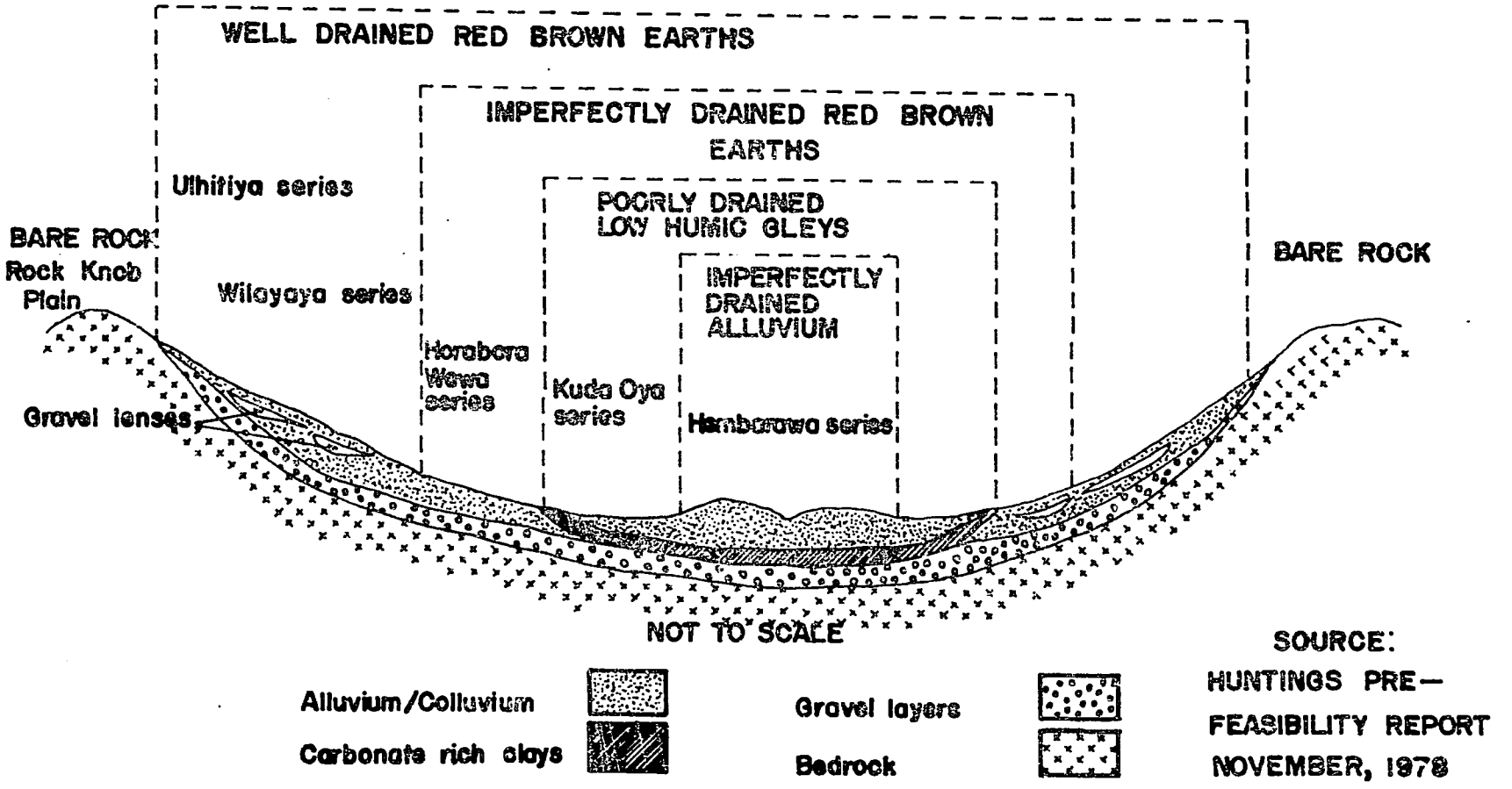
WELIKANDA SERIES

BOATTE WEWA SERIES

DISSECTED UNDULATING PLAIN (UPLAND)
RELATIONSHIP BETWEEN THE LANDSCAPE AND THE SOILS

SOURCE: LUD-APRIL 1979

FIGURE B-20



CATENARY SEQUENCE OF GREAT SOIL GROUPS IN SYSTEM C (SOUTH)

FIGURE B-21

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APPENDIX B-II

SYSTEMS OF LAND CLASSIFICATION

System A

The land classification for this system has evaluated land for its current suitabilities for irrigation but it assumes control of flooding whatever the cost of the Mahaweli Ganga.

The classification is based on physical land qualities. It does not take into account the present type of land use, nor the cost of clearing the location, land development costs or other factors which do not contriubte to the physical productivity of the land.

Four classes reflecting degree of suitability in decreasing order have been recognized by consultant personnel of System A. These land classification standards follow:

Class 1: Highly suitable land having no significant limitations to sustain application to a given use;

Class 2: Moderately suitable land having limitations which in aggregate are moderately severe for sustained application for a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive will be appreciably inferior to the expected on Class 1 land;

Class 3: Marginally suitable land having limitations which in aggregate are severe for sustained application of a given use, and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified on economic grounds; and

Class 6: Unsuitable land having limitations which may be surmountable in time but cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in a given manner.

In System A, the soils were appraised for their suitability for irrigation based on land qualities which have been taken from FAO (1976); and from W.Vander Kevie (1976). All nine land suitability maps at a scale of 1:31,680 are included in the Feasibility Report for System A (Joint Venture Randenigala 1980). Figure B-22 shows a sample of the land suitability map and legend which illustrates the technique used by the Consultants in System A for assessing the land suitability of the soils for irrigation. The Land Suitability (Land Classification) map shows three symbols in each unit. The uppermost symbol is a rating for upland crops; the second for intermediate crops; and the lower symbol for wetland rice or paddy. The Consultants for System A state that the upland soils could possibly grow

a wide range of crops consisting of cotton, groundnut, sugarcane, pulses, soy bean, chillies, vegetables, maize, etc. The more intermediate crops are sugarcane, banana, and soy beans.

The Consultants have further divided the four suitability classes into sub-classes reflecting the kinds of soil limitations. The sub-class is indicated by one or two suffix lower case letters for its major limitations; e.g. sub-class 3a has marginal suitability with alkalinity as it major limitation.

The System A Consultant recognized the following limitations:

- P, (for paddy only) low capacity for maintaining surface water;
- d, poor internal soil drainability;
- w, poor drainage conditions;
- f, low fertility and moisture capacity;
- t, topography with slope of more than 1.5%; and
- a, alkalinity.

The System A land classification scheme does not include a separate suffix for limited rooting depth which is normally used in suitability classifications. However, this limitation is not required for System A, where moderately deep soils have already been down-graded by other more severe limitations such as imperfect drainage and sandy topsoil (Ulpothawewa series, and Arasanagar series) or unfavorable topography.

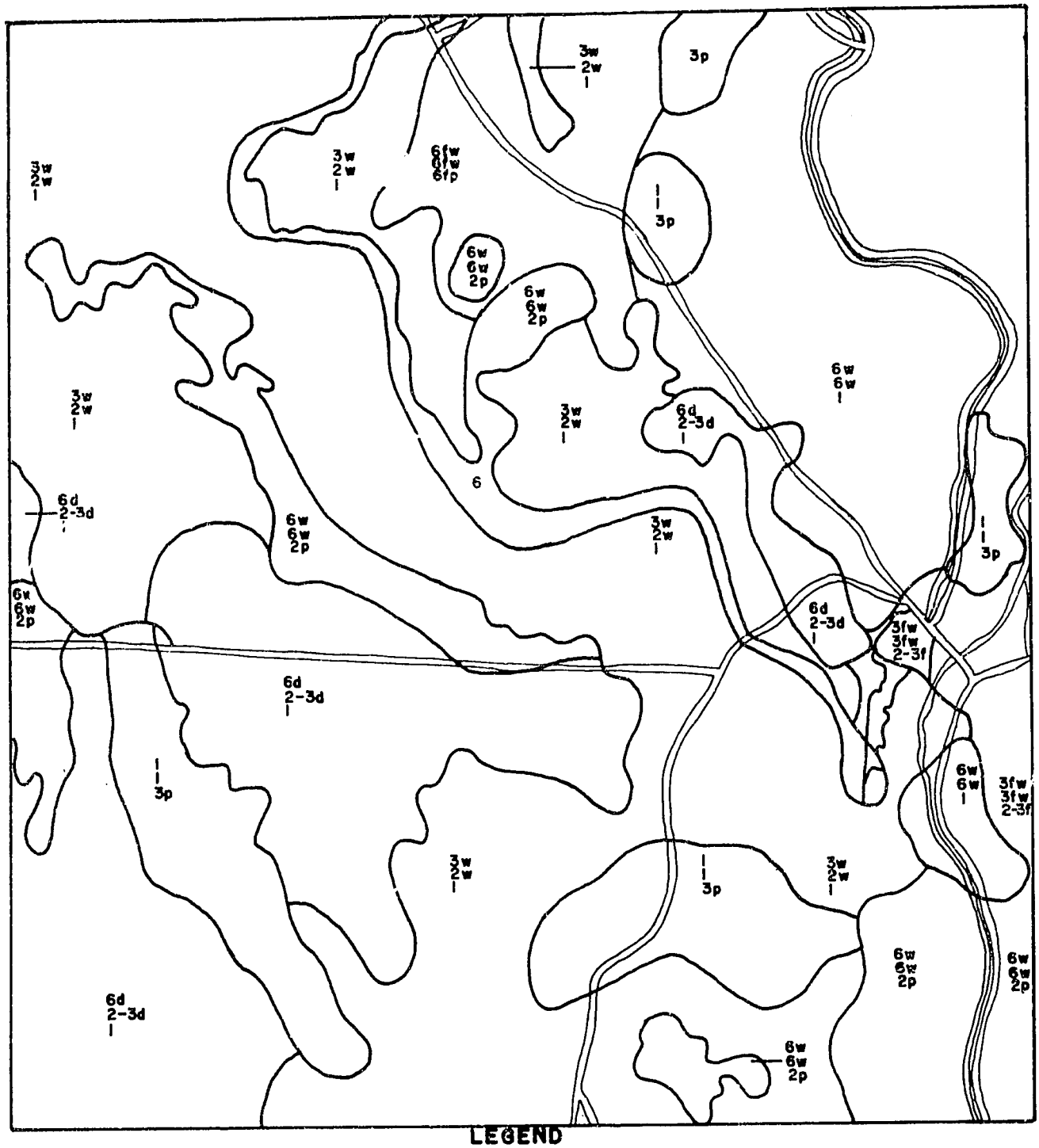
Tables B-17 and B-18, abstracted from the Consultants Feasibility Study, list the land quality used in grouping the soil units into land suitability classes. In Table B-16, the land qualities have been rated from good to poor, each quality is given a number 1, 2 and sometimes 3 to 4.

After rating the land qualities of each unit, the next step was to determine the highest suitability class in which the unit could be placed according to the most serious limitation for the kind of land use in question as illustrated in using Table B-18. Thereafter, the sub-class is determined adding one or two suffixes for the dominant limitations. The soil map legend which appears in Figure B-22 of this report also shows the ratings for three forms of land use.

On the Consultants soils maps, where associations of two series occur in one mapping unit, the suitability of the dominant series is given when it occupies more than 70% of a unit. When the dominant series occupies less than 70%, the important limitation of the associated series are taken into consideration.

A brief discussion of the ratings of the various soils by sub-area follows:

<u>The Central Floodplain</u> - Since at present this floodplain is subject to several periodic floods per year, and some parts are inundated from November till February, most of the floodplain



LEGEND

(SCALE - 1:31,880)

3wd — Suitability for irrigated upland crops
2wd — Suitability for irrigated intermediate crops(sugar ca-ne)
1 — Suitability wet-land rice

Suitability classes

1—Highly suitable for irrigation
2—Moderately suitable for irrigation
3—Marginally suitable for irrigation
6—Not suitable for irrigation

Limitations

p—(for paddy only) Low capacity for maintaining surface water
d—Poor internal soil drainability
w—Wetness; poor drainage conditions
f—Fertility and moisture availability are low
t—Topography with slope of more than 1·5 %
a—Alkalinity

SOURCE : JOINT VENTURE RANDENIGALA (1980).

EXAMPLE AREA FOR LAND SUITABILITY (LAND CLASSIFICATION) MAP FOR SYSTEM A FEASIBILITY STUDIES

FIGURE B-22

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Table B-17

Land Qualities and Individual Land Characteristics
with Related Limitations for System A

Parameter	Rating	Land Characteristic	
1. Capacity for maintaining surface water (for paddy only) (d)	1	slope less than 1.5% and slow or very slow permeability	
	2	depression (Villu) or slope 1.5 to 3% and slow or very slow permeability	
	3	slope 3-4% or moderate permeability	
	4	slope more than 4% or rapid permeability	
		Infilteration rate	Hydraulic Conductivity
2. Soil drainability	1	moderate : mostly well drained clay loam	rapid or moderate
	2	slow : mostly clay loam	slow
	3	very rapid or very slow sands or dense clays and solonetz soils	very slow
3. Drainage Condition (w)	1	well to moderately	well drained
	2	imperfectly drained	
	3	poorly to very poorly drained	
4. Fertility and arable Moisture Capacity (b)	1	more than 15% clay	
	2	less than 15% clay	
5. Adequacy of Topography for Gravity Irrigation (+)	1	0-2% slope	
	2	2-5% slope	
	3	more than 5% slope	
6. Alkalinity (a)	1	Non sodic	
	2	more than 15% ESP and distinctly solonetz profile with dense columnar B and albic horizon	

SOURCE: Joint Venture Randenigala (1980).

Table B-18

ESTIMATION OF MAXIMUM LAND CLASS
FOR IRRIGATED AGRICULTURE FOR SYSTEM A

MAX. LAND CLASS	1 GOOD			2 MODERATE			3 MARGINAL			6 UNSUITABLE		
LAND USE TYPE												
CAPACITY FOR MAINTAINING SURFACE WATER (FOR PADDY ONLY) (P)			1			2			3			4
SOIL DRAINABILITY (S)	1	1, 2		1	1, 2		2	1, 2		3	3	
DRAINAGE CONDITIONS (W)	1	1		1	2		2	2		3	3	
FERTILITY AND/OR AVAILABLE MOISTURE CAPACITY (F)	1	1	1	1	1	1	1	1	1	2	2	2
ADEQUACY OF TOPOGRAPHY FOR IRRIGATION (FOR RICE: SEE P) (T)	1	1		2	2		2	2		3	3	
ALKALINITY (A)	1	1	1	1	1	1	1	1	2	2	2	

SOURCE: JOINT VENTURE RANDENIGALA (1980)

— NOT RELEVANT

ordinarily would be rated Class 6, or unsuitable. However, assuming the presence of a low bund along the right bank of the Mahaweli and flood control of the Verugal Aru, the land evaluation ignored frequent flooding.

Fine textured alluvial Hembarawa and Handapanwila series have been rated highly suitable for wetland rice, moderately suitable for intermediate crops; but for upland crops Hembarawa is marginal and Handapanwila is unsuitable. The most favorable soils properties for rice on the floodplain is minimal loss of water, high nutrient status of the alluvial soils, a favorable pH, and a high reserve of weatherable minerals.

Low-lying Hewampitiyavillu and Katuwanwilla series are too wet for cultivation of upland crops, moderate for rice. If water control works are provided, villu soils can become productive, especially for pasturelands.

The light textured soils are of the Aluthnuwara, Kalinga Ela and Hembarawa which are less favorable for rice. They are more permeable and water losses will be high.

The Old River Terraces - Generally, the Arasangar series has been rated as unsuitable for irrigated crops of any kind and should be classified as 6 (non-arable). Ulpothawewa is marginal for upland crops (Class 6). Moogamana Ela is very suitable for wetland rice (Class 1R).

The main deficiency of Arasanagar is the great depth and loose consistency of the very sandy topsoil. When cleared for cultivation, these soils will become highly susceptible to erosion. Other severe limitations of the land are the low moisture holding quality, very low nutrient status, and in some areas exchangeable sodium content of the subsoil is high (unfortunately sodic areas are not mapped separately).

Summarizing, the relative potential of the sandy old river terraces is low for irrigated crops. For rainfed conditions, crops like groundnut or use as pasture would be feasible. Trees would make better use of the subsoil nutrients than annual crops which will root predominately in the sandy surface.

The Nearly Level Plain - The solodized solonetz soils are the least potentially productive of the survey area but constitute only a minor part. For rice, high sodium content is not particularly harmful but with roots restricted to a thin surface layer only, not more than marginal yields can be expected. These soils should be classed as 6 non-arable, but with marginal yields may be classified as 2Rs.

The Gently Undulating Plain - Undulating topography and elevated position in the landscape are the main limitations for the red and brown soils of this sub-region. These soils occur in minor extend and are scattered intermittently throughout the eastern and western peneplain and are a constraint to development.

The Alawakumbura series have been rated as marginal for rice because of rapid permeability and consequent water losses. They are therefore rated as land class 2R.

The sandy Galewa soil series, infertile, and low available water holding capacity rates is marginal and is essentially 6S, although in some circumstances may be rated as 2Rs rice soil. This extent, however, is small.

The Valley Bottom - The potential and characteristic of these poorly drained soils are similar to the Moogamana series, which can only be used for rice. The percolation ratio is low enough to prevent water losses. Properties of topsoil as well as subsoil promote good root development. These soils are rated as 1R class lands.

System B

The lands classification criteria for the System B Feasibility Study (ACRES 1979) is set forth in Table B-19. This has been adapted from the USBR Land Classification specifications which were used on the Ta Mong Project in Laos and Thailand in 1970. This type of criteria for diversified crop production coordinated with wetland rice production has proven quite successful for Asian tropical areas and developing areas in Central and South America.

The ACRES Feasibility Study team used the semi-detailed LUD soil survey and topographic mapping to develop the USBR type land classification based on the criteria outlined in Table B-19 in order to identify the arable and irrigable soils within the System B. The classification identified two arable classes (1U,2U) for upland crops, two arable classes for paddy (1R,2R) and one non-arable class. The major criteria evaluated were topography, soil texture, depth to limiting horizon (root zone), drainage and derived characteristic of available water holding capacity, salinity, alkalinity, and cation exchange capacity.

The standard USBR land classification groups the soils into classes and subclass depending on soil (s),topography (t) and drainage (d) limitations.

The Class 1U soils consist of deep and moderately deep, nearly level (0-2% slope), well to moderately well drained, medium to fine textured RBE soils. These soils present no serious limitations to sustained agricultural production of upland crops.

The Class 2U soils are the deep to moderately deep, nearly level to gently sloping (0-4%), well to moderately well drained, moderately coarse to medium textured RBE, NCB and RAL soils. Some of the soils have soil (s) limitations of moderately coarse tectures while others have a topographic (t) limitation of slopes of 2-4%. The Class 2U soils have moderate limitations to irrigated upland agriculture but can sustain a moderate level of productivity.

The Class 1R soils are moderately deep to deep, nearly level (0-2%), imperfectly to poorly drained, medium to fine textured RAL, OAL, RBE, and LHG soils. Generally, these soils have no serious limitations to double cropped paddy.

The Class 2R soils consist of moderately shallow to deep, nearly level to gently sloping, imperfectly to poorly drained moderately coarse to fine textured soils of the RAL, OAL, NCB, SS and LHG Great Groups. The Class 2R soils have moderate topographic (t) or soil (s) limitations but can sustain a moderate level of productivity under paddy cultivation.

The Class 6 soils are those lands which do not meet the minimum requirements of the arable land classes. The major limitations are coarse textures, rocky, shallow and moderately shallow phases and topography greater than 4% slopes.

System C

Since Systems B and C were carried out concurrently, maximum possible consistency between the Land Classification criteria applied to the two areas was desirable. The Land Classification criteria are similar in that they are derived from adaptable USBR land classification principles and practices, the differences being in the detail of assessment. System B Consultants have utilized two classes for upland, 1U and 2U; two classes for lowland riceland 1R and 2R; and non-arable class 6. System C consultants have specified three upland classes, 1, 2 and 3 (with subclasses 3d and 3td), three wetland rice classes 1, 2 (with subclass 2s and 2t), 3 (with subclasses 3t and 3st) and Class 6.

Tables B-20 and B-21 set forth the diagnostic criteria which System C Consultants have used from the Land Use Division in formulating their land classification standards.

Table B-22 outlines the soil series and their principal properties found in System C. Their corresponding highest land class categories are indicated both for upland crops as well as wetland rice.

The land classification used by the Consultants in System C is based on the six classes concept of the United States Bureau of Reclamation (USBR) 1953 System in which Classes 1,2,3 represent good,moderate, marginal (arable lands) and Class 6 unacceptable (non-arable lands) when used for irrigation. Class 4 land is that which could be classified as a pasture class and should be Class 3 or Class 6 under basic project conditions, but which if given specially modified conditions might produce returns equivalent

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to one of the higher classes. Class 5 is land which needs further study before it can be accurately classified.

A dual system of land classification has been adopted for both Systems B and C. This was primarily because the requirements for wetland rice (paddy) are very different from those of the upland (dryfoot) crops and in addition because rice would be equally or even more important than upland crops in an overall cropping system. Wetland rice requires flat land (or flat land that has been constructed into level terraces), low subsoil permeability and low infiltration rates. Rooting depth is usually of minor consideration. Upland crops, however, require good rooting depth; and good internal and surface drainage are critical, but land gradients can be more important.

Table B-22 presents the land classification criteria for upland (dryfoot) crop cultivation, and for wetland rice (paddy) land classification.

System D

Since of the four Systems being assessed, System D did not have land classification, TAMS applied a methodology which is recommended for adoption for the entire Accelerated Program area. Specific points of this system are presented below; a brief summary may be found in the main body of this TOPIC REPORT in the RECOMMENDED ACTIONS section.

UNIFORM LAND CLASSIFICATION

One of the goals of a feasibility land classification is the establishment on the land class maps of all boundaries between arable lands and Class 6, non-arable lands, with the area on each side of that boundary clearly labelled. The drafting techniques on all Consultant's Land Classification Maps has been to not label Class 6 areas. In the type of resource development in the Mahaweli development program, the Class 6 areas have an importance in resource development, not only the irrigable lands. There should also be an established boundary between Upland land class areas and paddy areas.

More detail in land classification mapping and drafting techniques would be required in the design stage, and it would be suggested that Class 6 lands and arable classes would all be labelled with the applicable sub-classes which would apply relative to the deficiencies in soils, drainage, or topography, or any combination of these.

A clear choice should be made in the criteria for detailed land classification that will best serve the Accelerated Mahaweli Development Program for the detailed land classification for the design stage. In order to facilitate the land classification criteria best suited for this development, the two sets of criteria are presented for the U.S.Bureau of Reclamation System of land classificaiton.

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Table B-19

Land Classification Criteria for System B Feasibility Study

Land Characteristics	Subclass Denotation	Upland Diversified Crop Production Class 1 (1U)	Upland Diversified Crop Production Class 2 (2U)	Lowland Rice Production Class 1(1R)	Lowland Rice Production Class 2(2R)	Class 6
1. Soil Texture*						
Surface	s	FSL-CL*	LS - C	FSL - C	LS - C	Non-arable lands which do not meet the minimum requirements of the other land classes.
Subsurface		SL-C	SL - C	LS - C	S - C	
2. Rooting Depth**						
Gravel Layer	s	>90 cm	> 60 cm	> 60 cm	> 30 cm	
Bedrock		> 120 cm	> 90 cm	> 90 cm	> 60 cm	
3. Available Water Holding Capacity	s	>15 cm in top 120 cm	> 10 cm in top 90 cm	Not applicable	Not applicable	
4. Salinity (E.C.-mmhos/cm)	s	< 2	< 4	< 2	< 4	
5. Alkalinity***	s	< SAR 10	< SAR 15	< ESP 15	< ESP 20	
6. Cation Exchange Capacity (m.e./100 g)	s	> 10	> 5	>10	> 5	
Topography	t					
Deep Soils 120 cms		< 4%	< 4%	<2%	< 4%	
Moderately deep 90-120 cms		< 2%	< 4%	<2%	< 4%	
Moderately shallow 90-90 cms		-	-	-	< 2%	
Shallow 60 cm		-	-	-	-	
Drainage	d	well to moderately well	well to moderately well	poor to very poor	imperfect	

* Texture - FSL= fine sandy loam, SL = sandy loam, LS = sandy loam, C = clay
** Rooting Depth - estimated after land development
*** Alkalinity - SAR = Sodium Absorption Ratio, ESP = Exchangeable Sodium Percentage

SOURCE: ACRES FEASIBILITY STUDY (1979)

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Table B-20

Land Classification Criteria for Dryfoot (Upland) Crops and Wetland Rice in System C

I. - LAND CLASSIFICATION : DRYFOOT CROPS : SURFACE IRRIGATION

Soil Type (Drainage)	Soil Depth Phase	Associated Gravel Depth (p)	SLOPE PHASE (t) 0.1.5%	1.5-3%	3-4%	4-6%	6%
RBEs, Well Drained	d:vd>120cm	90>cm	1	1	2t	3t	6t
	md90-120	60-90	1	2pt	3tp	6tp'	6tp
	ms60-90	30-60	3p	3pt	6pt'	6pt	6pt
	s <60	<30	6p	6pt	6pt	6pt	6pt
RBE, Imperfectly Drained	d:vd>120cm	>90 cm	3d	3d	3dt	6dt	-
	md90-120	60-90	3dp	3dp	6dtp'	6dtp	-
	ms60- 90	< 30-60	6dp	6dp	6dpt	6dpt	-
LHG (Poorly Drained)	d:vd>120cm	>90cm	5d	5d	5dt	6dt	-

II. - LAND CLASSIFICATION : WETLAND RICE

Soil type (Drainage)	Soil Depth Phase	SLOPE PHASE (t) 0-1.5%	1.5-3%	3-4%	4-6%
RBEs, Well Drained	All depth phases but shallow	R2s	R3st	R6st	R6st
	Shallow Depth Phase	R2p	R3pt	R6pt	R6pt
RBE, Imperfectly Drained + LHG (Poorly Drained)	All depth phases but shallow	R1	R2t	R3t	R6t
	Shallow Depth Phase	R2p	R3pt	R6pt	R6pt

Note: p,d, and t refer to depth, drainage, and topography (slope) subclasses respectively.

Subclasses 6tp', 6pt', etc. are marginally downgraded.

SOURCES : HUNTINGS FEASIBILITY REPORT (DECEMBER 1979).

Table B-21

Key to Depth, Rockiness and Slope Phases in Systems B and C

DEPTH PHASE			ROCKINESS PHASE		SLOPE PHASE	
Phase	Depth to prominent Gravel layer (cm)	Depth to Bed Rock	Phase	Percentage of the surface area covered by rock	Phase	Slope in percent
vd Very deep	120	150	fr Fairly rocky	2-10	1. Flat	00-1.5
d Deep	90-120	120-150	r Rocky	10-25	2. Very gently sloping	1.5-3.0
md Moderately deep	60-90	90-120	RKP I Very rocky (Rock Knob)	25-50	3. Gently - sloping	3.0-4.0
ms Moderately Shallow	30-60	60-90	RKP II Extremely rocky (Rock Knob Plain 11.)		4. Moderately sloping	4.0-6.0
					5. Sloping	6.0-20.0
s Shallow	30	60			6. Moderately Steep	20

SOURCE: LUD (1979)

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Table B-22

Soil Series of System C and Brief Physical Description

Soil Group	Soil Series	Description	Physiographic Unit: (Sub-Unit)	Highest Land Class: (dryfoot crops/wet land rice)
Well-drained RBEs	U Ulhitiya	Well-drained, moderately deep, dark reddish brown to dark red, sandy clay loams with gravelly sub-soil containing quartz gravel (dominant), some feldspar and mica underlain by reddish or yellowish D.P.R.	Undulating Plain-Upland : (Convex slope)	1/2s
	Mn Manampitiya	Well drained, moderately deep, dark reddish brown to dark red, sandy clay loams with gravelly sub-soil containing quartz and abundant feldspar gravel and mica, underlain by reddish or yellowish D.P.R.	Undulating Plain-Upland : (Convex slope)	1/2s
	W Wilayaya	Moderately well drained, moderately deep to deep, dark brown, sandy clay loam containing manganese nodules, underlain by whitish D.P.R.	Gently Undulating Plain-Upland : (Convex slope)	1/2s
	A Alutnuwara	Well to moderately well drained, brownish black to dark brown, deep sandy reddish brown, sandy clay loam, usually containing many fine mica grains, and Mn concretions.	Levee	1/2s
Imperfectly drained RBEs	H Horabora Wewa	Imperfectly drained, deep, dark grayish brown to yellowish brown, mottled, sandy clay loam with quartz gravel, (dominant), feldspar and mica in sub-soil, sometimes gleyed at depths greater than 75 cm.	Undulating Plain-(Concave lower slope)	3d/1
	Pa Padumunda Kulam	Imperfectly drained, deep, dark grayish brown to yellowish brown mottled, sandy clay loam with quartz and feldspar gravel and mica in sub-soil, sometimes gleyed at depth greater than 75 cm.	Undulating Plain-(Concave lower slope)	3d/1
	Hm Hemarawa	Imperfectly drained, deep brown to yellowish brown, mottled, clay loams, sometimes gleyed at depths greater than 75 cm.	Mahaweli Valley - (Back slope)	3d/1

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Table B-22
(Continued)

Soil Group	Soil Series	Description	Physiographic Unit: (Sub-Unit)	Highest Land Class: (dryfoot crops/wet rice)
Imperfectly drained RBEs contd.	Ha Handapan-wila	Imperfectly drained, deep dark brown, clay loams underlained by mottled, sandy loams sometimes gleyed at depths greater than 75 cm.	Mahaweli Valley (Basin-slope)	3d/1
	Up Ulpothawewa	Imperfectly drained, moderately deep to deep, pale brown to grayish brown, loamy sand and sand underlain by grayish, mottled, sandy clay, sometimes gleyed at depths greater than 75 cm.	Valley of Tributary: (partly dry stream valley - elevated area)	3d/1
Poorly drained RBEs	K Kuda Oya	Poorly drained, deep, greyish or bluish, gleyed, sandy clay loams and clay loams	Valley bottoms of undulating plain: (gently slopping)	5d/1
	D Damminne-wela	Very poorly drained, deep, greyish or bluish, gleyed, sandly clay loam, usually with carbonate (depth phases indicating depths to carbonate layer which is inpenetrable to roots have to be mapped).	Valley bottoms of undulating plain	5d/1
	M Moogamana	Poorly drained, moderately deep to deep, grey to dark grey gleyed, sandy clays, occasionally with a thin sand layer at the surface.	Valley of tributary: (depression)	5d/1
	Hw Hewampiti-yavillu	Poorly drained, deep, dark gray to gray, gleyed, clay loams and clays.	Valley of Mahaweli: (depression)	5d/1

Source: LUD, with minor adaptions by Consultants of System C

If the classes and subclass are going to be based on the economics of production, six land classes would be normally recognized. The number of classes mapped in any particular investigation depends on the diversity of land conditions encountered and other requirements dictated by the objectives of the particular investigation. If payment capacity and the economics of production are to be considered as well as the physical and chemical characteristics of the soil, then land classification criteria would have four basic classes to identify arable lands, one provisional class, and one class to identify non-arable lands (USBR 1951).

A brief description of the six classes follows:

Class 1 - Arable: Lands that are highly suitable for irrigation farming being capable of producing sustained and relatively high yield of climatically adapted crops at reasonable cost. These lands potentially have a relatively high payment capacity.

Class 2 - Arable: Lands that have a moderate suitability for irrigation. These are usually either adaptable to a narrower range of crops, more expensive to develop for irrigation, or less productive than Class 1. Potentially these lands have intermediate payment capacity.

Class 3 - Arable: Lands that have a marginal suitability for irrigation. They are less suitable than Class 2 lands and usually have either a serious single deficiency or a combination of several moderate deficiencies in soil, topography, or drainage properties. Although greater risk may be involved in farming these lands than those of Classes 1 and 2, under proper management they are expected to have adequate payment capacity.

Class 4 - Limited Arable or Special Uses: Lands that are adaptable to only a very limited range of crops. For example, lands suited only to such single crops as rice, pasture, or fruit might respectively be shown as Classes 4R, 4P, or 4F. Class 4 lands may have a range in payment capacity greater than that for the associated arable lands.

Class 5 - Non-arable: This land is temporarily considered as non-arable because of some specific deficiency such as excessive salinity, questionable drainage, flooding, or other deficiency which requires further studies to resolve. The deficiency or deficiencies are of such a nature and magnitude that special agronomic, economic, or engineering studies are required to resolve the costs or effect on the land. Class 5 designation is tentative and should be changed to either Class 6 or an arable classification during formulation of the recommended plan of development.

Class 6 - Non-arable: Land that is non-arable under the existing or projected economic conditions associated with the proposed project development. Generally, Class 6 comprises steep, rough, broken, rocky, or badly eroded lands, or lands with inadequate drainage, or other deficiencies. In some instances, lands considered to be Class 6 in one area may be arable in another area because of differences in economic conditions.

In the basic system, land suited only for crops having very special requiremets, such as paddy rice, would usually be placed in Class 4. This is not very satisfactory in areas where the speciality crop is predominant, as is the case with paddy rice in Southeast Asia. In projects in that area the USBR developed a useful adaptation of their system to solve this problem. In the modified system two basic diversified crop classes and two basic wetland rice classes are used to distinguish arable lands according to their suitability for irrigated agriculture together with one class to identify the non-arable lands (USBR 1967). Brief descriptions of the classes recognized follows:

Class 1U diversified crops - Arable: Lands that are highly suitable for irrigation farming being capable of producing sustained and relatively high yields of climatically suited upland crops at reasonable cost if properly provided with essential cultural management, including fertilization, drainage and irrigation facilities. These lands shall have relatively high net farm income potential.

Class 2U diversified crops - Arable: Lands of moderate to fair suitability for irrigation farming, being measurably lower than Class 1U in productive capacity, adapted to a narrower range of diversified crops and more costly to farm. Generally, greater risk may be involved in farming Class 2U lands than Class 1U land, but under proper management they are expected to have adequate net farm income.

Class 1R wetland rice - Arable: Lands that are highly suitable for paddy rice production under irrigation, being capable of producing sustained and relatively high yields of rice at reasonable cost. These lands shall have relatively high net farm income potential under wetland rice.

Class 2R wetland rice - Arable: Lands of moderate to fair suitability for paddy rice production under irrigation, being measurably lower than Class 1R in productive capacity or more costly to farm.

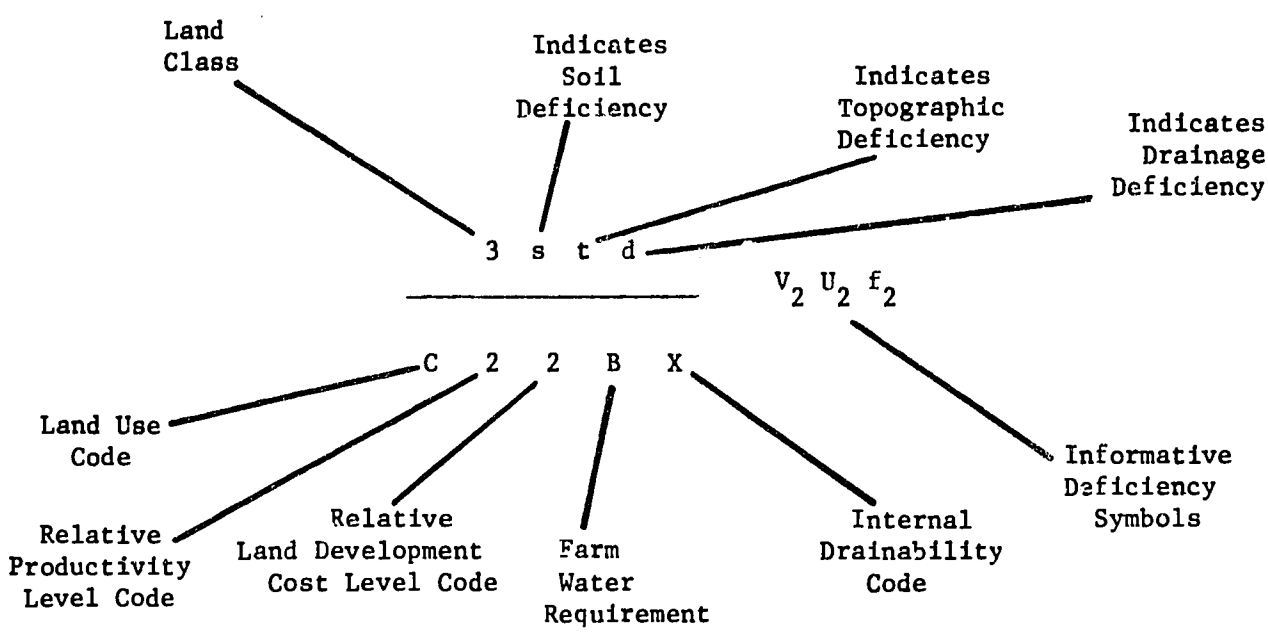
Class 6 - Non-arable: Lands in this class shall include those considered non-arable under the project plan because of the failure to meet the minumum requirements for the other classes of land; arable areas definitely not susceptible to delivery of irrigation water or to provision of project land development and drainage.

It will be noted that the relative merit of the arable classes in this classification is assessed in terms of net farm income rather than payment capacity.

Subclasses

The reasons for placing areas in a class lower than Class 1 are indicated by appending the letters "s", "t" and "d" singly or in combination, to the class number to show whether the deficiency is in "soil", "topography" or "farm drainage". Thus, the basic subclasses of the land classes are s, t, d, st, sd, td and std. The interaction or accumulative effects of deficiencies may justify placing the land in a lower class (USBR 1951). Figure B-23 shows the preferred appraisal of such deficiency interactions.

Typically, the mapping symbol employed by the USBR takes the following form:



Apart from the class and subclass symbols, which form the numerator of the fraction and which have been described in the previous section, the following codes are used to form this symbol:

Land Use Code:

C	- Irrigated cultivated
L	- Nonirrigated cultivated
P	- Irrigated permanent grassland
G	- Nonirrigated permanent grassland
B	- Brush or timber
H	- Suburban or homestead
W	- Waste or miscellaneous
ROW	- Established right of way

(Note: In some situations it may be preferable to identify symbols with specific crops).

Productivity and Land Development Codes

Productivity connotes the interaction of the economic factors of productive capacity and costs of production. It is defined as the capacity of land for producing a specified crop or sequence of crops under a given set of management practices. Land development costs are those borne by the farmer in preparation of the land for irrigation and specifically relating to the land which benefits. The two together determine the Land Class but additional information is provided by including each separately in the symbol. Each is rated 1,2,3,4 or 6 depending on the class level to which it separately corresponds. Thus, in the example given, Class 2 productivity and Class 2 development cost (symbol 22 in the denominator result in an overall land Class 3).

Farm Water Requirement Code

These appraisals take account of significant soil, topographic and drainage conditions, probable land use, methods of irrigation and other factors which affect the type, frequency and depth of irrigation on a specific tract of land. They are rated in relation to average water requirements of the surrounding area:

A - low
B - medium
C - high

Land Drainability Code

Normally, this relates to internal drainage conditions below a depth of 5 ft. (150 cm):

X - good drainability
Y - restricted drainability
Z - poor or negligible drainability

Additional Informative Symbols

Additional informative symbols can be added to the main symbol as shown in the example to provide information on a special condition where the data is required for farm unit planning and land development.

Such symbols might relate to soils, topography or drainage. They can be further qualified with subscript numerals to indicate a range in character, e.g. $k_1k_2k_3$ might indicate ranges of depth to gravel.

Suitable Code Symbols are - Soils:k - Shallow depth to coarse sand, gravel or cobble

b - Shallow depth to relatively impervious substrate

z - Shallow depth to concentrated zone of lime

v - Very coarse texture (sands, loamy sands)

h - Very fine texture (clays)

e - Structure

q - Available moisture capacity

i - Infiltration

p - Hydraulic conductivity

x - Stoniness

y - Soil fertility

a - Salinity and alkalinity

Topography: g - Slope

u - Surface

j - Irrigation pattern

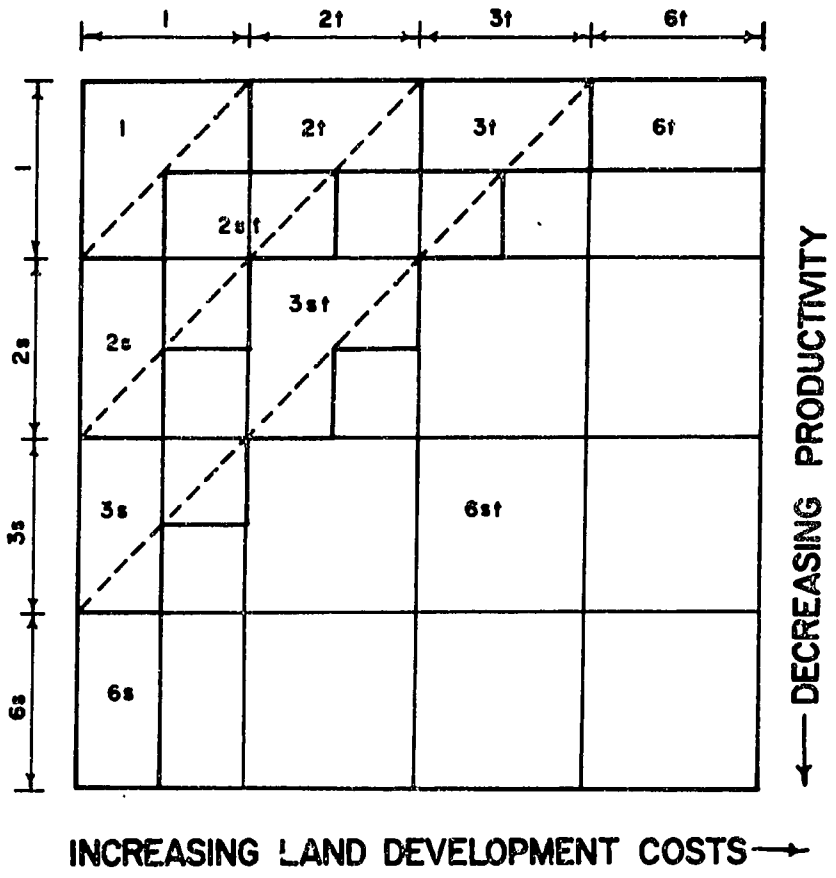
c - Brush or tree cover (need for removal)

r - Rock cover (need for removal)

Drainage : f - Surface drainage-flooding

w - Subsurface drainage-water table

o - Drainage outlet-problem



IRRIGATION SUITABILITY CLASSIFICATION OF THE U.S. BUREAU OF RECLAMATION: LAND CLASS AND SUBCLASS CORRELATION MODEL SHOWING PREFERRED APPRAISAL OF DEFICIENCY INTERACTIONS.

SOURCE: FAO (1976)

FIGURE B-23

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INTRODUCTION

In this report, existing conditions of land use are related to erosion in the Upper Catchment of the Mahaweli Ganga. The impact of erosion is shown in relation to sedimentation behind the Victoria Dam and the recommended actions to mitigate the erosion impact take the form of a watershed management plan. TOPIC REPORT B : LAND USE AND SOILS discusses existing conditions, impacts and recommended actions as they relate to the downstream irrigation systems.

The Upper Catchment of the Mahaweli Ganga is the principal source of water for the numerous hydropower and irrigation schemes in the Accelerated Mahaweli Development Program. It, therefore, is vital that these multi-million dollar investments be safeguarded by a regulated supply of acceptable sediment-free water.

A field reconnaissance by car and helicopter revealed that there were extensive areas of seriously eroding land adjacent to the Mahaweli Ganga and its tributaries. In order to quantify the extent of this problem, present land use and forestry maps were prepared which include an estimate of slope for each unit mapped. From this information an estimate of the annual loss of soil was calculated by individual land use class. It became immediately evident that productivity was being progressively reduced due to serious erosion problems.

This report outlines a watershed redevelopment program with a primary objective of improving soil conservation practices in the Upper Catchment. This program will have three directly beneficial side effects: improvement in agricultural product yields; provision of new sources of fuelwood; and eventual production of large supplies of timber.

Institutional arrangements as to the form of the authority to control and coordinate the program are discussed and a modified form of State Corporation is recommended. This institution will require special enabling legislation embodying the principles of a plethora of existing acts and regulations plus a few that hitherto have been unnecessary. A summary of the new legislation is presented with a justification for each section required.

The program itself includes descriptions of the areas of highest priority for redevelopment, a time schedule for operations, an estimate of manpower requirements and a description of soil conservation practices to be utilized. These practices comprise crop diversification, forest plantations and engineering works of various kinds.

EXISTING CONDITIONS

MAPPING OF UPPER CATCHMENT

Description of Catchment

The Upper Catchment of the Mahaweli Ganga is located in the mountainous core of the Central Highlands of Sri Lanka (See Figure C-1). The area of the catchment is approximately 316,000 hectares, of which there is aerial photographic coverage of 239,000 hectares or 76%.

The headwaters of the Mahaweli Ganga rise in the core of the Central Highlands at Nuwara Eliya with elevations in the vicinity ranging from 1,200 meters to over 2,000 meters. The river itself originates in the Hatton Plateau, a formation to the southwest with elevations ranging around 1,400 meters. The river flows north from this plateau until it curves around the town of Kandy in the Kandian Plateau at an elevation of 500 meters. From here it flows east towards the dry zone lowlands, crossing the wet zone boundary at an elevation of approximately 100 meters.

There are seven major subsidiary rivers feeding into the Mahaweli Ganga plus a number of smaller streams. The Ma Oya and Hulu Ganga flow in from the north, and the Kurundu Oya, Belihul Oya, Maha Oya, Kotmale Oya and Nan Oya flow in from the south.

The Upper Catchment experiences a monsoonal distribution of rainfall with the period of greatest rainfall during the Southwest Monsoon or Yala, from May to September. The next wettest months are the intermonsoon periods, October, November and March and April. The Northeast Monsoon, or Maha, during December and January produces the least rainfall and the month of February is usually the driest month of the year.

The mean annual rainfall for the three major towns in the area is 84 centimeters in Kandy, 200 centimeters in Hatton and 350 centimeters in Nuwara Eliya (Hunting Survey Corporation 1962). Much of the rain occurs as torrential downpours in storms of short duration. For instance, Table C-1 shows the shortest time in minutes for the precipitation of the amount of rainfall indicated at Ratnapura in 1970. The number in brackets gives the number of rainstorms of the same intensity each month (Department of Meteorology 1971).

Mapping

The Upper Catchment boundaries were taken to be the height of land on the north, west and south and the wet zone boundary on the east (See Figure C-2).

Present land use was interpreted from aerial photography taken in early 1979 at a scale of 1:20,000. This photography covered about 75% of the area of the catchment.

The land use type information annotated on the photographs was transferred to twelve base maps at a scale of 2" = 1 mile using a zoom transferscope by a Survey Department technician. Copies of these maps are provided in the Map Addendum. Originals of these maps are available on file at the Survey Department for future reproduction needs.

Table C - 1

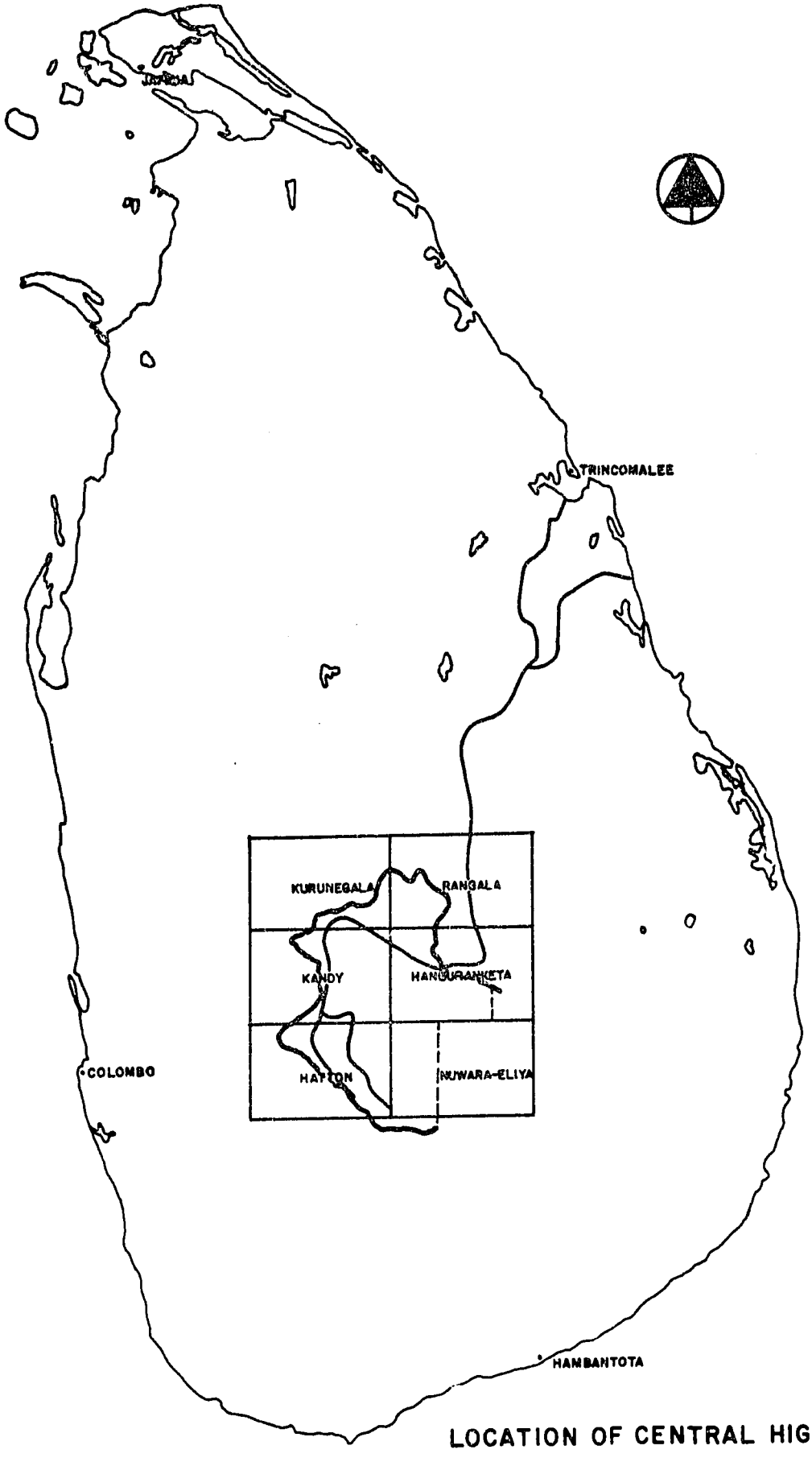
Time in Minutes and Number of Storms by Quantities of Rainfall

Ratnapura - 1970

Month	Rainfall - centimeters								
	1	2	3	4	5	6	7	8	9
January	13(2)*								
February	10(2)	33	51	-	-	-	-	-	-
March	3(4)	9(3)	18(3)	25(2)	47(2)	62	82	93	110
April	7(5)	14(3)	26(2)	47	60				
May	8	21	44						
June	7(5)	36	73						
July	8(5)	-	-	-	-	-	-	-	-
August	8(5)	-	-	-	-	-	-	-	-
September	9(3)	15(3)	33(3)	50	-	-	-	-	-
October	8(5)	24(2)	50(2)	85	-	-	-	-	-
November	4(4)	10(2)	26(2)	65	78(2)	-	-	-	-
December	11(2)	38	-	-	-	-	-	-	-

* Number in brackets shows number of storms

Source : Dept. of Meterology (1971)



LOCATION OF CENTRAL HIGHLANDS
FIGURE C-1

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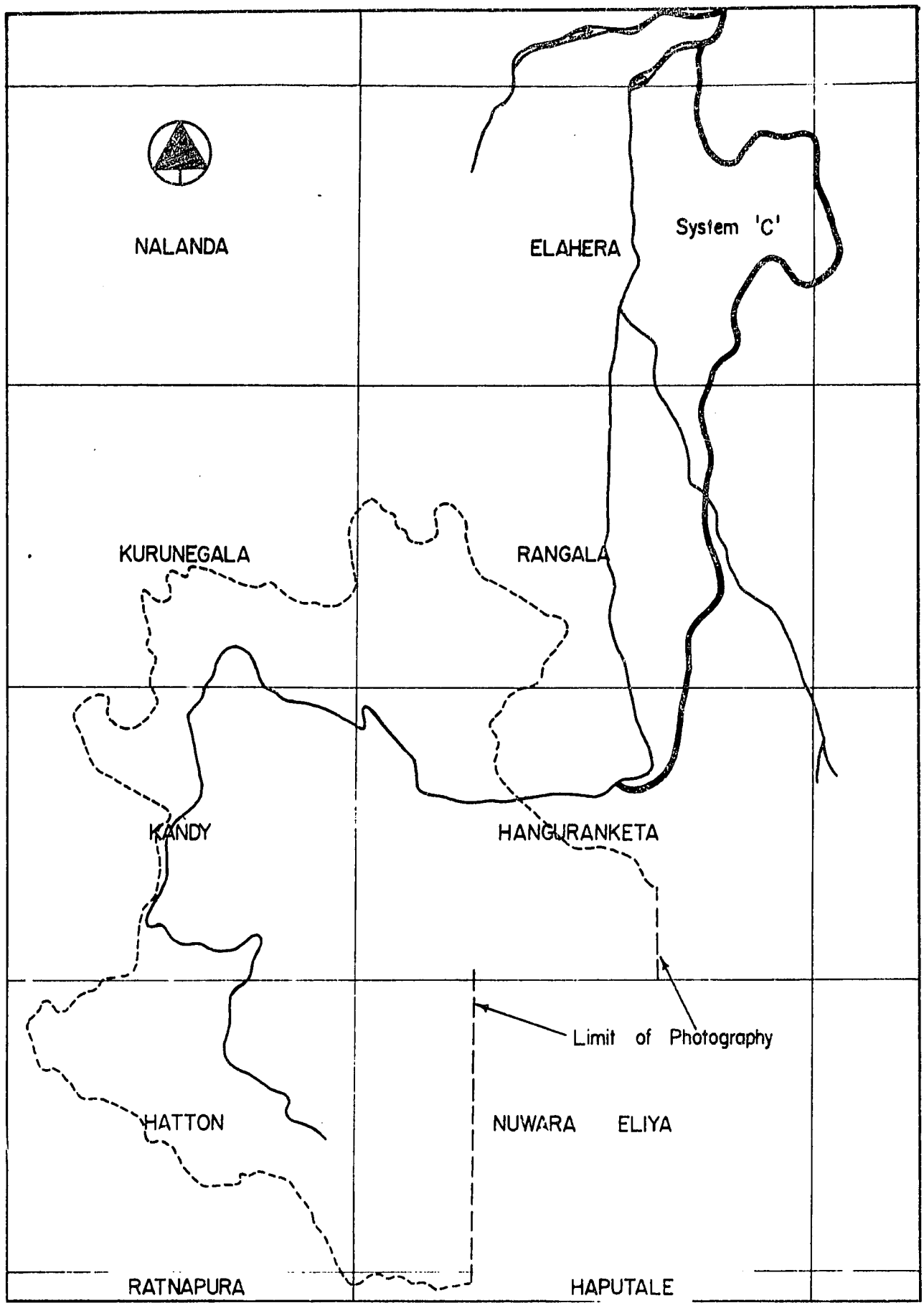

UPPER CATCHMENT BOUNDARY

FIGURE C-2

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Mapping Symbols - Land use typing was carried out using a generalized legend derived from the classification adopted by the Commission on World Land Use Survey, International Geographical Union. The classification used for the Upper Catchment is presented below:

1. Settlements and Associated Non-agricultural Lands
2. Horticulture
   - 2H Homestead Garden
3. Tree and Other Perennial Crops
   - 3C Coconut
   - 3Ca Cocoa
   - 3O Orchard
   - 3R Rubber
   - 3T Tea
   - 3Tm Poor Tea
   - 3Tx Abandoned Tea
4. Cropland
   - 4P Paddy
   - 4Pd Permanent Dry Cropping
   - 4S Shifting Cultivation (Chena)
5. Improved Permanent Pasture
6. Grassland and Scrubland
   - 6S Savanna or Patina
   - 6Sc Scrubland
7. Woodland
   - 7MW Medium Yield Wet Zone Forest
   - 7LW Low Yield Wet Zone Forest
   - 7NW Non Productive Wet Zone Forest
   - 7P Forest Plantation
8. Swamp and Marsh
9. Unused Land (Rock)

In addition to the land use symbols, a symbol for the slope was marked in each type. These slopes were calculated from the number of 100 foot contours per half inch on 1" = 1 mile topographic maps. The slope symbols are presented below:

1. Slopes less than 20 percent
2. Slopes between 21 percent and 40 percent
3. Slopes greater than 40 percent.

Final maps were traced from the topographic maps and the boundaries of the three principal soils groups were added. This completed a presentation of the data required to calculate the potential for erosion. The three soils groups are listed below in descending order of resistance to erosion.

1. Reddish Brown Latosols
2. Red Yellow Podzols
3. Reddish Brown Earths

The Class 3 soils also include Immature Brown Loams and Montane Regisols.

Compilation - To facilitate the compilation of the land use data the various land uses were grouped in three classes in descending order of erosion resistance as follows:

1. 2H, 3Ca, 3T, 4P, 7MW, 7LW, 7NW, 7P
2. 3C, 3O, 4Pd, 4S, 6S
3. 3Tm, 3Tx, 6Sc.

A dot grid was used to measure each land use type by slope, soil class and land use class. These areas were summarized for the catchment as a whole and are presented in the following section.

PRESENT LAND USE

Purpose

The purpose of the land use investigation in the Upper Catchment is to provide maps and written descriptions of man's activities on the land which have a relationship to soil erosion and soil conservation.

Description of Uses

The area may be described as having four major use groups; intensively managed agricultural land; unmanaged agricultural land; forest; and unused or misused land. The intensively managed lands comprise 49% of the area, of which two-thirds is under tea. Fourteen percent is under some form of dry land agriculture, 14% is covered by forest or forest plantations and 22% is unused or misused land, mostly scrub, chena, grassland and abandoned tea.

A summary of areas of each class of land use by soil type and slope class is presented in Table C-2. Descriptions of the land use classes in the Upper Catchment are presented in the following sub-sections.

1 - Settlement and Associated Non-agricultural Land

This category consists of the residential sections of towns and villages, military camps, air fields, industrial lands and botanic gardens. This class of land covers 5,400 hectares or about 2.2% of the area measured in the catchment. Most of this area comprises the towns of Kandy, Peradeniya, Campola, Hatton and Nuwara Eliya.

2H - Homestead Garden

This is a family residential unit, consisting of the homestead garden and fruit and other trees surrounding it. It can vary from a fraction of a hectare to several hectares, but the smaller gardens are more common. Most units are too small to map, so groups are delineated as a class of land use. These are mainly associated with a settlement, tank or patch of paddy.

The homestead gardens associated with paddy in the Kandian Plateau are most striking. These contain annual crops and a dense heterogeneous growth of food bearing trees such as coconut, arecanut, pepper, plantain, jack and breadfruit.

A total of 24,300 hectares of homestead gardens have been mapped in the catchment, amounting to 10.1% of the area.

Table C-2

Land Use Area Summary
(hundreds of hectares)

Land Use	Soil: Reddish Brown Latosols 0 - 20	Reddish Brown Latosols 21 - 40	Reddish Brown Latosols 41+	Red Yellow Podzolic 0 - 20	Red Yellow Podzolic 21 - 40	Red Yellow Podzolic 41+	Reddish Brown Earths 0 - 20	Reddish Brown Earths 21 - 40	Reddish Brown Earths 41+	Total	%
1	27			14			13			54	2.2
2H	89	6		8	7	*	121	12		243	10.1
3Ca	3						2			5	0.2
3T	1	15		19	473	2	4	213	1	728	30.4
4P	40			13			52			105	4.4
7NW	2	3		3	94	1	1	90	1	195	8.2
7LW					17			59		76	3.2
7MW	1				4		1	11		17	0.7
7P		*		6	11		1	17	*	35	1.5
Total	163	24		63	606	3	195	402	2	1458	60.9
3C	16	11		2	2		10	10		51	2.1
3O	2									2	0.1
4Pd	23	22		43	86		26	126	*	328	13.7
4S	*	*			34	5		84	*	123	5.2
6S		5	*	1	21	2	7	4	*	40	1.7
Total	41	38		46	143	7	43	226		544	22.8
3Tm		6			15			13		34	1.4
3Tx	4	12			33	2		25	6	82	3.4
6Sc	2	30	4	13	95	11	5	77	20	257	10.7
9								9	1	10	0.4
Total	6	48	4	13	143	13	5	124	27	383	15.9
Water	2			2			5			9	0.4
G.Total	212	110	4	124	892	23	248	752	29	2,394	
%	9	5		5	37	1	10	32	1		100

* Less than 50 hectares

3Ca - Cocoa

Cocoa is one of the minor land uses of the area comprising 500 hectares or 0.2% of the catchment. This crop is planted under a cover of shade trees and is difficult to identify on the photographs. Some cocoa also occurs in home gardens and under rubber. All of the cocoa mapped is located east of Kandy close to the Mahaweli River on the Pallekelly and Kundasalle estates.

3C - Coconut

This category, which accounts for 5,100 hectares or 2.1% of the area, includes only pure stands of coconut palm and does not include small patches associated with homestead gardens. Most of the coconut palm plantations were found in the same general area as the cocoa plantations.

3T - Tea

This category has been used to designate lands that are solely devoted to the cultivation of tea. This is the most extensive crop grown in the Upper Catchment and occurs mostly in large estates. In addition to this type of cultivation, there are numerous small holdings cultivated by farmers as a homestead crop. Where there are large groups of these small holdings they are mapped as tea.

Tea covers 72,800 hectares or 30.4% of the area of the catchment, mostly in the main body of the Central Highlands, with one less important producing area in the Kandian Plateau region.

3Tm - Poorly Managed Tea

This sub-category was mapped out to describe poorly managed tea lands which are still in production. They exhibit a sparse crown cover of tea bushes and show a pronounced breakdown in the terracing system and consequently are more susceptible to erosion. These areas cover 3,400 hectares or 1.4% of the area.

3Tx - Abandoned Tea

These areas still contain some bushes and distinct evidence of terracing, but are no longer in production and cover 8,200 hactares or 3.4% of the area. Both the poorly managed and abandoned tea lands are mostly found in the Kandian Plateau region. This is termed Mid-Country Tea, and the tea produced in this region has experienced poor market conditions for a number of years. The result of poor prices has thus reduced expenditures for maintenance on the estates. The High Country Tea has the most flavor and enjoys good market conditions in Europe, while the Low Country Tea has recently enjoyed a strong market in the Middle East because of its characteristically strong liquor.

3O - Orchard

This minor category includes a number of temperate climate fruit trees situated near Nuwara Eliya. They have an estimated area of 200 hectares or 0.1% of the Upper Catchment.

4P - Paddy

This includes both rainfed and irrigated paddy lands and are found in valley bottoms and terraced slopes throughout the catchment. Paddy land comprises 10,500 hectares or 4.4% of the catchment area.

4Pd - Permanent Dry Cropping

These areas usually occupy the slopes of hills and are laid out in more or less rectangular shapes. The technological level of agricultural practices is low, though some rotational cropping may occur. The crops include kurakkan, maize and other dry crops such as are found on chena lands. In recent times farmers have been producing more market oriented crops like vegetables, beans, gourds, chillies and tobacco.

Tobacco has been included in this category because it is impossible to recognize on the aerial photographs, and it is rotated with other crops at various times. There are about 4,000 hectares of tobacco being grown on the steep hillsides bordering the Mahaweli Ganga adjacent to the site of the reservoir for the Victoria Dam and in the vicinity of tributary streams to the river.

Permanent dry land cropping covers 32,800 hectares or 13.7% of the catchment area.

4S - Shifting Cultivation

This designation has been given to cultivated areas that are included in a system of land rotation called chena in Sri Lanka. Not only the lands that are currently being cultivated are mapped, but also those areas that have been cropped in the past and have reverted to brush or forest are included.

This is the most wasteful of land use practices. The cultivator cuts down all the larger trees in an area of forest and just before the onset of the monsoon rains burns the new chena lands. This reduces the grass and other vegetation to ash and removes competition of other plants with the planted crop. The burning removes the organic matter but does return a large amount of mineral matter to the soil for use by the crop. The growth of the crop is accompanied by a vigorous growth of weeds and grasses which compete with the crop, and this together with depleted soil fertility normally prevents a second year of cropping. This land is then abandoned and a new area of forest is selected for felling and burning, leaving behind a patch of land taken over by a worthless jungle of weeds, shrubs and trees. This practice yields very little agricultural produce, destroys timber values both present and future, depletes the soil and encourages erosion by removing the forest canopy.

Lands under chena in the catchment amount to 12,300 hectares or 5.2% of the area, most of which is found toward the eastern boundary on both sides of the Mahaweli Ganga.

6S - Savanna or Patina

This category includes both wet and dry pasture and Savanna grasslands. In the Upper Catchment it is mostly found on steep slopes at high elevations. The wet grasslands are found in the high plains. The Patinas have a natural growth of coarse grasses that are marginal for grazing. About 4,000 hectares or 1.7% of the catchment supports some form of grassland.

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6Sc - Scrub

Scrub is land with a scattered to dense growth of bushes. It is usually found after clear fellings in the forest or after chena cultivation. This wasteful use of land covers 25,700 hectares, or 10.7% of the catchment.

7 - Woodland

The categories of woodland have been given symbols describing their relative merchantable value and the zone in which they are found. For example, 7 MW signifies that it is a wet zone forest containing timber of average merchantability. Areas designated as 7 LW contain enough timber and firewood to permit a viable operation, and those labeled as 7 NW are nonproductive forest and have no economic value. The last category includes montane forest consisting of dense stands of short stunted trees growing at high elevations. It has no commercial value, but some species are suitable for specialized purposes. Details of volumes per acre by class can be found in the Forest Inventory of Ceylon (Andrews 1961).

Forest plantations are designated as 7 P. Some of the older plantations of mixed species may have been missed in photo interpretation because of the similarity of crown structure on adjacent natural forests, especially on steep slopes. The main species planted are eucalyptus, pine, cypress and acacia. Most of the planted forest occurs on Forest Reserves or at high elevations on the tea plantations.

The natural forest has been badly fragmented over the years because of the requirement for fuelwood by the villagers, tea factories and tobacco kilns. Construction timber has also been taken out from the forest on the Reserves and other public lands. In the mapped area of the Upper Catchment there are 82 patches of timber of less than 100 hectares, seven from 100 to 1,000 hectares and four that are larger then 1,000 hectares. The last mentioned are Forest Reserves. Most of the remaining timber in the catchment is above an elevation of 1,524 meters (5,000 feet) and in many places the timber has been cut to above the 1,829 meter elevation level.

There are 32,300 hectares of forest and forest plantation in the mapped area amounting to 13.6% of the total. The areas of each type are given as follows:

7NW	19,500 hectares	-	8.2%
7LW	7,500 hectates	-	3.2%
7MW	1,700 hectares	-	0.7%
7P	3,500 hectares	-	1.5%

9 - Unused Land

This category was used to map out extensive areas of rock, such as cliff faces and mountain tops that have been eroded clean after removal of the forest. Rock covers 1,000 hectares or 0.4% of the area.

Water

Though this 0.4% of the area is not a land use, it was included to round out the area measurement and comprises 900 hectares of lakes, reservoirs and wide portions of rivers.

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CHANGES IN LAND USE 1956 - 1979

Three map sheets of the land use study carried out in 1959 - 61 (Hunting Survey Corporation 1961) were located for making a comparison with this 1979 - 80 study. The same areas measured during the course of the latter study were demarked in the Kandy, Hanguranketa and Hatton land use map sheets of 1961. The area thus compared was 166,000 hectares, about 69% of the area mapped in 1979 - 80, or 53% of the Upper Catchment. The results of this comparison are presented in Table C - 3.

The most notable changes during this period were: the increase of the area of towns from 1,000 hectares to 4,000 hectares; the decrease in the area of intensive agriculture from 87,000 hectares to 63,000 hectares; and the reduction of the forest area by almost half.

The reduction of lands under tea by 15,000 hectares, a drop from 42% to 33% of comparable map area, has been accompanied by the development of 9,000 hectares of poor and abandoned tea lands as well as some conversion to dry land farming and scrub. The only intensive agricultural crop to increase in area during the period was coconut, which increased in area from 4,000 hectares to 5,000 hectares.

The reduction of the forest from 19,000 hectares to 10,000 hectares was also accompanied by a decrease in the value of the forest, the higher yielding types 7MW and 7LW being reduced from 8,000 hectares to 2,000 hectares. This is also an indication that the tree line is approaching the montane forest on the inhospitable thin soiled and precipitous mountain tops. The remaining good timber is located in inaccessible portions of four blocks of Forest Reserves. Plantation areas have remained almost static during the period, with the rate of new plantations equaling removals; however, as mentioned before, there may be a larger area at present than has been shown because of the difficulty of interpretation.

The 17,000 hectares of scrub presently mapped was not shown on the Hunting maps and represents the 9,000 hectates of forest cut, plus abandoned tea and some dry land farming areas.

SLOPE OF TERRAIN

About 24% of the area has a gradient of 20% or less. These flat to undulating areas are mainly found in the Kandian Plateau and in the Horton Plains plus some areas towards the eastern boundary along the Mahaweli Ganga. In general, the catchment is characterized by steep slopes, 74% of the region having slopes of 21 to 40%. Around 2% of the area was classified as over 40% slope and this consisted mainly of upper slopes and sharp mountain peaks.

SOILS

The soils were classified according to their erodability. The least erodable soil, Reddish Brown Latosols (Reddish Brown Lateritic Soils - Moorman and Panabokke, 1961) comprise 14% of the Upper Catchment. Red Yellow Podzolic soils and Reddish Brown Earths each comprise 43%.

Table C - 3

Comparison of Land Use

1958 - 1979

(Thousands of hectares)

Land Use	1958	%	1979	%
1	1	1	4	2
2H	20	12	14	8
3Cu	2	1	1	1
3C	4	2	5	3
3O	*		*	
3T	70	42	55	33
3Tm	-		3	2
3Tx	-		6	4
4P	15	9	7	4
4Pd	12	7	29	17
4S	12	7	12	7
6S	11	7	3	2
6Sc	-		17	10
7Nw	10	6	7	4
7Lw	6	4	1	1
7Mw	2	1	1	1
7P	1	1	1	1
	166	100	166	100

* Less than 500 hectares

SOURCE: Hunting Survey Corporation (1961); TAMS (1980).

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Red Yellow Podzolic

The predominant texture of the uneroded A horizon is either a sandy loam, sandy clay loam or loam. The structure is usually weak to moderate crumb or granular. The thickness of the B horizon is highly variable but usually more than one meter in profiles that have not been subject to much erosion. The clay content of the B horizon is usually higher than the A horizon with dominant textures being sandy clay loam, clay loam or clay. These well drained soils are the dominant soils of the wet zone of Sri Lanka. They are extensively used under a wide variety of crops with the upland regions mainly under tea. These soils require anti-erosion measures on the steep slopes.

Reddish Brown Earths

In these soils, the A horizon is usually less than 0.25 meters thick, with a texture of sandy clay loam or clay loam. Structures may be weak crumb or weak sub-angular blocky, or more often structureless. The texture of the B horizon is mostly clay loam or clay with a moderate sub-angular blocky structure. The C horizon consists of more or less decomposed parent material. Drainage is slow in the structural B horizon and without efficient weed control and tillage practices these soils are poor for agriculture in the wet zone and might best be used for forestry.

Immature Brown Loams

Included with the Reddish Brown Earths in the most erodable soil group are the Immature Brown Loams. These soils have an A horizon varying between 0.5 meters to 0.4 meters thick. The texture is sandy loam or loam and is usually rather light. The structure is moderate to strong crumb. The B horizon is predominantly sand loam or loam, with a weak crumb or weak sub-angular blocky structure. The C horizon is either decomposed rock or colluvium, and sometimes the B horizon rests directly on rock. These young soils are formed on surfaces that have been continuously exposed to erosion and are usually on steep slopes. Water retention is poorer than the Reddish Brown Latosols.

Montane Regisols

These soils, though of limited area, are also included in the above group. They are shallow soils without profile development.

IMPACT ANALYSIS

SOIL EROSION

Annual Soil Loss

In order to quantify the annual soil loss from the Upper Catchment, the Universal Soil Loss Equation (Wischmeier and Smith 1965) was adopted. This equation was developed to estimate soil losses over large areas for which there is very little measured data. The figures derived from the equation give orders of magnitude of losses and allow comparisons of the severity of erosion between areas, and between types of soil, a useful aid in setting priorities for remedial soil conservation work.

The equation is A = RKLSCP, where:

A = Annual soil loss per unit area
R = Rainfall factor
K = Erodability gradient factor
L = Length of slope factor
S = Slope gradient factor
C = Soil cover or crop management factor
P = Soil conservation practice factor.

Each of the factors in the equation has resulted from a great deal of research carried out in various places, and their numerical weights have been calculated in relation to the complex of forces that influence erosion.

A. The Soil Loss Per Unit Area - In the case of the Upper Catchment this is calculated in metric tons per hectare. This can be translated to cubic meters per hectare by dividing by 1.922.

R. The Rainfall Factor - This has been derived from an analysis of the soil erosive power of rainfall on various soils in Sri Lanka (Joshua 1977).

K. The Erodability Factor - This was calculated for evaluating soil erodability in Sri Lanka from soil properties such as particle size distribution, organic matter content, structural index and permeability (Wischmeier et al. 1977). The factors used were selected for each of the soil classes used in compiling the land use area data.

LS. Length of Slope and Gradient Factors - These factors were combined in order to take advantage of the Slope Effect Chart in the USDA "Procedure for Computing Sheet and Rill Erosion on Project Areas" (USDA Soil Conservation Service 1975). The two factors are combined as the soil loss is affected by both length and degree of slope. The chart had to be extended for the length of slope because of the long gradients in the Upper Catchment. Appropriate LS factors were derived for the three classes of slope used in compiling the land use data.

C. Cropping Management Factor - This factor was also taken from the USDA Bulletin. Values were selected as closely as possible to actual conditions found by field observations and photo-interpretation for crops, forest and scrub lands in Sri Lanka.

P. Erosion Control Factor - This factor accounts for control practices that reduce the erosion potential of the runoff by their influence on drainage patterns, runoff concentration and velocity. These practices include contouring, contour strip cropping and contour irrigated furrows. Terraces only reduce the length of slope. Since tea is the only major crop in the Upper Catchment with which intensive conservation practices are used and since this crop is so variable as to its susceptibility to erosion by reason of rotations of bare ground, young bushes, closed canopy and pruning, a factor of one was used.

Soil Loss Per Unit Area

The soil loss through erosion was calculated for the same parameters as used in the land use summary table; soil class, slope class and land use class. A summary of the annual loss in metric tons per hectare can be found in Table C-4.

It can be seen from Table C-4 that land uses comprising either well managed agriculture or dense forest cover suffer the least erosion even on the more erodable soils. It is also apparent that very heavy erosion occurs on land use such as scrub and abandoned tea on all soils.

Acceptable Rates of Erosion

The theoretical acceptable level of erosion is that at which the rate of soil loss and formation are balanced. This is difficult to recognize, so an alternative level has been adopted, namely, that at which soil fertility can be maintained for 20 to 25 years. A mean annual soil loss of 2 tons per hectare has been suggested for areas of more than 10 square kilometers (Morgan 1979).

Some other examples of estimates of annual losses that can be tolerated are: 2 - 11 metric tons/hectare in the USA, 13 - 15 tons per hectare on Volcanic Soils in Kenya, and 9 metric tons per hectare on Sandy Soils in Rhodesia (Hudson 1971).

Land uses in Class I in Table C-4 are within this general range of loss, the highest being on soil Class III on the steeper slopes, with a loss of seven tons/hectare. For the purpose of setting a tentative standard, a minimum acceptable soil loss of 10 tons per hectare appears reasonable as a target for the development of soil conservation practices and upgrading the level of land use in the Upper Catchment.

Total Catchment Erosion

The total volume of erosion for the catchment was calculated from the figures in Tables C-2 and C-4 and are shown in Table C-5.

Impact on Agricultural and Forest Productivity

Tables C-4 and C-5 show that 92,700 hectares, or 38.7% of the area of the Upper Catchment, are suffering extreme erosion, all well above the tentative standard of acceptable loss. The highest priority areas for soil conservation measures are Class III land uses comprising 15.9% of the catchment.

Table C - 4

Annual Soil Loss from Erosion
(Metric Tons per Hectare)

Land Use Class	Soil								
	Class I Reddish Brown Latosol			Class II Red Yellow Podzolic			Class III Reddish Brown Earths		
	Slope								
	0-20%	21-40%	41%	0-20%	21-40%	41%+	0-20%	21-40%	41%+
I	0.3	2	5	0.4	3	6	0.5	3	7
II	3	22	50	4	28	65	5	34	80
III	21	138	321	27	178	415	33	218	570

Land Use I 2H, 3Ca, 3T, 4P, 7MW, 7LW, 7NW, 7P

II 3C, 3O, 4Pd, 4S, 6S

III 3Tm, 3Tx, 6Sc

Table C - 5

Total Volume of Annual Loss Through Erosion
(Thousands of Metric Tons)

Land Use	Soil									
	Reddish Brown Latosols			Red Yellow Podzolic			Reddish Brown Earth			
	Slope									
	0-20%	21-40%	41%	0-20%	21-40%	41%	0-20%	21-40%	41%	Total
I	5	5	-	2	1818	21	9	125	1	1986
II	13	82	-	19	400	46	22	776	-	1358
III	12	660	55	35	2545	540	16	2709	1376	7948
TOTAL	30	747	55	56	4763	607	47	3610	1377	11,292

The aggregate annual soil loss from the mapped portion of the catchment of 11,292,000 tonnes (5,876,000m^3) represents a 5,900 hectare equivalent of productivity lost, calculated on the basis of 10 cm of top soil per hectare, or 1.85 cm depth of soil over the mapped area of the catchment.

SEDIMENTATION

Method of Estimation

Insufficient time was available to make a detailed estimate of such a large and geomorphological complex area as the Upper Catchment. However, a recent study on the Kotmale sub-catchment (Russell 1980) can be used to arrive at a reasonable range of values for sediment yield of the Mahaweli Ganga catchment.

The Kotmale catchment has an area of 62,000 hectares comprising one-fifth of the Mahaweli catchment. Because of a complete lack of monitoring on the Kotmale Oya, no sedimentation data were available, so a combination of geomorphological techniques were employed to derive approximate figures. The Kotmale basin was divided into three physiographic regions: a plain consisting of undulating hills with a relief of 100 meters and an altitude of 2,150 meters varying to 2,380 meters; an area of low hills with slopes of less than 250 meters; and a large section with steep slopes. Most of the soils in the catchment have high infiltration rates. The land use pattern is complex with paddy on the valley floors, home gardens on the slopes and tea and grassland on the higher areas.

The rates of sediment yield were determined using a formula derived by Russell (1980) from a modified version of an empirical relationship originally developed by Fournier. The formula was designed to determine suspended sediment yields based upon precipitation rates, basin height and basin slope.

The basin was divided into 26 sub-catchments and the modified Fournier formula applied to each. The Fournier values, when contoured on a map showing the minor catchments, ranged from 0 to 800 m^3/km^2/year. Values of below 100/ m^3/km^2/year were obtained across an area of the high and low surface regions. Values increase steadily as the gorge region is approached and reach maximum figures in excess of 800 m^3/km^2/year in the Katerwella massif.

A weighted average of 317 m^3/km^2/year was derived from the sediment yields, for the individual drainage units of the basin. This was modified by soil infiltration analysis which yielded a supply rate of 130 m^3/km^2/year. A final estimate of 180 m^3/km^2/year was considered as appropriate.

It would appear from the analysis of the Kotmale catchment that the slopes are on the whole less steep than the average for the whole Upper Catchment and that the slopes are considerably shorter. Infiltration rates do not differ markedly; however, the land use pattern of paddy, home garden, grass and forest appears to be close to the Class I land use in the remaining Upper Catchment. This would imply that the figure of 180 m^3/km^2/year would be far too conservative to apply to the Upper Catchment and that a more realistic figure might be about 300 m^3/km^2/year.

Impact of Sediment Yield on Kotmale and Victoria Reservoirs

Assuming a sediment yield of 300 m^3/km^2/year and a total catchment area of 3,160 square kilimeters, the total suspended load sediment yield would be 948,000 m^3 which should be increased by 10% for bed load to 1,043,000 m^3/year.

The volume of the Victoria Reservoir (Figure C-3) is estimated to be 720,000,000 m^3 (NEDECO 1979). The annual sediment deposit thus represents 0.14% of this volume. In comparison, the Kotmale Reservoir has an estimated annual volume loss of about one-half or 0.073%. The dead storage capacity for Victoria is 60,000,000 m^3 of which the annual sediment deposit represents 1.7%.

These calculations do not include streambank erosion. Work done on catchments in Northern California indicated that up to 55% of the sediment in rivers occur from streambreak erosion. No volumes are available for the Mahaweli Ganga drainage, and although sediment from this source is probably significant, it is probably not as high as 55%. The ratio between erosion and sediment yield in the reservoir is 1,042,000 m^3 ÷ 5,876,000 m^3 or 18%. This agrees with comparable work done in the U. S. A. which suggests that about 20% is an appropriate ratio (Russel 1980).

No account has been taken for the especially heavy erosion that can be expected from the steep lands adjacent to the reservoir presently under crops of tobacco and with few conservation measures. These lands were classified as 4Pd, dry land agriculture in land use Class II instead of Class III because of the difficulty of photo interpretation.

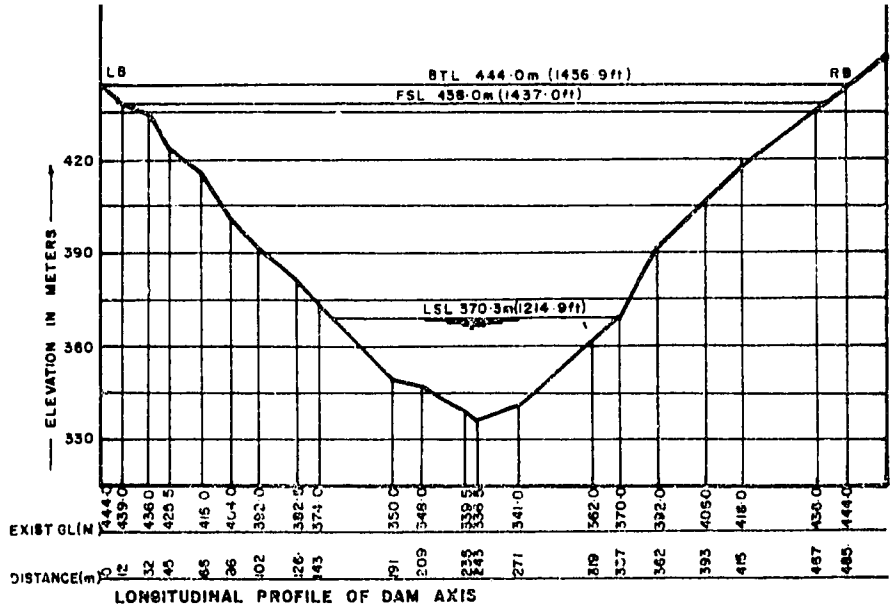
Detailed field examinations of tobacco lands adjacent to the Victoria Dam site indicate severe erosion problems as shown in Table C-6.

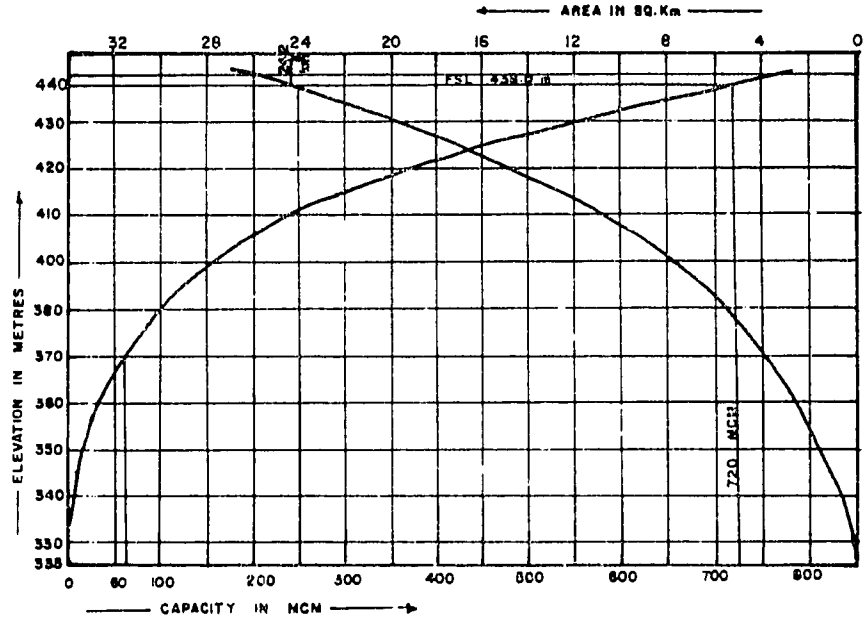
The calculation of total erosion and sediment yield applies to the mapped area of the catchment or 76% of the total, and is thus conservative. However, it does not take into account the sediment that will be trapped in the Kotmale Reservoir either. It is assumed that these will balance. More accurate estimates can be made in the future with full coverage of photography and more intensive land use studies. These estimates of soil loss are much higher than the catchment averages, since the cultivation of tobacco requires that the soil be bare and is thus subject to severe erosion.

Overall, it appears that sedimentation will not interfere with efficiency of either the Kotmale or Victoria Reservoirs in the short run. The effective operating life of these reservoirs should not be impaired at all for well over 50 years.

However, neither sufficient aerial photography nor baseline sediment load data are available to make a thorough assessment of the potential effects of sedimentation on the other major proposed reservoirs. However, the Victoria Reservoir will effectively trap a large amount of sediment which would otherwise enter the Randenigala Reservoir. Similarly, these upstream reservoirs will limit sediment from reaching the Ulhitiya Oya and Maduru Oya Reservoirs.

In summary, present information indicates that the proposed reservoirs for the Accelerated Program should not be significantly adversely affected by the accumulation of sediment. However, experience has shown that if left





AREA — CAPACITY CURVES

SOURCE: NEDECO (1979)

STORAGE CAPACITY OF VICTORIA RESERVOIR

FIGURE C-3

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Table C - 6

Annual Soil Loss Maha Oya Catchment on Tobacco Land

	Location	Sub Watershed	Soil	Slope	Soil Loss T/Ha/Annum
1.	Mailapitiya	Maha Oya	RBL	45	388
2.	Mailapitiya	Maha Oya	RBL	55	486
3.	Mailapitiya	Maha Oya	IBL	50	719
4.	Mailapitiya	Maha Oya	IBL	30	308
5.	Mailapitiya	Maha Oya	IBL	40	514
6.	Moragahamulla	Maha Oya	IBL	35	411
7.	Kande Junction	Maha Oya	RYP	60	913

RBL = Red Brown Latosol

IBL = Immature Brown Loam

RYP = Red Yellow Podsolic

unchecked, the rate of erosion will keep accelerating, and this certainly will be the case if the steady deterioration of land usage in the Upper Catchment is not arrested.

RECOMMENDED ACTIONS

NATURE OF SOIL CONSERVATION MEASURES

Agriculture

Tea is the most important crop in the highland wet zone. When well managed, tea plantations do not suffer from severe erosion; however, there are possibilities of improving techniques of weeding, infilling and replanting to further minimize erosion.

Because of good steady market prices as much land as possible should be kept under tea, and only when the soil has been degraded by erosion or for some other reason production is too low to provide adequate net revenues, should the estates be converted to other crops. The tea Master Plan (H. M. Associates 1979) was based on the policy of expanding production and indicates the improvement in financial benefit from using clonal varieties, infilling, fertilizer application and factory modernization.

For the large areas of abandoned and poorly managed tea, grassland and scrub tree crop diversification is showing good results. A recent study (UNDP/FAO 1979) has resulted in the formation of the Agricultural Diversification Division (ADD) of the Ministry of Agriculture which negotiated investment funds from the World Bank. The National Agricultural Diversification and Settlement Authority (NADSA) was created as the implementing agency. The purpose of this body is to broaden the agricultutal base by increased diversified total value of agricultural production while simultaneously improving land use techniques, soil fertility and soil conservation.

The immediate objective has been to rehabilitate degraded tea land for sub-division and settlement or forestry. The Janatha Estates Development Board and the State Plantation Corporation have turned over parts of estates to NADSA for rehabilitation and tree crop diversification in the Nilambe Atabage catchment south of Gampola in the Upper Catchment. Another World Bank sponsored project on tea crop rehabilitation is being carried out south of Hatton on both sides of the height of land. See Figure C-4.

The tree crop diversification scheme involves settling families on 2.25 acres of degraded tea land for the purpose of growing mixed crops of jack, breadfruit, cardamons, pepper, etc. Out of 5,000 people initially planned to be settled, 1,000 are now working under the scheme. The total area of the forest phase is 4,960 hectares (12,250 acres). It appears that this type of redevelopment could be used on suitable lands requiring rehabilitation throughout the catchment.

Cattle farming also has a place in the Upper Catchment on areas of grassland or on poorly managed dryland farming. These would require introduction of improved species of grass. A thorough study of this activity will be required before it can be adopted.

Various areas of the catchment are suitable for other tree crops such as citrus, apples, avacado, pears, cacao and coffee and a number of spices.

Forestry - Natural Forest

The natural forests in the Upper Catchment have been reduced far below the minimum for the control of runoff. In many cases, forests have been cut far above the 1,524 meter (5,000 feet) level and a large proportion of the erosion on the Upper Catchment can be attributed to this. It is recommended that further cutting in any natural forest in the catchment be prohibited.

Plantations

There are three types of plantation work required to prevent soil erosion in the catchment: protection, fuelwood and timber.

Protection - Erosion control plantations are established on steep slopes abutting the present timber line and on ridges and mountain tops where there is sufficient soil remaining to sustain them. This type of plantation is also necessary in gallop and ravines in steep areas on tea estates. Plantations should be established along streams and rivers to help prevent erosion of the banks and in strategic locations to form windbreaks. Plantations for this purpose should never be cut.

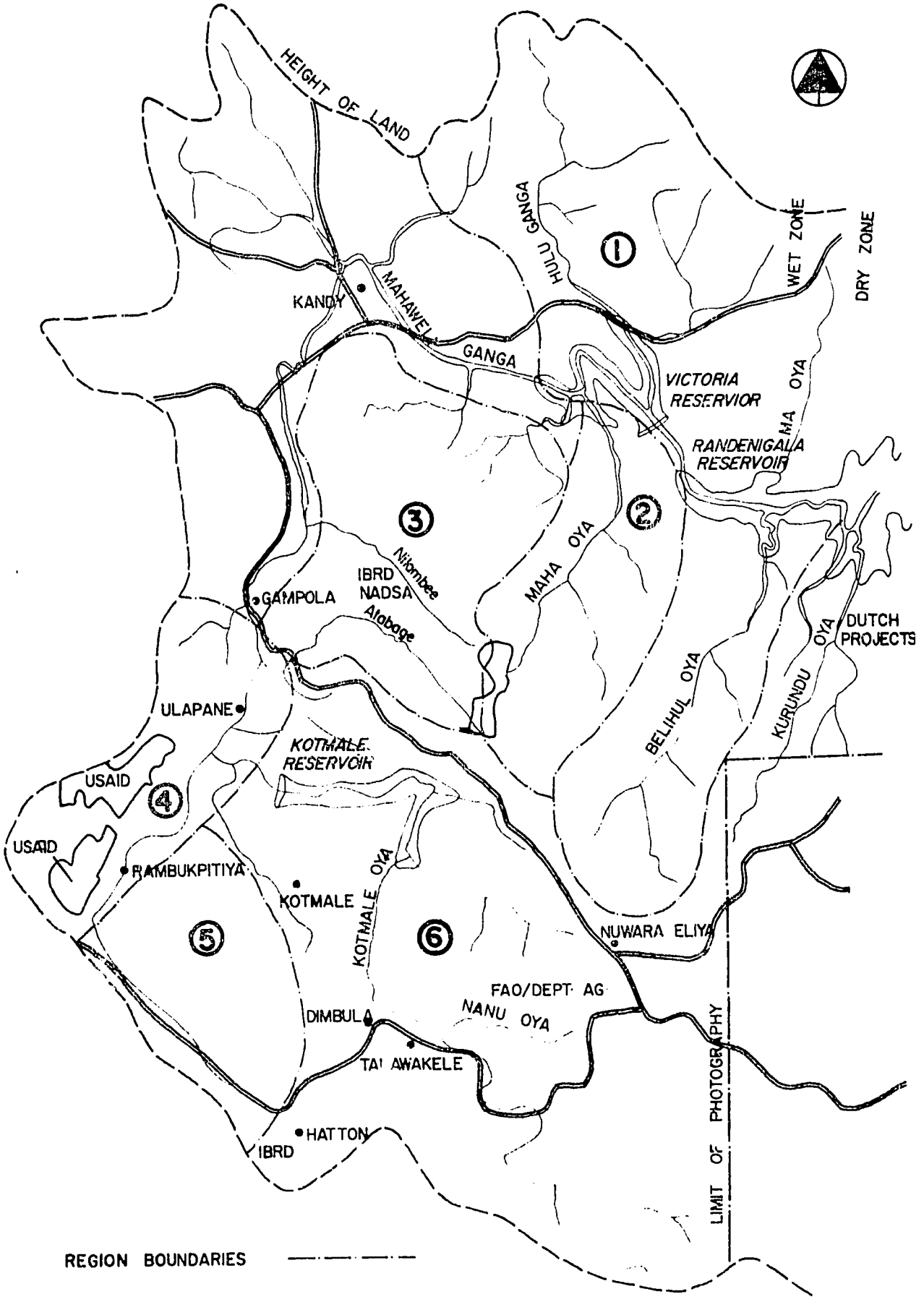
Fuelwood - Since the natural forests have been largely removed, an increasing shortage of fuelwood is being experienced in the Upper Catchment. Transportation costs for fuelwood are too high to move it economically for any distance over 20 kilometers, and ideally it should be located within walking or bicycling distance of the consuming centre. To overcome this problem, small plantations should be established close to each community. The size of the plantation can be calculated from the number of people. The Forest Department estimates that the consumption of fuelwood per year is 0.57 cubic meters per person assuming a family of five persons (Vivekandan 1980). They also estimate that fuelwood plantations of eucalyptus and casuarine species will yield 140 m^3 per hectare in 10 years.

The population of the Kandy and Nuwara Eliya Districts was 1,638,203 in the 1971 Census (Department of Census and Statistics 1974), and the rate of increase between 1963 and 1971 was 1.7%. Using this rate of growth, the population of the two districts will be about 2.5 million in 1990. The districts are subdivided into 95 town wards and a number of District Revenue Offices and Grama Sevaka Divisions. There will be an average of 4,380 persons per community requiring 1,226 m^3 of fuelwood annually. Plantations averaging 8.75 hectares would provide the community requirements and this would amount to 4,500 hectares of plantations to be planted annually in the Upper Catchment.

Since most of the areas in the regions requiring redevelopment are remote from the main population concentrations it is suggested that only 2,000 hectares of this area be replanted with fuelwood. The remaining 2,500 hectares of fuelwood should be located on small patches of poor agricultural land near settlements. The settlement area plantations may be reduced in size by planting the faster growing ipil ipil in locations below 3,000 feet elevation.

Timber - The area of timber to be planted each year has to be integrated into the overall planting program for the island because of limitations of budget and personnel.

The USAID plantation program in cooperation with the Forest Department specifies that 1,215 hectares are to be planted every year for 5 years. These



REGION BOUNDARIES AND AID PROGRAMS

FIGURE C-4

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plantations are located near Dolosbage and Rumbukpetiya in the Upper Catchment (See Figure C-4).

The Forest Department is also cooperating with NADSA and plans to plant 1,500 hectares in 1980.

Timber plantations must be planted in large contiguous areas in order to make them convenient for forest management. This includes: protection from fire, theft and damage; improvement cutting; thinning; pruning where necessary; and economical logging. The establishment or conversion of villages to a forestry oriented employment base located within or near the plantations would provide obvious benefits in the development of a competent permanent work force familiar with the above mentioned management practices.

Unlike plantations for erosion protection and fuelwood, lands choosen for timber plantation should be fertile and not too seriously eroded. Just as agricultural crops require a good site for productivity, so do forest crops, and it appears they will be just as valuable and necessary to the economy in the near future.

The Forest Department has done considerable area testing of new species and provinces for plantations. Many of these species, shown in Table C-7, should be used in the large plantations in the Upper Catchment.

Engineering Works

In conjunction with cultured control, a variety of engineering works will be required to control erosion and conserve soil. The major works will be designed to control the flow of water such as stone and bench terracing, bunds, paved waterways, river bank stabilization, ditching, culverts, detention reservoirs and ponds, and check dams. Some work will have to be done by way of stabilizing hillsides prone to landslides along railways, roadways and reservoirs, by cribbing and shoring.

REDEVELOPMENT RECOMMENDATIONS

In addition to the above general recommendations, it is recommended that 7,000 hectares be planted per year in the Upper Catchment for soil conservation, including 2,000 hectares of fuelwood and 3,000 hectares of timber plantations. In addition 2,000 hectares should be developed under diversified agriculture.

An integrated watershed management plan is required and in order for it to be carried out in an efficient manner, a unified central coordinating and control body must be established. It is recommended that a Redevelopment Corporation be established under new legislation embodying a Master Plan of operations. A design for legislation and the proposed Redevelopment Corporation is presented in the following sections.

UPPER CATCHMENT SOIL CONSERVATION PLAN

Objectives

In order to control the ever increasing erosion in the Upper Catchment an organized program with a master plan for soil conservation and redevelopment is required. A single organization is necessary to control, coordinate

Table C-7

Forest Plantation Species Recommended

Purpose	Species	Rotation Age	Status
Protection	Pinus carabeal bahamensis		Proven
Fuelwood	Eucalyptus grandis	10	Proven
	Eucalyptus tobusta	10 - 5	Proven
	Eucalyptus torreliana	10	Proven
	Acacia mangium	5 - 13	Trial
	Acacia auriculiforms	5 - 6	Trial
	Acacia decurrens	10	Proven
	Acacia melanoxy	10	Proven
	Caliandra callothysus	3 years	Trial
Timber	Gmelina arborea	15 - 30	Proven
	Ailanthus excels	15 - 20	Proven
	Albizia falcataria	10 - 15	Proven
	Melia composita	20 - 30	Proven
	Pinus carebaea SPP	30 - 50	Proven
	Melina arborea	15 - 20	Proven
	Eucalyptus robusta	35 - 50	Proven
	Pinus carabeae (privinence)	30 - 50	Trial

Source : Vivekandan(1980)

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and manage the area as a unit. At present a large number of government organizations are conducting projects scattered about the catchment and in adjacent upland areas with similar problems. There are over a dozen laws with clauses covering various aspects of conservation and the use of land, all of which embody compulsion and have aspects of a punitive nature.

The objectives of this Master Plan are soil conservation and the control of erosion. The steps to be taken to achieve this objective are:

- Improve soil conservation legislation to enable the management organization to carry out its function effectively;
- Establish the nature of an organization to control, coordinate and manage the redevelopment of the Upper Catchment;
- Define the nature of soil conservation measures;
- Establish a schedule of priorities for redevelopment, sub-catchment by sub-catchment;
- Establish a time schedule for organization and operation of the Plan;
- Outline marketing information necessary;
- Estimate personnel and training required;
- Estimate the magnitude of costs involved; and
- Establish areas of development compatible with foreign aid and local and foreign investment.

History of Soil Conservation in the Mahaweli Catchment

A summary of the history of conservation in the Upper Catchment was prepared by a committee chaired by W. R. H. Perera, the then Conservator of Forests, and published in 1978 (Perera 1978). This was a multi-disciplined committee and their recommendations covered the subjects of agriculture, forestry and settlement.

The problem of erosion was considered important by the government and included in a decision of the cabinet under the Post-War Development Proposals in 1946. In 1947 heavy downpours in the central highlands caused severe floods and extensive damage which caused concrete consideration of the problem and resulted in the setting up of the Soil Conservation Division in 1950 and the passing of the Soil Conservation Act No. 25 of 1951 (Government of Sri Lanka 1951) under the Department of Agriculture. The main types of activities of this division are investigations of erosion problems, planning and programming soil conservation projects and providing technical assistance.

Soil conservation work has been mainly concentrated on those parts of the hill country that has been declared "erodable areas" under the Soil Conservation Act. They comprise the Upper Catchment of the Mahaweli (above Minipe) and the Kelani (above Kitulgala) which covers the Nuwara Eliya and Kandy Districts.

Institutions Affected by Land Use

Erosion control and soil conservation will concern the interest of private landholders and a large number of government organizations including:

1. Agricultural Department
   - Agricultural Diversification Division
   - Agricultural Planning Unit

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- Soil Conservation Department

2. Land Commissioners Department
3. National Agricultural Diversification and Settlement Authority
4. Janatha Estates Development Board
5. Sri Lanka State Plantation Corporation
6. Land Reform Commission
7. Land Development Department
8. Plantation Ministry
9. Minor Export Crops Department
10. Forest Department
11. Wildlife Department
12. Tea Commissioner's Department
13. Coconut Development Board
14. Land Commissioner's Board
15. Irrigation Department
16. Electricity Board
17. Public Roads Department
18. Ceylon Tourist Board
19. Local Government Department (Municipal, U.C. and T.C. Kandy)
20. Town and Country Planning Department
21. Agricultural Development Authority
22. Survey Department
23. Ministry of Education
24. Public Works Department
25. Department of Health.

National Considerations

The rapid deterioration of the production capacity and the severity of erosion in the Upper Catchment can in no small measure be attributed to the lack of cohesive and defined policy towards its management. The uncoordinated and unplanned efforts of a large number of diverse organizations has been proven to be unequal to the task of maintaining productivity and controlling erosion. For this purpose, a single competent authority operating under a clear policy and with a detailed management plan is required.

The objectives of soil conservation, curtailment of erosion and increased agricultural productivity can be accomplished to a satisfactory degree with determined effort within a relatively short period of time. However, given the terrain and rainfall pattern in the Upper Catchment, soil conservation measures will continue indefinitely. In any case, the major redevelopment could be completed in 10 years. By that time general economic conditions would have changed, and the government may find that different institutional arrangements may be more appropriate to carry out their soil conservation policy.

On the national level, it is suggested that a consolidation of the powers and responsibilities of a large number of agencies could effectively provide more efficient management if they were concentrated into a fewer number of departments, each administering a compatible grouping of functions. In the case of soil conservation, perhaps a Coordinating Agency for Natural Resources should be established comprising the Departments of Soil Conservation, Forestry, Wildlife, Parks and the Division of Land and Water Use plus the State Timber Corporation. Under such a grouping in a single agency, each of these departments would assume their rightful share of importance to the wellbeing of the country. Until

now, they have been tacked on to large and powerful Ministries without receiving an equivalence in funding with other departments or divisions.

It is thus suggested that when the competent authority has accomplished its major task of redeveloping the Upper Catchment its powers can be relegated to suitable departments and the staff of trained and experienced people can be allotted to the departments concerned.

SOIL CONSERVATION LEGISLATION

Principles Involved

Inherent in legislation which encourages positive action, such as in changing present land use, lie the principles of compulsion and penalty. However, these should be considered as a last resort and emphasis placed on an enlightened self-interest engendered by public information, aggressive extension service, financial help and technical and mechanical assistance.

Another principle embodied in compulsive legislation is that of expropriation of land from persons that have failed to carry out actions prescribed under the law, such as increased productivity or soil conservation practices. This can be either temporary, under which a designated organization carries out the work and returns control of the property after compensation for costs is assured, or permanent, with title of the land being vested in the state. These two actions should also be avoided if possible as it would spawn a multiplicity of organizations managing small tracts of land, all of which in turn would have to be supervised.

The prime consideration of the legislation is to induce individual or corporate owners to practice good conservation and to increase agricultural productivity with state help and guidance and without the state having to take responsibility of ownership or management of the property.

Summary of Present Legislations

The three principal Acts dealing with soil conservation and agricultural productivity are the following:

1. Soil Conservation Acts No. 25 of 1951 and 27 of 1953 (Government of Ceylon 1958)

   This is called, "an Act to make provision for the conservation of soil resources, for the prevention or mitigation of soil erosion and for the protection of land against damage by floods or drought."

   Under this Act, the Director is charged with surveys to indicate the nature and extent of soil erosion and thus enable the Minister to determine the areas to be gazetted as an erodable area. The Minister may make regulations applicable to all erodable areas or to a specific area. These regulations require the owner of land to take measures to prevent or control soil erosion including reforestation of sources and banks of streams. It includes measures restricting cattle grazing, restriction of

the use of fire and authorization for designated officers to give directions as to changes in crop or cultivation practices. A further regulation deals with cambering and cross draining of government roads and the control of scouring of drains and water-channels.

Any person who does not comply with the regulations or follow the instructions of a designated officer is guilty of an offense and liable to a fine. The owner of the land is interpreted to include a lessee or mortgagee of the land.

2. Agrarian Services Act of 1979
(Government of Sri Lanka 1979)

This is an "Act to provide security of tenure to tenant cultivators; to specify the rent payable by tenant cultivators to landlords; to provide for maximum productivity of paddy and other agricultural lands through the proper use and management of agricultural crops and livestock; to provide for the establishment of Agrarian Services committees; to provide for the determination of tenurial and other disputes relating to agricultural land by the Commissioner of Agrarian Services, to confer and impose certain powers and duties on the Commissioner; to provide for the appointment of cultivation officers; to provide for the repeal of the Agricultural Productivity Law, No. 2 or 1972 and the Agricultural Land Law No. 42 of 1973, and to provide for matters connected therewith or incidental thereto."

Part III of this Act provides for the efficient cultivation of agricultural land, and states that it is the duty of the owner or occupier of the land to farm the land with the crops or breeds of cattle most suitable to the land and manage it according to the rules of good management as defined by the law. The owner or occupier must use methods of cropping in a manner to maintain the land fertility and maximum conservation of soil and water. He must carry out maintenance and repairs, take steps to protect and preserve the crops from damage, and establish proper drainage.

If the owner/occupier fails to fulfill the obligations of the law he is guilty of an offense. When the Minister is satisfied that any agricultural land is not being managed according to the law he can place the owner or occupier under a "Supervision Order." If the land management does not improve under supervision, the Minister may make an order of dispossession. The Law also stipulates the formation of Agrarian Services Committees whose function is the coordination of agricultural activities and their implementation according to the agricultural policies of the government under the direction of the Commissioner. They have the power to hold, take or give on lease, mortgage, pledge, sell or otherwise dispose of any moveable or immoveable property.

The Commissioner shall, for the purpose of hearing or deciding any dispute referred to him under this Act, have all the powers of a District Court. The Minister may make regulations to implement the matters required under this Act. Any person who contravenes this Law or its regulations is guilty of an offence.

3. Forest Ordinance No. 16 of 1907, Act Nos. 34 of 1951, 49 of 1954 and Forest (Amendment) Act No. 56 of 1979

This is called, "an Ordinance to consolidate and amend the Law relating to Forests and the felling and transport of Timber." (Government of Sri Lanka 1908).

Under this Law the Minister may, by order, declare any lands to be reserved forest. Prohibited acts in a reserved forest include trespass, permitting cattle to trespass, hunting or fishing, making any fresh clearing, setting fire to the forest, or felling any tree, clearing for cultivation, and constructing roads or buildings. To contravene the law is an offence punishable by fine or imprisonment. However, permission may be granted by a Forest Officer to carry out some of the above activities with a permit under the regulations to the Ordinance.

The Minister may, by order, establish any portion of a forest a Village Forest and prescribe regulations as to how the villages may obtain forest products from it. Some species specified in a schedule are decreed to be reserved trees and may not be cut or otherwise injured except with a permit. Other national forests may not be cleared or felled without a permit.

The Minister may make regulations respecting the transit of all forest produce by land or water and issue passes that must accompany forest products in transit.

A Reserved Forest also includes plantations, forest depots, and chena planted with forest trees.

Other laws pertaining to the control of land and soil conservation are:

- Land Acquisition Act No.9 1950 (Government of Sri Lanka 1950). Land can be acquired by the government for public purposes.
- Land Grants (Special Provisions) Act No. 43 of 1979 (Government of Sri Lanka 1979)

  This act provides for the transfer of lands from the Land Reform Commission in order to be able to transfer these lands to landless persons. The conditions of transfer include the stipulation that the transferee must carry out soil conservation measures specified by the Government Agent.

Proposed New Law

The proposed new Law as written in this report is a list of items considered for inclusion in new legislation, and no attempt has been made to put it in legal language or specify any penalties for contravention. It may, in fact, be possible to use various components of this new law to amend existing legislation to attain the desired results.

Mahaweli Catchment Redevelopment Law

A law to make provision for the conservation of soil resources, for the prevention or mitigation of soil erosion, for the rehabilitation of unproductive lands, for the productive use of land for agriculture or forestry; to provide for the establishment of the Mahaweli Catchment Redevelopment Corporation.

Part I

1. This Law may be cited as the Mahaweli Catchment Redevelopment Law.
2. It will be the duty of the Corporation to cause surveys and investigations to be made for the purpose of the preparation of land capability maps, ownership maps and a Master Plan.
3. For the purpose of carrying on investigations or surveys of properties it will be lawful for any officer of the Corporation with authorization in writing in the form of an identification card with the photograph of the bearer, to enter and inspect any land at any reasonable time together with such other persons he may require to carry out his investigations.
4. The Corporation will prepare a Master Plan to be used as a basis for its activiites and which will:

    a. Specify the area requiring redevelopment;
    b. Specify type of redevelopment most suitable;
    c. Make provision for resettlement where desirable;
    d. Specify crops to be planted;
    e. Specify agricultural methods and management required;
    f. Specify soil conservation measures to be taken;
    g. Make provision for losses and provide financial assistance.
    h. Coordinate all public, private and foreign bodies working in the area;
    i. Stipulate the agencies or persons who will be required to carry out the plan under the direction of the Corporation; and
    j. Include an annual budget with the stipulation of the sources of funds for each activity under the Plan.
5. The Plan when it is approved by the Board of Directors of the Corporation will be deemed to form a part of this law.
6. When a property is scheduled to be redeveloped under this law an officer of the Corporation will visit the owner or occupier or both and show him the Master Plan as it applies to the property, explain what is proposed to be done, elicit an opinion, and explain the benefits of the proposed changes to him. He

will also explain the methods to be followed; assistance to be provided; and the cooperation that will be required.

7. Upon failure on the part of the owner or occupier to cooperate, the land shall be taken over under a Supervision Order by the Corporation and the land will be redeveloped in a manner shown by the plan.

8. The costs of redevelopment will be apportioned between the Corporation and the owner in an equitable manner (although it is recognized that many owners may have insufficient capital).

9. The costs attributed to the owner can be recovered over a reasonable period of time from benefits accruing to the owner as a result of redevelopment.

10. Where an owner suffers a loss through redevelopment he is entitled to compensation to be awarded on the basis of the established criteria under the Agrarian Services Act No. 58 of 1979.

11. On dissatisfaction with the compensation award, the owner may appeal to the Courts in the normal manner.

12. If after redevelopment the owner or occupier does not manage the property in a manner consistent with achieving the aims of this Law with respect to soil conservation and productivity, and after two warnings delivered personally by officers of the Corporation, the land may be again placed under a Supervision Order and be managed by the Corporation.

13. If after the land is under management by the Corporation for a period of six months and the owner is unwilling or unable to manage the land according to the Plan, it may be confiscated by the Corporation.

14. All felling of natural forest or tree growth above an elevation of 1,525 meters (5,000 feet) is prohibited. Contravention of this section is punishable by fine or imprisonment.

15. All plantations of forest trees are to be regarded as Forest Reserves following the definition of the Forest Ordinance No. 16 of 1907.

16. No one shall cut or otherwise interfere with a forest plantation without a permit issued by a Forest Officer and the activity carried out under the direct supervision of Forest Department personnel.

17. The activities of the public corporations, government departments and other agencies on areas coming under the jurisdiction of the Corporation will be coordinated under the provisions of the Master Plan.

Part II

Establishment of Mahaweli Catchment Development Corporation

18. A Corporation to be called the Mahaweli Catchment Redevelopment Corporation is hereby established.

19. The Corporation shall be a body corporate and be capable of acquiring, holding and alienating property movable and immovable, and of carrying out its business in the manner of any body corporate.

20. The head office of the Corporation will be at Kandy.

21. The general supervision, control and administration of the affairs of the corporation will be vested in the Board of Directors of the Corporation.
22. The Corporation is, subject to the provisions of this Law, to organize and transact the various kinds of business specified in section 29.
23. Ministries of Agriculture, Plantation and Lands and Land Development will provide representatives to the Board of Directors of the Corporation.
24. The government may nominate five other members of the Board in addition to the Ministry representatives.
25. The Chairman of the Board shall be elected to the Board from amongst their members.
26. A meeting of the Board will be held as often as may be necessary but at least once a month.
27. Funds for the Corporation will be advanced from the Consolidated Funds and additional sums may be granted by Parliament.
28. The Board shall have the power to appoint the General Manager, Managers, Secretary and Accountant.

Part III

Business of the Corporation

29. Subject to the provision of this Law, the Corporation is authorized to carry on and transact business hereinafter specified:

    a. To prepare a Master Plan for the redevelopment of the Mahaweli Catchment.
    b. The Catchment is defined as the Mahaweli Watershed bounded by the heights of land on the North, West and South and by the wet zone boundary on the East.
    c. To administer and develop the catchment under the Master Plan.
    d. To negotiate loans or other financial aid to persons or bodies to construct work or carry out activities required by the plan, through the Agriculture and Industrial Credit Corporation (Government of Sri Lanka 1956).
    e. To undertake works or activities required by the Plan.
    f. To manage lands placed under a Supervision Order.
    g. To coordinate all the various corporations, public bodies and other agencies in their activities according to the Master Plan.
    h. To actively carry on a campaign of Public Information about redevelopment of the catchment.
    i. To develop an effective extension service, coordinated through existing government agencies.
    j. To develop a marketing organization within the Corporation to take regular market surveys, national and international for the products of the Mahaweli Catchment and adjust planting policy accordingly. This organization will undertake the sale or marketing of produce inadequately serviced by other organizations.

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k. To own or lease buildings, own or lease and operate machinery, buy agricultural chemicals, operate nurseries, engage in research and carry out any other activity on the furtherance of the objectives of the Master Plan.

Article IV

30. The Board may make rules with respect to the following:

a. The powers, duties and functions of officers and employees of the Corporation.
b. The forms to be used by the Corporation.
c. Any other matters necessary for the conduct of business.

ORGANIZATION OF REDEVELOPMENT CORPORATION

The administrative and organization responsibilities of respective sectors of the proposed Redevelopment Corporation are presented in Figure C-5. The following describes specific functions for the sectors:

General Manager - Chief executive officer of the Corporation reporting to the Board of Directors.
Secretary - Heads the service divisions and is responsible for the financial control of the corporation.
Assistant General Manager - Master Plan - This AGM is responsible for developing the Master Plan, keeping it up-to-date and revising it when necessary.
AGM - Marketing - This officer conducts marketing surveys for the various crops produced in the catchment to determine if the volume produced will adversely affect the price. Suggest crops enjoying a stable market and good prices, establish a marketing agency for products not adequately serviced by present organizations.
AGM - Operations - The operations department is composed of the following divisions, some of which will largely serve in a coordination role for other government agencies:

- Surveys and Mapping - This department is responsible for land use, soils and land capability maps prepared from photo-interpretation and ground work. They also monitor sediment in the rivers at strategic locations and monitor auxiliary meteorological status.
- Extension and Public Education - This department prepares and disseminates in the media, schools, churches, and social clubs explanatory information about the Master Plan, concerning its necessity and the benefits expected. The extension service representatives will visit individual land holders to explain the program preparatory to work on their properties. This division also coordinates the activities of private, public and international bodies working in the Upper Catchment.
- The Agricultural Department coordinates agriculture diversification schemes and indicates to other government departments the work to be done on their lands. It assists the Forest Department in plantation work, and manages land taken

over under supervision orders.

- Financial Aid - This department organizes financial support for persons to carry out work under the plan. This takes the form of credit, loans or other suitable arrangements.
- Mechanical Operations - This department operates, runs and coordinates the machinery, equipment and vehicles necessary for building roads, erosion control and other measures. It also maintains equipment, allocates and plans the work, and is responsible for training machine and vehicle operators.

REDEVELOPMENT SCHEDULE

Division Into Regions

The Upper Catchment can be divided into six regions of high priority in order to concentrate and organize redevelopment work. The order of priority is based for the first five regions on their proximity and opportunity for direct sedimentation into the reservoir at Victoria, and the sixth is the catchment of the Kotmale Oya (Figure C-4).

Priority Region 1 is the catchment of the Hulu Ganga which empties directly into the reservoir behind the Victoria Dam. Region 2 is the catchment of the Maha Oya, also directly flowing into the reservoir. Both of these catchments contain the bulk of the steep tobacco growing land. Region 3 comprises the catchment of a number of small streams flowing north to the Mahaweli Ganga and the catchment of the Nelambe and Atahage Oyas flowing west to the river. Region 4 embraces the area on both sides of the Mahaweli as it flows south west from Gampola to its southeastern turning, south of Rambakpitiya. Region 5 comprises the triangle east of the river between the catchment of the Kotmale Oya and Hatton. Region 6 contains the catchment of the Kotmale Oya.

The catchments of the Ma Oya, Belihul Oya and Kurundu Oya will directly affect the proposed Randenigala Reservoir, and, until the dam is built, will be a source of sediment for downstream reservoirs. These catchments can be incorporated in the Master Plan at a later date as work progresses. In like manner, the areas of abandoned tea and scrub on the heights of land surrounding the Kandian Plateau have been left to a later date, as generally the plateau area of paddy and home garden does not constitute an erosion problem.

Table C-8 describes the distributions of areas of land use scheduled for redevelopment. Figure C-6 shows the locations of special introduction of areas for redevelopment.

Program

Areas for redevelopment comprise 63,000 hectares for Regions 1 to 5, plus an estimated 8,000 hectares in Region 6. Redevelopment of this area taken over nine years amounts to 7,000 hectares per year.

The annual development for the first two years (years two and three) takes into account activities already in progress (Ministry of Lands and Land Development 1980):

Fuelwood plantations	2,000 hectares
USAID Timber Plantations	1,200
NADSA Timber Plantations	1,500
NADSA Agricultural Diversification	1,600
Timber, Crop Diversification, Cattle	700
Total	7,000 hectares

The remaining 2,500 hectares of fuelwood mentioned previously might come under the Netherlands integrated development program or the World Food Program.

The NADSA program is for three years and covers 4,900 hectares in the Upper Catchment and should be completed in 1982. However, the program is doing so well that the World Bank may consider continuing the program. In any event, this type of program is ideal for the redevelopment of the remaining suitable areas in need of erosion control and settlement in the catchment.

Seven hundred hectares have been shown above as timber, crop diversification or cattle farming. During the first few years of operation, the Corporation will need flexibility because of a limited number of options. For example, reforestation of the remaining 700 hectares shown above may be too much for the capabilities of the Forest Department with their many commitments and constraints of staff. This may also be true of NADSA which is just starting operations. In its turn, the Corporation will require time to develop its expertise and personnel to coordinate the redevelopment and time to establish bankable projects to secure financing.

The apportionment of years four to seven are projected as follows:

Fuelwood	2,000 hectares
Timber Plantations	3,000
Agricultural Diversification	2,000
Total	7,000 hectares

It will be noted that the 7,000 hectares per year is an average, and the number of hectares in each region varies quite a bit. Thus, as was mentioned previously there will be years that two or more regions may be worked. Actual areas redeveloped in a given year will also vary from the 7,000 hectare target depending on numerous circumstances.

Schedule

Because of the general nature of this preliminary planning, the schedule is described by quarters for year and the date by years. Because of the urgency of redevelopment of the Upper Catchment year one will probably be 1981. The following schedule is graphically depicted on Figure C-7.

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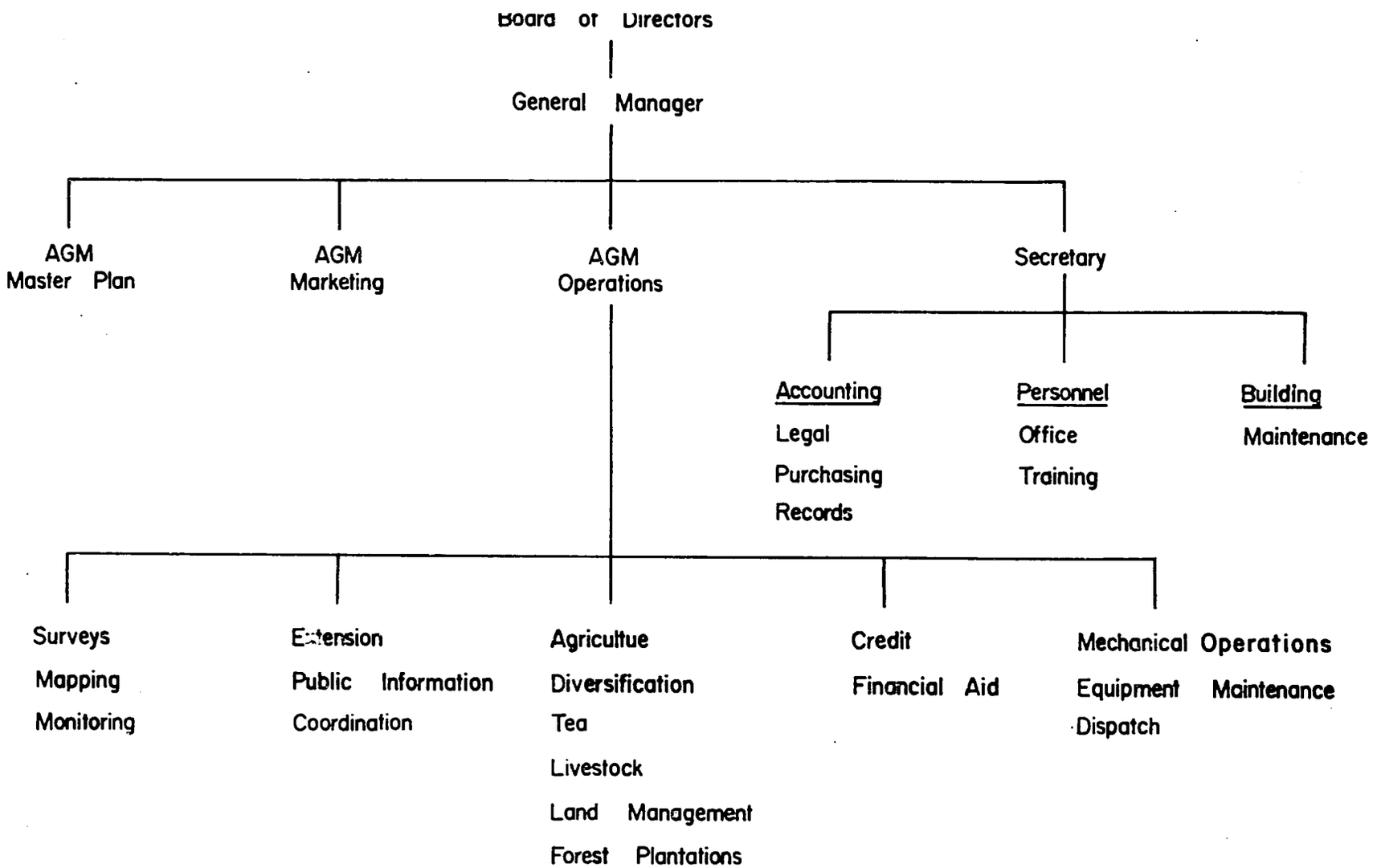
Table C - 8

Areas for Redevelopment by Regions

Area of Land-use
(1000 hectares)

Region	Tx Tm	6Sc 6S	4S	4Pd	Total for Redevelopment
1	2.0	9.3	2.4	4.0	17.7
2	0.4	2.4	-	7.3	10.1
3	4.5	-	2.8	3.6	10.9
4	4.0	2.8	-	2.0	8.8
5	1.2	0.1	-	0.4	7.7
6	-	-	-	-	-
	12.1	20.6	5.2	17.3	55.2

* No complete photo coverage of Region 6



ORGANIZATION CHART OF THE MAHAWELI REDEVELOPMENT CORPORATION

FIGURE C-5

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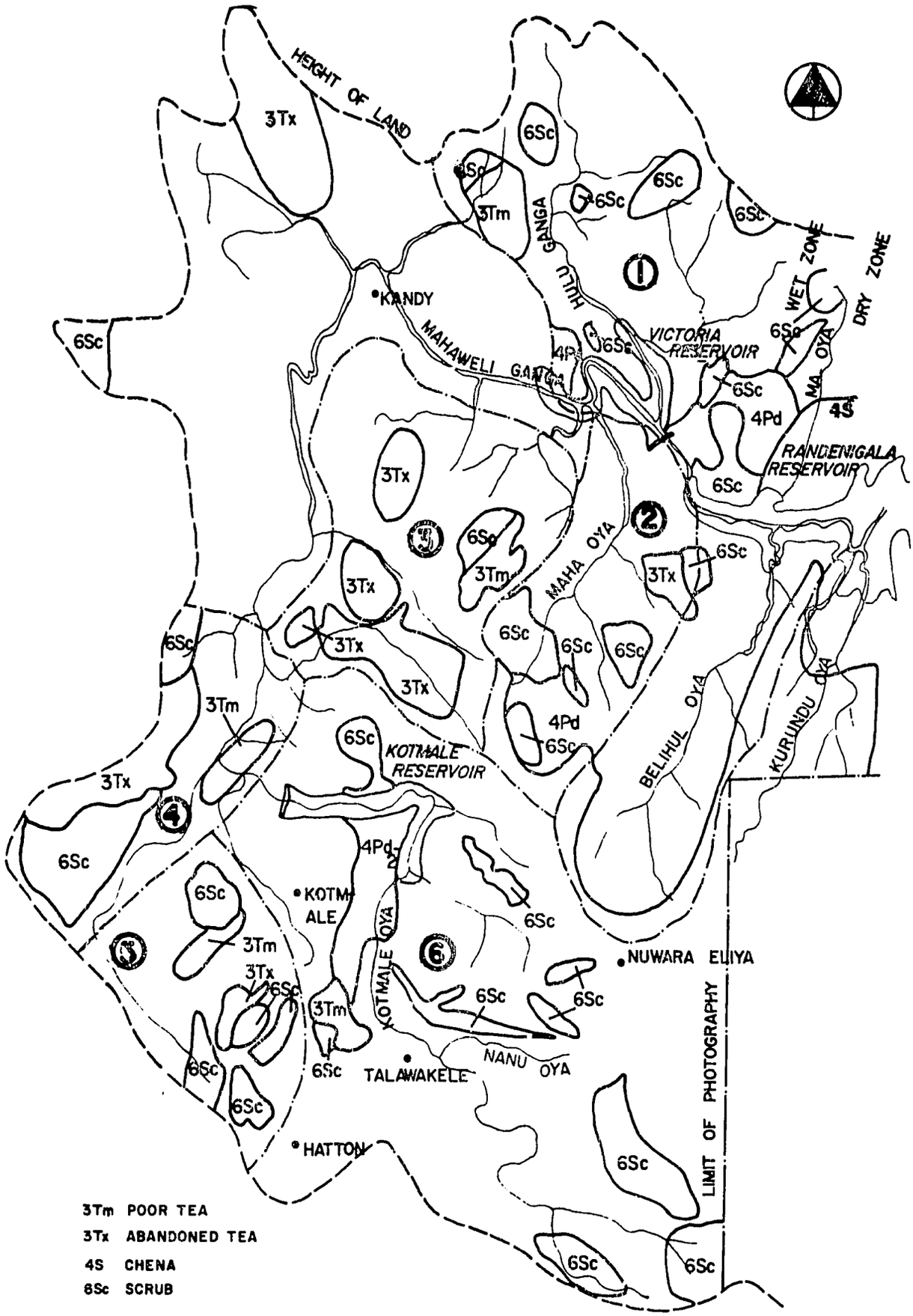

AREA REQUIRING REDEVELOPMENT
FIGURE C-6

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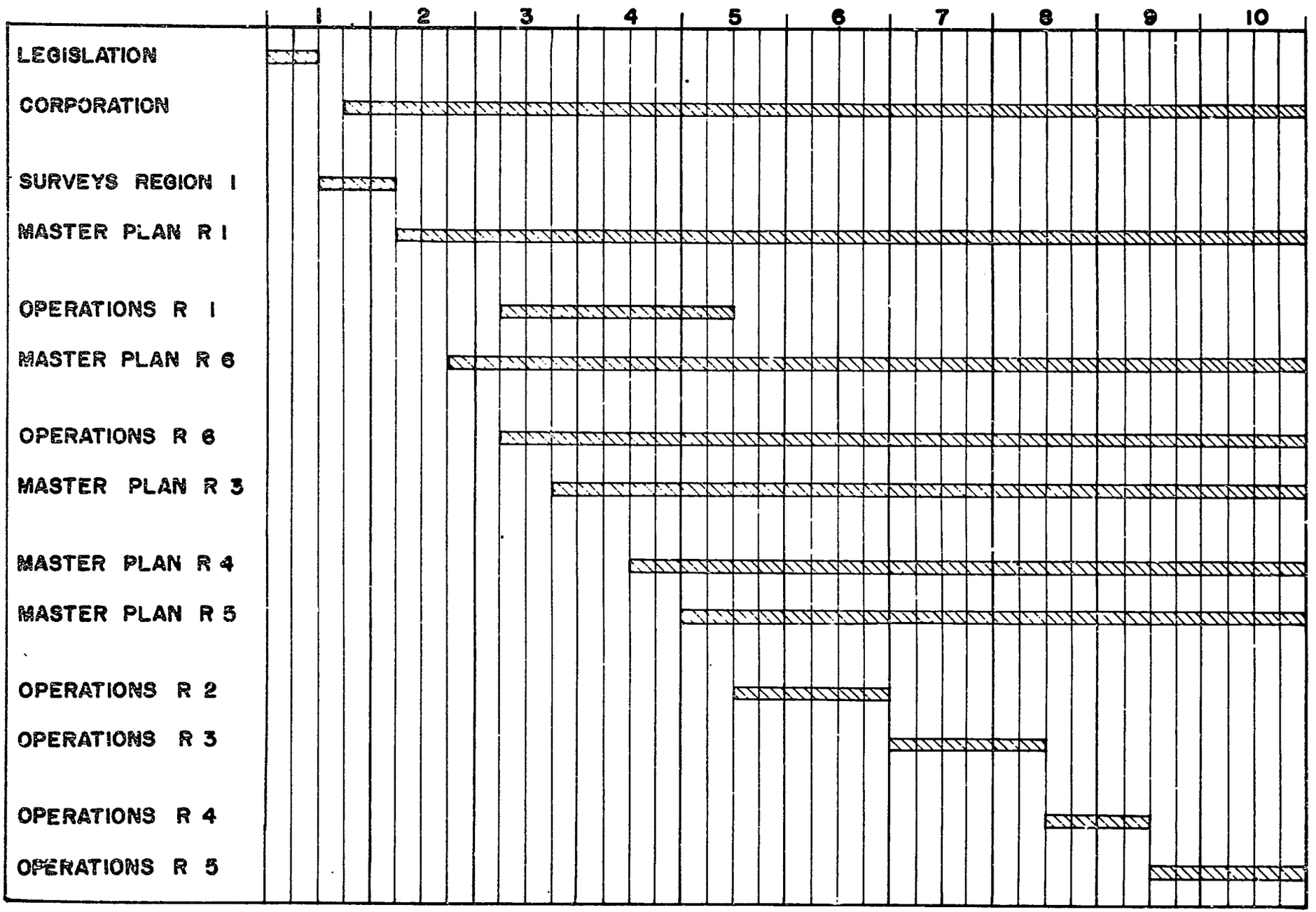

SCHEDULE OF REDEVELOPMENT OF THE UPPER CATCHMENT

FIGURE C-7

Year 1 - 1st Quarter

a. Draughting of Legislation.

2nd Quarter

a. Passage of Legislation.
b. Arrange financing for Corporation.
c. Set up Committee to organize Corporation; select General Manager and other senior executives.
d. Locate office in Kandy.
e. Develop list of equipment and vehicles to start operations.
f. Instruct Government departments to carry out intensive photo interpretation and ground sampling to prepare detailed present land use, soil class and land class maps for Regions using 1979 photography. Maps to be prepared at 1:10,000 and topographic maps enlarged from 1:31,680 to 1:10,000.
g. Instruct the Department of Agriculture to carry out field reconnaissance for inspection of soils, topography, erosion, and other factors in order to prepare a list of suitable crops for later selection.

3rd Quarter

a. Select officers for Corporation and commence staffing.

4th Quarter

a. Organize Corporation in Kandy.
b. Arrange financing for assistance to land owners and occupiers.
c. Second year of resettlement of persons displaced by Victoria Dam in Region 1 and displaced by Kotmale Dam in Region 6.
d. Second year of USAID Plantations Region 4.
e. Second year of resettlement by NADSA in Region 3.

Year 2 - 1st Quarter

a. Prepare the Land Capability Map of Region 1.
b. Select soil conservation measures, crops, agricultural methods and work out budget for Region 1.
c. Prepare Master Plan for Region 1.
d. Carry out preparatory measures - establish nurseries locate roads, plan infrastructure, housing and public health.
e. Send extension staff to interview first group of owners and occupiers to explain plan.
f. Arrange for completion of air photo coverage of Upper Catchment, especially Region 6.

2nd Quarter

a. Commence operations under Master Plan, Region 1.
b. Continue mapping program in Regions 2 and 6.

4th Quarter

a. Prepare land capability map Region 2 and 6.
b. Prepare Master Plan Region 6.

Year 3 - 1st Quarter

a. Start field survey Region 3.

2nd Quarter

a. Prepare Master Plan Region 2.
b. Commence operations on Region 6.

3rd Quarter

a. Prepare capability map Region 3.

4th Quarter

a. Prepare Master Plan Region 3
b. Start field survey Region 4.

Year 4 - 2nd Quarter

a. Capability map Region 4.
b. Start field surveys Region 5.

3rd Quarter

a. Prepare Master Plan Region 4.

4th Quarter

a. Prepare capability map Region 5.
b. USAID Plantation Program completed.

Year 5 - 1st Quarter

a. Prepare Master Plan Region 5.

2nd Quarter

a. Operations in Region 1 complete.

3rd Quarter

a. Operations in Region 2 started.

Year 6 - 4th Quarter

a. Operations in Region 2 complete.

Year 7 - 1st Quarter

a. Operations start in Region 3.

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Year 8 - 2nd Quarter

a. Operations in Region 3 complete.
b. Start operations Region 4.

Year 9 - 2nd Quarter

a. Operations Region 4 complete.

3rd Quarter

a. Start operations Region 5.

Year 10 - 4th Quarter

a. Operations in Regions 5 and 6 complete.

Analysis of Schedule

An area approximately 63,000 hectares has been scheduled to be redeveloped during the 10 year period. As no actual work is done during the first year this amounts to an average of 6,100 hectares per year in Regions 1 to 5. It was estimated that there were approximately 8,000 hectares in need of redevelopment in Region 6, so it is assumed that along with the 6,100 hectares per year for the other five Regions, an additional 900 hectares of Region 6 will be worked on simultaneously. Figure C-7 shows the principal elements of the schedule.

Since Regions 1 and 6 most directly affect the reservoirs at Victoria and Kotmale, their immediate environs should receive special attention in the Master Plan. Perhaps these areas could likewise have special reserve status with stricter regulation and control of activities with the purpose of later creating centres of tourism. Such a plan for Victoria has already been prepared for the environs of the Victoria Reservoir (Fernando 1980) setting up a special agency for the wet region, which in the case of the Corporation might be vested in the Assistant General Manager in charge of the Master Plan.

In the schedule, the work in the Regions is shown to be terminated at given dates. However, this should be considered to mean that the major areas of severely eroded land have been redeveloped. Flexibility of the use of equipment and labor will also dictate the location of individual work programs so that operations in the various Regions will likely overlap at times.

The Master Plan preparation has been shown to continue to the tenth year, because it will be under constant review and revision in the light of new experience and knowledge and the force of outside circumstances.

SETTLEMENT AND INFRASTRUCTURE

Settlement

Part of the redevelopment process will involve relocating people that have to be moved from reservoir sites and other areas involved in the proposed developments. For this purpose, a resettlement program will be included in

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the Master Plan. In planning for resettlement major emphasis should be placed on replacing the land being confiscated with land of equivalent size, productivity and locally available amenities.

For settlement of landless persons or persons displaced because their land is to be reforested, land should be chosen that is of sufficient size and productivity that the settlers can make a better than subsistence level living.

The land use capability maps will form a sound basis for these decisions when taken in conjunction with crop production priorities in the Master Plan.

Infrastructure

In the settlement of large numbers of persons on land presently devoid of human habitation, an infrastructure of roads, villages, fuelwood plantations, etc. must be also established. A section of the Master Plan will detail such matters as siting of roads and villages, type of housing, water and sewage installations, public health measures, schools, shops and amenities.

If this part of the program is not planned it will happen spontaneously in a haphazard manner resulting in poor sanitation, inadequate servicing of the population and concentrated development along the roads.

MARKETING

Products

Since one of the principal aims of the redevelopment of the Upper Catchment is to increase the productivity of the land and diversify the commodities produced, some products will be produced in much greater volume than in the past. There is some danger of overproducing products for the home market such as jack and breadfruit or products for export such as pepper, cardamon and cloves. The marketing divisions of the Corporation have been included in order to carry out marketing studies for the prupose of encouraging or restricting the production of individual items of produce in accordance with market absorption and prices.

Markets

This division will also function as a marketing agency in the program for products that do not already have an efficient marketing organization. This will entail collection, refining, grading, transporting, storage, promotion and selling of products that will be grown in large quantities.

TECHNICAL PERSONNEL

Estimates of personnel required are based on the Forest Department estimates for the USAID program (USAID 1980) and from NADSA (NADSA 1978; Goonetilleke 1980).

The reforestation of 5,000 hectares of timber and fuelwood plantation will require one Assistant Conservator, 16 Foresters and 50 Forest Guards. This would severely strain the present staff of the Forest Department which

stands at 402 Forest Guards, even with 12 graduating this year and a planned expansion of the China Bay Forest School to graduate 24 next year. An analysis of the training of forestry personnel can be found in TOPIC REPORT D: FORESTRY.

Technical staff presently engaged in NADSA on the agricultural diversification program number 40 to develop 1,600 hectares per year. In order to handle 2,000 hectares per year, it is estimated that an extra 10 would be required for a total of 50.

COSTS

It is estimated that establishing forest plantations will cost Rs. 2,514 per hectare for fuelwood and Rs. 3,008 per hectare for commercial timber or a total of Rs. 14.0 million per year for 5,000 hectares.

The present cost for agricultural diversification is Rs. 13,600 per hectare.

Two thousand hectares a year are programmed so the annual cost will be Rs. 27.2 million and the total cost for both forestry and agriculture will be Rs. 41.2 million. The total for the nine year period will come to Rs.370.8 million. These costs are exclusive of the costs that will be incurred in establishing the Corporation and obtaining its equipment.

FOREIGN AID FINANCING

Continuing Financing

The USAID financed timber plantation program is well planned and organized and an application should be made to continue this program for a further five years.

The World Bank crop diversification program is showing good results even at this early stage. Presentations should be made to continue this program for the remaining eight years.

The Maduru Oya catchment was not included in the present study as it would duplicate the work being carried out by a Canadian consulting group under the Canadian International Development Agency. The specific purpose of this Lower Uva Regional Planning Study is to identify and help speed implementation of measures to protect the catchment areas of the Maduru Oya and Ulhitiya Oya in order to preserve the environment and to safeguard the quality of water supply to Systems B and C. One of the major proposals that have arisen from the study thus far has been the recommended extension of the Maduru Oya National Park to form an extensive contiguous wildlife reserve with the wildlife reserve of the Gal Oya National Park.

Future Possibilities of Financing

The Government of the Netherlands is conducting projects in the Upper Catchment, including a study of the tobacco lands and an integrated rural development project at Nuwara Eliya. It is suggested that these efforts be directed to a part of Region 6.

The Asian Development Bank has sent representatives to discuss a rural fuelwood supply project. An area such as Region 3 would be an appropriate choice for an area that requires a well planned rural fuelwood program.

The World Food Program is developing a plan to reforest patina lands and chena with incentives to attract labor in the form of food aid.

CIDA might well be amenable to implementing the land use capability mapping if it were shown to be an essential component of the Master Plan and presented as a well designed project.

USAID financed this present study and might well consider financing preparation of the Master Plan as a follow-up operation.

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K. Vivekandan, Research Officer

Survey Department

J. B. M. Seneviratne
S. Srida, Resources
B. F. Sciambi, Director Cadastral Surveys

State Timber Corporation

M. S. Ranatunge, General Manager
Henry Perera, Operations Manager

Ceylon Plywood Corporation

Sam S. Perera

Sri Lanka Air Force

Squadron Leader Fernando

Irrigation Department

K. D. de Alwis, Head Land Use Division

Mahaweli Development Board

Dr. D. V. W. Abeygunewardena, General Manager
P. C. D. Samarasekera, Superintendent of Stores

Department of Agriculture

J. S. Gunasekera, Head Soils Conservation Group
Dr. L. Kandiah, Head Agricultural Engineering
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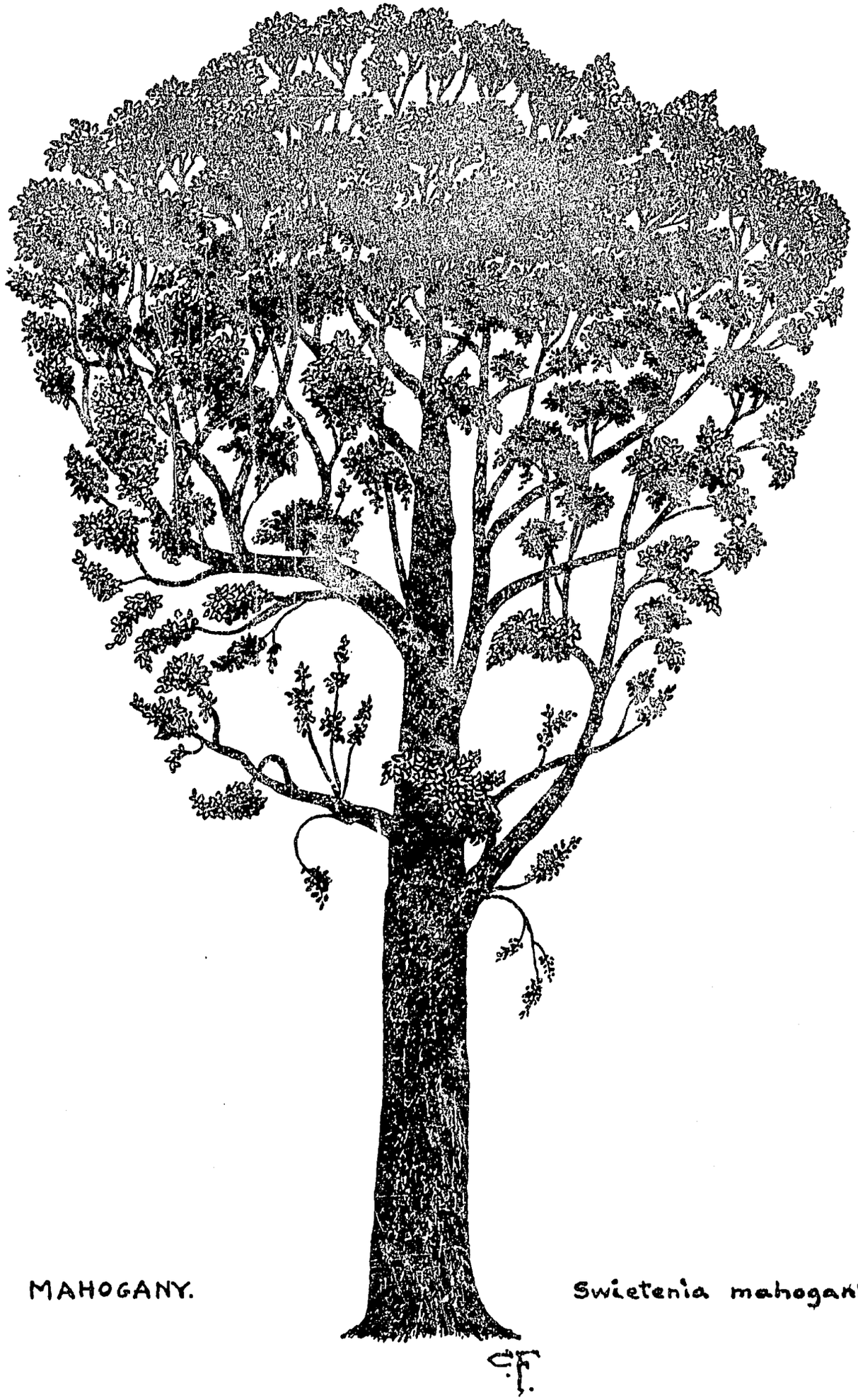


MAHOGANY. *Swietenia mahogani.*

INTRODUCTION

Sri Lanka is now in a transition stage between forest exploitation and plantation management. Most of the valuable timber has been cut, and the remaining forest stands must be protected from encroachment in order to conserve the soil and wildlife.

The forest industries must also adapt to the new raw materials and rebuild to handle them efficiently. With the momentum for development of the economy and the burgeoning population, Sri Lanka can no longer afford the careless and wasteful practices of the past.

By planting 12,000 hectares annually for the next 20 years and managing them in a sound technical manner the country could be almost self-sufficient in most forest products.

Plantation analysis has shown an internal rate of return of 25% (TOPIC REPORT M : ECONOMICS) as well as the many other benefits of soil conservation and water regulation. Thus, the plantations will not only provide for the industrial needs of the nation at a monetary gain but also will reach this level of development well within the working life of the 10 million persons presently under the age of 30 in Sri Lanka.

EXISTING CONDITIONS

SRI-LANKA - NATIONAL FORESTRY RESOURCES

Estimate of Forest Resources

The last forest inventory report was published in 1961 (Andrews 1961) based on aerial photography taken in 1956. In order to prepare an impact statement on the Accelerated Development Program it was necessary to make an estimate of the area and volume of forest as it is now.

The preparation of the new estimate was carried out by sketching the forests within and adjacent to forest reserves during a three day helicopter trip. The area covered in this manner was to the south, east and north of the Central Highlands. Each reserve or forest area was typed and marked on 1" = mile scale maps, along with other land use information such as chena, dry land farming or scrub as it occurred on the reserves. One hundred and ten reserves were covered in this way, plus two large forested areas: one to the south, near Yala National Park and one in the north in the vicinity of the Wilpatu National Park.

The extent of the forests in the Upper Catchment of the Mahaweli Ganga and the Accelerated Program area were compiled from present land use and forestry maps prepared from interpretation of 1979 photography.

Information on reserves not covered by the preceding methods was obtained by circulating a list of 359 Forest Reserves and Proposed Reserves in the Forest Department for comments on status and condition. These reserves are listed in Appendices D-I and D-II and shown on Figure D-1. The information obtained indicated the area of each reserve, those that had been exploited, the planted area and the area released. Valuable information on the Wet Zone Forest Reserve was obtained from an article by the former Conservator of Forests (Perera, 1972). Information on the forest plantations such as species, age and extent was obtained from the Forest Department.

The system of typing the forest was the same as was used in the original inventory:

7 HW High Yield Wet Zone Forest

7 MW Medium Yield Wet Zone Forest

7 LW Low Yield Wet Zone Forest

7 NW Non-Productive Wet Zone Forest

7 MD Medium Yield Dry Zone Forest

7 LD Low Yield Dry Zone Forest

7 ND Non-Productive Dry Zone Forest

There were no High Yield Forests remaining in the Wet Zone with the possible exception of parts of the Sinharajah Forest Reserve that were left unexploited.

Medium Yield Forests contain a high proportion of merchantable timber. Low Yield Forests have sufficient valuable timber and fuelwood to justify exploitation, and Non Productive Forests have very little usable timber with the exception of scattered trees of valuable species. Average volumes per hectare are shown in Table D-1.

Area of Natural Forest

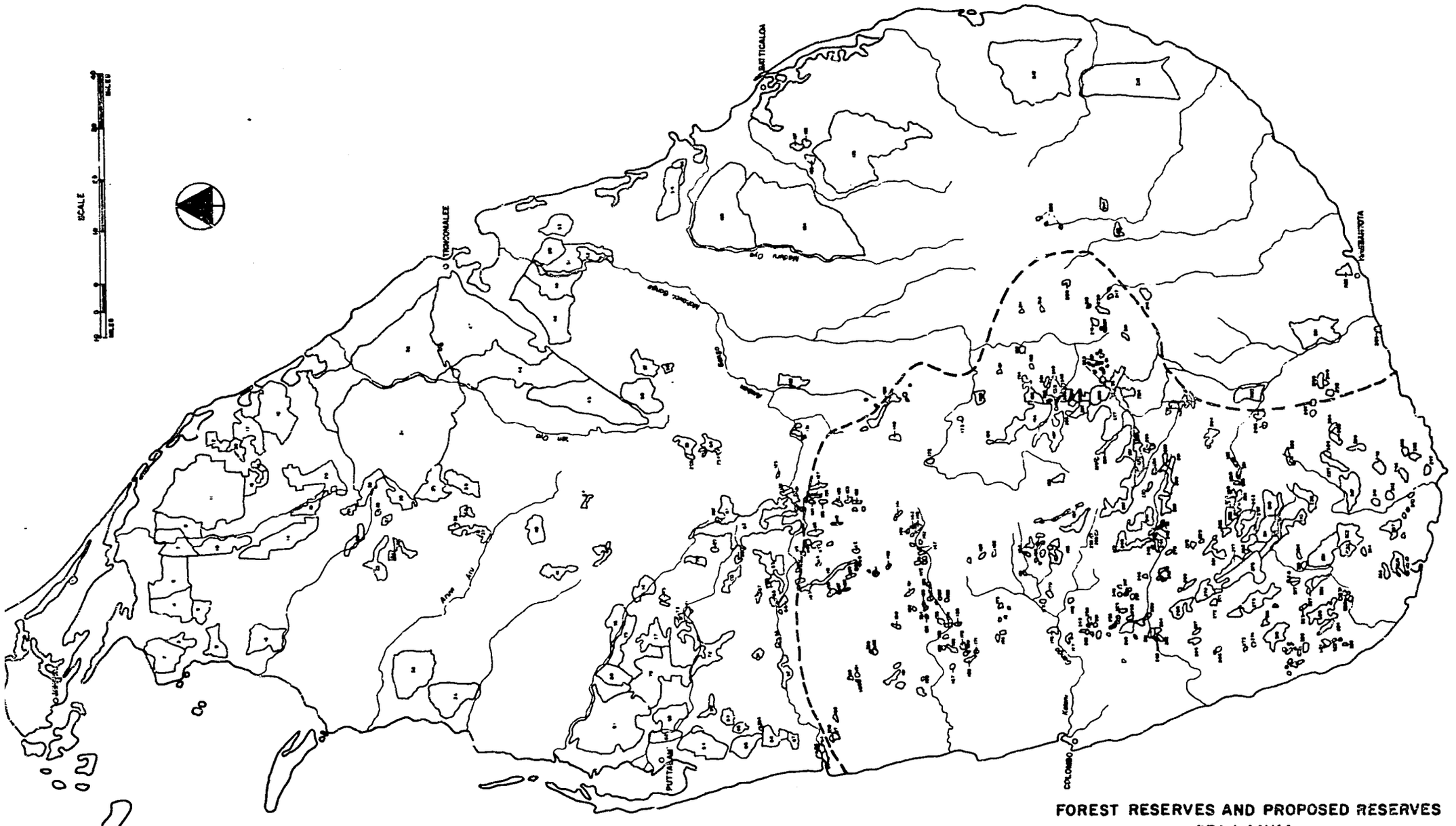
The total estimated area of forest in Sri Lanka is 1,549,000 hectares (Table D-2). The area of wet zone forest was taken to be the sum of the areas still remaining in the Forest Reserves and only the large contiguous areas of dry zone forest outside the project area were mapped. These were subdivided into three Blocks. The Southern Block encompases the Panama and Kumbukkan Reserves plus 100,000 hectares of other national forest. The Eastern Block includes the Hurula Anaolundawa and Kantalai Reserves. The Northern Block includes the Mavillu, Vepal, Etakaduwa, Karumkalikulam, Padawiya, Nainamadu, Paranthan and Vannivalamkulam Reserves plus 1,800 hectares of other national forest. The areas by type may be seen in Table D-3. Figure D-2 indicates the major areas of forest remaining in Sri Lanka.

Volume of Natural Forest

The wet zone forests of any operable size have all been exploited. In the Upper Catchment of the Mahaweli Ganga, the forest remaining is fragmented and is mostly found well above 1,574 meters in elevation and is mainly composed on montane species. The Peak Wilderness Reserve still has valleys of good timber, but has been declared a Man and Bioshpere Reserve. All the forest in the catchment is protection forest.

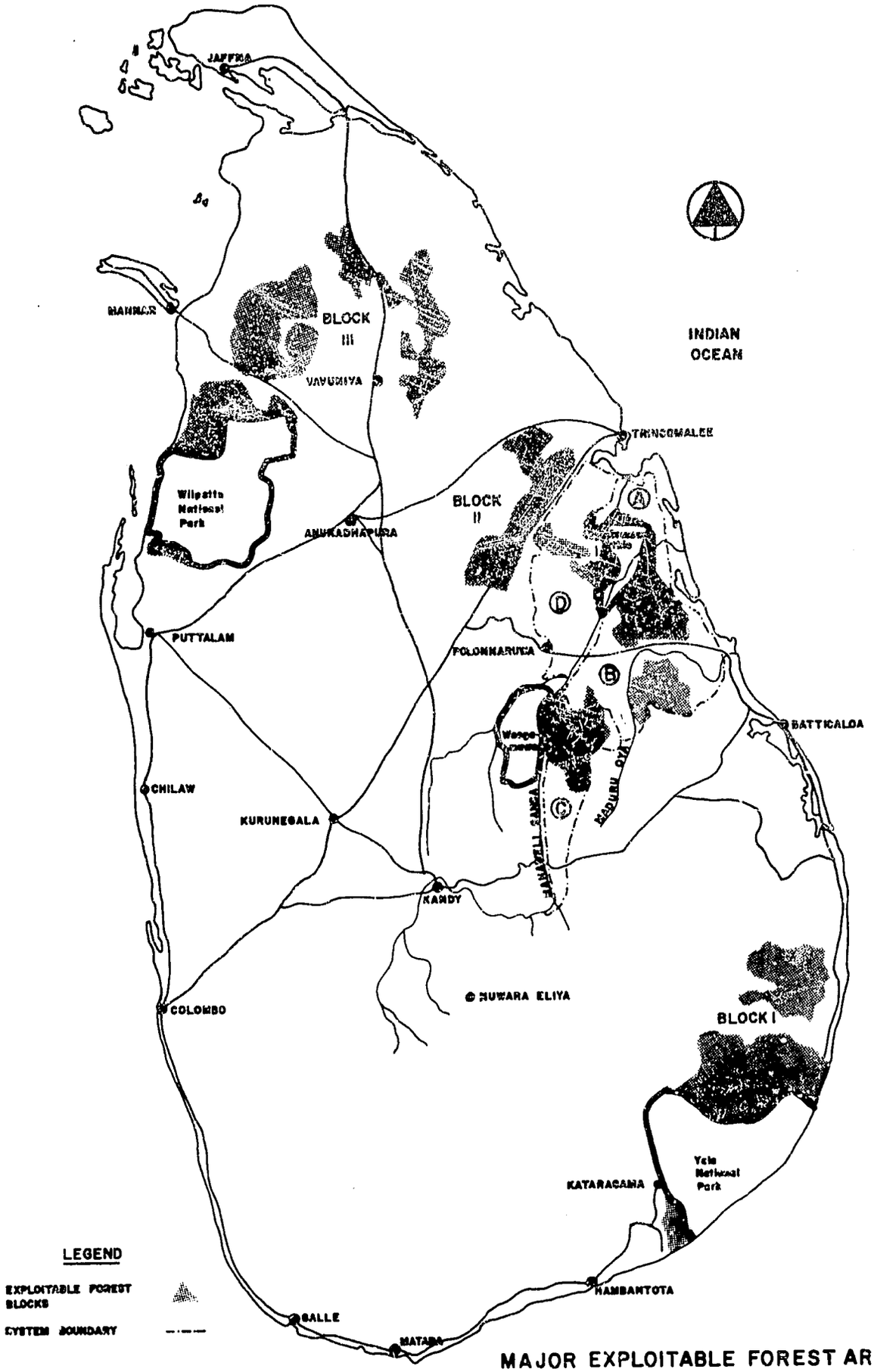
In the southern hilly section of the wet zone there is a number of large Reserves that were exploited in the past to a diameter limit. These were mainly cut by contractors using elephants and thus retain areas of merchantable timber. An example of this is the Kanneliya, Nakinyadeniya, Dediyagala group of Forest Reserves being managed by the Ceylon Plywood Corporation. They take out about 18,000 m^3 annually from 200 hectares. This is above the average for medium yield forest of $48m^3$/ha. Not many other reserves are as good as this one, but it is thought that a number of them could produce $35m^3$/ha on re-logging to a diameter limit of 51 cm. The area of wet zone reserves is 92,000 hectares which if reduced by the 29,000 hectares of the Upper Catchment would leave 63,000 hectares, from which 40,000 hectares are capable of yielding an annual cut.

The volume of the dry zone forest is estimated to be 1,923,000 m^3, of which 257,000 are in the Accelerated Program area and the remainder in the three Blocks mentioned above. The distribution of volume by types can be seen in Table D-4.



FOREST RESERVES AND PROPOSED RESERVES
SRI LANKA

FIGURE D-1



MAJOR EXPLOITABLE FOREST AREAS IN SRI LANKA

FIGURE D-2

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Table D-1

Merchantable Yields per Hectare
of Forest Types

Zone	Medium Yield	Low Yield	Non Productive
	(m^3/ha)	(m^3/ha)	(m^3/ha)
Wet Zone	48	15	8
Dry Zone	26	6	1

* Volumes of trees 51 cm and greater diameter breast height and minus the species Wira in the Dry Zone.

Table D-2

Natural Forest Cover in Sri Lanka
(1000 hectares)

Class of Forest Area	Wet Zone	Dry Zone	Total	Percent
Forest Reserves and Proposed Reserves	92	589	681	44
Other National	-	118	118	8
Wildlife Parks and Reserves	27	586	613	40
Small Natural	22	-	22	1
Mahaweli Area Systems A-D	-	115	115	7
	141	1408	1549	100
Percent	9	91		100

Table D-3

Area of Dry Zone Forest by Block
(1000 hectares)

Block	Type 7ND	7LD	7MD	Total
Southern	125	47	-	172
Eastern	2	22	29	53
Northern	17	59	-	76
	144	128	29	301

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Change in Forest Area Since 1956

During the 23 year period between 1956 and 1979 the forest area has diminished by 46% from 2,880,000 hectares to 1,549,000 hectares as is shown in Table D-5.

The area of Sri Lanka is 6,570,134 hectares of which 43.8% was forested in 1956 compared with 23.6% in 1979. This amounts to an annual diminution of 58,000 hectares over the past 24 years. However, the actual drop in value is much greater than the 23.6% would indicate, because most of the best timber in the wet zone has been exploited.

Area of Plantations

The published area of plantations in Sri Lanka (Forest Department 1980) is 125,803 hectares. Table D-6 lists the areas of plantations by year for the past 20 years for the major plantation species. The 23,783 hectares on mahagony were established with jak or as line enrichment plantings and therefore have high variability in number of trees per hectare. No information was available for the years of planting for mahagony and other species. There is a discrepancy in the totals planted that can be partially explained by areas of bamboo being omitted from these calculations and for inconsistencies in old records. The 3,725 hectares of plantations of other species are planted with 22 different varieties as pilot species trials.

The areas of teak plantations have been reduced by 3,263 hectares because of cyclone damage in 1978 to all the plantations in the Eastern District. The total area of teak plantation is 27,922 hectares, of which those of the Eastern Division comprise 74%.

Plantations represent 1.9% of the area of Sri Lanka and 7.5% of the total forest cover, both natural and artificial. The total forested area of Sri Lanka is 1,675,000 hectares or about 25% of the area of the country.

Yield of Plantations

Plantation yields vary greatly depending on the suitability of the site, quality of seed stock and management care. There is very little growth data available in Sri Lanka, and the plantations have so far been unmanaged. The estimates presented in Table D-7 for yields of the plantations and for future plantations are based on formed opinions in the Forest Department, current literature on various species and personal observation.

Further refinements on forecasting yields for the purpose of this report were not justifiable with the limited data available. When detailed planning is undertaken a considerable use of a number of exotics and indigenous species will be recommended for specific sites.

Table D-4

Volume of Dry Zone Forest by Types

(1000 m^3)

Area	7ND	7LD	7MD	Total
Block South	125	282	-	407
Block East	2	132	754	888
Block North	17	354	-	371
Mahaweli	93	120	44	257
Total	237	888	798	1923
Percent	13	46	41	100

Table D-5

Change in Forest Area between 1956 & 1979

(1000 ha)

	Zone		
Year	Wet	Dry	Total
1956	242	2638	2880
1979	141	1408	1549
Difference	101	1230	1331
Difference Percent	33	47	46

Table D-6

Areas of Plantations by Species And Planting Date (hectares)

	Eucalyptus	Pine	Light Handwood	Mahagony	Teak	Other	Total
1980***	6300	3500	300	(400)	2200	(300)	
-							
1979	2619	2306	71		2277		
1978	1485	2330	69		2849		
1977	1105	1588	184		3840		
1976	741	1630	92		5255		
1975	448	1346	190		4764		
1974	390	876	212		4231		
1973	448	904	164		4414		
1972***	279	1230	198		4063		
1971	289	364	98		2806		
1970	451	290	136		2696		
1969	572	197	166		2587		
1968	606	96	115		2336		
1967	419	36	118		1893		
1966	510	-	115		2429		
1965	367	-	138		1506		
1964	228	-	130		943		
1963	245	-	38		1088		
1962	359	-	38		1281		
1961	4	-	61		1523		
1951-60	340	-	6		1565		
Total	18205	16743	3245	24000	56,546	2000	120,739

* Line planting and mixed with Jak

** Estimated

*** Teak area damaged by cyclone Teak plantations 8 years and over substracted.

SOURCE: Forest Department

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Forest Production and Consumption of Roundwood

Production - The State Timber Corporation (STC) produces, processes and sells timber products. They own or operate 20 small sawmills and timber depots throughout the island. They produce annually about 100,000 m^3 of logs and 15,000 m^3 of lumber plus poles, posts and sleepers. Their roundwood production for the past seven years is shown in Table D-8.

In addition to the above they produce lumber, fenceposts and about 38,000 m^3 of fuelwood. Ebony log production has dropped from 977 m^3 in 1976 to 89 m^3 in 1978 and was not included in the total for 1979.

Table D-8 shows a general decline in log production which was due in part to a moratorium of cutting in 1977 together with a general decline in timber supply. Production in 1979 was due to the effects of the cyclone and to timber in the clearing for the Mahaweli Accelerated Program. Sleeper production has been steadily declining because of a lack of a supply of suitable wood logs, as these are also used in furniture making and other uses. The big jump in the production of poles in 1979 was occasioned by the destruction of the teak plantations by the cyclone in 1978.

The Ceylon Plywood Corporation (CPC) operates two plywood factories, two sawmills, a chipboard plant and a furniture factory. Log supplies are obtained from their operations in the Keneliya group of reserves which produces 21,000 m^3 annually from STC private sources and rubber plantations. The complex is chronically short of log supplies and imports veneer to keep up production. Log supplies for the past three years are shown in Table D-9.

The other industries in Sri Lanka include more than 200 small, ill-equipped sawmills, a large number of furniture factories and seven match factories. These all purchase their logs from STC and other sources, and all are chronically short of logs.

Consumption - A detailed estimate of forest products consumption was prepared by the STC in June 1979. This is shown in Table D-10.

The consumption estimate for 1979 was stated to be low because a number of products were omitted, and a figure for demand for 1979 was taken to be 453,000 m^3. The STC also concluded from their recent experience that the annual growth of demand was 5%.

Imports - Imports of wood products have been increasing rapidly from less than Rs.25 million in 1977 to Rs. 83 million in 1978 and Rs. 174 million in 1979. The major components of the imports where unmanufactured wood (logs), sawnwood, veneer and plywood as shown in Table D-11.

The values shown in Table D-11 for the trade statistics are accurate, since these imports are inspected closely by customs. The volume figures are not as reliable, as in some entries they are inaccurate or entirely omitted on various articles. However, they are close enough to indicate a definite rapid upward trend in imports, almost tripling between 1978 and 1979.

Estimated Yields of Plantations
(m^3/ha/yr)

Species	Rotation Age	Old Plantations	Proposed Plantations
Teak	40	3.7	4.4
Pine	15	18.7	18.7
Eucalyptus	15	20.0	30.0
Light Hardwood	15	15.0	15.0
Mahagony*	40	17.0	17.0

* No planting dates available and volume/ha dependant on spacing

Table D-8

Annual Roundwood Production by State Timber Corporation
(1000 m^3)

Product	Year						
	1973	1974	1975	1976	1977	1978	1979
Plywood Logs	19	22	18	17	10	3	2
Other logs	86	92	79	78	58	56	88
Sleepers	10	8	10	10	4	2	1
Poles	2	3	3	3	2	1	33
	117	125	110	108	74	62	124

SOURCE: Compiled from STC Annual Reports 1973-79.

Table D-9

Log Supplies to Ceylon Plywood Corporation
(1000m^3)

Mill Location	1977	1978	1979
Salawa	11	2	3
Gintota	17	20	22
Carp	2	4	*
	30	26	25

*228m^3
SOURCE: C.P.C.

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Table D - 10

Consumption of Roundwood 1979
($1000m^3$)

Use	Volume
Furniture	136
Roofing	19
Door & Window	9
Door, Window Sash	7
Panneling	3
Ceiling Boards	75
Flooring	18
Curio	1
Poles	2
Matches	28
Plywood	85
Sleepers	17
Transmission Poles	5
	405

SOURCE: STC

Table D - 11

Imports of Wood Products

	1978		1979		1980-1st ¼	
	Quantity ($000m^3$)	Value (000Rs)	Quantity ($000m^3$)	Value (000Rs)	Quantity ($000m^3$)	Value (000Rs)
Logs	*	3,199	9	35,159	*	-
Sawnwood	3	3,616	16	52,172	1	3,258
Veneer & Plywood	13	76,707	28	82,784	4	68,077
Utensils, Tools etc.	*	2,583	-	3,719	*	780
	18	86,105	53	173,834	5	72,115

*Less than 500

SOURCE: Compiled from External Trade Statistics Sri Lanka Customs 1978, 1979, 1980

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Fuelwood

Consumption of fuelwood in Sri Lanka is based on an average of 0.57 m^3 per person. This was calculated taking into account consumption of other energy sources such as kerosene and electricity and estimating the use of farm waste products that are used where available to replace wood. The total fuelwood consumption is estimated to be 8.3 million m^3 per year and increasing in direct proportion to the increase in population.

Despite the fact that the island is still forested on 25% of its area, there are severe shortages of fuelwood in many localities. The forests are located in sparsely populated areas on the dry zone and on mountain tops in the wet zone, and because of the high cost of transportation, fuelwood available from them is economically inaccessible.

ACCELERATED PROGRAM AREA

Area of Forest

The forested area of the Accelerated Program area comprised 114,700 hectares or 28% of the total area in March 1978. It also comprised 7% of the remaining forest area of the country. The distribution of this area by system and type is shown in Table D-12.

Thirty one hundred hectares of plantations were mapped, 100 in System A and the remainder in System B. The largest contiguous forest area includes the northern part of System C and the eastern portion of System B as can be seen in Figure D-3.

Deforestation in the four irrigation systems has been very rapid during past three years through premature clearing for development, chena, illicit felling and spontaneous colonization by people hoping to get title to land when the program is put in operation. This is evident from the 20,000 hectares under development, 96,800 hectares of chena, and 35,200 hectares of scrub, which amount to more than 36% of the total area.

The State Timber Corporation has been operating in the area since 1977 removing the merchantable timber and is now engaged in removing timber from 30,000 hectares in Systems B and C before the end of 1983.

Volume of Forest

The estimated volume of forests for trees more than 51 centimeters in diameter breast height minus the species wira (*Drypetes sepiaria*) is shown in Table D-13.

The best quality stands of timber are in Systems B and C, while System D has been heavily exploited and is in very poor condition. The fuelwood available in the four systems is estimated to be 2,817,000 m^3 for which a distribution by types and systems is shown in Table D-14.

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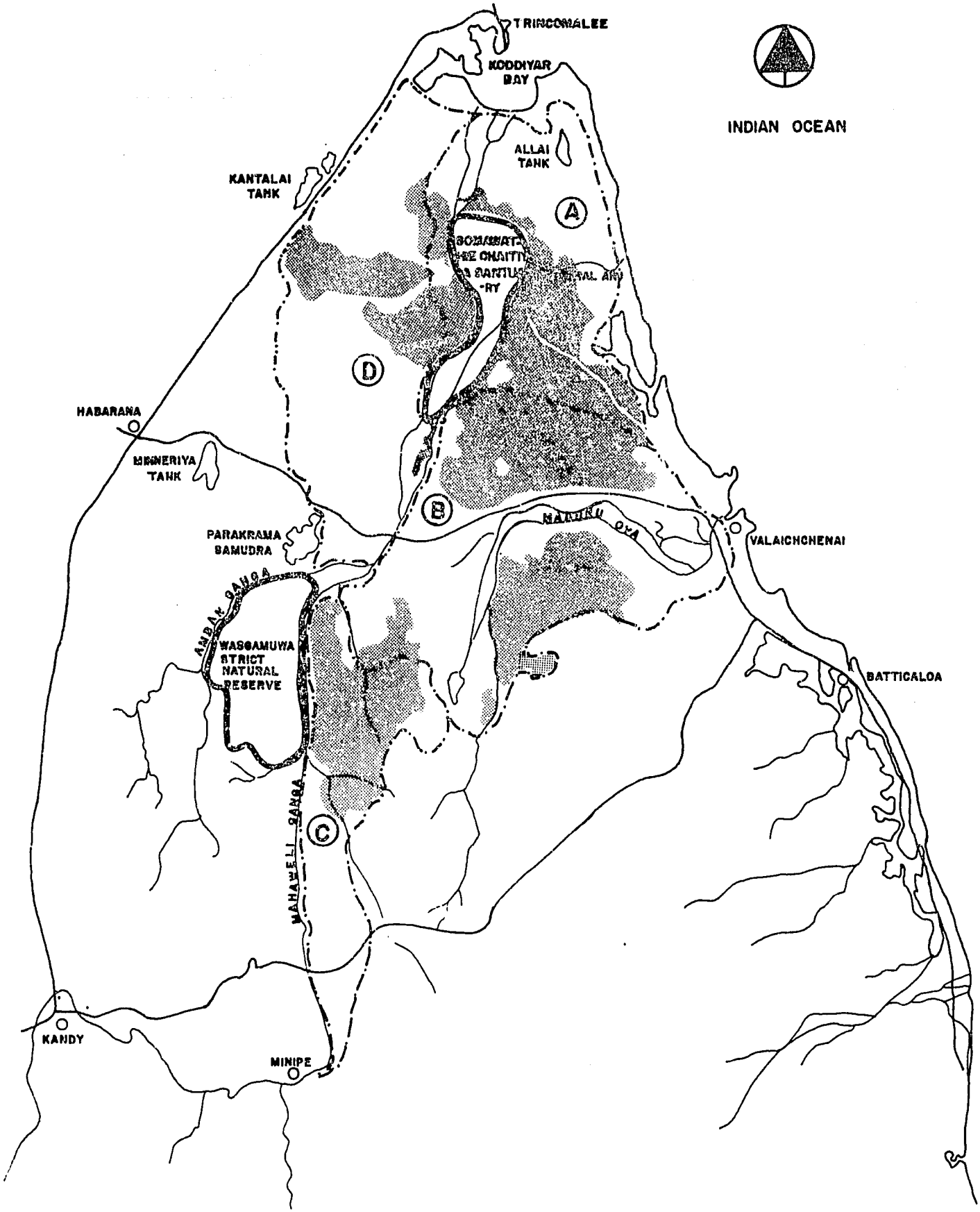

LEGEND

FOREST AREAS

AREAS OF FOREST IN THE ACCELERATED PROGRAM AREA

FIGURE D-3

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Table D-12

Area of Forest in Mahaweli Development Area

(1000 ha)

Forest Type	System				
	A	B	C	D	Total
7ND	30	41	7	15	93
7LD	3	1	16	-	20
7MD	1.7	-	-	-	1.7
Total	34.7	42	23	15	114.7

Table D-13

Volume Estimate of Mahaweli Development Area By Types and Systems ($1000m^3$)

Type	System				
	A	B	C	D	Total
7ND	30	41	7	15	93
7LD	18	6	96	-	120
2MD	44	-	-	-	44
Total	92	47	103	15	257

Table D-14

Distribution of Fuelwood in Mahaweli Development Area

($1000m^3$)

Type	Volume	System				
	M^3/ha	A	B	C	D	Total
7ND	57	97	-	-	-	97
7LD	43	129	43	688	-	860
7MD	20	600	820	140	300	1860
Total		826	863	828	300	2817

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Reserves

There are two reserves in the development area, the Somawathie Chatiya Sanctuary and the Koralai Forest Reserve. There were four other Forest Reserves, but they were released for development by the Forest Department (see Figure D-3).

The Somawathie lies between the Mahaweli Ganga and a major tributary, the Kandikadu Ela, with most of the north bounded by the Somapura-Kantalai Road. The northern part of the Sanctuary is heavily forested and forms part of the former Mahaweli Ganga North Forest Reserve and the Mahaweli Ganga Proposed Reserve. These reserves have been selectively logged for the past three years by a contractor of the State Timber Corporation (STC). During this period more than 1,800 m^3 of timber has been removed. This year there has also been a great deal of activity such as well drilling, soil surveying and cutting lines for land surveying.

There is a considerable game population, including elephants and leopards, that inhabit the northern part of the Somawathie which will be severely affected by any further reduction of their habitat and increased human activity.

The Koralai Forest Reserve lies on the Batticaloa - Polonnaruwa road about 24 kilometers from the former. Most of the Reserve is planted to teak; however, all the plantations of more than 10 years of age were blown down by the cyclone of 1978.

Most of the reserve is suitable for irrigation and it was agreed at a meeting at the Mahaweli Authority that the consultant will use the irrigable area in their plans and replace it with adjacent non-irrigable area to the north. The Forest Department agreed to this change as they had no immediate plans to reforest the area. The consultant agreed to leave all young teak plantations that would not interfere with their development plans. New boundaries for the Forest Reserve will be drawn at a later date when plans are finalized.

Forest Description

Fieldwork - In order to get some specific data on the floristic composition of the forest, an agreement was made with the Forest Department to borrow the class of Forest Guards at the Forest Ranger School at China Bay for 10 days in return for training them in forest inventory methods. Tents were borrowed from the Survey Department and jeeps were provided by the Mahaweli Development Board. A camp was set up in the Somawathie Sanctuary and instructions were given to the 12 students on the job. Thirty-four one-fifth hectare samples were taken on five strips in various parts of the uncut area of the forest.

Vegetation Pattern - The forest of the project area is described as a Tropical Dry Mixed Evergreen Forest (De Rosayro 1956). It is a secondary forest that has developed after about 1400 AD which marked the end of a long period of an early civilization based on irrigation agriculture.

Evidence of that era can be found throughout the project area in the form of abandoned tanks. Since that time the forest has been disturbed by chena agriculture and in more recent time by illicit felling. Along the Mahaweli Ganga and its major tributaries seasonal crops of tobacco are grown along the river tanks.

The forest is usually characterized by concentrations of 10 major species of which wira (Drypetes sepiaria) is the most predominant, comprising between 20 to 30% of the trees in a stand. Other prominent species are: Manilkara hexandra, satin or buruta (Chlorixylon swietenia), ebony or kaluwara (Diospyros ebenum), milla (Vitex pinnata), and halmilla (Berrya cordifolia). There were 92 species identified in the dry zone in the 1961 survey and these are found in varying mixtures according to site conditions.

The forest in the development area may be divided into four different classes of vegetation: high forest, riverine or gallery forest, villus and dry scrub.

The Somawathie is not strictly representative of the majority of the forest in the development area as it contains a large percentage of riverine and transitional types. However, it does contain the high forest on an undulating plain in the central part, riverine forest, villus and an extent of dry scrubby forest in the north. The forest type fits the description of the low yield dry zone type in growth characteristics as is shown by the similarity of the height/diameter curves with those of the 1961 survey (Figure D-4).

One striking fact emerged from the sampling; within the Somawathie, the tally did not show the presence of a single satin tree and only one ebony. This indicates that this area must have been culled over for these valuable species for many years. A list of the 10 species of highest frequency of occurrence can be seen in Table D-15.

The riverine forest grows on river banks and adjacent flood plains. These are sandier sites subject to seasonal inundation and are sometimes indicated by gregarious stands of welliwena (Dimorphocalyx glabellas). This was noticeable in the survey where 8% of the number of stems tallied were of this species. On the banks of the rivers typical species to be found are kumbuk (Terminalia arjuna), helamba (Mitagyna parvifolia), mi (Madhuka longifolia) and owila (Polyalthia longifolia). Helamba was the only species of this group that was represented in the riverine forest sample and constituted 4.6% of the stand tally. This was because none of the strips were located directly on river banks.

The villus have very little tree growth because of seasonal inundation. The trees that grow around the perimeter are mara (Samanwa saman), eremadu (Erythrina spp.) nebedda (Vitex leucoxylon) and Barringtonia racemonsa.

The dry scrub forest is characteristically shorter than the high forest with a higher proportion of thorny trees and shrubs. However, in the Somawathie it has the same species composition and apparently is

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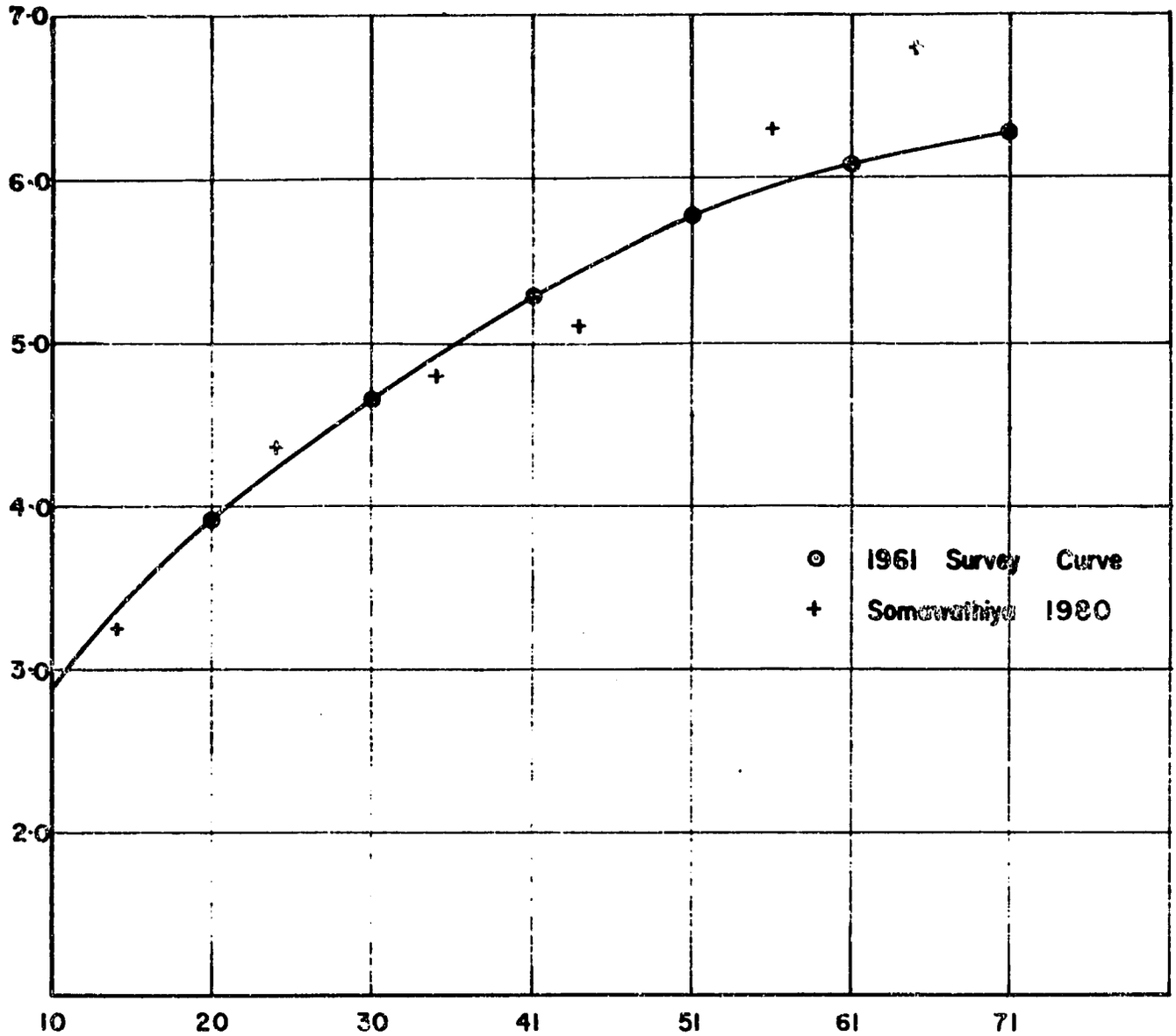
Table D - 15

List of Ten Species of Highest Frequency of Occurence

COMMON NAME	SCIENTIFIC NAME	Percent of Trees in Stand	
		1960	1979
1. Wira	Drypetes sepiaria	31.7	20.8
2. Halmilla	Berrya cordifolia	1.4	18.6
3. Kunumella	Diospyros ovalifolia	7.4	14.0
4. Weliwenna	Dimorphocalyx glabellus	3.0	8.0
5. Welang	Pterospermum canescens	9.7	6.3
6. Palu	Manilkara hexandra	4.6	5.0
7. Helamba	Mitragyna parvifolia	-	4.6
8. Milla	Vitex pinnata	3.0	3.5
9. Kurundu	Atalantia monophylla	-	2.9
10. Kuma	Gleniea unijuga	5.9	2.5



COMPARISON OF HEIGHT / DIAMETER CURVE
FROM 1961 TO PRESENT

FIGURE D-4

formed as a result of dryer soil conditions. Palu (Manilkara hexandra) is one of the indicators of dryness. n the 1961 survey it ranked sixteenth in the 7MD type, ninth in the 7LD type and second to wira in the 7ND type. In the Somawathie it ranked sixth with 5% of the trees sampled.

One formation that should also be mentioned is the damana, a grassy parkland with scattered clumps of trees. This formation is found extensively in the northern part of System B. It is usually found on shallow soils over bedrock or other impermeable layers such as clay pan. The major species found are Euphorbia spp., madam (Syzgium cumini), dawu (Anogeissus latifolia) and aralo (Terminalia chebula).

Critical Communities

There is one remaining remnant of the original dry zone forest located near the temple at Gunner's Quoin which contains a number of rare plants including Sterculia villosa, a tree that has not been recognized anywhere else in the dry zone.

Forest as a Habitat

The forest is a delicate complex of interrelated life forms and activities. It has strong recuperative powers, but when seriously interfered with, various systems breakdown: food chains are broken, population control mechanisms fail, symbiotic links in breeding cycles are removed and in drastic cases the habitat itself changes. A simple example would be in the total removal of one species of tree whose flowers are necessary for the maintenance of the indigenous bees thus cutting off pollination of numerous other species.

There is very little known about the composition and characteristics of flora in Sri Lanka. For example, Professor Klostermans of Peradeniya University, working alone, has identified and described more than 60 species of trees during the past two years. Some large areas of forest must be preserved in order to investigate them further and derive the untold benefits therein yet undiscovered.

The forest constitutes a gene pool for all the living forms within it and has a critical size below which species start to die out. In Sri Lanka, the Forest Reserves, Parks and Sanctuaries will soon be the only areas in which one can find undisturbed habitats. They must be safeguarded to provide a source of new crops, food and medicine so far undiscovered.

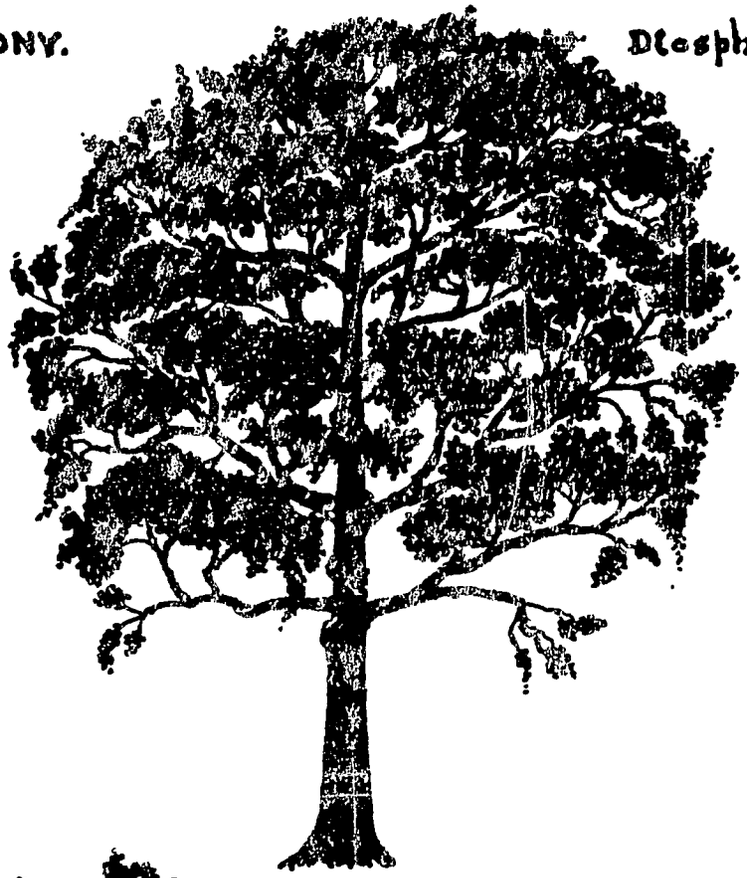
The forest in a narrower sense is a habitat for wildlife and provides a variety of forage for the herbivores such as bael fruit, (Aegle marmelos), wild lime (Alentia spp.), cashew nuts (Anacardium accidentale) and many other species.

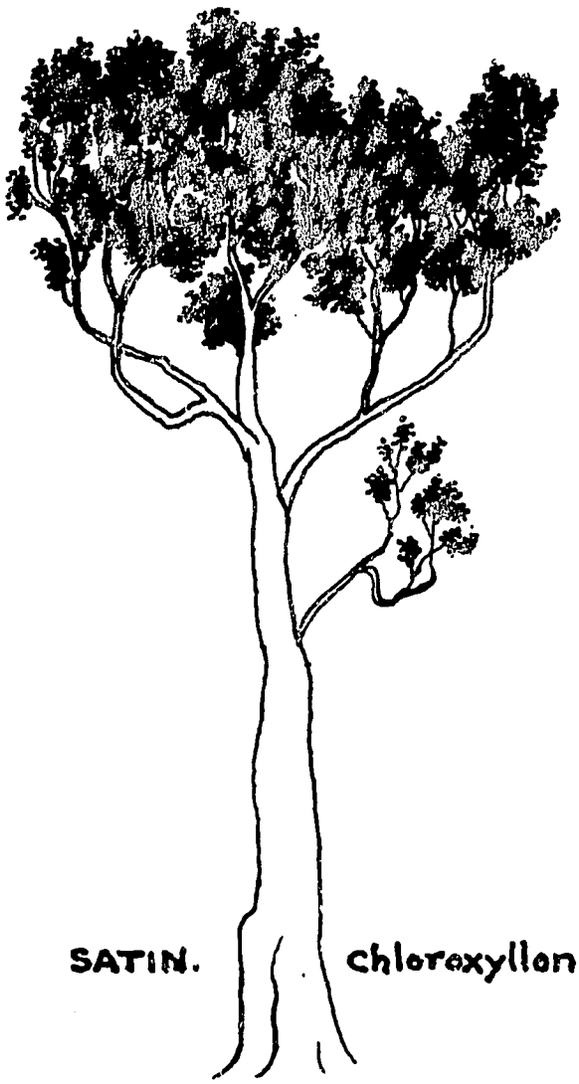
In a study of the forest of the Ruhuna National Park the species preferred by elephants for browsing were determined from crown distortion (Mueller-Dombois 1972). In the study, tree crown distortion due to browsing was subdivided into classes indicative of species preference of

elephants. Two of the strongly crown distorted species were Diospyros ovalifolia and Drypetes sepiaria, both well represented in the Somawathie.

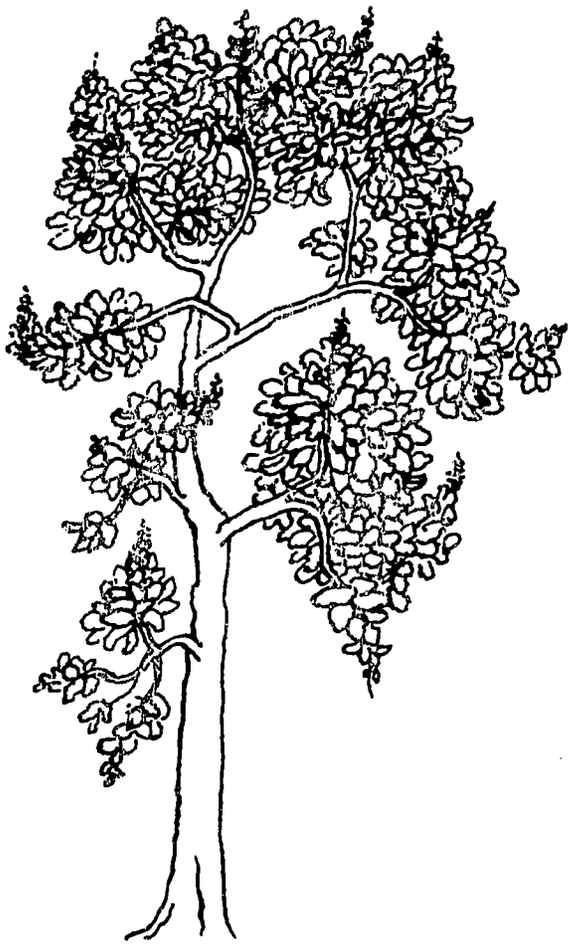
The Somawathie is an ideal habitat for wildlife, as it has a number of rivers and streams for water, villus for grazing and a heavy and varied forest for browsing and cover. If it can be preserved, it also would be the only block of forest unthreatened by encroaching agriculture.

EBONY. Diospyros ebenum.





SATIN. Chloroxylon swietenia.



TEAK. Tectona grandis.

C.F.

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IMPACT ANALYSIS

SRI LANKA

Forecast of Timber Production

Plantations - A forecast of timber production from plantations was made based on the mean annual increment per hectare and the plantation areas by species and age class presented in earlier sections of this report and as is shown in Table D-16.

The eucalyptus forecast production was reduced by 30% to allow for fuelwood. The production of mahogany was estimated from a consideration of the area under plantation and past reported yields. The miscellaneous species comprising 21 or more were estimated from their total area.

Teak did not enter the calculation, since it would be below rotation at the year 2,000. The total expected volume of timber was reduced by 30% to allow for poor stocking due to lack of any form of past management.

Natural Forest - The annual production estimated for the wet zone forest was 7,000 m^3, which assumes that an equal amount to the 35,000 m^3 of annual removals by the Ceylon Plywood Corporation can be obtained in the low country forest.

The dry zone production has been varied year by year to compensate for variations in plantation yields and keep imports within practical limits. It is estimated that there should be 250,000 hectares of dry zone forest still intact by the year 2000. This presupposes that indiscriminate chena and unorganized settlement would be curtailed. In deciding on the magnitude of the proposed annual production, the practical capabilities of the State Timber Corporation were also considered.

Private Lands - An allowance was made for supplies from private lands of 50,000 m^3. This amounts to about 25% of the difference between the estimated demand in 1979 of 453,000 m^3 and the 184,000 m^3 produced by STC and CPC, plus 55,000 m^3 of imports. The remaining 164,000 m^3 in 1979 is assumed to be illicit felling for which no allowance has been made in these calculations of future demand.

Forecast of Imports

Timber import volumes are increasing rapidly with the accelerated pace in construction associated with industrial, civil and agricultural development. New construction under way or planned includes the following:

- Housing development - 100,000 units;
- Six new hotels;
- New Capital in Cote;
- Ruhunu University;

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Table D - 16

Forecast of Production from Plantations 1981-2000
(1000 m^3)

Year	Species					Total	Loss
	Eucalyptus	Pine	Light Hardwood	Mahogany	Other		
1981	137	-	1	3	2	143	100
1982	143	10	9	3	2	167	117
1983	98	27	9	3	2	149	104
1984	91	55	29	3	2	180	126
1985	147	81	31	3	2	261	185
1986	205	101	26	3	2	336	235
1987	167	344	27	3	2	543	380
1988	243	253	26	3	2	527	369
1989	229	245	37	3	2	516	361
1990	181	391	31	3	2	608	426
1991	115	456	22	3	2	698	489
1992	111	445	45	3	2	606	424
1993	179	653	37	3	2	874	612
1994	155	646	48	3	2	855	599
1995	179	672	43	3	2	900	630
1996	237	672	21	3	2	995	696
1997	442	672	41	3	2	1155	808
1998	594	672	16	3	2	1287	901
1999	1047	672	16	3	2	1741	1219
2000	1400	672	68	3	2	2145	1501

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- New supermarket complex;
- Two bank buildings;
- Factories in the Free Trade Zone;
- Three power dams; and
- Settlement of the Mahaweli area.

Since most of the construction is reinforced concrete, the quantity of forming lumber alone will be substantial, and it is already in short supply.

It is estimated that the quantity of imports will increase from 80,000 m^3 in 1980 to over 200,000 m^3 and stay at this high level until the majority of the major construction projects are completed in 1986 or 1987. From this point, imports will decline at a more or less even rate to a point that most of the products required are available from local supplies. Some special items, sizes or species will always be imported.

The forecast of timber imports are shown on Figure D-5. Imports are shown on the chart as varying widely between 1986 and 1993 which results from variations in plantation production affecting local supply. In practice, some plantations would be cut sooner or held over until later and this line would be more like the trend line shown in the Figure. Imports are shown to cease in 1987 because production of plantations exceeds forecast demand in this year. This indicates that if all the assumptions in the forecast are reasonable and if the plantations are efficiently managed, that it is possible for the country to be self-sufficient in at least the major timber requirements by the end of the century.

The value of imports is increasing proportionately to the volume. Figure D-6 shows the rapid rate of increase in the cost of imports. This line was derived as a linear regression using the import costs for 1977, 1978 and 1979. The line crosses the one billion rupee mark in 1989 just two years later than the import volumes are estimated to start to decline. With the decline in import volumes, the costs will decline also; however, no attempt has been made to indicate this on Figure D-6.

Forecast of Consumption of Timber

Consumption of timber products has been estimated by taking a 5% annual increment from the base volume in 1979 projected to 1990 and from there at a 2% rate to the year 2000. This allows for the heavy construction activities mentioned previously for the first 10 years and then a 2% rate presently estimated for the rate of population increase (see Figure D-7).

The consumption figures were plotted also on the basis of the number of cubic meters per 1000 population as shown in Figure D-8. Consumption in 1979 was 32.7 m^3 and 44.8 in 1990 and 2000. This compares favorably with figures of other countries (Cigot 1979) as follows:

U.S.	354 m^3
Japan	300 m^3
Singapore	71.4 m^3
Malaysia	22.6 m^3
Philippines	11.3 m^3

The consumption of Sri Lanka lies between that of Singapore and Malaysia.

Balance of Supply and Consumption

The major considerations in calculating the consumption-supply balance were to limit exploitation of the natural forest as much as possible and to keep estimated imports within reasonable limits. In Table D-17 it can be seen that consumption is forecast to be almost double by the year 2000. Even though the Table shows that imports stop in 1998, this is unlikely to happen because a large proportion of the plantation production is pine. Destruction of any further dry zone forest after the end of the century should be avoided if possible, and it should only be cleared for high yield agriculture or other pressing requirements. Figure D-9 shows graphically the information in Table D-17.

Though these forecasts are based on very meager data, they do serve to indicate the order of magnitude of four definite trends: demand for timber will almost double by the year 2000; a large increase in imports will occur during the next 10 years; there will be an accelerated depletion of the dry zone forest; and the present plantations will come close to satisfying anticipated requirements at about the year 2000.

Fuelwood

It is assumed throughout these calculations that the 1980 rate of plantations will be carried through the next 20 years. One of the major impacts of the rapid deforestation during the last 20 years has been to remove locally available sources of fuelwood. Because of the high cost of transportation, fuelwood sources must be located close to the consumers to be priced within a range that they can afford. This means that fuelwood plantations must be established near communities or within reach of concentrations of population.

It is estimated that the annual requirement per person for fuelwood for cooking is 0.57 m^3. If the population in Sri Lanka is calculated to be 14,484,000 in 1980 this would indicate a demand for about 8.3 million m^3 of fuelwood. Using a species with rapid growth such as ipil ipil (Leucaena leucocephala) or Calliandra callothyrsis with yields of 30 m^3 per hectare per year and a five year rotation, it would require approximately 55,000 hectares of plantation to satisfy the annual demand. This area would have to be increased by 2% per year to keep pace with the population growth. This estimate is high because many people use other forms of fuel such as rubber, wood and agricultural waste when they are available. With the escalating costs of all forms of energy it is time to make a survey of fuel requirements in the country to obtain an accurate estimate of the area of fuelwood plantations required and their location.

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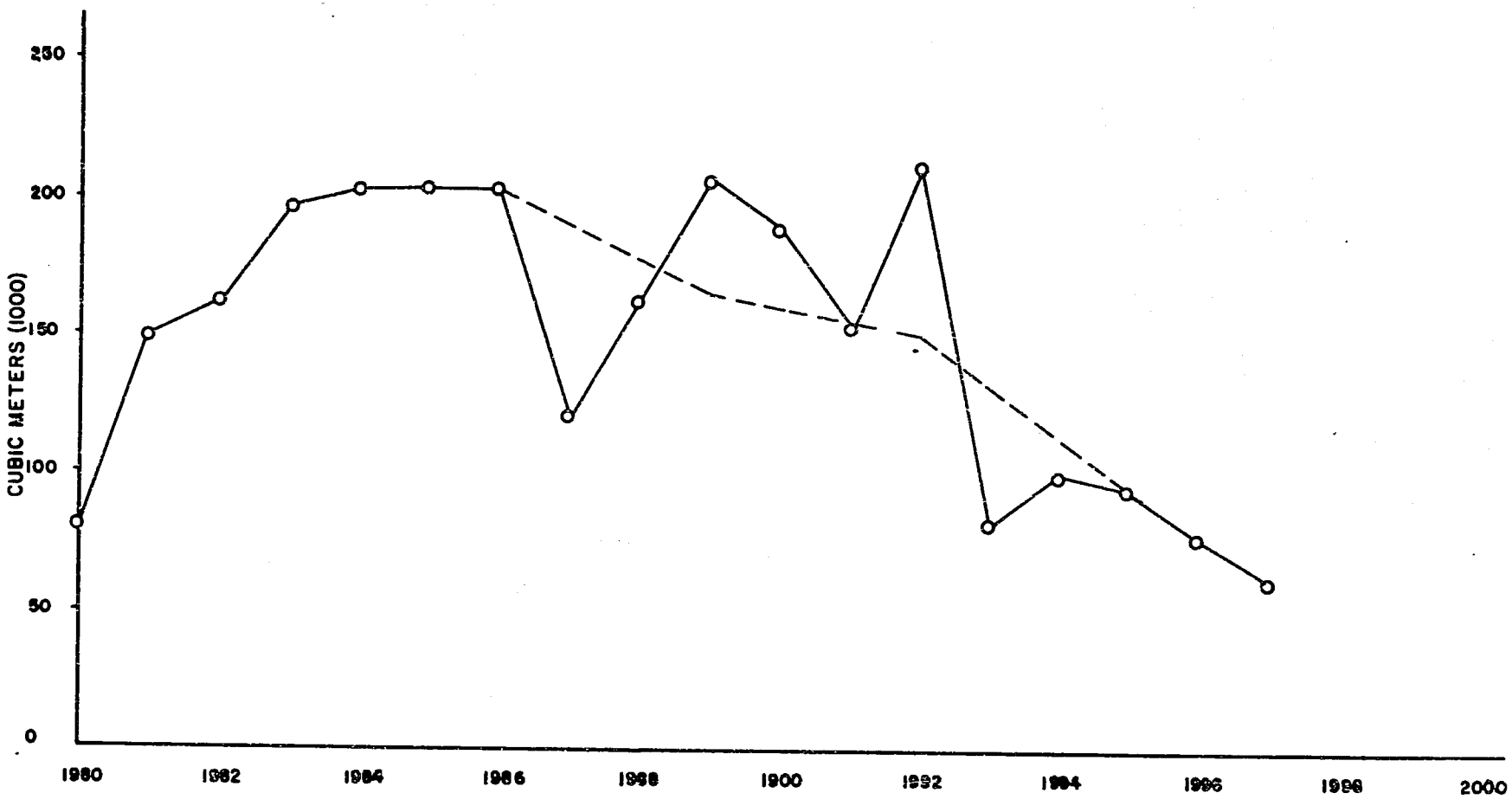

PROJECTED VOLUME OF TIMBER PRODUCTS IMPORTS
SRI LANKA – 1980-2000

FIGURE D-5

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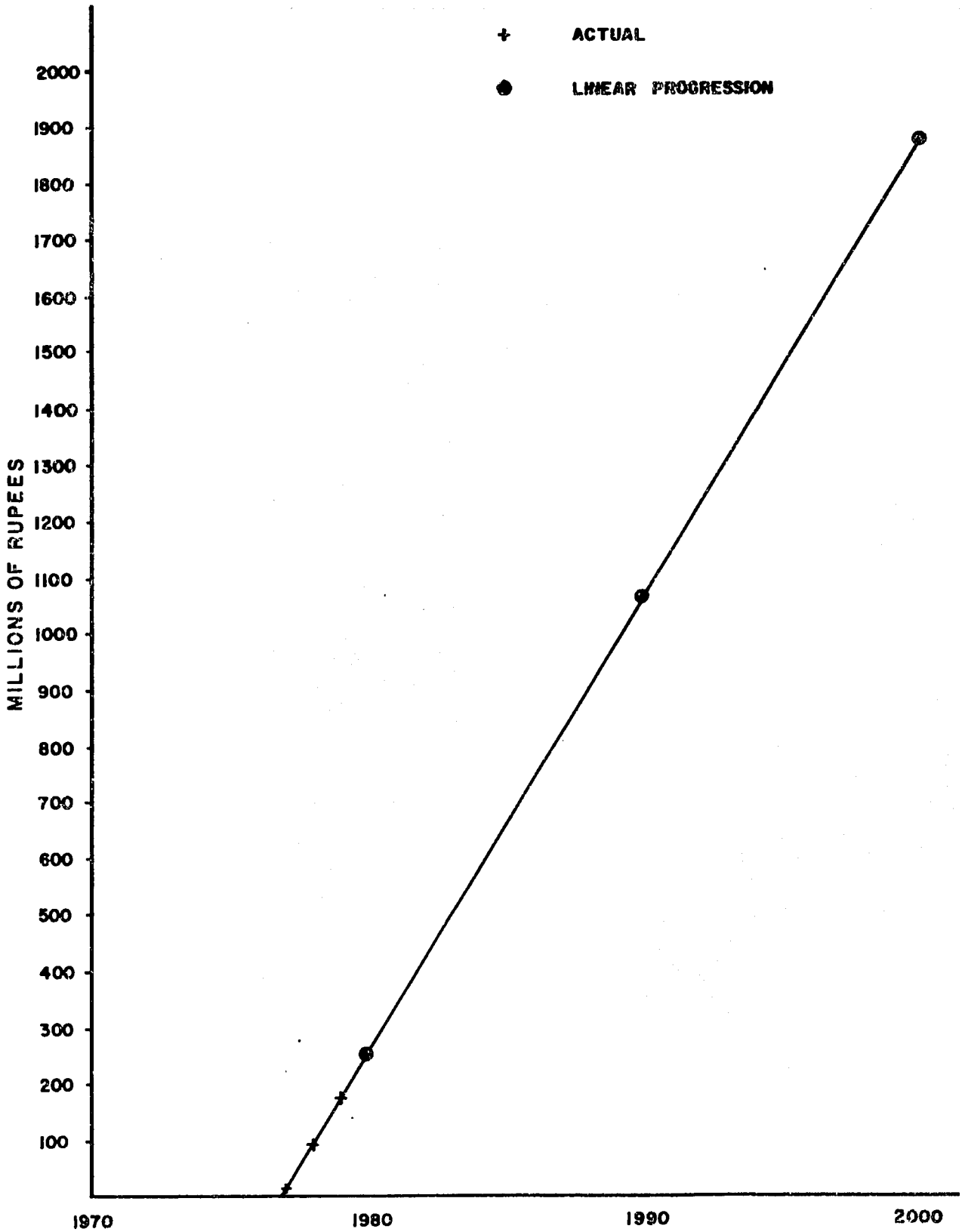

PROJECTED IMPORT COST OF FOREST PRODUCTS
SRI LANKA

FIGURE D-6

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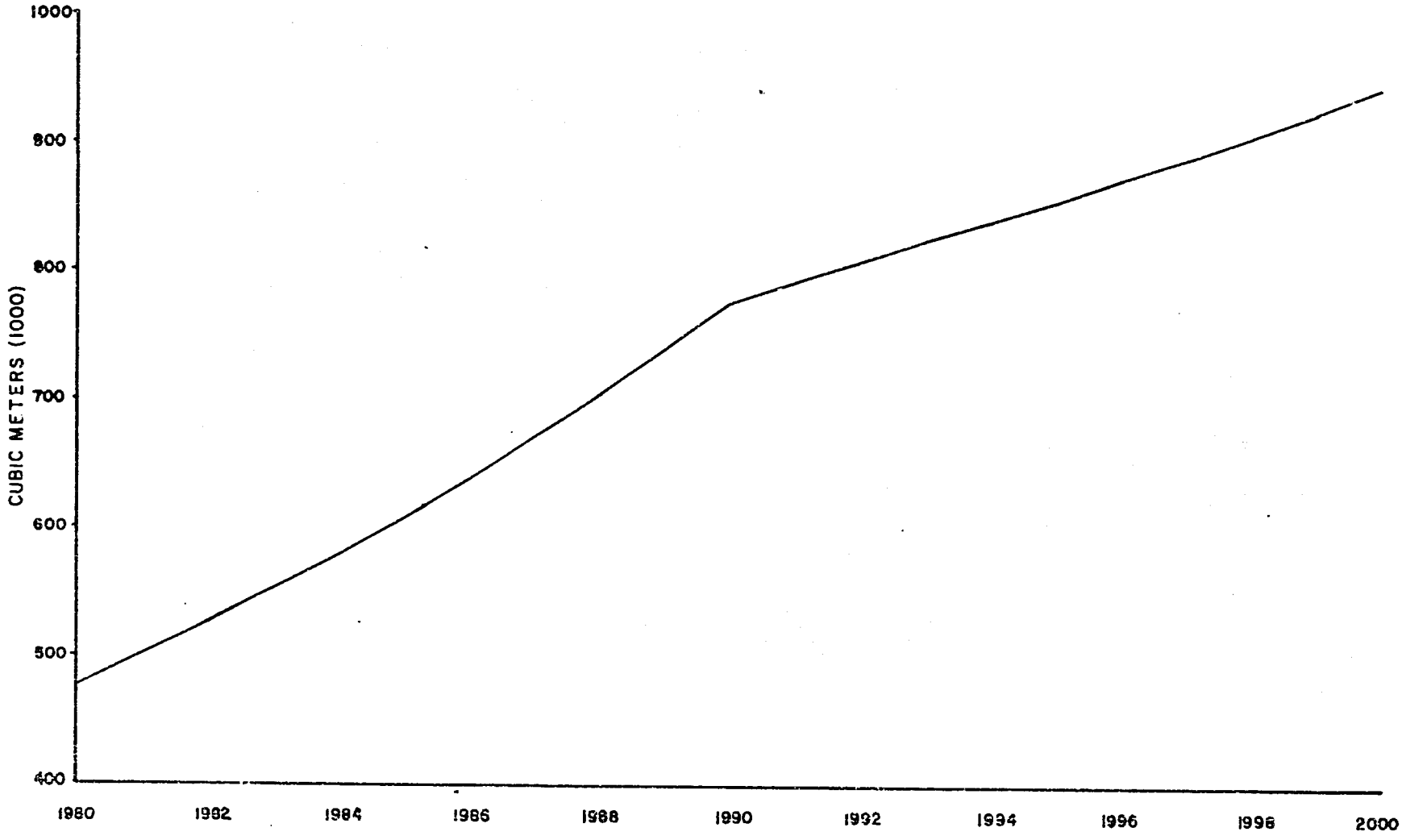

CONSUMPTION OF TIMBER 1980-2000
FIGURE D-7

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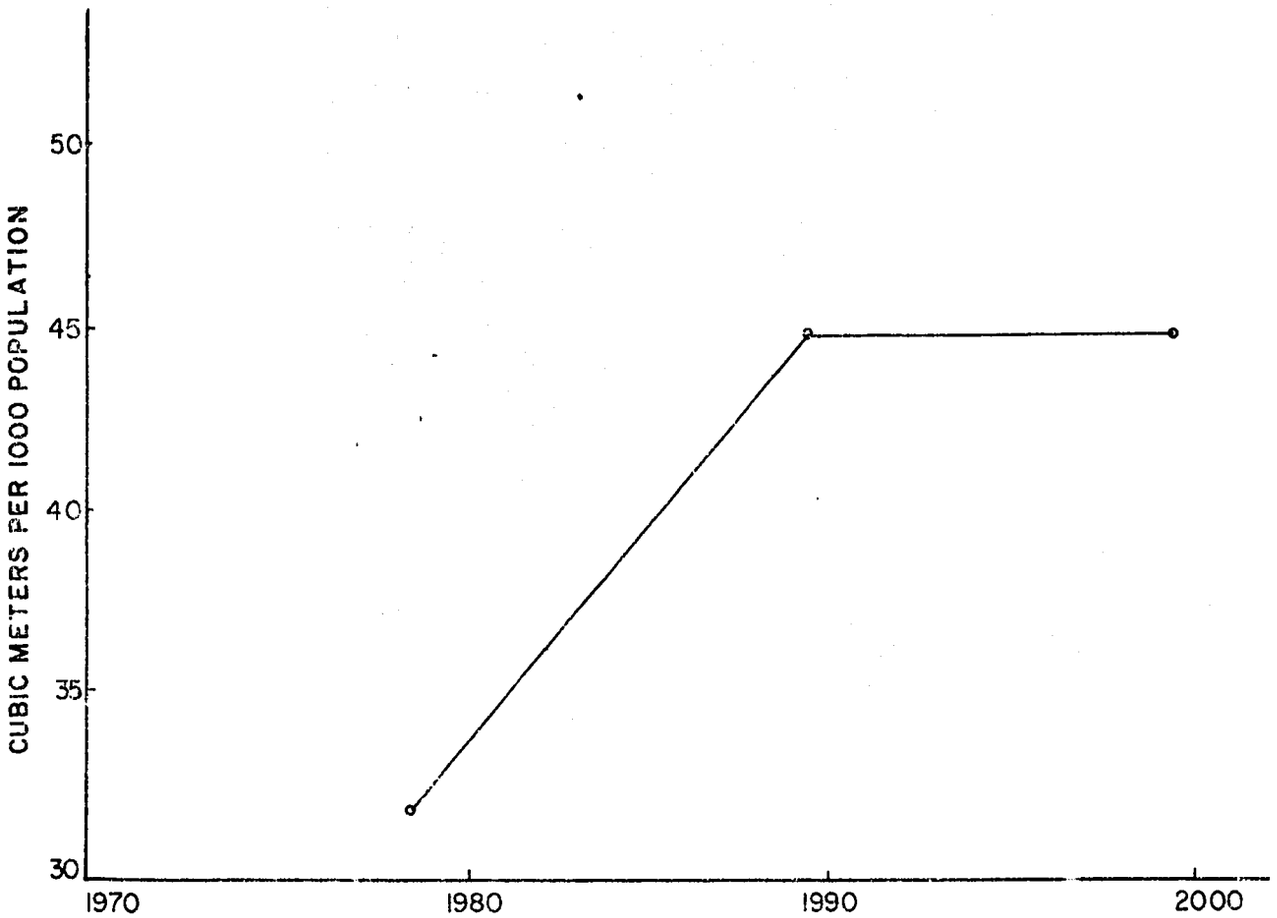

CONSUMPTION OF TIMBER
CUBIC METERS PER 1000 POPULATION
FIGURE D-8

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Table D - 17

Estimated Production Imports and Consumption of Timber

SRI LANKA

1981 - 2000
(1000 m^3)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Present Plantations	100	117	104	126	185	235	380	369	361	426
New Plantations										
Wet Zone Forest	70	70	70	70	70	70	70	70	70	70
Dry Zone Forest	130	130	130	130	100	80	60	60	60	50
Private Lands	50	50	50	50	50	50	40	40	40	40
Imports	150	162	197	202	202	203	120	164	207	189
Estimated Consumption	500	525	551	578	607	638	670	703	738	775

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Present Plantations	489	424	612	599	160	226	338	431	749	1031
New Plantations *					470	470	470	470	470	470
Wet Zone Forest	70	70	70	70	70	70	70	-	-	-
Dry Zone Forest	50	70	30	30	30	10	-	-	-	-
Private Lands	30	30	30	30	30	20	20	7	-	-
Imports	152	213	81	100	95	77	61	-	-	-
Estimated Consumption	791	807	823	839	855	803	890	908	926	945

* planting of pine starting in 1980 to replace plantations cut at 1 Rotation Age

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ACCELERATED PROGRAM AREA

Changes in Vegetation Cover

Three quarters of the development area have already been denuded of forest. Of the total area of 421,700 hectares, more than 36% has been cleared for the development already, or is in chena and scrub. The State Timber Corporation is engaged in removing the merchantable timber on a further area in System B and C of 30,000 hectares (State Timber Corporation 1980). This will mean a further reduction of 26% of the forest area. None of this clearing and felling is being done according to an organized schedule integrated with the agricultural development plants for the four irrigation systems.

Only those areas required for development need to be cleared ahead of time, leaving the remaining forest for locally available fuelwood and timber supplies for the settlers in their first few years of occupation. In clearing, a conscious effort must be made to conserve strips of forest along rivers and streams and ridges for protection against erosion. Clearing itself should occur as nearly to the time of actual development as is practicably possible, and fuelwood poles and other useful material should be stacked and left for immediate use by the settlers. The time lag between clearing and development should not exceed about six months.

The consultants are in the final stages of completing their development plans and when these are complete a clearing plan and schedule can be prepared. The final plans show a marked reduction in the area to be irrigated from that previously planned, because of further information on soils and drainage. A great deal of forest has been cleared needlessly in the past; however, clearing can now be planned and coordinated to remove timber only from those areas necessary for development.

Loss of Timber Resources

The 114,700 hectares of forest remaining in the development area have an estimated 257,000 m^3 of timber and 2,817,000 m^3 of fuelwood. The average volume per hectare for timber is 2.2 m^3 and for fuelwood is 24 m^3. The State Timber Corporation is planning to take only the better stands with an estimated yield of 2.8 m^3 per hectare with a total removal of 212,000 m^3 or 82% of the volume in the forest area of the four systems. The volume of fuelwood that will remain on the 30,400 hectares to be cut by the STC is estimated to be 73,000 m^3.

The Mahaweli Development Board is planning to settle one million people in the four systems, and they estimate that these will require 1.25 m^3 per person for the timber requirements of the settlement program. This would mean that there would be a deficit of about 300,000 m^3, even if the logs produced from the planned operations were sawn and used in the area. Up to now, logs and sawn timber have been mostly shipped to Colombo.

BALANCE OF PRODUCTION AND CONSUMPTION
FIGURE D-9

Effects on Fuelwood Supply

The one million settlers will have a fuel requirement of 570,000 m^3 annually, and thus, the area can yield about five years requirement. Since timber will be left along river banks and non agricultural areas and transportation costs will curtail supplies to some localities, one can assume that only about one-quarter to one-half of this material will actually be available for use by the settlers.

This is all the more reason to plan the operations to conserve timber and fuelwood in situ to save time and costs in settlement operations as well as only cutting areas of timber actually required. If fuelwood plantations of species with rapid growth are planted in close proximity to planned settlements there should be enough fuelwood still available until the first cuttings can be made from the plantations. The settlers' requirements for fuelwood can be met by an estimated initial plantation area of 2,300 hectares. A large charcoal project is being planned by a joint venture group to utilize fuelwood from the development area and later to use the large plantations being sponsored by USAID. This could utilize wood not economically available to the settlers because of distance, and should be included in operating plans.

RECOMMENDED ACTIONS

SRI LANKA

Studies Required

In order to supervise and manage the exploitation of the remaining forest resources and manage the plantations, it is recommended that a National Forest Authority be established combining the functions of the Forest Department, the State Timber Corporation and other wood based corporations.

The predicted rapid expansion of activitities related to the forest industries will require coordination under a plan covering the production, manufacture and marketing of forest products. It is recommended that a Master Plan for the forestry sector of Sri Lanka be prepared that is compatible with the land use plan for the country (TOPIC REPORT B: LAND USE AND SOILS). A suggested organization is presented herein for the Forest Authority and Master Plan in a later section of the report.

In order to prepare the Master Plan for the forestry sector a great deal of new information will be required. For this purpose it is recommended that the following studies be undertaken:

- Forest and plantation inventory;
- Census of forestry related industries;
- Census of energy and fuelwood requirements;
- Forest products market demand study;
- Feasibility study of supply of pulpwood for National Paper Corporation;
- Feasibility study of supply of logs for Ceylon Plywood Corporation;
- Feasibility study for new sawmills; and
- Feasibility study for charcoal industry.

Financing

A number of agencies have shown interest in these various studies with the exception of the feasibility studies for the Paper and Plywood Corporations and the sawmills. A list of agencies and their declared interests is shown in Table D-18.

Cost

The World Bank has estimated that the cost of a similarly constituted sector plan and associated studies was $20 million in 1979 (World Bank 1980). A project is recommended to coordinate the funding agencies and develop a detailed outline of the Master Plan. This would probably be funded by any one of the agencies already involved.

Table D - 18

Stated Interest, Plans and Programs of Various Agencies for Forestry

	USAID	IBRD	ADB	CIDA	FAO	ODM	Holland Sweden Norway
Regional Development Plans				*** Uva			
Plantations	***		**		*		
Technical Assistance	***						
Rural Integrated Development Plans		***					***
Landuse Survey					*		
Demand Study Fuelwood & Industrial wood					*		
Forest Inventory					**		
Agro Forestry Production					*		
Forest Management Plans					*		
Watershed Research					*		
Institution Master Plan					*		
National Training Capacity	***				*		
Village Fuelwood and Charcoal	***						
Village Forests			*				
Forest Research	***						
Forest Extension Service	***						
Village Level Training Program			**				
Organize Forest Department			**				
National Publicity and Information			**				
Charcoal Marketing Study			**				
Community Oriented Research	***		**				Holland*
Soil Conservation		*** NADSA					

Interest*; Plans**; Programs***

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Education and Training

The extensive plantation program necessary for the provision of timber and fuelwood supplies for the next 20 years will requirean extensive training program. The Department of Forestry has already built and equipped a new building at the China Bay Ranger School. The present complement of technical field staff is 38 Foresters, 176 Forest Rangers of which 40 are trained, and 402 Forest Guards. The Forest School is now set up to handle 15 Forest Guards per year in a one year course, with a principal and three instructors. They are planning a Forest Ranger Course with 40 students for a two year period.

The present staff was stretched to the limit planting 8,100 hectares in 1979. In 1980, it is planned to plant 12,200 hectares. It is estimated that in the next five years, the requirement will be 60 foresters, 220 forest rangers and 350 forest guards. The most urgent need is to obtain sufficiently trained men quickly. It is suggested that 45 Rangers be given a two year course, but in two stages three years apart. The number of forest guards in school should be doubled and they should get an intensive six month course in planting and return after three years to complete the other six months. This will require double the number of instructurs for the Forest Guards and at least seven additional instructors for the Forest Rangers.

In addition to training on planting, silvicultural operations such as marking for thinning and improvement cutting will have to be taught. This can be taught to the Forest Rangers during their second year and the Forest Guards during their second six months.

The Forest Authority will also need at least 10 new Professional Foresters. A post graduate school of Forestry is presently being set up at the Sri Jayawardenepura University for a two year course for graduates of bachelor courses in science.

It is recommended that assistance be increased to forestry training to include more facilities at the Ranger School, to accommodate much larger enrollment, and to provide more technical assistance in the form of instructors for the training school and at the University.

NATIONAL FOREST AUTHORITY

A new form of organization will be required to supervise the evaluation from exploitation of natural forest to management of forest plantations. It is recommeneded that a National Forest Authority be established combining the functions of the Forest Department, the State Timber Corporation and other wood based corporations (i.e. Plywood Corporation, Paper Corporation, etc.) for this purpose. This organization should include the following divisions:

- Administration;
- Plan and Project Preparation;
- Forest and Plantation Management;
- Community Forestry;
- Forest Operations;
- Timber Utilization;

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- Forest Research;
- Public Education and Information;
- Extension Service; and
- Division Offices.

The Administration would include all the supporting services such as personnel, accounting, records, legal, etc.

The Plans and Project Preparation division would have responsibility of coordinating all the activities of the funding institutions connected with forestry such as the AID plantation program, cooperation with NADSA for reforestation, and the bilateral aid countries for integrated rural development programs. It would also evolve proposals for further projects in order to implement the National Forest Master Plan, and would coordinate forestry activities of other government departments and institutions.

The Forest Management Division would be responsible for forest and plantation surveys and preparation of management plans. From these it would prepare an annual schedule of forestry operations such as planting, thinning and final cuts, allocating the various products to the consuming centers. These activities would be coordinated with the requirements of industries and their locations.

The Community Forestry Division would help develop a system of community forests along the lines of the proposed village forest program under development in cooperation with the Asian Development Bank. These forests would be managed by the community to supply fuelwood and other forest products for use and for sale. USAID is also proposing a program of village run fuelwood and charcoaling facilities.

The Forest Operations Division would carry out two distinct types of operations. These would be silvicultural improvement cuttings and final cutting in both plantations in natural forest. These two types of operation would employ entirely different techniques and equipment.

Timber utilization will require a much stronger emphasis than heretofore, because the annual production of logs is expected to double during the next 20 years and the technology of the industry has to change to handle plantation wood. For instance, new sawmills will be required to efficiently handle a large volume of small logs of uniform size.

Forest Research will also require much greater emphasis to conduct research on suitable species for planting and to conduct provenance trials to improve the useful qualities of the species selected. They also need to conduct research on the control of insects and diseases, growth, yield and stand management. USAID is already developing a program of assistance along these lines.

The Public Relations and Education Division will have the responsibility to change the public's view of the forest as being inexhaustible and its products free for anyone to use, to one of conservation and appreciation. It will have to instruct the public as to the actual realities of the extent of the forest and the value of plantations for the production of essential materials. The Asian Development Bank is including support in this regard, with reference to their village forest program.

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The Extension Services will be mainly based in the Divisional Offices. Its function will be to foster interest at the community level in the preservation of natural forest and starting plantations. It will also provide ongoing advice to the villagers on the management of their plantations. The USAID is proposing a program of training and supplying technical advisors to get the Division started.

In order to efficiently manage the new plantation regime it will be necessary to decentralize a great deal of the responsibilities formerly administered in Colombo. For this purpose Regional Managers should have senior rank and their staff should have representatives of all the Divisions in the head office.

FORESTRY SECTOR MASTER PLAN

Purpose

The purpose of the Master Plan is to coordinate all the activities connected with the production, manufacture and marketing of forest products.

Scope

The plan covers all aspects of the size and location of plantations, species used, rotation ages and silvicultural treatment. These decisions are based on the location and requirements of local industry. The plan also would specify the size and type of new industries and quality and grading specifications for products designed to meet market requirements. Attention will be paid to the grouping of industries so that waste is reduced to a minimum, for example, centralizing sawmills to supply a pulp and paper mill or chipboard plant.

The plan will include a monitoring system for fuelwood requirements and will provide marketing outlets for village forest products. The plan will include specifics for action on soil conservation requirements.

Though the plan will be under constant revision it should have a term of ten years, after which it would be rewritten to cover the forecast requirements for the next ten years based on new survey data.

Program

An annual program will be prepared according to the requirements laid down in the plan, outlining in detail the work to be done, people responsible, equipment required, time schedule, and budget.

ACCELERATED PROGRAM AREA

Control Plan for Clearing Operations in the Project Area

Heretofore, clearing the forest in the Accelerated Program area has been carried out with no coordinated plan defining the area actually to be used for agricultural development. The State Timber Corporation is presently

engaged in logging the northern protions of Systems B and C under a plan to remove all the merchantable timber by 1983. This entails cutting 30,400 ha or 12% of the forest area; however, only the best stands will be taken and 82% of the merchantable area will be removed. Sixteen Timberjacks have been delivered and are already in operation. The remainder of the timber, wira and other material are planned to be used for charcoal by a joint venture company pending the time USAID plantations are old enough to provide supplies.

It is recommended that no further timber be cut in the project area other than the occupying lands designated for development by the consultants. This would include areas designated for villages and the Somawathie Sanctuary. It is also recommended that liaison be provided between the Mahaweli Board Planners and the Irrigation Department to assist them in locating village sites. Such a project could be done by the following method.

Scope

1. Outline all the forest areas on the present and land use maps;

2. Superimpose the areas planned for development and areas selected for village sites and draw boundaries for the limit of cutting;

3. Inspect the boundary lines on the ground and finalize them;

4. Designate village sites by coordinating planning of Mahaweli Board and Irrigation Department and reconcile this with the Land Use Map, Land Class Map and the Consultants recommendations. The village sites should be left forested to provide fuelwood, building materials and trees to be left for shade. Up to now the STC has been shipping logs and lumber cut in the project area to Colombo;

5. Supervise the survey of the boundary lines with a traverse and paint all border trees;

6. The Mahaweli Board will issue the maps and instruct the STC and Contractors as to their cutting boundaries. Cutting can proceed even as borders are being marked; and

7. Set up regular monitoring system with the Mahaweli Board to detect noncompliance.

Personnel and Time

One Forest and Land Use Planner for eight months to do mapping, supervise surveying and painting lines and set up monitoring system.

Counterpart

One Mahaweli Board Environmental Officer.

Control Plan - Somawathie Sanctuary

It is recommended that no further cutting is done in the Sanctuary until it is definitely established that the area will be developed. If it is to be developed, boundary lines will be established as above.

Fuelwood Plantations

If the cutting is controlled in the remaining forest areas, there will be sufficient fuelwood for three years. In areas already denuded, plantations of rapidly growing species should be established as quickly as possible after the village sites are located. It is estimated that 0.57 m^3 will be required per person per year, thus the planned population of one million by 1990 would require 570,000 m^3. With plantations growing at an annual rate of 28 m^3/ha in five years, they would yield 140 m^3 per hectare and the area required would be about 20,000 hectares. The fuelwood plantations should be established on areas not required for agriculture as close to the villages as possible and their extent would be dictated by the population.

Shelterbelts

There is a steady hot dry wind at Trincomalee that blows from the northeast during the months of May to September. This wind has an average velocity of 15-20 km/hr and an average duration of 10-22 hours per day. In Batticaloa, in December and February the winds exceed 10 km/hr for 18-19 hours per day.

The depth of the sheltered zone is largely dependent on the height of the trees. Wind is slowed before it reaches the shelterbelt, and the reduction in velocity of about 70% of the original, begins at about nine times the height of the trees. When the wind strikes the shelterbelt, part of the air current passes through the trees and is broken up in minor turbulences. On the lee side of the trees the speed continues to diminish and reaches its minimum form one to five times the height of the trees. From this point the velocity increases, eventually reaching its original velocity. Wind velocity is reduced for a distance of 25 to 30 times the height of the shelterbelt, and actual distance depends on the windspeed and the design of the barrier (Goor and Barney 1971).

A permeable windbreak is considered to be better than an impermeable barrier, permitting about a 20% windflow through small, evenly distributed openings.

Since the principal problem in designing a series of belts is to achieve the maximum protection with a minimum sacrifice of land, they should be planted along roads or canals wherever possible, or along natural ridges where these are oriented as nearly as is reasonable at right angles to the prevailing wind direction. The area occupied by shelterbelts varies from 1.5% to 3.5% of the area to be protected.

The selection of species and spacing is important, and hardy fast growing types with large crowns are needed. Seedlings are planted two meters

apart in rows three meters apart. It is advantageous to only use one species to simplify management; however if eucalyptus is used, a shorter shrubby tree must be used to fill the space between ground and crown. However, with eucalyptus this effect can be accomplished by cutting alternate rows of trees, and the coppice will fill in below the crowns of the remaining rows. Some species that could be considered for the Accelerated Program area are Eucalyptus camaldulensis, Acacia spp. and Pinus carabaea handurensis.

Bund Support and Stabilization

There is one small indigenous tree that is used to provide bund support, Sisbania sisba, which also provides fuelwood, and both the leaves and flowers are edible.

River and Stream Protection

In order to stabilize the banks of rivers and streams and to provide shade to inhibit mosquito breeding and the growth of aquatic weeds, a 200 meter wide strip on both sides is recommended. This will require a total of 5,100 hectares for System A, 5,600 hectares for System B, 2,800 hectares for System C and 1,500 hectares for System D. The total area is 15,000 hectares.

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APPENDIX D-I

FOREST RESERVES AND PROPOSED RESERVES

Extent of Natural Forest

Number of Reserve	Name of Reserve	Former Area Acres	Present Area Acres	Remarks
1	Pallai F.R.	1,139	-	
2	Mandakalar F.R.	20,725	18,705	
3	Chunnavil F.R.	5,680	5,680	
4	Akkiriyan F.R.	20,212	18,790	
5	Akkiriyan F.R.	6,625	6,625	
6	Kilinochchi F.R.	27,653	26,458	
7	Iranaimadu F.R.	20,563	17,132	
8	Vadakkachchi F.R.	17,568	17,568	
9	Nagapaduwan F.R.	10,254	7,244	
10	Panikkankulam F.R.	18,048	16,918	
11	Teravil Oddusuddan F.R.	94,880	38,457	
12(a)	Kulamurippu F.R.	8,036	6,186	
13	Nenthavil F.R.	20,078	—	6 Sc
14	Vannivilankulam F.R.	27,069	75,200	
15	Chamalankulam F.R.	8,109	8,026	
16	Tanduwan F.R.	2,756	1,956	
17	Nagancholai F.R.	16,732	15,177	
18	Andankulam F.R.	37,458	36,658	
19	Paranthan F.R.	7,159	6,000	
20	Nainamadu F.R.	24,259	24,259	

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21	Irampaikkulam F.R.	2,336	2,336	
22	Melkulam F.R.	5,429	4,773	
23	Puvarasankulam F.R.)	10,817	-	4 pd
24	Puvarasankulam F.R.)			
25	Irasenthirankulam	3,604	2,928	
27	Maha Irampaikkulam F.R.	1,989	1,629	
28	Mamadu F.R.	569	569	
29	Karunkalikkulam F.R.	19,859	15,726	
30(b)	Kulamurippu F.R.	4,409	4,374	
31	Padawiya P.R.	241,920	241,287	
32	Northern Block P.R.	123,120	-	4 pd
33	Mavilu F.R.	36,080	32,400	
34	Veppal F.R.	25,992	25,600	
35	Etakaduwa P.R.	19,000	9,500	
36	Issenbessawewa F.R.	1,092	-	p
37	Medawachchiya P.R.	7,147	6,849	
38	Hinna P.R.	2,525	-	4 pd 6Sc
39	Wedakanda P.R.	12,800	-	6 Sc
40	Mihintale F.R.	8,175	-	6 Sc p
41	Nuwaragama F.R.	6,387	Nil	
42	Yodaela F.R.	5,654	2,746	
44	Alutabendawewa P.R.	1,088	1,088	
45	Hurulu F.R.	61,620	41,019	
46	Anaolondewa P.R.	13,242	11,567	
47	Kantalai F.R.	110,680	110,432	
48	Chundankadu F.R.	41,331	Release	
49	Chundankadu F.R.	27,308	Release	
50	Mahaweli Ganga North F.R.	22,757	Release	

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51	Mahaweli Ganga P.R.	16,000	Release	
52	Mahaweli Ganga South F.R. included in No.50		Release	
53	Vappiah Verugal F.R.	10,805	Release	
54	Koralai F.R.	19,210	11,237	
55	Koralai P.R.	2,880	2,880	
56	Giritale P.R.	2,662	2,653	
57	Minneriya P.R.	6,040	2,134	
58	Gal Oya P.R.	22,330		6 Sc
59	Inamaluwa F.R.	4,687		burned
60	Pelwehera F.R.	4,759		4 Pd
61	Kahalla F.R.	8,396		4 Pd
62	Pallekele F.R.	36,480		4 S
* 63	Kalugala P.R.	8,315	7,440	
64	Timbiriwewa P.R.	3,148	1,225	
65	Potuwewa P.R.	597	597	
66	Minuwangeta P.R.	1,844	1,844	
67	Panawewa F.R.	597	597	
68	Dambuwa P.R.	2,625	2,125	
69	Nikawakanda P.R.	375	375	
70	Galgiriyakanda P.R.	2,922	2,922	
71	Getadivula P.R.	1,437	1,437	
72	Mudungoda P.R.	1,913	1,913	
73	Motarampatana P.R.	739	663	
74	Nikolawewa F.R.	9,359		4 Pd
75	Kala Oya P.R.	12,231		4 Pd
76	Lunu Oya F.R.	9,013		4 Pd
77	Sangapparle P.R.	11,601	11,561	
78	Sawarangalawa P.R.	15,591	13,634	

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79	Wanniyagama P.R.	38,540	13,634	
80	Epolagama P.R.	11,000		6 Sc P
81	Weerakulicholai Eluvankulam P.R.	74,450	68,120	
82	Sellankandal F.R.	10,548	10,541	
83	Sellankandal P.R.	13,655	11,223	
84	Attavillu F.R.	22,250		6 Sc
85	Galkuliya P.R.	11,800	10,200	
86	Wilpota P.R.	6,586	6,436	
87	Ambanmukalana F.R.	2,482	2,282	
88	Etaretiya P.R.	3,580	2,130	
89	Unaliya P.R.	3,460	2,810	
90	Tonigala F.R.	3,674	1,922	
91	Nugampola P.R.	840	790	
92	Mahawattagama F.R.	5,320	3,860	
93	Elawala P.R.	416	208	
94	Weherabendikele P.R.	706	667	
*95	Manuwangama F.R.)	1,328	Nil	
96	Nariyagama F.R.)			
97	Pyrandawa F.R.	892	Nil	
98	Kaduruwewa P.R.	207	Nil	
99	Paragaharuppe F.R.	133	133	
100	Digalla F.R.	233	208	
101	Banhedawaka P.R.	393	162	
102	Barigoda F.R.	194	Nil	
103	Gonagama P.R.	1,131	1,381	
104	Pannawa Gopallawa P.R.	782	777	
105	Melawa F.R.	110	110	
106	Kadawatkele P.R.	700	590	

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107	Nawagatta P.R.	155	135	
108	Dampitiya P.R.	240	240	
109	Sundapola F.R.	758	Nil	
110	Herallyawala P.R.	34	34	
111	Kumbalpola P.R.	254	238	
112	Badagama F.R.	565	Nil	
113	Yakdessakanda P.R.	2,500	2,500	
114	Galketiyagama P.R.	100	100	
115	Dunkanda P.R.	744	744	
116	Attavillu	1,730	Nil	
117	Dolukanda P.R.	990	980	
118	Manapaya P.R.	776	776	
119	Kirindigala F.R.	422	Nil	
120	Pansalhinna P.R.	305	Nil	
121	Henegederalanda P.R.	1,808	987	
122	Wegodapola P.R.	1,034	984	
123	Potawa P.R.	191	191	
124	Angurukandeyaya P.R.	340		6 Sc
125	Kanugollayaya P.R.	523		6 Sc
126	Mipitiyakanda P.R.	583		6 Sc
127	Neugalakanda P.R.	929		6 Sc
128	Gorakadola F.R.	474	Nil	
129	Kalugalkanda P.R.	378	Nil	
*130	Pannagama P.R.	410	Nil	
131	Elagomuwa P.R.	2,150	2,150	
132	Medauplota P.R.	5,782	5,782	
133	Baron's Cap P.R.	94,200	91,832	
134	Omunagala F.R.	135,920		6 Sc P
135	Nuwaragala F.R.	108,090		6 Sc P

136	Kirigal Mukalana P.R.	46		exploited
137	Dunkanda P.R. (included in No. 135)			
138	Madhu Area	352,550	144,180	
*139	Dotulugola P.R.	4,625	4,325	
*140	Cambell's Lane F.R.	723	420	
*141	Weuda Mukaland F.R.	376	376	
*142	Nagolla F.R.	304	304	
*143	Welikanda P.R.	598	Nil	
144	Yatala P.R.	140	129	
*145	Iriminna F.R.	64	Released	
146	Gangekumbura F.R.	386	165	
147	Gondenikanda F.R.	180	Nil	
148	Dambulla F.R.	426	Nil	
149	Moragolla F.R.	52	49	
150	Welikumbura F.R.	200	Nil	
151	Udapollakande F.R.	158	158	
152	Dahelgomuwa F.R.	143	143	
153	Badapeilyagoda F.R.	123	Nil	
154	Habilikanda P.R.	447	Nil	
155	Polgolla F.R.	132	Nil	
156	Kendahena F.R.	171	Nil	
157	Dawatagolla F.R.	107	Nil	
158	Paspolakanda P.R.	278	Nil	
159	Meeambakanda F.R.	308	218	
160	Dikkele F.R.	831	Nil	

161	Kankaniyamulla F.R.	2,738	Nil	
162	Walbotalekanda P.R.	103	103	
163	Baijangoda P.R.	434	Nil	
164	Polkatukanda F.R.	374	374	
165	Kebellawita P.R.	284	Nil	
*166	Mirigamkanda P.R.	344	Nil	
167	Mahakanda P.R.	421	194	
168	Kotakanda P.R.	609	300	
*170	Welikulakanda P.R.	870	658	
171	Dambukanda P.R.	103	63	
*172	Udawattekele F.R.	257	251	
173	Maha Oya F.R.	120	120	
*174	Ataudakanda P.R.	871	600	
*175	Welhella-Ketagilla P.R.	388	250	
*176	Mitirigala F.R.	1,263		exploited
*177	Kananpella F.R.	729	Nil	
*178	Yalapitiya P.R.	107	Nil	
*179	Eluwana-Handa-Munawa F.R.	211	Nil	
*180	Maniyuwgama Timbiri-pola F.R.	516	45	
*181	Badullawela P.R.	106	Nil	
*182	Debetgama Bossella P.R.	255	Nil	
*183	Alapalawala P.R.	452	Nil	
*184	Amanawala-Ampana P.R.	1,230	45	
*185	Kitulgala P.R.	657	45	

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*186	Kelani Valley F.R.	2,854		6 Sc
*187	Kelani Valley P.R.	6,400	4,000	
*188	Rilagala P.R.	1,400	1,400	
*189	Galaha F.R.	600	600	
*190	Pannila P.R.	2,901		exploited
191	Dambakele F.R.	176	176	
192	Kohila P.R.	30	Nil	
193	Ambaliyadda P.R.	153	153	
*194	Harasbedda P.R.	900	715	
*195	Mahakudagala P.R.	4,355	3,880	
*196	Pidurutalagal P.R.	17,000	16,232	
*197	Kikilimana P.R.	12,030	9,740	
198	Galway's Land F.R.	140	140	
*199	Galpalama P.R.	182	181	
*200	Kandapola Sitaeliya F.R.	6,724	4,863	
*201	Ragalla P.R.	663	663	
*202	Kandapola Sitaeliya P.R.	2,710		exploited
*203	Nanu Oya P.R.	1,040	674	
*204	Meepilimana F.R.	488	Nil	
205	Dedadaturawa P.R.	400	400	
206	Hakgala Strict Natural Reserve	1,046	984	
*207	Conical Hill P.R.	3,379	Nil	
208	Bakinigahawela F.R.	495	495	
*209	Humunukula P.R.	690	690	
210	Judges Hill P.R.	27	27	
211	Walagama F.R.	45	45	
212	Panama P.R.	92,940	76,800	
213	Kumbukkan F.R.	65,890	53,600	

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214	Daragoda F.R.	1,851	1,621	
215	Mamandiya F.R.	2,129	1,579	
216	Bibilehele P.R.	1,508	1,491	
217	Migollegama P.R.	349	349	
218	Ella P.R.	129	129	
219	Ettalapitiya P.R.	665	515	
* 220	Rawanaella P.R.	820	820	
*221	Haputale F.R.	349	346	
222	Bandarawela P.R.	39	Nil	
*223	Etabedda P.R.	3,803	Nil	
*224	Welegama P.R.	1,579	1,579	
*225	Ohiya P.R.	4,758	2,869	
*226	Pattipola-Ambewela P.R.	3,702	2,770	
*227	Agra Bopats P.R.	24,596	16,770	
**				
*229	Queenwood P.R.	130	130	
*230	Preston Elsmere P.R.	500	150	
*231	Bogawantalawa P.R.	9,086	9,014	
*232	Rajawaka P.R.	5,900		exploited
*233	Helapandeniya P.R.	558	53	
*234)) *235)	Bambarabotuwa F.R. (Area included in Nos.289-290)			
*236	Walawe Basin F.R.	4,526		exploited
*237	Peak-Wilderness P.R.	11,604	11,604	SNR
*238	Imbulpitiya F.R.	30	Nil	
*239	Hunnpitikanda P.R.	90	Nil	
*240	Eratne P.R.)	14,412	Nil	
*241	Gilimale)			

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*242	Demanagammana P.R.	284		6 Sc
*243	Hidellana F.R.	120		6 Sc
*244	Weralupe P.R.	338		6 Sc
*245	Dambuluwana F.R.	1,199		6 Sc P
*246	Talagaskanda F.R.	149	Nil	6 Sc P
*247	Mudunkotuwa P.R.	193	Released	
*248	Merekel F.R.	190	Nil	
*249	Dunkolahena P.R.	320	140	
*250	Pallepattu F.R.	1,682		4 S
*251	Getamawarahena P.R.	320		4 S
*252	Indikada P.R.	2,150		4 SP
253	Inamaluwa P.R.	765	765	
254	Pelwehera P.R.	593	593	
*255	Pallepattu F.R. (Area included in No.250)	-		
*256	Tibbotukanda P.R.	578	478	
*257	Ettabedda F.R.	225	Nil	
*258	Karandana F.R.	192	Nil	
*259	Kurana Madakada F.R.	3,450		4 Sp
*260	Tandikele P.R.	915	160	
*261	Ingiriya F.R.	868		4 S
*262	Wagawatta P.R.	354		4 S
*263	Diwalakada P.R.	695	Nil	Nil
*264	Botale P.R.	682	Released	
*265	Mahagama F.R.	911	500	
*266	Rangwaragalakanda P.R.	475	300	
*267	Kuda Ganga F.R.	349	131	
*268	Delmella Yatagampitiya P.R.	5,025	1,445	
*269	Ayagama P.R.	1,635	529	
*270	Neluketiya Mukalana P.R.	6,487	5,000	

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*271	Nelunketiya Mukalana P.R. (Area included in No. 270)			
*272	Pelenda West P.R.	359	Nil	
*273	Kabaragala P.R.	79	79	
*274	Badagama P.R.	61	61	
*275	Kalugala P.R.	11,441		exploited
*276	Morapitiya-Runakanda P.R.	17,180		exploited
*277	Waratelgoda P.R.	4,670		exploited
*278	Muwagamkanda F.R.	407		6 SoP
*279	Magurugoda F.R.	681	350	
*280	Iriyagahahena F.R.	184	Nil	
*281	Karawita P.R.	3,400	2,240	
*282	Hangarangala-Wewelkandura P.R.	1,292		exploited
*283	Delwala P.R.	3,925		4 S
*284	Ramalkanda P.R.	1,015		exploited
*285	Walankanda F.R.	2,495		exploited
*286	Kudumiriya P.R.	5,337		exploited
*287	Kobahadukanda	2,200		4 S
*288	Delgoda P.R.	2,805		exploited
*289	Bambarabotuwa F.R.)) Bambarabotuwa F.R.)	9,931		exploited
*291	Massena P.R.	1,626		exploited
*292	Morahela F.R.))	2,233	Nil	
*293	Morahela F.R.)			
*294	Ranwala P.R.	2,762	Nil	4 Pd
*295	Ratkarawa P.R.	10,380		4 Pd
*296	Kamburagomuwa F.R.	3,764		4 S

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297	Middeniya F.R.	921	475	
298	Kaperella Uswewa F.R.	1,395	Nil	
299	Kaparella Uswewa P.R.	530	Nil	
300	Gonadeniya F.R.	1,024	602	
301	Bedigantota P.R.	20,000	18,600	
302	Hambantota P.R.	2,880	2,370	
303	Ussangoda P.R.	685	685	
*304	Mahakalu Weragoda F.R	590	Nil	
*305	Mapitakanda F.R.	1,971	690	
*306	Ramalakanda F.R.)) Ramalakanda F.R.)	4,196		exploited
*308	Panilkanda F.R.	1,454	1,225	
*309	Diyadawa F.R.	6,371	2,030	
*310	Sinharaja F.R.	9,204	5,700 SNR	
*311	Sinharaja P.R.	6,850	6,600 SNR	
*312	Sinharaja F.R. (Area included in No.310)			
*313	Dellawa P.R.	5,526		exploited
*314	Panagoda P.R.	650	650	
*315	Tawalama P.R.	414	Nil	
*316	Habarakada P.R.	510	Nil	
*317	Haycock F.R.	894	894	
*318	Meegahatenna P.R.	699		4 S
*319	Yagirala P.R.	7,449	4,110	
*320	Uragaha P.R.	3,873	Nil	
*321	Yakkatuwa P.R.	732	Nil	
*322	Olabedda P.R.	330	Nil	
*323	Polhunna P.R.	307	Released	
*324	Kudagala P.R.	3,315	3,315	
*325	Beraliya P.R.	10,400	4,750	

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*326	Kelunkanda F.R.	615	615	
*327	Polgahakanda F.R.	2,131	1,265	
*328	Malambure F.R.	2,502	2,000	
*329	Polgahawila P.R.	753	Nil	
*330	Darakulkanda F.R.	1,131	230	
*331	Kanneliya F.R.	14,437	12,725	SPC
*332	Dediyagala F.R.	8,910	7,504	SPC
*333 *334	Nakiadeniya P.R.) Nakiadeniya P.R.)	4,185	3,740	SPC
*335 *336	Kottawa P.R.) Kottawa-Kombala P.R.)	5,658	4,006	
*337	Beraliya P.R.	4,596	4,276	
*338	Mulatiyana F.R.	8,099	5,775	
*339	Kanumuldeniya F.R.	1,677	Nil	
*340	Viharekele F.R.	1,838	900	
*341	Welihena F.R.	824	Nil	
*342	Oliyagankele F.R.	1,208	1,145	
*343	Badullakele F.R.	424	102	
*344	Masmullakela F.R.	1,990	705	
*345	Kirinda Mahayaya F.R.	924	Nil	
*346	Dandeniya-aparekka F.R.	1,304	223	
*347	Kekanadure kele F.R.	993	935	
*348	Kotakitulakanda P.R.	150	150	
*349	Karandekumbura P.R.	180	180	
*350	MahitiMukalana F.R.	872		exploited
*351	Madampe F.R.	777		exploited
*352	Masimbula P.R.	630	Nil	
*353	Maragalkanda F.R.	289	289	
354	Makele P.R.	200	95	

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*355	Madampe P.R.	100	100
*356	Pannila F.R.	557	300
357	Kahalla P.R.	84	Nil
358	Pyrandawa P.R.	310	273
359	Barigoda P.R.	179	179

* Wet Zone

** 4 Pd Dry Farming

4 S Chena

6 Sc Scrub

P Plantation

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APPENDIX D-II

Annex D-2

List of Small Reserves and Other National Forests

Reserves	Area Acs	Remarks
1. Waulkele F.R.	45 Acs	Mahogany
2 Dambulla Oya F.R.	300 Acs	Teak
3. Moragolla P.R.	47 Acs	Teak
4. Wedihitikanda	40 Acs	Teak
5. Omaragalla	442 Acs	Mahogany
6. Halmillagalla	300 Acs	Mahogany
7. Tonikalu P.R.	1284 Acs	
8. Welikanda P.R.	300 Acs	
9. Makele (Dengiruya)	48 Acs	
10. Kendahena F.R.	123 Acs	
11. Badapeliyagoda F.R.	123 Acs	
12. Dewalakanda F.R. 1	100 Acs	
13. Talgamuwa F.R.	168 Acs	
14. Kandawattegoda	239 Acs	
15. Hangarangala	285 Acs	
16. Nekagaha P.R.	35 Acs	
17. Tambiripola	100 Acs	
18. Epilagoda	50 Acs	
19. Mahagama	275 Acs	
20. Yatagampitiya P.R.	25 Acs	
21. Walankanda F.R.	406 Acs	
22. Rugam P.R.	5297 Acs	Planted 472 Acs
23. Dambulla Oya P.R.	03	Planted 300 Acs
24. Kudagalkanda P.R.	284	Planted 170

		Area	Planted
1	Veharakele	188	Teak
2	Etgala	100	Teak
3	Nayagoda	150	Teak
4	Etimale	80	Teal
5	Anapallama	800	Teak
6	Dambana	60	Teak
7	Nagadipa	70	Teak
8	Minipe	25	Bamboo
9	Tanpaladdai	526	Teak (released)
10	Ella Plantation	966	
11	Denagama	50	
12	Mutugala	50	
13	Bogahapelessa	1565	
14	Bogahawewa	425	
15	Pewewa	1557	
16	Karawita	551	
17	Welipolana	63	
18	Kurudana	135	
19	Nilandahinna	100	
20	Thanganalai	25	
21	Bandiyagala	470	
22	Hillabedda	40	
23	Madawalagama	275	
24	Ragala	9	
25	Kanguranketa	159	
26	Rilagala	15	
27	Rambukpitiya	135	
28	Weweltulana	25	

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29	Petiyagoda	80
30	Metigahatenna	550
31	Lunugala	125
32	Bibilegama	100
33	Dambana	24
34	Tholabowatta	100
35	Sooriyagodapatana	75 Acs
36	Peesapatana	25 Acs
37	Haraspatana	25 Acs
38	Karandagolla	25 Acs
39	Malapatawa	50 Acs
40	Poonagala	50 Acs
41	Attampitiya	50 Acs
42	Anapallama	2587 Acs
43	Nayagoda	106 Acs
44	Etimale	130 Acs
45	Hawankanda	60 Acs
46	Ellakanda	70 Acs
47	Welikada Kanda	20 Acs
48	Karasbedda	200 Acs
49	Gonapitiya	100 Acs
50	Kinigama	237 Acs
51	Labukele	170 Acs
52	Perawatta	275 Acs
53	Weheratalawa	300 Acs
54	Naranwalakada	45 Acs
55	Diyatalawa	250 Acs
56	Mahakanda 1	25 Acs
57	Welanhirina	250 Acs

58	Kahatalawala	50 Acs
59	Koslanda	50 Acs
60	Ginigathala	604 Acs
61	Wangedigala	92 Acs
62	Seelatenna	61 Acs
63	Etimale	108 Acs
64	Haldumulla	60 Acs
65	Thunbatthena	100 Acs
66	Belihuloya	130 Acs
67	Puwakgahawela	25 Acs
68	Boralanda	25 Acs
69	Idalgashinna	25 Acs
70	Weeraganagama	25 Acs
71	Kaṇdatenna	25 Acs
72	Katumana	20 Acs
73	Okurugala	10 Acs
74	Poramaruwa	66 Acs
75	Welikanda	123 Acs
76	Yatale	11 Acs
77	Hunnasgiriya	147 Acs
78	Amuboruwa	5 Acs
79	Tarangala	45 Acs
80	Deenston	25 Acs
81	Murapola	10 Acs
82	Medapalata	515 Acs
83	Erabaduwala	133 Acs
84	Miriahawatta	750 Acs

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85	Ettalapitiya	765 Acs
86	Morrinton	107 Acs
87	Edinbugh	15 Acs
88	Dunsincane	40 Acs
89	Underbank	6 Acs
90	Boburaella	5 Acs
91	Sibalangamuwa	154 Acs
92	Brae Estate	355 Acs
93	Withhire Estate	600 Acs
94	Marakwatura	297 Acs
95	Galagedara	164 Acs
96	Meelakela	163 Acs
97	Halukanda	14 Acs
98	Millawana	360 Acs
99	Nitgala	220 Acs
100	Komari	460 Acs
101	Kerimetiyawa	50 Acs
102	Hulunuge	103 Acs
103	Sengamuwa	60 Acs
104	Hudugala	10 Acs
105	Thimbirigala	60 Acs
106	Thampalam Cholari	132 Acs
107	Rugam	933 Acs
108	Mannawalam Paddanai	32 Acs
109	Rathmalai	601 Acs
110	Haluppe	30 Acs
111	Palugama	256 Acs

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SUMMARY

Existing Conditions

The project area is comprised of a variety of wildlife habitats such as villus, grasslands and numerous forest types: several designated wildlife reserves are partly or wholly within the project area. However, all of these have been encroached upon significantly by settlements and/or various cultivation practices.

The diverse fauna inhabiting the project area includes seven endangered and two threatened animal species:

- Elephant
- Leopard
- Red-faced Malkoha
- Swamp Crocodile
- Estuarine Crocodile
- Bengal Monitor
- Python
- Purple-faced Langur
- Toque Macaque

The project area is also the natural habitat for a number of endemic animals including eight species of fish, four amphibians, 19 reptiles, eight birds and three mammals. There are also 53 endemic plant species found here.

In addition, relatively common large mammal species known to occur in the project area include wild boar, deer and sambhur. Also, a majority of the 251 resident bird species found in Sri Lanka can be observed here. During the winter months, at least 75 more bird species migrate into the area.

Certain localities within the project area are categorized in this investigation as "high-quality" wildlife habitats and include:

- The Somawathie Sancturary;
- The Mahaweli Ganga Floodplain between the Somawathie Sanctuary and the Wasgomuwa Strict Natural Reserve; and
- A section of the northern part of System C adjacent to the Wasgomuwa Strict Natural Reserve.

Impact Analysis

Project implementation will result in the conversion of about 80,000 hectares of undeveloped land for agricultural and related uses.

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[illegible] in the project area. This will include a reduction of population levels for most endemic and probably all of the endangered/threatened species found in the region.

The high-quality wildlife habitats which are presently being considered for cultivation schemes include an area of about 5,600 hectares in the northern part of the Somawathie Sanctuary and most of the northern section of System C. In addition, about one-half of the high-quality habitat in the Mahaweli Ganga Floodplain will be lost due to reduced river flows. These impacts would result in irrevocable losses of relatively exceptional wildlife habitats.

The overall diminution of high-quality and related wildlife habitats is balanced to some extent by the commitment of the government to maintain the Wasgomuwa Strict Natural Reserve in its entirety. This reserve was originally scheduled for development as part of System E within the Mahaweli Development Program. Further, the government has recently initiated plans to establish the proposed Maduru Oya National Park adjacent to Systems B and C.

It should be noted that without the development of the proposed projects, significant amounts of forested area are likely to be removed in any event by encroaching chena farmers. Unless controlled, large segments of the project area natural wildlife habitats, including the high-quality ones, will probably be lost because of this.

Recommended Actions

The most feasible means of conserving the largest number of wildlife species is by providing as much contiguous natural habitat as possible. This is particularly true for the wide ranging endangered species such as leopards and elephants. Therefore, it is recommended that the emphasis on wildlife conservation be focused upon the expansion and legal protection of present wildlife reserves and the establishment of others where possible in and around the project area.

Because of the importance of the high-quality habitats for the conservation of endemic and endangered species, it is recommended that as much of these areas as possible be fully protected in appropriate wildlife reserves. It is also recommended that any planned clearing of high-quality habitats be delayed until feasibility studies pertaining to these areas are completed and reviewed, and it is then concluded that clearing is absolutely necessary for the continuation of the program.

The major recommendations concerning the development of wildlife reserve areas and their respective statuses are:

- Elevate the status of the Somawathie Sanctuary to a National Park and expand its boundaries both to the east and to the west and possibly to the north pending the results of the System A feasibility studies;

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- Designate the wetland (villu) area between the Somawathie and Wasgomuwa Reserve as the Mahaweli Ganga Conservation Park;

- Change the status of the Wasgomuwa Reserve to a National Park and expand it east and northeast along the river floodplain as well as to adjacent areas to the north, west and southwest;

- Establish the Hurulu National Park and the Kaudulla Reserve immediately west of the project area;

- Expand the new Maduru Oya National Park as a Conservation Park linking it to the Gal Oya National Park;

- Maintain a 200 meter strip of riverine forests along all major rivers and streams; and

- Maintain corridors only temporarily and investigate a trade-off of the Nelugala Corridor for comparable wet-season grazing areas east of the Somawathie Reserve.

Recommendations involving wildlife management, planning and administration include:

- Expand the terms of reference for formulating a National Wildlife Conservation Policy;

- Expand substantially the administrative and management capacity of the Department of Wildlife Conservation on both a central and regional level;

- Establish a Wildlife Management and Training Institute;

- Assemble a National Wildlife Management and Park Planning Team to plan and coordinate the development of the reserve system on an island-wide basis; and

- Conduct a park design planning study aimed specifically at the wildlife reserves in and around the project area.

EXISTING CONDITIONS

INTRODUCTION

Much of the information published on the fauna inhabiting the project area refers to its general distribution over Sri Lanka and its taxonomy. There is very little site specific ecological information available for this area, particularly on the important elements of the fauna such as the elephant, leopard, bear and other large mammals. In order to augment the limited baseline information, TAMS organized three wildlife survey teams comprising TAMS' wildlife ecologists, faculty members of the Universities of Colombo and Peradeniya and other interested individuals. The major objectives of the field studies are given in Appendix E-I.

From November 1979 to May 1980, the wildlife survey teams spent several days each month collecting field data from Systems A, B, C and D of the Accelerated Program area. The duration of information gathering included some months of both the wet and dry seasons. Results obtained from these surveys are incorporated in the following discussion where applicable.

The completion of comparable wildlife surveys in areas adjacent to or in the vicinity of the four proposed irrigation systems was beyond the scope of the overall study. However, available data from published sources pertaining to these areas surrounding the project area and to other portions of the country was compiled and reviewed. This data was augmented to a certain extent by site reconnaissance trips to the areas adjoining the irrigation systems and to other regions of Sri Lanka, especially to the existing National Parks.

STATUS OF WILDLIFE HABITATS

When wildlife habitats are proclaimed as wildlife reserves they are given one of six legal statuses and afforded different degrees of protection. These statuses are Strict Natural Reserve, National Park, Nature Reserve, Jungle Corridor, Intermediate Zone and Sanctuary. Among these, a Strict Natural Reserve provides the greatest degree of protection to wildlife. In this type of reserve neither fauna nor flora can be disturbed in any way, and entry is prohibited except on a permit obtained specifically for the purpose of conducting scientific research. A National Park also provides full protection to fauna and flora and contains no permanent human settlements, but people may enter it upon payment of a fee to observe wildlife. A Nature Reserve affords the same protection to wildlife as a National Park. However, it is not developed like a National Park for wildlife observations, and it allows existing rights to human land usage. A Jungle Corridor mainly provides animals with safe paths of movement, and like a Nature Reserve affords full protection to fauna and flora and accommodates existing land rights. In an Intermediate Zone, licensed hunting is allowed. A Sanctuary is a wildlife reserve where animals cannot be disturbed in any way, but where all other human activities including habitat elimination and private ownership of land are allowed. All wildlife reserves come under the jurisdiction of the Department of Wildlife Conservation.

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Wildlife habitats that lie outside wildlife reserves fall into three different categories. The first category includes forest reserves in which logging is generally permitted. Occasionally, a portion of the total area of a forest reserve overlaps with a wildlife reserve of low status. The second category comprises Man and Biosphere Reserves. These reserves include wild and domesticated habitats which are placed under protection for the purpose of conserving and safeguarding the diversity and integrity of biotic communities. These two categories of wildlifehabitats come under the purview of the Forest Department. The third category includes government forests which are administered at the district level and released for development schemes whenever necessary.

WILDLIFE HABITATS WITHIN THE PROJECT AREA

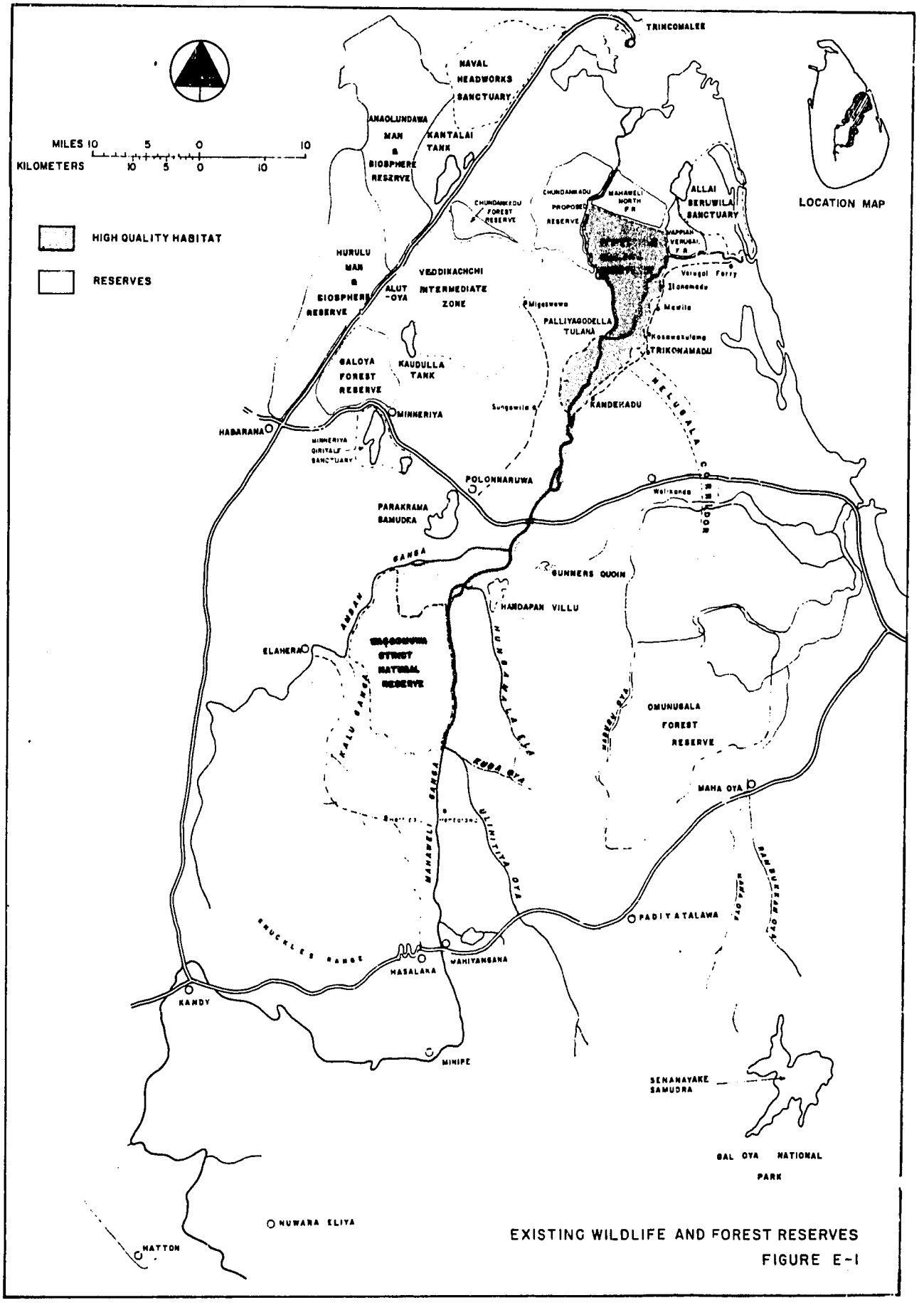
Within the project area a total of 95,150 hectares is being considered for irrigated development, and of this total 80,800 hectares are largely undeveloped areas. These undeveloped areas essentially consist of a variety of prime wildlife habitats, a sizeable portion of which is included within the roughly 82,000 hectares of land (out of 421,000 total project area hectares) proclaimed as wildlife reserves through legislation passed over the last several decades. Overall land use present found in the project area can be summarized as follows (see TOPIC REPORT B: LAND USE AND SOILS):

Land Use	Hectares
Rice Land	83,000
Chena	96,800
Other Cropland	50,500
Pastures/Grasslands	25,200
Forests/Woodland/Scrub	153,000
Surface Water	9,100
Other Lands	4,100
Total:	421,700

At present there are five wildlife reserves whose boundaries fall totally or partially within the project area (Figure E-1 and Table E-1). A major portion of 32,800 hectares of the Veddikachchi Intermediate Zone is included within the overall development area. The Nelugala Corridor which is 10,400 hectares in extent falls mostly within System B, and the Somawathie Sanctuary which is 22,275 hectares in area lies within System A. The Polonnaruwa and Seruwila-Allai Sanctuaries are partially within System D and A, respectively. In addition, there are five forest reserves which increase the total area of suitable wildlife habitats found within the project area (Table E-2). However, all of the more than 70,000 hectares of these forest reserves have been released for development under the proposed project.

Lying outside the project area and adjacent to System C is Wasgomuwa, which is a 29,200 hectare expanse of Strict Natural Reserve that was established in 1940. The closest national park is the Gal Oya National Park, located about 50 kilometers south of the project area.

Wildlife habitats may also be classified in terms of relative quality on the basis of the physiological, behavioral, ecological and evolutionary requirements of various species. In this regard, habitat quality may be reflected by wildlife population density and diversity and by species composition, particularly when this involves endemic, endangered or threatened species. The latter may be defined as follows:



EXISTING WILDLIFE AND FOREST RESERVES
FIGURE E-1

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Table E-1

Wildlife Reserves Within Accelerated Mahaweli Program Area

Name	Status	Extent (hectares)	Date of Declaration	Reserve Boundaries
Somawathie	Sanctuary	22,275	9 Sep 1966	Completely within project area
Nelugala	Jungle corridor	10,400	16 Jan 1970	" " " "
Veddikachchi	Intermediate Zone	32,800	27 May 1938	Major portion within project area
Polonnaruwa	Sanctuary	1,520	27 May 1938	Partly within project area
Seruwila-Allai	Sanctuary	15,550	9 Oct 1970	" " " "

Source: Water Resources Map of Survey Dept. (1978), and Dept. of Wildlife Conservation's List of Wildlife Reserves.

Table E-2

Forest Reserves Within Accelerated Mahaweli Program Area

Name of Forest Reserve	Extent (hectares)	Date of Declaration
Mahaweli Ganga North & South	8,650	22 Dec 1939
Vappiah-Verugal	4,350	3 Oct 1941
Chundankadu	4,350	1 Mar 1940
Omunugala	53,665	18 Mar 1927
Koralai	7,710	4 Jan 1929

Source: Forest Department

- Endemic Species are those which occur in one specified locality and nowhere else in the world. Generally, in this report, endemic species refer to those occurring only in Sri Lanka;

- Endangered Species are species in danger of extinction throughout all or a significant portion of their respective ranges; and

- Threatened Species are those which are likely to become endangered species within the foreseeable future throughout all or a significant portion of their respective ranges.

The endangered and threatened species definitions were established by the U.S. Fish and Wildlife Service.

In a general sense, virtually all of the project area could be considered as relatively important wildlife habitat, since internationally endangered species have home ranges throughout the region. However, certain sections of the project area are apparently more significant than others in terms of specific requirements of endemic and endangered, as well as other wildlife species. For purposes of this report, specific areas where an exceptional diversity of species occurs and a particularly intensive level of wildlife activity is found, especially for endangered and endemic species, are defined as "high-quality wildlife habitats".

Their designations are based upon information gathered from the TAMS wildlife surveys and from other available data sources. These high-quality habitats in the project area (Figure E-1) include:

- The Somawathie Sanctuary;

- The Mahaweli Ganga Floodplain between the Somawathie Sanctuary and the Wasgomuwa Strict Natural Reserve; and

- A section of the northern part of System C adjacent to Wasgomuwa.

In addition, the Wasgomuwa Strict Natural Reserve, although just outside the project area boundaries, would also be classified as a high-quality habitat.

The wild habitats within the project area can also be broadly classified by vegetative cover into villus, dry zone forests, riverine forests, grasslands and mangrove swamps. Some features of the fauna and flora of these habitat types and the others discussed above are presented in the following sections.

Villus

Villus are seasonally inundated marshy areas found along the Mahaweli Ganga (see TOPIC REPORT H: WETLANDS for description). They support the greatest animal biomass density of all habitat types found within the

Accelerated Program Area. The aquatic medium of the villus and the grassy areas surrounding them sustain an abundance of small as well as large life forms of several invertebrate and vertebrate taxa. However, the most numerous of the villu fauna are fish and birds, but large villus like the Handapan Villu (System C) which have a plentiful supply of grass and water are also frequented by elephants and other herbivores such as hare and deer (TAMS Survey 1979-80). Herbivores in turn attract carnivores of different sizes (jackal, leopard) as well as carrion feeders (wild boar, bengal monitor). Because these faunally rich areas are restricted in their location to river banks they comprise only about 12,800 hectares of the project area. The flood-plain villus along the Mahaweli may be considered as "high-quality wildlife habitats".

Dry Zone Forests

In terms of size, forest habitats make up the largest proportion of the wildlife habitats within the project area. Much of the forest could be classified as dry zone forest, but on the western side of the project area, the forest tends to be taller and more dense and bears physiognomic affinities with the forests of the intermediate zone. To the east the forest becomes more sparse and scrubby as the soil becomes more sandy. In the typical dry zone forests of Kantalai, Trikonamadu, Polonnaruwa, Welikanda and Wadamuni, *Drypetes sepiaria* (Wira) with its gnarled and fluted trunk predominates over all other tree species (McCormack and Pillai 1961; Dittus 1977; TAMS Survey 1979-80). The widespread dominance of this species suggests that its presence may play an important role in maintaining the viability of forest ecosystems of the dry zone. This species offers food to a wide range of animals including frugivorous birds, deer, monkeys, wildboar and elephant.

Other tree species which are common in dry zone forests are *Vitex pinnata*, *Chloroxylon swientenia*, *Manilkara hexandra*, *Premna tomentosa*, *Diospyros ovalifolia* and *Crewia polygama*. The fruits of *M. hexandra* which are produced during the dry season are favorite food items of monkeys, bear and deer, while its leaves, and the bark and foliage of *G. polygama* are eaten by elephants (Norris 1967; McKay 1973).

Scattered within the dry zone forest there are rocky outcrops which are sometimes clad with vegetation. Particularly notable among these is Gunner's Quoin which is located in System B. Bear and mongoose frequent the rocky outcrops, because they offer suitable daytime resting places. Within the forests there are also natural and man-made pools of water which are utilized by a variety of animal life especially during dry seasons. Numerous combinations of physical, climatic and floral characteristics of dry zone forests satisfy the ecological niche requirements of a wide range of animal species.

Riverine Forests

Within the project area, riverine forests are best represented along the Mahaweli Ganga, but they are also found along Maduru Oya, Ulhitiya Oya, Hungamala Ela and other small streams. As the Mahaweli flows along the boundary of the northern sector of System C, riverine forests occur on either side of the steep banks of the river. Further downriver they are usually found between the river bank and the villu system.

A ninety mile canoe trip down the Mahaweli undertaken by the TAMS team in March 1980 indicated that riverine forests support an extremely abundant mammalian fauna. On this trip, the team members saw seven herds of elephants, bear, sambhur, deer, water-buffalo, jackal, mongoose, hare, wild-boar, giant squirrel, toque macaque, purple-faced langur, grey langur and several species of unidentified bats and rodents. A leopard was heard sawing within close proximity of one of the field camps. Other mammalian species whose presence was noted including fishing cat, muntjac, mouse deer, porcupine and slender loris. It was also found that toque macaques and purple-faced langurs were far more abundant along riverine forests than any other habitat surveyed within the project area. Birds and reptiles were no less abundant. In fact, TAMS wildlife surveys showed that riverine forests were the preferred habitat of several vertebrate endemic species found within the project area. Furthermore, the riverine and adjacent forest in the northern part of System C directly east of Wasgomuwa was the only specific locality within the project area where eight of the nine endangered/threatened vertebrates variously distributed in Sri Lanka, were found to be part of a single faunal complement. This gives this particular forested region special significance as a high-quality wildlife habitat (Figure E-1).

In riverine forests too, D. sepiaria appears to dominate all other species, but taller trees such as Schleicnera oleosa, Diaspyros malabarica, Terminalia arjuna, and Madhuca longifolia are also quite common, and offer a wide variety of food items to wildlife.

Grasslands

Natural grasslands within the Accelerated Program area are mainly restricted to those which surround villus. These grasslands are exploited by domestic cattle as well as wildlife, and in some areas where there is heavy cattle usage a weed Xanthium strumerium which bears spiny fruits appears to be outcompeting the grass species. This is especially evident at Meen Villu which is located within Somawathie Sanctuary. Most of the other grasslands within the project area seem to be man-made by forest clearing for chena or shifting cultivation. These types of grasslands are quite numerous along the Mahaweli Ganga, and it was in these areas that many of the elephant herds mentioned before have been observed. Elephants appear to take shelter in the adjoining forest during the day and move into the grassland in the evening.

Mangrove Swamps

Mangrove swamps are restricted to a narrow belt along the eastern side of the project area (see TOPIC REPORT H: WETLANDS). These habitats have been so extensively exploited by humans, that at present they are small in size and do not usually support any large species of wildlife. Species that may be found in this habitat type include crocodiles, water monitors, terrapins, harriers, eagles and several species of kingfishers.

WILDLIFE DIVERSITY

The preceding sections clearly indicate that the Accelerated Program area contains a wide variety of animals. The vertebrate fauna alone consists of several species of fish, amphibians, and reptiles, a majority of the 251 resident bird species found in Sri Lanka, and large mammals, such as the elephant, leopard, bear, deer and sambhur. In addition, during the winter months, about 75 bird species migrate into this area from Europe and other distant places. Nearly 20 of these species belong to a single family but the full complement of migrants represents over 25 bird families (Table E-3). Consequently, these visitors increase the variety of the already abundant fauna found in the different habitat types. Winter visitors such as sandpipers, plovers, ducks, terns and gulls take up residence close to water especially in villus. A large number of migrant wagtails occupy riverine forests while flycatchers, warblers and thrushes utilize dry zone forests and dense scrub. The kingfishers live in swamps and lagoons, and the harriers frequent open marshes. Bird species observed in the recent TAMS wildlife surveys are listed in Appendix E-II.

ENDEMIC SPECIES

The project area is a part of the natural habitat of a number of endemic animals, i.e. those found only in Sri Lanka and nowhere else in the world. In order to obtain the most current information on this unique component of Sri Lanka's fauna (and flora) in the project area, TAMS sponsored an "Endemic Species Seminar and Workshop" in December 1979 at the Natural History Museum in Colombo.

The workshop was attended by representatives of several local and foreign institutions including the Department of Wildlife Conservation, Forest Department, Mahaweli Development Board, National Science Council, National Museum, the Universities of Colombo, Kelaniya, Matara and Peradeniya, Wildlife and Nature Protection Society, USAID and the Smithsonian Institution. The participants of the workshop identified 39 species of endemic vertebrates, but indicated that many more may be found within the project area (Appendix E-III). Their tentative list comprised eight species of fish (TOPIC REPORT G: FISHERIES), two amphibians, 18 reptiles, eight birds and three mammals. During the discussions it was pointed out that the project area also included several endemic invertebrates and tree species, but the participants felt that more information was required before the status, abundance and distribution of these species could be correctly assessed. Many of the participants indicated that riverine forests within the project area were rich in endemic wildlife and expressed concern about the proposed clearing of these areas for agricultural development. It was agreed that extensive habitat destruction rather than direct killing posed the greatest threat to Sri Lanka's endemic wildlife.

The TAMS wildlife survey teams located two endemic amphibians and one reptile species hitherto unrecorded from localities within the project area (Appendix E-II). This increases the number of vertebrate endemics found within the project area to 42. The presence of 23 of these species was confirmed in the field, and sufficient data was collected on the habitat preferences of 16 of them (Table E-4). These species occupy a wide range of habitats from open grasslands to high forest, but each species appears to have a narrow range of preferred habitat. As indicated earlier, riverine forest was the preferred habitat of a majority of the species studied.

Table E-3

Migrant Bird Species Found Within the Accelerated Mahaweli Program Area and Their Habitat Preferences

Family	Common Name	No. migrant species	Habitat preference
Charadriidae	Plover,sandpipers	24	lagoons and villus
Motacillidae	Pipits Wagtails	8	Riverine forest
Laridae	Terns gulls	9	lagoons & sea shore
Accipitridae	Eagles,hawks harriers	6	Forest, open marsh
Anatidae	Geese, ducks	4	villus & lagoons
Muscicapidae	Flycatchers	3	Forest
Hirundinidae	Swallows	1	open plains
Starcorariidae	Skuas	2	sea shore
Ardeidae	Herons, bitterns	1	lagoon & swamp
Turdidae	Chats, robins,thrushes	1	Forest
Sylviidae	Warblers	2	Forest
Laniidae	Shrikes	1	scrub grassland
Pittidae	Pittas	1	Forest floor
Meropidae	Bee eaters	1	open scrub
Pandionidae	Osprey	1	Sea shore & lagoon
Falconidae	Falcons	3	Cliffs & open areas
Rallidae	Rails	1	Marsh & swamp
Hydrovatidae	Storm petrels	1	Sea shore
Ciconiidae	Storks	1	Lagoons
Cuculidae	Cuckoos	4	Forest
Alcedinidae	Kingfishers	1	Lagoons
Oriolidae	Orioles	1	Forests
Total		76	

Sources: TAMS Wildlife Survey Team (1979-1980), and Phillips(1978).

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Table E-4

Micro-habitat Preferences of Some Endemic Species Located within the Accelerated Mahaweli Programme Area

Species	Habitat Preference
FISH	
Puntius bimaculatus	clear stagnant or running water
AMPHIBIANS	
Rana gracilis	temporary pools with reeds
REPTILES	
Rhinophis oxyrhynchus	burrows in open grassland
Gymnodactylus frenatus	rock outcrops
Geckoella yakhuna	forest floor leaf litter
Galotes ceylonensis	tree trunks in riverine forest
Otocryptis weigmanni	open riverine forest floor
Sphenomorphus fallax	soggy meadows
BIRDS	
Gallus lafayetti	forest, parkland, chena
Galloperdix bicalcarata	riverine forest
Loriculus beryllinus	emergent canopy of riverine forest
Psittacula calthorpae	emergent canopy of riverine forest
Pellorneum fuscocapillum	forest floor
Phaenicophaeus pyrrhocephalus	tall riverine forest
MAMMALS	
Macaca sinica	riverine forest
Presbytis senex	riverine forest

Source: TAM Wildlife Survey Team (1979-1980).

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The endemic fauna of the localities visited recently were also studied between 1959 and 1962 by P.B. Karunaratne, one of the TAMS Wildlife Survey Team. Comparisons between the two studies indicate that many endemics such as the red-faced malkoha (P. pyrrhocephalus), Ceylon spurfowl (G. bicalcarata), purple-faced langur (P. senex) and an agamid lizard (Otocryptis weigmanni) are in general much less abundant now than before. The last three species are also absent from some areas of their previous range of distribution. The conversion of their natural habitat to agricultural land appears to be the reason for the reduction in numbers and area of distribution.

ENDANGERED SPECIES

The fauna of the project area comprises seven endangered and two threatened animal species as listed by the International Union for Conservation of Nature and Natural Resources and in the U.S. Federal Register (Table E-5). All of these endangered and threatened species are found in other parts of Sri Lanka, and except for the toque macaque, purple-faced langur and the red-faced malkoha, are also distributed in other parts of the world. However, all nine species mentioned above are listed as threatened or endangered throughout most of their world distribution. Accurate distributions of the respective endangered species populations have not been investigated in Sri Lanka. Some data is available for elephants, which is discussed in a succeeding section. In terms of population dynamics, critical minimum population levels have not been defined for any of these species.

Distribution of Endangered Species within the Project Area

The recent field surveys indicated that of the nine endangered and threatened species, the bengal monitor had the most extensive distribution. It was commonly found more or less continuously throughout the project area The distributions of the other species here were restricted to different degrees. The red-faced malkoha had the most restricted distribution being confined to the riverine forest between Wasgomuwa and the northern sector of System C. The reason for this is unknown. The restricted distribution of crocodiles was probably due to their ecological needs for an aquatic environment. They were located along the Mahaweli Ganga and in Handapan, Manikkampatiya, Karapola and Trikonamadu Villus, but nowhere were they numerous.

The restricted distribution of elephant, leopard, toque macaque and purple-faced langur reflects a reduction of their former ranges which extended throughout most of the project area (Hill 1934; Phillips 1935, 1957). This has mainly been due to habitat destruction, and these species have been partly or totally eliminated from all areas of human activity. Furthermore, within their present range of distribution they seemed to be abundant only in a few localities. The two species of monkeys were numerous only along the riverine forest of the Mahaweli and near tanks such as Kantalai, Kaudulla and Parakrama Samudra. Leopards appeared to be relatively abundant in the northern sector of System C although their presence was noted in Kantalai, Trikonamadu, the Ulhitiya Reservoir site and Somawathie Sanctuary. Elephants were numerous in the Somawathie Sanctuary and the northern sector of System C, but evidence of this species was also found in several other areas.

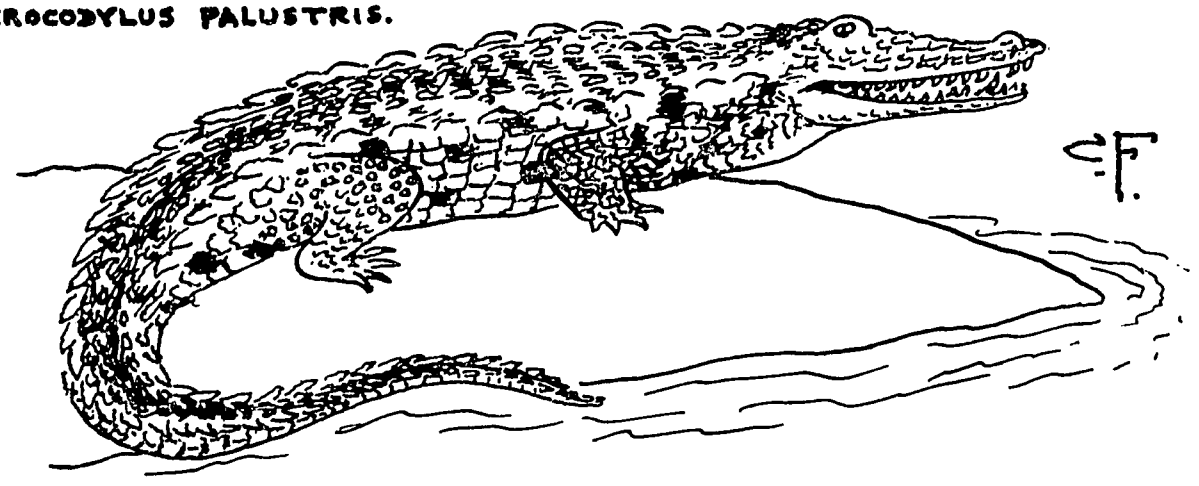
Table E-5

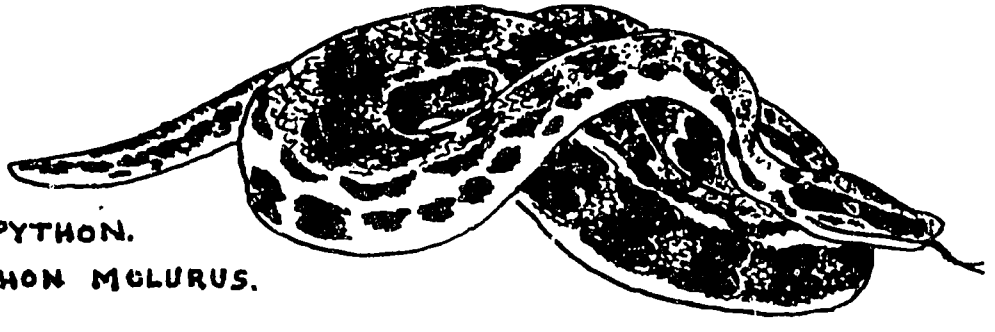
Endangered and Threatened Species Found in the Accelerated Mahaweli Programme Area and Their World Distribution

Species	Known Distribution	Portion of Range Where Endangered or Threatened
	Endangered	
Elephant	India, Burma, Laos Thailand, Cambodia, Malaysia, Sri Lanka, Vietnam	Entire
Leopard	Africa, Asia	Entire
Red-faced malkoha	Sri Lanka	Entire
Swamp-Crocodile	Sri Lanka, Africa	Entire
Estuarine Crocodile	Sri Lanka, Malay Peninsula, Philippines, New Guinea Australia, Fiji	Entire except New Guinea
Bengal Monitor	Iran, India, Burma, Afghanistan, Sri Lanka, Vietnam, Thailand, Malaysia	Entire
Python	Sri Lanka, India	Entire
	Threatened	
Purple-faced langur	Sri Lanka	Entire
Toque Macaque	Sri Lanka	Entire

Source: U.S. Federal Register (January 1978 and December 1979).

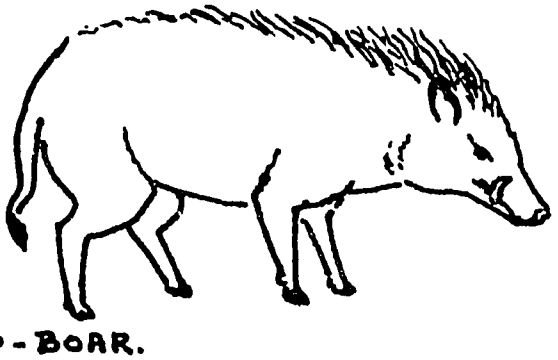
MARSH CROCODILE.
CROCODYLUS PALUSTRIS.



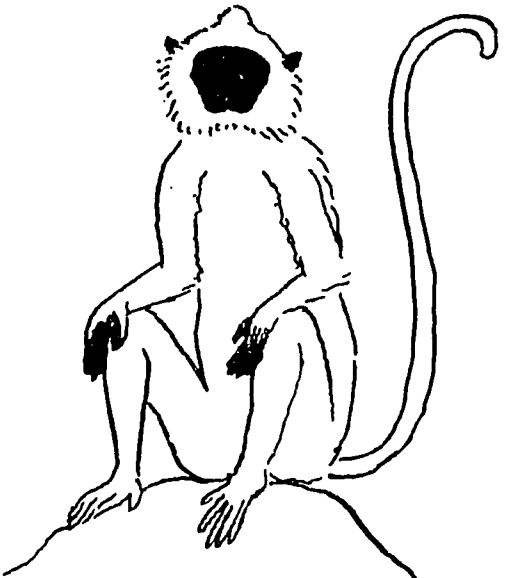


PYTHON.
PYTHON MOLURUS.

LEOPARD.
PANTHERA PARDUS.



WILD-BOAR.
SUS CRISTATUS.



PURPLE-FACED
LANGUR. SEMNOPITHECUS ENTELLUS

Details pertaining to the elephant are expanded upon in the following sections due to the relative significance of this species in Sri Lanka.

Elephant Populations

At the beginning of the nineteenth century there were an estimated 12,000 elephants in Sri Lanka (McKay 1973). At that time, this species was found in the dry zone as well as the wet zone and at the highest elevations of Horton Plains (Phillips 1935). In the 1850's the British Colonial Government paid rewards for the destruction of 5,500 animals (Tennent 1863). During this period of decline, sport figured as one of the major reasons for the killing of elephants. Major Rogers, a mid-nineteenth century sportsman holds the record of having killed 1,100 elephants (Storey 1907). More recently, however, crop protection has been the chief cause for the killing of elephants. Between 1952 and 1957, 239 of the 475 known elephants deaths occurred during the alleged defence of crops (Sessional Paper No. 19 1959). At present, this species is mainly restricted to the dry zone. The total number of elephants currently inhabiting Sri Lanka has been variously approximated from about 2,000 (McKay 1973) to around 6,000 (Hoffman 1978). The Department of Wildlife Conservation estimates the total at about 2,500, of which roughly 800 are believed to inhabit the project area and its environs (L. de Alwis, personal communication).

During the recent field investigations, elephant activity was noted in several localities within the project area (Table E-6). The fewer locations of elephant activity noted in Systems A and D is a reflection of the shorter time spent surveying these areas than Systems B and C. They do not imply that elephants are less abundant in Systems A and D than in B and C. Indeed, the largest concentration of elephants which consisted of 88 animals was seen at Vello Villu in System A. Moreover, locations of high activity changed from month to month, which suggested that elephants moved between areas on a regular basis.

Seasonal Movement and Habitat Use by Elephants

Interviews with local residents and available scientific information indicated several consistent patterns of elephant movements within the project area. Some of these patterns were clarified in certain areas by the TAMS field surveys.

In System C, areas of high elephant activity were seasonally displaced with respect to the Mahaweli Ganga. For example, in the wet season month of December 1979, a high incidence of elephant activity was noted along the Damanawila-Dehiattekandiya road which is over 10 kilometers to the east of the Mahaweli Ganga (TAMS Survey, Ishwaram et. al. 1979). But by March and April 1980, when this area was experiencing dry weather, elephant activity had declined to zero. During dry weather, however, areas closer to the Mahaweli Ganga showed a higher incidence of elephant activity. Transects that were within one kilometer of the river usually showed the highest incidence of elephant activity (Table E-7). There was also an inverse relation between the incidence of elephant activity in any given area and its distance from the river. In six east-west transects elephant activity was relatively high up to four or five kilometers from the river and usually declined thereafter (Table E-8). Similarly, in north-south transects elephant activity declined after a distance of 4.7 kms from the Mahaweli Ganga (Table E-9).

Table E-6

Locations of Elephant Activity Found Within the Accelerated Mahaweli Programme Area, November 1979 - May 1980

System	Locations of Activity
A	Somawathiya+, Mahaweli North Forest Reserve Trikonamadu+
B	Mannampitiya, Welikanda (NLDB farm) Kandakadu, Punani, Dimbulagala+, Kallichchi, Akuranai, Baron's Cap, Nelugala Corridor+, Maduru Oya dam site road+
C	Ginnoruwa, Hembarawa, Henenegala-kandiya Dehiattekandiya+, Damanewil areas north of Kuda oya upto Handap Villu+
D	Kantalai, Kantalai-Allai road; Suriyawewa, left bank of Mahaweli Ganga+

+ areas of high elephant activity

Source: TAMS Wildlife Survey (1979-1980).

Table E-7

System C - Elephant Feces Counts Within 1 Kilometer of the Right Bank of Mahaweli Ganga - March 1980

Transect	Length of Transect (km)	Feces Counts/km
rA	0.8	20
rB	0.6	43.1
rC	0.6	66.5

Source: TAMS Wildlife Survey (1980).

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Table E-8

System C - Elephant Feces Counts on Each Kilometer on the West-East Transects on Right Bank of Mahaweli Ganga - March 1980

Transect	Feces Counts on Each km.									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	km.
A	40	39	31	7	8					
B	37	36	43	31	14	24	31	18	7	
C	70	49	65	23	36	20	19	20		
D	10	10	35	43	64	19	20			
E	19	17	43	29	16.7					
F	39	43	32	35						

Source: TAMS Wildlife Survey (1980).

Table E-9

System C - Elephant Feces Counts (Average/kilometer on North - South Transects on the Right Bank of Mahaweli Ganga - March 1980

Transect	Average Distance from River	Feces Counts (Ave./km.)
1	0.7	31.3
2	2.7	26.0
3	3.7	30.0
4	4.7	23.2
5	5.7	7.9
6	7.8	14.6

Source: TAMS Wildlife Survey (1980).

Certain generalizations can be made from the above observations and other available information. It appears that during the dry season several social groups of elephants, each consisting of three to over 30 individuals aggregate near permanent sources of water, such as rivers and tanks. In areas around the Hembarewa Tank (System C) and along the Mahaweli an aggregation sometimes consists of 100-200 animals. These aggregations utilize the perennial rivers and tanks for drinking purposes and feed on the grass at the water's edge. From these foci of activity an aggregation may fragment as social groups move to somewhat different areas of nearby forests to supplement their diet with browse. However, social groups return regularly to their dry season sources of water and periodically reform aggregations. The onset of the rains appears to terminate the elephant's period of dependence on perennial sources of water. Social groups then begin to disperse away from perennial sources of water to areas which perhaps offer nutritionally rich food items. Consequently, large aggregations tend to occur less frequently in the wet season than in the dry season.

The above pattern of movements has been described for elephants of Wilpattu National Park by Eisenberg and Lockhard (1972), but McKay (1973) described a slightly different movement pattern for the Gal Oya elephants. The wet season dispersal of the Somawathie elephants from the Mahaweli Ganga appears to be more related to factors other than food. In this area, although food is plentiful during the wet season, flooding possibly forces elephants to move to higher ground. In any case, each social group appears to have at least two fairly large areas of intensive feeding activity. Some areas are used during the dry season while others are exploited during the wet season, and the social group moves between these areas on a regular basis. The total area used for feeding and movements is referred to as the home range of the group.

The size of the home range depends on several factors among which the habitat conditions and the size of the social group may be important, and this specific area is probably utilized for several generations by the social group. Consequently, each group exhibits a special attachment to its home range and cannot be easily moved out of this area. This view is supported by the Department of Wildlife Conservation's recent experience in attempting to drive elephants out of System H. Home ranges of neighboring groups, however, may show different degrees of overlap and in these overlap areas the groups come into relatively close contact without conflict. Lone elephants also use specific areas of the habitat and sometimes intermingle with social groups which use the same area.

Crop Damage by Elephants

The extent of crop damage due to elephants was investigated in certain localities within the project area. The Kantalai Sugar Corporation incurred a revenue loss of three million rupees due to elephant activity between 1977 and 1979. Similarly, the livestock farms at Tirikomamadu, Kandakadu, Weiikandu, and Galela regularly suffered considerable damage to their grazing area and property.

The wildlife survey team also assessed the extent of damage to paddy and other crops. The assessment was done in the agricultural area lying on the left bank of the Mahaweli between Hasalaka and Hettipola. Residents of four villages were interviewed, and the information from Wilgomuwa provides some

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instructive trends (Table E-10). In this village, at least nine farmers suffered crop damage due to elephants on the nights of 17 and/or 18 December 1979. A total of 4.3 hectares of paddy was completely damaged, and another 4.2 hectares were partially destroyed. Assuming an average production of about three tons of rice per hectare for this area and the price of paddy as Rs. 1,900 per ton, the estimate of revenue loss due to complete damage incurred in the two nights amounted to Rs.24,510. At least two of the farmers again suffered crop damage within the next ten days. Since all farmers of Wilgomuwa were not interviewed, the estimated extent of damage recorded must be considered minimal.

Either lone elephants or a single social group are generally responsible for recurring crop damage in any given village. Paddy fields at Wilgomuwa, however, were damaged by groups of six and 15 elephants (Table E-10). In October 1979 both groups apparently entered a banana plantation and destroyed Rs.12,000 worth of produce in a single night.

The social organization of elephants and their naturally evolved systems of land tenure and habitat use help explain the temporal and spatial pattern of crop damage. Although some crop damage occurs during the dry season, it is far more frequent in the wet season. The elephant's dependence on permanent sources of water during the dry season and its wet season dispersal partly explain the temporal pattern of agricultural crop damage.

When home ranges of social groups of elephants are taken over for development, many groups lose all access to at least part of their home ranges. These displaced groups use the remaining areas of their home ranges and damage agricultural crops grown at the periphery of the developed area. The usual pattern of development also leaves certain land features (such as streams and rocky outcrops) found within the developed area in their natural state. Some of these natural land features, particularly streams, extend across the boundary of the developed area. This allows limited access for one or a few elephant groups to enter (e.g. along stream beds) portions of their former home ranges which lie within the developed area. Consequently, agricultural crop damage occurs at the periphery as well as within the developed area, and is the result of an elephant group's attachment to its particular home range.

Crop damage is most frequent during the early phases of development, and it takes several years before even partial success is achieved in keeping elephants out of developed areas. As indicated before the Kantalai Sugar Plantations, which were established nearly 20 years ago, still suffer considerable damage from elephants. Sometimes the conflict between humans and elephants can become extremely intense. This is clearly shown by the destruction caused by elephants in 1977 to 4,500 acres of teak plantations in the Wanniyagama, Hurulu and Gal Oya forest reserves (Perera 1977a). At an average yield of 2,500 cu. ft. of mature teak per acre and at its present price of Rs.100 per cu. ft. the damage amount to a loss of Rs.1.125 billion ($75 million) of future revenue.

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Table E-10

Elephant Damage to Agricultural Crops and Property in Villages to the East of Hettipola-Hasalaka Road (Left Bank of Mahaweli)

Name of Farmer	No.of elephants involved	Area Damaged (ha.)	Date of Damage
	Wilgomuwa Village - Damage to paddy		
Kapilaratne	15	1.01	17 December
L.B. Ekanayake	15	?	17 December
Karunaratne	6	0.20	17 December
Piyasena	6	0.40	17 December
R.B. Ekanayake	6	0.30	18 December
Ranasinghe	6	0.40	18 December
K.M. Muthubanda	15	(2.02 (complete) (2.83 (partial)	17/18 December
M.G. Ranbanda	?	0.20 (partial)	18 December
J. Ranbanda	?	1.21 (partial)	18 December

Heen Banda and Samaneris incurred a loss of Rs. 12,000 due to elephant damage to their banana plantation in late October 1979- about 20 elephants were involved and damage occurred in a single night.

	Devagiriya Village - Damage to paddy and other crops		
U.G. Seya	1	0.4 (maize, cow pea, millet)	mid November
P.G. Surendra	3	0.2 (paddy)	2nd week December
P.G. Setunge	1	0.2 (maize)	1st week December
W.G. Punchibaba	1	0.2 (maize, cow pea)	2nd week December
D.G. Lokubanda	1	? (partial damage paddy)	3 nights between 13-20 December
D.M. Wijeratne Banda	1	0.2 (paddy)	1st week December
P.G. Mutubanda	3	0.8-1.2 (partial)	20 November 20 December
H.G. Mudiyanse	1	minor (paddy)	1st week December
P.G. Jayatunga	?	0.6 (paddy partial)	2nd week December
W.G. Samadara	3	0.2 (paddy, maize, manioc)	2nd week December

R.D. Sirimanne's house was destroyed by an elephant during the first week of December 1979.

	Bogawela Village - Damaged to other crops		
B.G. Gunaya	3	0.2 (maize, manioc)	1st week December
	Nanini Oya - Damage to paddy		
R.A.C. Jayatissa	3	0.6 (paddy)	18 December
Seneviratne Banda	3	0.8 (paddy)	18 December

Source: MAMS Wildlife Survey (1979-1980).

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OTHER WILDLIFE SPECIES

General Trends

As indicated earlier, current information on many wildlife species is scarce. However, by the late 1950s the decline of several species in Sri Lanka had been documented (Phillips 1957). The factors which caused the decline were human population increase, habitat encroachment, faster modes of communnications and transport and commercial exploitation. Some of these factors probably operate more intensively now than nearly 20 years ago. Therefore, a continuing general reduction of wildlife populations may be expected.

Phillips (1957) listed elephant, leopard, bear, sambhur, spotted deer, gray langur, purple-faced langur, toque macaque, flying squirrel, and giant squirrel as some of the decreasing mammalian species populations. Among birds, the comb duck and glossy ibis became extinct as breeding residents during the first 50 years of this century. Several birds of prey and water birds also showed substantial decline in numbers. Decreasing populations of reptiles included the two species of monitor lizards and the swamp crocodile. Populations of three bird species, however, had increased i.e., house crow, black crows and mynah.

The recent field studies documented the population increase by rose-ringed parakeet, spotted munia and white-backed munia. Bird censuses in different habitat types showed that the parakeet and the munias were absent in undisturbed areas but present in disturbed habitats and forests near paddy or chena cultivation (Table E-11). At Polonnaruwa, parakeets accounted for 50% of the total numbers of 24 species censused in areas near paddy cultivation. Available information suggests that parakeets and munias adapt easily to modifications of natural habitat and proliferate quickly to reach pest proportions.

Crop Damage by Other Species

Besides elephants, other wildlife species such as parakeets, munias and wildboar have been identified as agricultural pests causing considerable economic loss. All three species affected paddy production in several areas, but the major pest in each area was different. For example, at Kantalai, Polonnaruwa, and Wilgomuwa, the major paddy pests were munia, parakeet and wildboar, respectively. The Kantalai farmers lost about seven bushels per acre mainly to munias. The extensive loss to munia was believed to be related to the presence of nearby sugar cane plantations which provided ideal nesting and roosting sites for these birds and facilitated their proliferation. Polonnaruwa and Wilgomuwa farmers lost one bushel and 10 bushels per acre respectively to these major paddy pests. At Kantalai a systematic study of sugar cane damage showed an annual yield loss of 20% and a revenue loss of Rs.5.9 million due to wildboar activity (Rajendra 1973, 1974). In fact, at Kantalai, wildboar appeared to cause more serious damage to sugar cane than elephants.

FLORA OF THE PROJECT AREA

Wildlife includes the flora as well as the fauna of an area. The project area contains at least three endemic genera of plants (Cramer 1977). A. Klostermans, Visiting Professor at the Department of Botany, University of Peradeniya has tentatively identified 53 endemic plant species within the project area, of which 17 are considered rare or very rare (Table E-12).

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Table E-11

Percentage Abundance of Agricultural Pests in Total Avifauna of Different Habitat Types - December 1979

Transect Location	Habitat Type	% Abundance of Bird Pests
Tirikonamadu	Scrub forest	5.6
Dimbulagala	Open forest	-
Ellona kanda	Closed forest	-
Polonnaruwa	Open forest near paddy	50
Giranduru Kotte	Closed forest near chena	18.4

Source: TAMS Wildlife Survey (1979).

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Table E-12

Endemic Plant Species Found in the Project Area

Annonaceae

- Uvaria sphenocarpa
- Xylopia nigricans
- Mitrephora heyneana
- Milinsa indica
- Alphonsea lutea (very rare)
- Alphonsea sclerocarpa (very rare)

Menispermaceae

- Cocculus villosus (rare)

Capparidaceae

- Capparis chelidonii (very rare)

Violaceae

- Alsoderia virgata (rare)

Malvaceae

- Dicellostylis axillaris (very rare)

Sterculiaceae

- Sterculia thwaitesii (very rare)

iliaceae

- Grewia diplocarpa (rare)
- Friumfetta glabra (very rare)

Linaceae

- Hugonia ferruginea (very rare)
- Erythroxylon lucidum

Oxalidaceae

- Biophytum nervifolium

Rutaceae

- Muraya glenieii
- Atalantia zeylanica var. rotundifolia

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Table E-12

(continued)

Meliaceae

- Dysoxylum zeylanicum
- Dysoxylum pyriforme

Celastraceae

- Elaeodendron balae
- Elaeodendron glaucum

Sapindaceae

- Gleniea zeylanica
- Gleniea unijuga
- Nephelium gardneri (very rare)

Leguminosae

- Derris parviflora
- Derris paniculata (very rare)
- Sophora violacea (very rare)

Myrtaceae

- Syzygium fergusonii
- Syzygium rotundatum

Flacourtiaceae

- Homalium dewitii (very rare)

Rubiaceae

- Wandiandia notoniana, var. zeylanica (very rare)

Sapotaceae

- Mimusops zeylanica (rare)

Apocynaceae

- Holarrhema mitis
- Wrightia flavido-rosea
- Wrightia angustifolia
- Gymnema rotundatum
- Tylophora membranifolia
- Ceropegia parviflora

Table E-12
(continued)

Loganiaceae

- Strychnos micrantha

Convolvulaceae

- Argyreia pormacea, var. triflora

Acanthaceae

- Cardanthera thwaitesii
- Barleria nodiflora
- Gymnostachyum zeylanicum

Verbenaceae

- Glassocarya scandens

Amarantacea

- Cyathula zeylanica
- Psilotrichum scleranthum

Lauraceae

- Alseodaphne semecarpifolia (rare)

Enphorbiaceae

- Phyllanthus thwaitesianus
- Hemicyclea gardneri
- Mallotus eriocarpus

Scitaminae

- Curcuma oligantha

Roxburghiaceae

- Stemona minor

An additional number of plant species found in this area are regarded as prime candidates for the production of new drugs which may be used in the treatment of cancer and other human maladies (Table E-13). Antifertility compounds have been identified in 18 plant species, and the World Health Organization is presently investigating the extraction of these chemicals (Table E-14). Many of the plants are also used in the traditional medical system called Ayurveda.

Undoubtedly the flora of the project area has very important medicinal and scientific values, and in conjunction with the fauna possesses a significant ecosystem value. Its timber value however, has been substantially exploited (TOPIC REPORT D: FORESTRY). Nevertheless, during the past three years the State Timber Corporation has been removing the last remaining valuable timber from the project area. The use of heavy machinery for timber extraction has caused extensive damage to other vegetation. More recently, the State Timber Corporation has embarked on a program of charcoal manufacture. Within the last few months several charcoal pits have been established in the project area particularly in Systems B and C. For the purpose of charcoal manufacture only Drypetes sepiaria is being used, because its wood is considered to have no other value. Little attention has been paid to the ecologically dominant status of this species or its possible role in maintaining the integrity of dry zone forest ecosystems. The State Timber Corporation's intention of exploiting valuable timber and timber of little value can only lead to complete elimination of forests in its areas of activity.

EXISTING INSTITUTIONAL CAPABILITIES

The Department of Zoology at the University of Peradeniya has two faculty members who are qualified terrestrial ecologists. The other universities have specialists in marine and soil ecology and limnology. However, faculty members of all universities are fully occupied with lecture schedules and find little time for wildlife field studies. A shortage of vehicles also limits their activities. In the past, therefore, wildlife ecology was not taught as a special course at the universities. However, this academic year the University of Colombo has inaugurated a post-graduate program on environmental sciences. It is hoped that some students following this program will qualify next year and at least partly fill the need for wildlife ecologists in the country.

The Department of Wildlife Conservation is responsible for the formulation and execution of the fauna policy of Sri Lanka. This department has its central administrative office in Colombo and operates on an annual budget of about Rs.6.5 million (U.S. $390,000). Nearly 85% of the budget is spent on salaries, permanent structures and capital equipment, while none is allocated for scientific research (Appendix E-IV).

The cadre of the Wildlife Department includes six administrators, several clerks, typists and 412 field personnel. Only two people in the entire department hold basic zoology degrees, and both are charged with administrative duties. The educational qualification of about 90% of the field personnel is eighth grade or lower.

Table E-13

Some Plants of Medicinal Value Found Within the Accelerated Mahaweli Programme Area

Species	Medical use/active principle
Heliotropoum indicum	Anticancer
Mucuna prurita	Parkinsons disease/L - Dopa
Leucaena latisiligna	Parkinsons disease/L - Dopa
Terminalia chebula	Skin disorders
Hemidesmus indicus	Antipyretic
Azadirachta indica	Antimalarial
Solanum jacquini	Expectorant
Phyllanthus emblica	Liver disorders
Plumbago indica	Gastro intestinal disorders
Acacia catechu	Gastro intestinal disorders
Boerhavia diffusa	Diuretic
Dioscorea sp.	/Diosgenin
Datura sp.	Anti inflammatory/scopolamine

Source: Natural Products for Sri Lanka's Future-report of a workshop sponsored by the National Science Council of Sri Lanka and the National Academy of Science U.S.A.

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Table E-14

Plants Containing Antifertility Compounds
Found Within the Project Area

Species	Family	Plant Part Containing Anti-fertility Compound
Caesalpinia bonducella	Leguminosae	leaf,root,stembark,stem
Caesalpinia pulcherima	Leguminosae	leaf,root,stembark,stem
Costus speciosus	Zingiberaceae	rhizome, root
Curcuma aromatica	Zingiberaceae	rhizome, root
Cyperus rotundus	Cyperceae	rhizome, root
Granjea madaraspatana	Compositae	aerial part, root
Herpetis monniera	Scrophulariaceae	whole plant
Momodica clerantia	Cucurbitaceae	stem, vine
Petiveria alliacea	Phytolaccaceae	leaf, root, stem
Plumbago zeylanica	Plumbaginaceae	leaf, root, stem
Portulace oleracea	Portulacaceae	whole plant
Ricinus communis	Euphorbiaceae	leaf, root
Rubia cordifolia	Rubiaceae	stem, root
Saraca indica	Leguminogae-Mimusoidae	
Urena lobata	Malvaceae	leaf, root, stem
Achyranthes aspera	Amaranthaceae	aerial,part,root

Source: Prof. S. Balasubramaniam, Dept. of Botany Peradeniya

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The field personnel are entrusted with the responsibility of maintaining 58 wildlife reserves which come under the department's purview. About 65% of them are stationed in the five National Parks while the remainder are scattered over the other 58 wildlife reserves. This disparate distribution of personnel is partly due to the fact that the National Parks contribute a fairly large proportion to the total area of wildlife reserves and partly because of heavy tourist pressure on the National Parks. In any case, at present a large number of wildlife reserves are inadequately manned and thus poorly protected from habitat destruction, human encroachment and poaching. The problem of inadequate staff is aggravated by the lack of vehicles for transport and communication. The department has a pool of only 29 jeeps and three motor bicycles at its disposal. As such, the officers manning many of the wildlife guard posts do not have any mode of conveyance. The net effect of the existing situation is that small and scattered groups of the department's personnel undergo a great deal of personal hardship and harassment to effectively discharge their official duties.

SOCIAL VALUES WITH RESPECT TO WILDLIFE

> "The forest is a peculiar organism of unlimited kindness and benevolence that makes no demand for its sustenance and extends generously the products of its life activity; it affords protection to all beings, offering shade even to the axeman who destroys it" - Guatama Buddha.

> "O great king the birds of the air and the beasts have an equal right to live and move about in any part of this land as thou. The land belongs to the people and all other beings and thou art only the guardian of it" - Arahat Mahinda to King Devanampiyatissa circa 300 B.C.

Conservation of nature and concern of wildlife are extremely old traditions of Sri Lanka and date back to the spread of Buddhism in this country. Historically, therefore, a high social value has been placed on wildlife through religious and cultural practices. Nevertheless, some of the present trends of human endeavors bring men into severe conflict with wildlife. Thus wild animals are generally viewed as an obstacle to man's progress and destroyed, but it is interesting that this destruction most frequently occurs through indirect methods, such as habitat modification. Social values prevent the direct killing of wildlife although this sometimes does occur. However, the recent shooting of three elephants caused sufficient concern to be highlighted in the local newspapers for at least two weeks. This clearly shows that old practices die hard, and that traditional values are extremely difficult to change. Traditional values are maintained even in this age of economic progress.

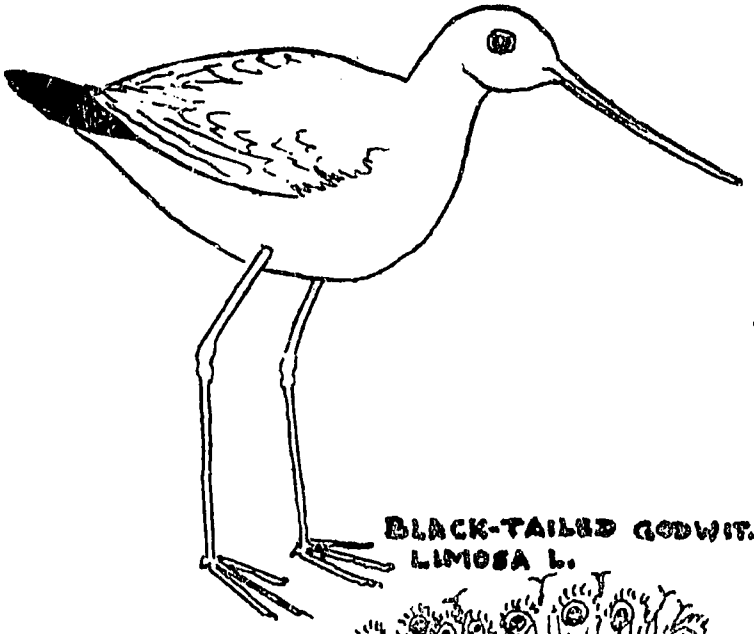
The conflict between traditional values concerning wildlife and economic progress arises from the lack of understanding of the intimate relationship between wildlife and its habitat. Consequently, wild animals (and traditional values) are destroyed indirectly through habitat encroachment (and economic progress).

In the past, development programs were designed disregarding wildlife and problems related to it. After the implementation of the program, however, the task of facing wildlife problems has fallen directly on those who lived on the "developed" land, i.e. the Sri Lanka peasantry. Ironically, those who faced the greatest problems were the same as those that the development program was designed to help most.

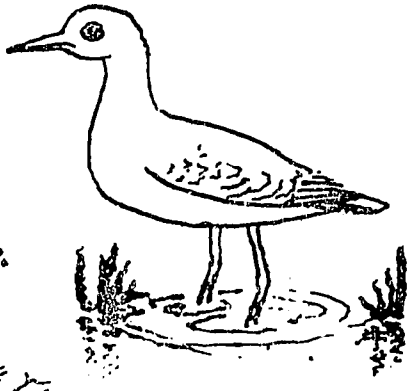
Traditional values play an important role in mitigating the gravity of improper planning and development. The peasant who is affected by wildlife problems usually resigns himself to his "karma" or fate. Sometimes frustration leads to a breakdown of social norms, and the peasant may directly kill wildlife to save his livelihood.

CURRENT AWARENESS OF WILDLIFE PROBLEMS

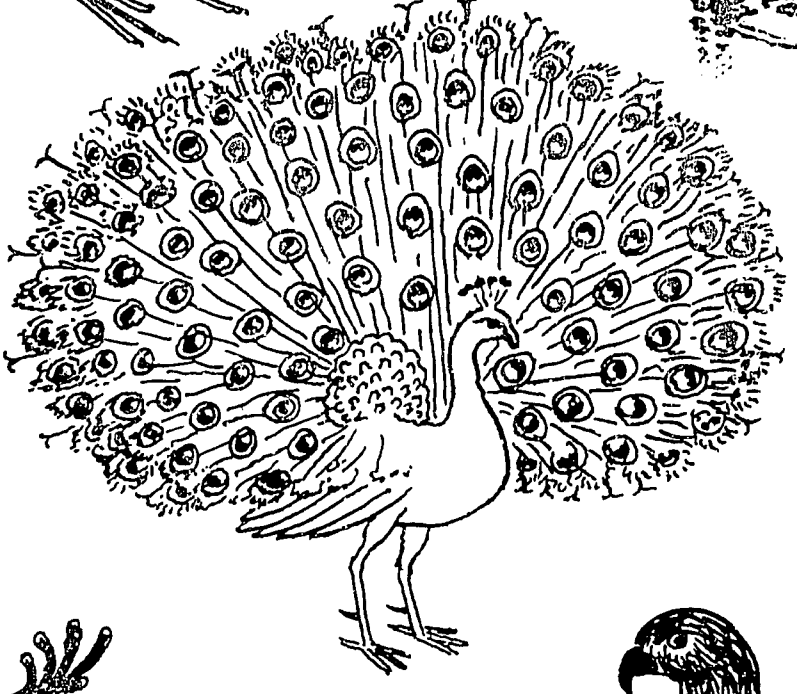
Although there is a general lack of understanding of the cause and nature of wildlife problems, there is a growing awareness of these issues and a belief that they should be resolved. It must be noted that the very fact of this report indicates a new sense of awareness of the wildlife problems. The Accelerated Mahaweli Development Program was the first program in the recent history of development in Sri Lanka which included the Department of Wildlife Conservation in the discussions for planning agricultural development. Recent articles in the newspapers and radio talks on wildlife and conservation also reflect the current concern for wildlife and its problems. This augers well for the future of Sri Lanka wildlife whose problems could be resolved through careful planning and some foresight. Resolution of these problems would also go a long way in benefiting human welfare.



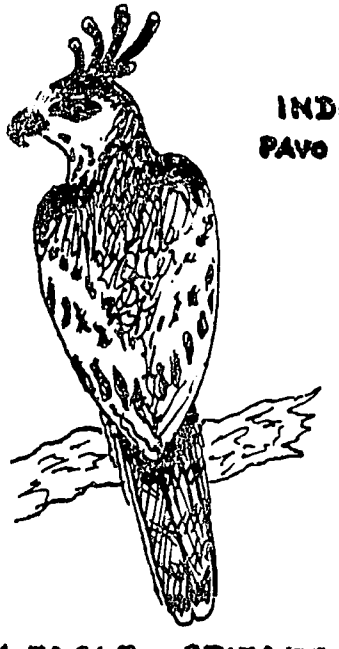
BLACK-TAILED GODWIT.
LIMOSA L.



MARSH SANDPIPER.
TRINGA STAGNATILIS.



INDIAN PEACOCK.
PAVO CRISTATUS.



C. HAWK-EAGLE. SPIZAETUS CIRRHATUS.

C. TANK EAGLE.
ICHTYOPHAGA
ICHTHYAETUS.

IMPACT ANALYSIS

HABITAT ALTERATION

The elimination of a total of about 80,000 hectares of mostly natural habitat is undoubtedly the single most serious problem which threatens the survival of the wildlife found in the project area. Nearly 70% of the project area consists of undeveloped land comprising numerous types of natural habitats.

Portions of what may be considered as high-quality wildlife habitats will be converted for agricultural development. This includes most of the high-quality habitat area in the northern part of System C and about 5,600 hectares which presently comprises the northern section of the Somawathie Sanctuary. In addition, about one-half of high-quality wildlife habitat in the Mahaweli Ganga floodplain will be lost due to reduced river flows. These impacts will result in irrevocable losses of relatively exceptional wildlife habitats. On the other hand, they are balanced to some extent by the commitment of the government to maintain the Wasgomuwa Strict Natural Reserve in its entirety. This reserve was originally scheduled for development as part of what has been designated as System E in the Mahaweli Development Program. Furthermore, the government has recently initiated plans to establish the proposed Maduru Oya National Park adjacent to Systems B and C (See Figure E-4). This may also partially compensate for the overall loss to high-quality and related wildlife habitats due to the proposed development.

Two other legally designated wildlife reserves in the project area will be affected by the proposed development. About 2,500 hectares of the existing Nelugala Corridor in System B is considered as highly suitable for rice cultivation. Development of this area would effectively eliminate the corridor. However, large parts of the corridor have been encroached upon, and surveillance is negligible. Similarly, a large part of the Veddikachchi Intermediate Zone will be developed for cultivation in System D. However, reduction of this latter zone cannot be considered as especially significant since it affords no protection to wildlife species, and the area it presently covers is mostly under cultivation already.

Habitat alteration will result from changes in the pattern of water resources, deforestation and also from limited salinity intrusion in the lower reaches of the Mahaweli and Maduru Oya. At the local level this must not be considered as a problem for wildlife alone, but as an issue of paramount importance from the scientific, agricultural, economic and social viewpoints. Under the global trends of deforestation which were recently highlighted at a conference sponsored by the U.S. Department of State and USAID, habitat destruction must be of international concern as well. The major conclusion which emerged from this conference read as follows:

> "The world is being confronted by an extremely serious problem with immediate and long-range socioeconomic and ecological consequences as the result of the accelerated loss of forest and vegetative cover in the humid and semi-arid lands within or near the tropical latitudes. Further, the community of nations must quickly launch an accelerated and coordinated attack on the problem if these greatly undervalued and probably irreplaceable resources are to be protected from virtual destruction by the early part of the next century." (U.S. Strategy Conference on Tropical Deforestation 1978).

Within the project area, extensive elimination of natural ecosystems will displace vast numbers of animals from their home ranges and crowd several others into the remaining parts of their habitats. Displaced animals would become extremely vulnerable to wanton destruction. Excessively crowded animals usually suffer from food shortage and over exploit their environment. This could subsequently lead to significant decreases in populations. Such reductions have been documented for deer and elephants in different parts of the world (Leopald 1943; Buechner and Dawkins 1961; Glover and Sheldrick 1964; van Wyk and Fairall 1969; Caughley 1970). Furthermore, at high population levels some species exhibit behaviour patterns which are deleterious to their own populations e.g., infanticide in the Sri Lankan gray langur and purple-faced langur (Gunasena, personal communication; Rudran 1963; Calhoun 1962).

Modification of natural ecosystems will result in the reduction of present carrying capacities for most wildlife species and the consequent decrease of their populations. Animal species which have a history of decreasing populations may be completely eliminated from the project area. Furthermore, it is possible that the genetic diversity of wild plants will be substantially reduced or completely lost. The consequences of the loss of species is not entirely clear. It is evident however, that one cannot be certain which species will be eliminated or how these species would be of help to mankind in the future. Nevertheless, in the past some of the most significant advances in human progress stemmed from the study of wild species. The study of the black bear lead to an improved high protein, low fluid diet for patients with kidney failure. Investigations of echo location by bats resulted in the understanding of human genetics. Frankly, it is impossible to predict which species or habitat could provide another key to human progress, but these options would be limited with the continued elimination of natural habitats.

A few species which adapt to habitat change, e.g., wildboar, rats, parakeets and munias will proliferate further and may become more serious agricultural pests within the project area. This, in turn, will adversely affect potential crop production.

In terms of natural forest habitats, all five of the proclaimed forest reserves located within the project area have been released from the Forest Department and slated for development. As mentioned previously, forested areas in some of the Nelugala Corridor, the northern part of the Somawathie Sanctuary and the Veddikachchi Intermediate Zone are also slated for development. However, much of these areas have already been encroached upon and considerable amounts of forested area in the region were destroyed by the 1978 cyclone. Nearly 30 years ago 50% of the dry zone (which includes the Accelerated Program area) was forested. Now only 20% of this region is forested (Perera 1977b, 1978). At present, forest cover comprises only 25% of Sri Lanka's total land area (See TOPIC REPORT D: FORESTRY).

As indicated earlier, the exploitative activities of the State Timber Corporation within the project area is a matter of serious concern. This agency's method of forest clearing will leave very little in the form of flora and fauna in its areas of operation. Furthermore, its area of operation includes the central portion of Somawathie Sanctuary for which development plans have not been finalized. Therefore, continued habitat elimination would preclude other development possibilities which presently exist for this area.

It should be noted that without the development of the proposed projects, significant amounts of forested area are likely to be removed in any event by encroaching chena farmers. Without appropriate land use planning to balance human and natural environments and without proper surveillance and protection, this problem will inevitably escalate due to the heavy demands for agricultural land from the nation's growing population. Unless controlled, large segments of the project area natural wildlife habitats, including the high-quality ones, will probaby be lost to encroaching farmers.

IMPACTS ON THE VILLU FAUNA

The decreased water flow due to dam construction on the Mahaweli Ganga is expected to reduce the size of villus by about one-half (see TOPIC REPORT A: CLIMATE AND HYDROLOGY). This would deplete the ecological resources required by several wildlife species, particularly wading birds. Moreover, the reduction of villus will aggravate the existing problem of weed proliferation by domestic cattle. The loss of the villu habitat will be unavoidable, and it is unlikely that this impact can be effectively mitigated. Although villus within the project area have not been developed for wildlife viewing, these habitat types have traditionally been some of the best localities for observing wildlife. This opportunity will be lost if the ecology of the villu fauna is affected. People who depend on villus for their livelihood will also be indirectly affected.

IMPACTS ON MIGRANT BIRDS

Certain migrant birds such as the pitta, the orange-headed ground thrush and Philippine shrike have stringent site specific requirements and return to the same patch of habitat year after year (Phillips 1978). Populations of such migrants will be substantially affected by forest destruction and changes in the pattern of water resources. These two factors will reduce food resources and affect some of the other migrants as well.

Migrant birds undertake relatively long migratory flights, and a shortage of food as soon as they arrive here can take an immediate toll on their numbers. The lack of food leading to exhaustion and death can also occur on their return flight. Possibly to avoid this problem, more and more migrant birds are remaining in Sri Lanka throughout the year. The bluetailed bee-eater, which was once a regular migrant is now a breeding resident. Many other birds, particularly the waders, remain in Sri Lanka even after they assume their breeding plummage. The number of species migrating to Sri Lanka has also increased in recent years. The influx of migrants may intensify interspecific competition resulting in serious consequences to the resident bird fauna.

The changing pattern of water resources will result in some localized expansions of aquatic habitats, especially with respect to the proposed reservoirs. As these habitats stabilize, they may prove beneficial to some migratory (and resident) waterfowl in terms of increased feeding and nesting areas. On the other hand, pesticide accumulations in some of the newly formed aquatic habitats may be magnified in some bird species diets and could eventually reduce their reproductive capabilities (see TOPIC REPORT F: WATER QUALITY).

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IMPACTS ON ENDEMIC SPECIES

Endemism usually arises through prolonged isolation of populations living in relatively stable habitats. Habitat stability due to geographical isolation and relative uniformity of the environment allow endemics to evolve and occupy well defined and relatively narrow ecological niches. Consequently, endemic species are particularly sensitive to environmental perturbations such as habitat modification and increase in food competition, e.g., from migrant birds. Therefore, this unique complement of Sri Lanka's fauna will be considerably impacted by the proposed development scheme. It was indica ed earlier that populations of four endemic species seem to have already been reduced; the other endemic species populations (Appendix E-III) are also expected to decrease in the project area. The elimination of riverine forests, which appears to be the preferred habitat of many endemics, would have the most serious effect on endemic populations.

IMPACTS ON ENDANGERED SPECIES

Species such as the elephant and leopard are listed as endangered because they already face the threat of extinction. Extinctions irreversibly reduce the diversity of ecosystems and makes them more susceptible to unwanted change. For example, the extinction of the leopard would provide its prey species, such as deer and wildboar, an added potential to multiply rapidly and reach pest proportions. This occurs even now, as the leopard population decreases, but extinction of this species would mean an irreversible loss of a biological phenomenon which is beneficial to man. Also, and perhaps more significantly, the preservation of leopards, elephants and other species has an aesthetic, religious and cultural significance in Sri Lankan society which should not be overlooked.

Species become endangered when the viabilities of their population are low through all or part of their area of distribution. All nine threatened or endangered species found within the project area are listed as such through most of their world distributions (Table E-5). Moreover, red-faced malkoha, purple-faced langur and toque macaque are endangered or threatened endemics (i.e. found only in Sri Lanka). Therefore, the expected adverse impacts on these species may be considered even more serious than for the other endangered species.

One of the major problems faced by species threatened with extinction is the gradual reduction of suitable habitat. Continued reduction of suitable habitat within the project area will drive them closer towards extinction. Extinction implies the dying out or the end of a species, the end of a population, and the end of a line of evolution that may have developed over millions of years. On a geologic time scale spanning several million years, extinction is a natural process, but during the last four hundred years, man's activities have contibuted to the extinction of three fourths of the species that died out. Thus, extinction is rarely a natural process anymore, but a man induced phenomenon which can be detrimental to his own welfare.

The details of the impacts on the elephant, which is the most conspicuous and culturally significant endangered species found within the project area are given below.

IMPACTS ON ELEPHANT POPULATIONS

The initial phase of development will evict several social groups of elephants from at least parts of their home ranges. This would deprive elephants of their natural food and crowd them into the remaining area of their habitat. Food deprivation and excessive crowding of elephants may lead to habitat destruction, which would make the area sub-optimal for elephants as well as several other species that depend on the same habitat. Evidence of this has been documented from the African elephants in Kruger National Park, South Africa, Kabalega National Park, Uganda, and Tsavo National Park, Kenya. It was indicated earlier that in Sri Lanka a case of habitat destruction by elephants occurred in 1977. This particular incident was probably precipitated by moderate crowding and a lack of food which was aggravated by a prolonged drought. Any further crowding of elephants may result in habitat destruction even under normal climatic conditions.

During the later phases of development, if agricultural areas gradually surround natural habitats, pockets of elephants could be formed which ultimately become completely isolated from other members of the population. This may be a relatively slow process, but eventually with the growing demand for agricultural land in the country, elephants and other wildlife may become more restricted to more or less confined areas. For example, McKay's investigations (1973) indicate that the isolation of elephants in and around Gal Oya, Labugala and Yala into three groups of 300,150 and 150 animals, respectively, is becoming more pronounced. Within these subpopulations, evidence of further pocketing was also found, i.e., one of the six groups studied at Gal Oya was completely isolated due to agricultural expansion surrounding its home range.

An additional example of pocketing has occurred in the Bundala Sanctuary. Elephants which had ranged as far as Uda Walawe and Ridiyagama were recently driven into this small sanctuary, where the isolation of about 60 elephants is complete or imminent due to surrounding settlement expansion (P.B. Karunaratne, personal communication). Further, small pockets of elephants which occurred at Angunakolapelessa were eliminated by nearby farmers to prevent crop damage.

The TAMS wildlife survey team identified a group of about 20 animals which will probably become pocketed upon completion of the Randenigala Reservoir near Kehelella. Similarly, many small groups which enter the agricultural areas between Hasalaka and Hettipola from the right bank of the Mahaweli may be pocketed there by the development in System C.

Excessive pocketing should be recognized as the precursor to the decline of elephant populations. Isolated pockets consisting of a few elephants suffer the effects of inbreeding which results in reduced fecundity and a decline in numbers and viability. Pockets with larger numbers of elephants may or may not be viable, but they also face adverse consequences because pocketing is normally associated with overcrowding. Thus, the existing pattern of development may create a situation of double jeopardy to the elephant, i.e. overcrowding and inbreeding in different parts of its distribution. The proposed development pattern will also have the effect of intensifying the already existing conflict between human interests and the elephant which further affects the survival of this species.

There are an estimated 800 elephants that inhabit the project area and its environs. About one-half of these could be accommodated in wildlife reserves within and at the periphery of the project area provided some wildlife management measures are implemented. This would include habitat enrichment, the establishment of buffer zones and most importantly, the monitoring and protection of the reserves.

The fate of the other 50% of the project area elephant population which will be displaced could be varied under the existing patterns of development. Development may immediately eliminate individuals of some social groups, and thus, reduce the size of the viability of these groups. Other social groups would live in semi or completely isolated pockets of habitats. In areas where these groups are crowded they may destroy their habitat. In other parts, especially high-quality wildlife habitats, crop damage by elephants may be very high and could lead to retaliation by cultivators and result in further elephant deaths and wounding. Ultimately, it is likely that most of these displaced elephants will die, although some could be saved by a concerted capture program for increasing the domestic population. In any event, the displaced animals will be removed from natural breeding populations, further reducing the overall viability of this endangered species.

IMPACTS ON OTHER WILDLIFE SPECIES

This section deals with the impacts on wildlife other than the endemic fauna, endangered species and migrant birds found within the project area.

Although the problems of elephants were discussed in some detail, it must be noted that several other species share the same problem. Elimination of natural ecosystems followed by habitat fragmentation and a population decrease can be expected to affect many species of mammals, birds, reptiles and amphibians within the project area.

Animal populations usually maintain themselves at or near the carrying capacity of their habitat through natural processes such as emigration, immigration, mortality and natality. Population viability cannot be maintained by mortality and natality alone. Emigration is important to reduce population pressure in any given area and immigration is necessary for the influx of new genotypes and the prevention of inbreeding. If barriers against immigration and emigration are created, the population in the isolated habitat becomes susceptible to decline. This is amply demostrated by faunal studies of islands where water acts as a barrier (MacArthur and Wilson 1967). For example, since the time Sri Lanka became isolated as an island it has lost two species of rhino and a species each of hippo, lion, red dog and gaur from its large mammal fauna (Deraniyagala 1958).

Within the project area, habitat elimination and fragmentation will create barriers (i.e. agricultural areas) and isolate wildlife habitats. This will disrupt the emigration and immigration patterns of many species. Animals that are inately shy (e.g. leopard, sloth bear, jackal, mouse deer), those which are hunted (e.g. sambhur, spotted deer, muntjac), and species which are almost totally dependant on trees and forests (e.g. purple-faced langur, porcupine, giant squirrel, flying squirrel) will be the most seriously affected by the agricultural barriers to their immigration and emigration. Some species, especially nocturnal forms may move across these barriers (e.g. mongooses, civets, wildboar, some rodents), but if the barriers are too wide, the movements of these species will also be affected. Widespread disruption of emigration and immigration will affect gene flow and increase the probability of inbreeding.

Consequently, the viability of wildlife populations and the species diversity of natural habitats will be reduced.

The reduction of species diversity through habitat elimination and modification is expected to have serious impacts on biological food chains. These food chains transfer energy from plants to animals through a stepwise process of eating and being eaten, and stabilize the population levels of predator and prey within a biological community. Thus, the reduction of leopards would lead to an increase of its prey species. Similarly, the decline of insectivorous animals (amphibians, reptiles, birds, mammals and predatory insects) may result in the proliferation of insect disease vectors and agricultural pests. This increase would necessitate the use of pesticides and insecticides which will further disrupt biological food chains. The chemicals would be carried along the links of the food chain and most seriously affect the top predators of aquatic avian and terrestrial communities within the project area. This includes, crocodiles, monitor lizards, storks, eagles, hawks, leopards and man. Thus, habitat elimination will precipitate a series of escalating problems and threaten the welfare of wildlife as well as humans.

In addition to agricultural expansion, human needs for fuelwood will have an extremely serious impact on wildlife habitats and animal populations. Extensive tree falling will affect endangered and endemic plants and species which are valuable for medicinal purposes. Encroachment will also bring human activity in close proximity to wildlife and increase pressure due to hunting for food and commercial purposes. The star tortoise, crocodile, bengal monitor, peacock, jungle fowl, deer, sambhur, muntjac, mouse deer, hare, wildboar and leopard will be affected to different degrees due to hunting pressure.

Changes in the pattern of water resources and salinity intrusion may also have considerable impacts on wildlife habitats, aquatic forms and water birds. It must be noted that both species which disappeared from Sir Lanka's fauna in the recent past were water birds, i.e., glossy ibis and comb duck. The reason for their disappearance is unclear but it is possible that their dependence on specific aquatic habitats may have contributed to their extirpation.

AGRICULTURAL PESTS AND THE LOSS OF BIOLOGICAL CONTROLS

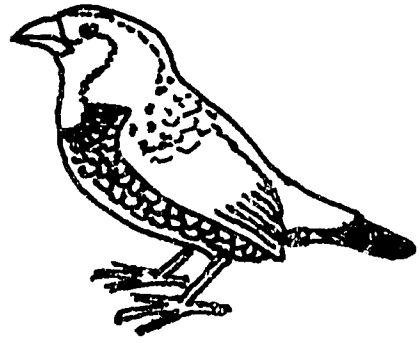
At present, the elephant, wildboar, rose-ringed parakeet and two species of munia have been identified as agricultural pests which will have a negative impact on the proposed program of development. Munias nest and roost in the thick cover of sugar cane plantations. From these areas they emerge in large numbers and damage rice fields over extensive areas. The munia problem has been identified around the Kantalai and the Uda Walawe sugar cane plantations. This indicates that there would be substantial economic loss if sugar cane and rice fields are established side by side.

In 1977, elephant raids in teak plantations resulted in a loss of $75 million of future revenue. This must not be viewed as an isolated incident but rather as a minimal estimate of economic loss if elephant habitat continues to be destroyed through agricultural expansion. Habitat destruction also appears to be the reason for the sudden and dramatic increase of parrots. About 30 years ago, the rose-ringed parakeet was restricted to the dry zone where it was found in relatively small numbers. Now its abundance has reached pest proportions and its distribution has extended into

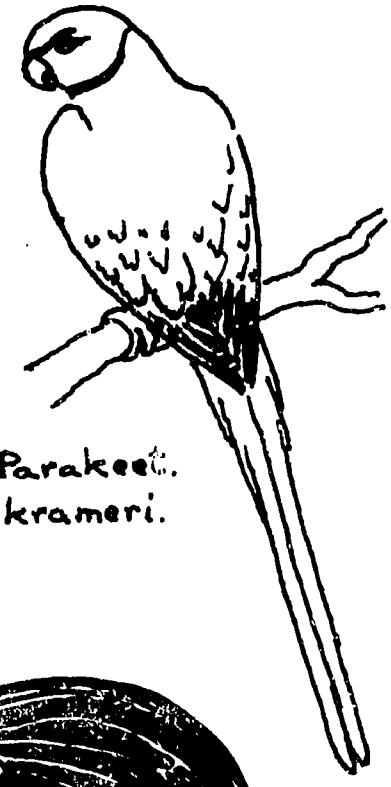
the wet zone and the central highlands. Evidently, extensive deforestation has favored the parrot by reducing bird populations which compete with the parrot for food and nest holes. This loss of biological control through interspecific competition has led to the parrot becoming one of the most serious pests of rice and other food crops.

The wildboar problem presents another example of the loss of biological control and the importance of maintaining natural systems of predator-prey interactions. Analysis of predation by the Sri Lankan leopard showed that wildboar and spotted deer kills constituted 28% and 49%, respectively, of the total prey items captured (Eisenberg and Lockhard 1972). While the spotted deer was captured less than twice as frequently as the wildboar, its density was more than ten times that of the wildboar. This suggests that leopard prefers wildboar to the spotted deer. In fact, wildboar appears to be the most preferred of all leopard prey; and the wildboar's relatively large litter size was probably evolved to offset this predation pressure. In the absence of predation pressure, however, the wildboar has the potential of proliferating very quickly and becoming an agricultural pest. This occurs when natural ecosystems are modified in such a manner that they accommodate the prey species but excludes the predator, e.g. the modification of natural habitats to sugar cane plantations.

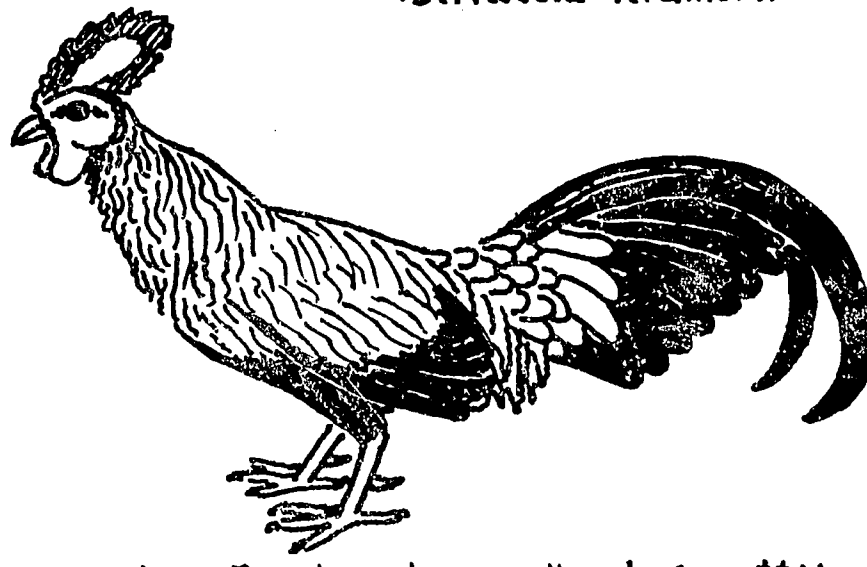
Natural ecosystems are reservoirs of many vertebrate and invertebrate species which act as biological control agents of pests as well as human disease vectors. They also provide commercial timber, fuelwood, medicinal plants, a host of natural products and a gene pool for the production of new varieties of agricultural crops. Moreover, natural ecosystems regulate water flow and prevent soil erosion and have a great deal of potential for promoting tourism. Unfortunately, the total value of the service rendered by natural ecosystems cannot be easily assessed in economic terms. More often than not the contribution of natural ecosystems to human welfare is realized only after they are destroyed.



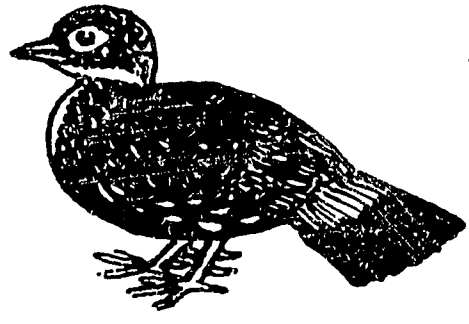
Spotted Munia.
Uroloncha punctulata.



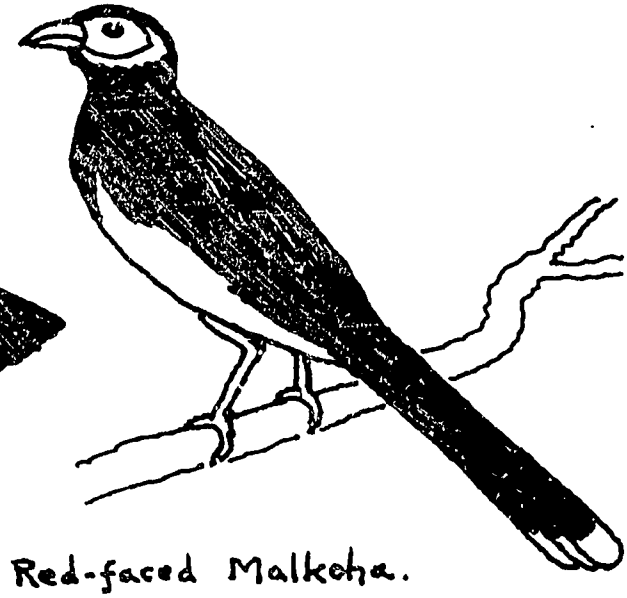
Rose-ringed Parakeet.
Psittacula krameri.



Ceylon Junglefowl. Gallus lafayettii.



Ceylon Spurfowl.
Galloperdix bicalcarata.



Red-faced Malkoha.
Phaenicophaeus pyrrhocephalus.

C.F.

REVIEW OF PROPOSED WILDLIFE MANAGEMENT PROGRAMS

PROGRAM PROPOSED BY THE DEPARTMENT OF WILDLIFE CONSERVATION

As requested by the Environmental Panel of the Mahaweli Development Board, the Director of Wildlife Conservation has put forward a wildlife mitigation proposal for the Accelerated Program (see Figure E-2). This can be summarized as follows:

- The creation of Maduru Oya National Park in the catchment of the Maduru, Ratkinda and Ulhitiya Oyas;
- The establishment of a corridor from the proposed Maduru Oya National Park into Wasgomuwa;
- The establishment of a corridor from Wasgomuwa along the left bank of the Mahaweli into the Somawathie;
- The retention of the entire extent of existing wildlife reserves found within or on the borders of the Accelerated Mahaweli Project Area, e.g. Nelugala Corridor, Wasgomuwa and Somawathie; and
- The establishment of a corridor between Maduru Oya and Gal Oya National Park.

It must also be noted that the proposal is a modification of a much more extensive plan set forth in 1959 by a government committee on the preservation of wildlife (Sessional paper No. 19).

NEDECO'S RECOMMENDATIONS

The NEDECO team's study supported the first, third and part of the fourth recommendation and indicated that the second recommendation required further scrutiny. This study also mentioned that the Nelugala Corridor is ineffective because its southern end does not lead into a national reserve. However, the NEDECO team probably did not realize that the southern end leads to the riverine forest along the Maduru Oya.

The NEDECO team made two additional recommendations related to the accelerated phase of the Mahaweli Development Program. One is to enhance the communicating systems of wildlife reserves by establishing a forest reserve or jungle corridor from the northern part of the Wasgomuwa Reserve to the Minneriya-Giritale Sanctuary. The other is to extend the Somawathie Sanctuary along the west bank of the Mahaweli so that it includes the Mahaweli north forest reserve.

SYSTEM B FEASIBILITY REPORT

The feasibility report of System B development recommended that:

- The three elephant corridors as proposed by the Director of Wildlife Conservation be implemented at least on a temporary basis until the wildlife and the elephants can leave or be translocated from the area of development;

- The speed and methods of project implementation be regulated to minimize impact on the environment; and

- Fertilization of sprinkler irrigation during the dry season to assure a perennial food supply for elephants within the proposed Maduru Oya National Park.

The first and third recommendations are considered to be simplistic, but the second recommendation is a good one. Wild animals do not leave their habitat permanently unless they are killed or translocated. At present, effective translocation cannot be undertaken in Sri Lanka because of a lack of equipment, funds and technical expertise. In any case, the large scale translocation that would be necessary to overcome wildlife losses in the project area is unfeasible because alternative areas required to accommodate substantial amounts of displaced wildlife do not exist. Habitats surrounding the project area are likely to presently support animal populations close to respective carrying capacity limits for most species. Enriching the habitat within these areas could make them more attractive only to some selected species which range just beyond their boundaries.

Habitat enrichment through extensive fertilization and sprinkler irrigation as implied by the feasibility report is a futile exercise in attempting to contain the elephants of System B. When crowded into a small area elephants do extensive damage to the habitat, reducing the carrying capacity and adversely affecting other wildlife.

RANDENIGALA RESERVOIR REPORT

The Randenigala project report which is based mainly on the NEDECO team's findings, recommends that environmental monitoring be continued during and after the period of planned implementation. The report also recommends that three islands totalling 70 hectares which rise within the reservoir be made wildlife reserves. This however, is considered inadequate to mitigate wildlife problems arising from the dam construction at Randenigala.

SYSTEM C FEASIBILITY REPORT

The System C feasibility report makes two separate sets of recommendations for dealing with wildlife problems.

The first set of recommendations highlights habitat encroachment and suggests strongly that this must be arrested at once. An integrated approach to development is advised and the preservation of several small patches of forests in non-irrigable areas is recommended. It is also recommended that if parrots are identified as agricultural pests, substantial areas be kept under forest. Several other useful suggestions are included in this set of recommendations.

The second set of recommendations mainly argues against the Department of Wildlife Conservation's proposal for establishing a corridor between Wasgomuwa and the Maduru Oya National Park. The reasoning is that habitat encroachment has already made the establishment of a completely forested corridor unfeasible. A large corridor forested along its entire length would be the ideal, but one which includes the existing forests and some previously encroached areas assured

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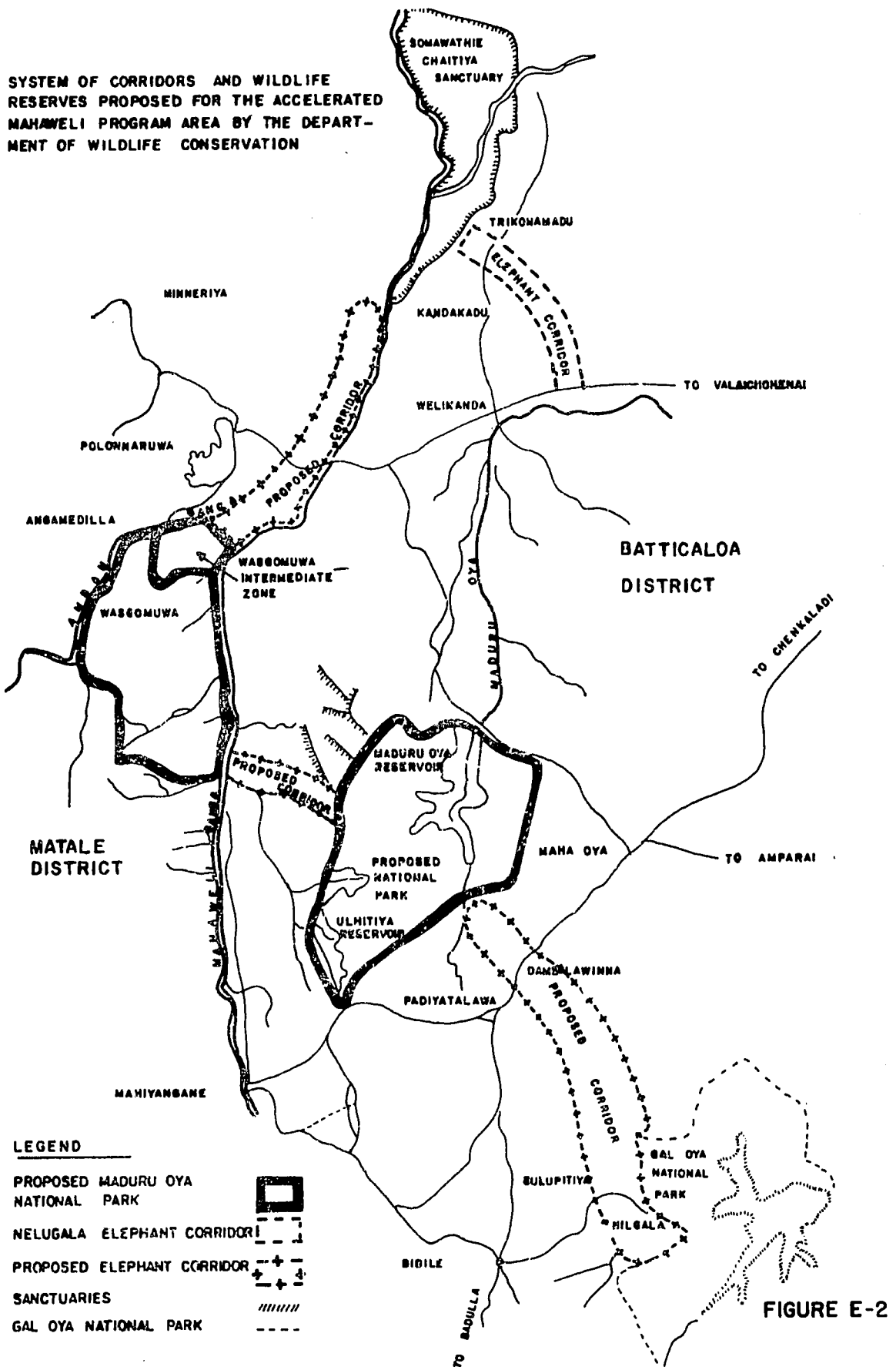

FIGURE E-2

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of future protection would also suffice to link the two wildlife reserves. However, the practicality of maintaining the corridor from encroachment in the long term is questionable; also, this corridor would serve the needs of only a limited number of species at the expense of substantial agricultural development and human settlement.

The System C report also states that no solution can be found for the elephants within the system, although their numbers are estimated at or more than 200 in this area. Neither the fact that such large numbers of elephants can cause considerable economic loss, nor the fact that these numbers comprise a significant proportion of an endangered species population is taken into account. The report's suggestion that this may cause elephants to be moved to areas outside System C is not considered technically and biologically feasible.

RECOMMENDED ACTIONS

GENERAL

The important relation between human welfare and natural resource conservation was previously indicated. The following recommended actions are based on the premise that the proposed development should protect human welfare through the rational use of fast dwindling natural resources, as well as fulfill human needs for food and employment opportunities. The protection of human welfare and the fulfillment of human needs are considered complementary rather than conflicting endeavors. Thus, it is strongly recommended that an integrated approach to development be implemented so that a balanced program of agricultural production, employment opportunities and natural resource conservation could be evolved.

It is recommended that the integrated approach to development include the following major elements:

- Establishment of a Natural Resources Coordinating Agency;
- The formulation and implementation of a national wildlife conservation policy;
- Expansion of existing wildlife reserves and establishment of new ones; and
- Expansion of the national park administration and management capacity.

ESTABLISHMENT OF A NATURAL RESOURCES COORDINATING AGENCY

It is recommended that the future course of action include an effective national policy and legal measures for environmental protection and natural resource conservation. In view of the present trends in the elimination of natural habitats the importance of such a policy and legislation cannot be over-emphasized. As a step towards integrated development, the above policy should be incorporated into a comprehensive national policy on land use, and it is urged that the land use policy place equal emphasis on agricultural production and environmental protection (Figure E-3).

The formulation of policy guidelines and legislation for natural resource conservation is logically related to the establishment of an agency which will have executive and implementation powers. The government's recent decision to create such an agency in the form of an institute called the Natural Resources, Energy and Environmental Authority is fully endorsed by this report. However, it is recommended that this institute be integrated with other conservation related government departments to form a Natural Resources Coordinating Agency (See also TOPIC REPORT C: WATERSHED MANAGEMENT). The establishment of this agency would provide credibility to the national concern for natural resources conservation and a forum for in-depth analysis, discussion and resolution of Sri Lanka's environmental problems. Furthermore, it will stimulate coordination between conservation oriented departments. It is recommended that the proposed agency be mandated to reduce and mitigate human pressure on natural resources, maintain or improve the quality of the environment and thereby address itself to long term human welfare.

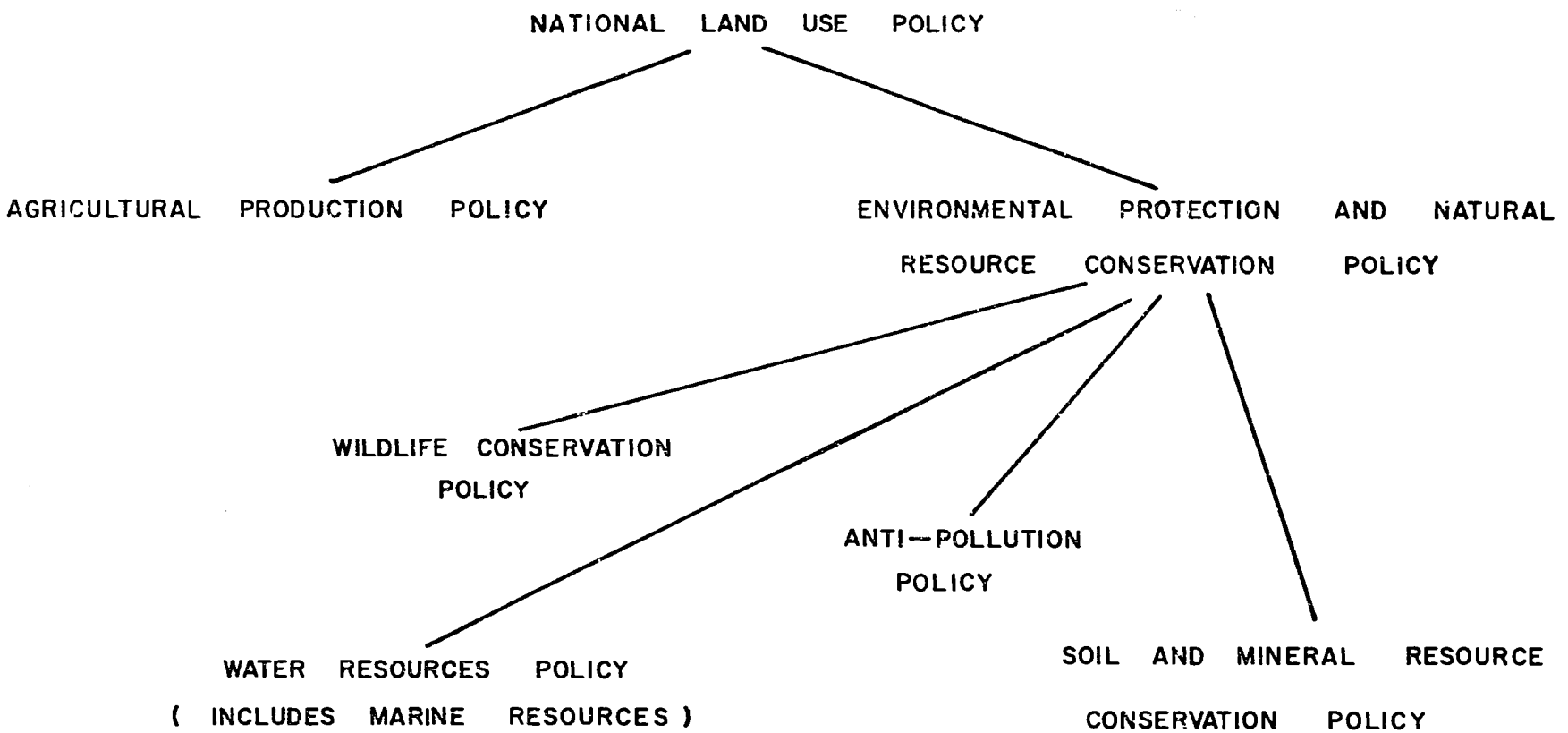
Under the present system of administration, coordination between conservation oriented departments is either lacking or non-existent. This is largely because these departments exist as small units which are attached to different ministries. It is advised that these scattered units be brought under one umbrella, expanded, and restructured to enable greater inter-departmental collaboration. The departments that could be brought under the proposed agency and their major tasks are as follows:

Department	Major Tasks
Fauna and Flora (i.e., Wildlife) Conservation	Protection of terrestrial habitats; Wildlife and ecosystem monitoring and management; National Park planning and wildlife reserve development.
Water Resources	Protection of freshwater and marine habitat; Monitoring and management of aquatic resources; and Water quality analysis.
Anti-pollution	Prevention of air pollution; Prevention of noise, sewage and industrial pollution; and Control of pesticide use and prevention of agriculture based pollution.
Soil and Mineral Resource Conservation	Prevention of inland erosion; Coast conservation; Conservation of mineral resources.
Conservation Education	Coordination and documentation of available information; Promotion of conservation awareness; and Publicity for legislation pertaining to environmental protection and natural resource conservation.

The inter-related interests of these departments would provide the basis of inter-departmental cooperation. It is recommended that each of the above departments formulate their own policy and legislation. These guidelines could then be made part and parcel of the policy on Environmental Protection and Natural Resource Conservation recommended earlier (Figure E-3). It is envisaged that the departments under the Natural Resources Coordinating Agency will work in collaboration with the Ministries of Lands, Agriculture, Fisheries, Education and State, etc.

NATIONAL WILDLIFE CONSERVATION POLICY

The lack of a national policy on wildlife conservation has been one of the major problems facing fauna and flora protection in Sri Lanka (Hoffman 1972). Recently however, the Hon. Minister of State set up a committee for the formulation of such a policy. The recommendations of this committee are not yet available for perusal. In any case, the terms of reference of this committee appear to be limited and pertain only to areas that should be declared, redefined, revised or improved as wildlife reserves. It is advised that this committee be requested to include in its terms of reference:



FLOW DIAGRAM OF INTERRELATED POLICIES
FIGURE E-3

- The new legal measures that are being formulated to strengthen the existing wildlife conservation laws;

- Recommendations for the integration of the wildlife conservation policy with national development programs;

- Master Plan for national system of Wildlife Reserves; and

- Details for revamping and expanding the Department of Wildlife Conservation.

It is hoped that the guidelines and recommendations provided in this report would prove useful in the formulation of the National Policy on Wildlife Conservation. Once this policy is formulated, it is strongly recommended that it be implemented as soon as possible.

EXPANDED SYSTEM OF WILDLIFE RESERVES

The Rationale

The rationale for recommending the expansion of existing wildlife reserves and establishing new areas takes into consideration long term human welfare as well as habitat and wildlife protection.

From the human perspective it is stressed that environmental protection and natural resource conservation are necessary and important prerequisites for long term human welfare. This is particularly true with relation to forests on which Sri Lankans depend on for a variety of their daily needs. However, the recent trends in habitat destruction show that the forests of Sri Lanka are disappearing at an alarming rate. During recent times while many countries have maintained their forest cover, Sri Lanka's forest cover has decreased rapidly below critical levels (FAO 1955, 1973). Vigorous reafforestation programs may arrest this trend but these programs are much more costly than maintaining natural forests. Moreover, reforested areas are usually very poor substitutes for the scientific, educational, wildlife and diversity values of natural forests. Therefore, it is recommended that as much as possible of the remaining natural forests and other wildlife habitats be legally protected. This can be achieved by expanding the size of already protected wildlife areas and establishing new reserves. The expanded system of wildlife reserves could be developed to provide increased economic benefits through tourism and immediate employment opportunities related to fauna and flora protection, wildlife management, environmental monitoring and conservation education.

From the point of view of wildlife, it should be recognized that the extensive agricultural development proposed within the Accelerated Program area will displace a large number of animals. It is unreasonable to assume that even a representative sample of all of the displaced animals could be accommodated within Wasgomuwa, Somawathie and the proposed Maduru Oya National Park, because these areas already contain population densities at or approaching full carrying capacities, respectively. Habitat enrichment may increase a carrying capacity, but enriching the habitat for one species may lead to detrimental effects on other species. Hence, habitat enrichment should only be practiced on a limited scale, and only a very small proportion of displaced animals could be accommodated in this manner.

Accommodation of dispalced animals in captive populations also has limited scope. Firstly, captive operations will take several years for completion because of the large numbers of animals involved, and will entail high mortality rates for certain species. Endangered animals such as elephant can ill afford such losses. Secondly, the lack of knowledge of captive maintenance of some animals (e.g., the purple-faced langur, an endemic and threatened species) precludes the possibility of these animals being included in zoo collections. Thirdly, while it is possible to capture and maintain several animal species, the numbers which will be displaced will far exceed the capacity of the world's zoos and domestic stock to absorb them. Therefore, the adverse impact on the majority of the displaced animals would have to be mitigated by other means. It is recommended that the expansion of existing wildlife reserves and establishment of new areas be the principal means of mitigating the problems of displaced animals, and providing for long term conservation of wildlife species. In addition, a program of habitat enrichment and captive maintenance is justified to the extent practical, especially for certain species.

Mitigating the problems of displaced animals becomes a critical issue when endangered species are considered. Because of their low viability it is important that the existing populations be preserved. This, however, will not be completely possible under the proposed development scheme. Thus, the next best alternative is to make every effort to minimize the displacement as well as the elimination of endangered animals and to ensure the preservation and survival of those that remain. In the case of elephant and leopard, which have a natural tendency to occupy relatively large home ranges, the above alternative would require an expanded system of wildlife reserves.

A portion of the displaced elephants could be captured for use in the domestic work force. This would include small, relatively young elephants, but could constitute perhaps 5 to 10% of the animals which will be displaced. Present techniques may have to be upgraded to accomplish a large number of successful captures; however, this could be attractive economically since trained elephants are worth about Rs. 100,000 each.

In summary, it is recommended that a multi-pronged strategy be used for dealing with displaced animals, particularly endangered species, and for establishing long range wildlife conservation programs. The three aspects of this strategy in order of importance are:

- Expansion and increased protection of the existing system of wildlife reserves;

- Scientifically planned habitat enrichment for selected localities within the expanded system of wildlife reserves; and

- Capture by traditional or modern methods of certain species for establishing breeding colonies, enhancing domestic stock and zoo maintenance.

It is stressed that all three aspects must be put in operation to effectively mitigate the problem of displaced animals in a humane manner. Furthermore, it is noted that any operation which emphasizes the second and/or third aspects will lead to the unnecessary elimination of a vast majority of displaced animals; and will not address itself to the far graver problem of destruction of natural wildlife habitats.

It should be noted that the elimination of relatively large numbers of wildlife will be unavoidable with a project of this magnitude, despite the implementation of mitigation measures. Under the envisioned rapid pace of development, large animals may become pocketed and culling (especially of elephants) may then be the only effective means of limiting crop damage or direct confrontations. However, it should be emphasized that a deliberate culling program is culturally unacceptable; to the extent possible, translocation is recommended for pocketed animals.

In the selection of areas for wildlife reserves, priority should be given to those regions which have been identified as high-quality wildlife habitats (Figure E-1). However, preservation of all of the high-quality habitat areas would in some cases preclude proposed agricultural development on lands highly suitable for cultivation. Furthermore, this approach would significantly reduce the size of some of the proposed irrigation schemes to a level which would in all likelihood render entire irrigation systems economically and technically unfeasible. This would have a very negative effect on solving critical problems facing Sri Lanka in the areas of employment, food production and related human needs. Therefore, while a decision to maintain all of the high-quality habitat areas would be favorable from the point of view of wildlife conservation, it would not be appropriate as a balanced recommended view when the human environment is also taken into consideration, especially since it is apparent that substantial land areas are available and suitable for wildlife reserves which would not present land use conflicts with future agricultural development.

However, because of the importance of the high-quality habitats for the conservation of endemic and endangered species, it is recommended that as much of these areas as possible be fully protected in appropriate wildlife reserves. Those high-quality habitats which involve minimal conflict between wildlife and other productive land uses can be preserved and enhanced, such as the floodplain vill. along the Mahaweli Ganga. It is also recommended that when the feasibility study of System A is completed, serious consideration be given to not only maintaining the Somawathie Sanctuary but to expanding it to adjacent areas.

Further, it is recommended that the clearing of high-quality habitats be delayed until feasibility studies pertaining to these areas are completed and reviewed, and it is then concluded that clearing is absolutely necessary for the continuation of the program. Given the phased development program envisioned, no more than minimal activity in any high-quality wildlife habitat area is necessary for the next few years.

Finally, to in part compensate for the loss of high-quality and other wildlife habitats in the Mahaweli area, it is recommended that large contiguous reserves be established in and around the project area. Area specific recommendations in this regard are given below based upon the rationale developed in the preceding paragraphs (See Figure E-4).

The Status of Proposed Wildlife Reserves

The status of the proposed wildlife reserves should consider the presence of human settlements and the overlapping interests of the Forestry and Wildlife Departments in some of the areas. It should also allow for complete habitat protection and policing activities which can be performed in conjunction with tourism as in national parks. None of the existing statutes of wildlife reserves fulfill all of the above criteria. Therefore, a new status designated as

Conservation Park is proposed. A Conservation Park may be defined as an area which accommodates domesticated habitats and existing human activity, but is managed like a National Park so that is simultaneously provides complete protection for the remaining natural habitat and economic benefits through tourism. Thus, a Conservation Park would occupy a status intermediate to National Parks and Nature Reserves.

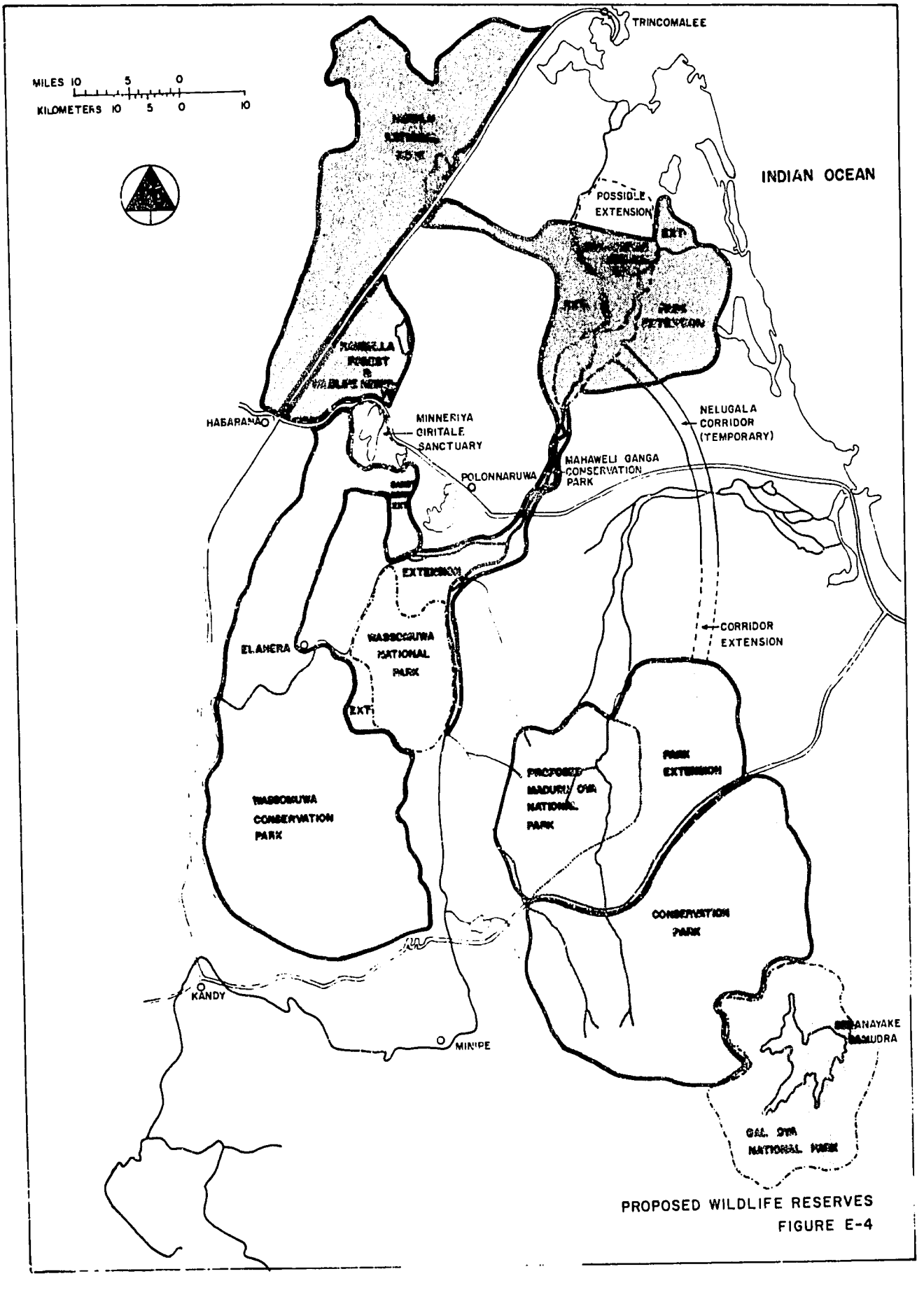
All of the Wildlife Reserves proposed below could be designated as Conservation Parks. However, it is preferable that the expanded Wasgomuwa Reserve be declared and developed as a National Park because there is no conflict with existing settlements or with the Forestry Department. Furthermore, the importance of the expanded Somawathie and Hurulu Reserves should be recognized by declaring these also as National Parks. This may entail human resettlement, but as in previous cases of national park development, these persons could be given alternate land i.e., within the Accelerated Program area. The inclusion of established forest reserves into the Somawathie National Park would provide no conflict between the Forestry and Wildlife Departments because the former department has already relinquished its authority over these areas. Similarly, the establishment of Hurulu National Park should not lead to any inter-department conflict, because both forest reserves included within the proposed park are designated as Man and Biosphere Reserves, where logging is prohibited.

The establishment of the proposed Wasgomuwa, Somawathie, Hurulu and Maduru Oya National Parks would provide safe havens for wildlife as well as reduce tourist pressure on existing national parks. Moreover, the proposed national parks would allow nearby communities to observe wildlife without having to make extended and costly journeys to places like Wilpattu and Yala. Other proposed wildlife reserves, i.e, the Kaudulla Reserve, the extensions of Wasgomuwa to the south and north including the Minneriya - Giritale Sanctuary, the area between proposed Maduru Oya and Gal Oya National Parks and the westward extension of the proposed Hurulu National Park could be declared as Conservation Parks. The floodplain between Wasgomuwa and Somawathie could also be declared as a Conservation Park.

It is recommended that the "Intermediate Zone" designation be deleted from future wildlife planning, since it affords no protection for wildlife and may encourage poaching of nearby protected reserves

Expansion of the Somawathie Sanctuary

The Somawathie Sanctuary is unique in many respects. Firstly, it contains the highest density of elephants found anywhere in Sri Lanka (Hoffman 1966; McKay 1973; Nettesinghe 1973). Secondly, this alluvial floodplain habitat represents the arena in which much of the evolution of the Asiatic elephant took place (Olivier 1978). In other words, through millenia the Asiatic elephant appears to have evolved in relation to the ecological conditions of an abundant and constant supply of grass, browse and water afforded by riverine forests such as the Somawathie. Thus, they are best adapted to such habitats, which is reflected by the high elephant density in these areas. Historically, however, accessible and fertile floodplains have been the first to be affected by human interference. Therefore, elephants have disappeared from many such areas within their distribution, and Somawathie is perhaps the only floodplain left in Asia where elephants can be found in their ancestral habitat throughout the year. This gives a special significance to Somawathie which is considered as a high-quality wildlife habitat.



PROPOSED WILDLIFE RESERVES
FIGURE E-4

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If this area and its elephants are to be preserved in perpetuity, it is strongly recommended that Somawathie be expanded and given complete legal protection as a National Park.

In addition, it is recommended that the Somawathie be extended under appropriate reserve designations to include the following (Refer to Figure E-1 and E-4 for localities and boundaries).

- The east, to include the triangular area bordered on two sides by the all-weather road from Kandekadu to Trikonamadu and on the third side by the dry season track between the same places (Part of this area falls within the already existing Nelugala Corridor). To the north of this triangle it is recommended that the existing boundary be moved eastward so that it conincides with the road from Trikonamadu to Koswakulama, Mawila, Illanda modu and the Verugal ferry. It is also suggested that the Vappiah Verugal Forest Reserve be included in the park. It is further recommended that other areas east and southeast of the park which will not be developed for agriculture be considered for inclusion within the Somawathie as well.

- The west, by including as much land as possible of the Chundakadu proposed reserve and the section of Palliyagodella Tulana lying to the east of the road from Migaswewa to Sungawila. This extension would connect the existing reserve to the undisturbed areas of Veddikachchi Intermediate Zone and the Chundankadu Forest Reserve and to the Hurulu Park.

The majority of the areas recommended for inclusion on the eastern side of the park are either Class 3 or Class 6 lands which are unproductive as agricultural areas (See TOPIC REPORT B: LAND USE AND SOILS). Hence, there is little foreseeable land use conflict with an expansion of the park into this region. Similarly, the western extension should include areas which will not be developed as part of the proposed System D.

The expansion of Somawathie to the east and west will only partially balance the loss of the northern portion of the reserve to agricultural development. The specific 5,600 hectare area of the present sanctuary which is being planned for cultivation is well forested and is a significant wet season grazing habitat for elephants and other large herbivores. The annual costs associated with foregoing development of these 5,600 hectares would be about Rs.107 million attributable to potential crop and homestead income returns. Not developing this region would provide some economic returns in terms of savings of infrastructure and savings to crop losses and some tourism benefits. However, it is clear that preserving this section of the Somawathie would not be justifiable on a strictly economic basis.

However, technical and economic feasibility for developing this region has not yet been firmly established. Consequently, the possibility of preserving this area may arise, and if so, it is strongly recommended that the area along with other forested portions in the northern part of System A, be incorporated in the Somawathie Park. In the meantime, clearing or other construction activities in this area should be strictly prohibited.

Establishment of the Mahaweli Ganga Conservation Park

It is recommended that the high-quality wildlife habitat identified as the floodplain villu area between the Somawathie Sanctuary and the Wasgomuwa Strict Natural Reserve be designated as the Mahaweli Ganga Conservation Park. Gunner's Quoin and its immediate surroundings should also be included in the park. Although this area will be reduced due to decreased river flows in the future, it will still constitute a high-quality habitat, especially for migratory birds and many endemic species. Protection of the floodplain from further development would not result in a conflict with any cultivation plans of the Accelerated Program. Most of the large villu areas which would be included in the Conservation Park are located along the right bank of the river. The park would include a corridor along the left bank of the river as earlier requested by the Department of Wildlife Conservation (De Alwis 1978).

Expansion of the Wasgomuwa Reserve

Wasgomuwa and its environs to the east comprise a somewhat unique wildlife area in Sri Lanka that includes eight of the nine endangered/threatened species within a single faunal complement. Moreover, recent field surveys showed that several animal species, particularly the endangered species, are common to abundant in this area. In terms of elephant density this area is perhaps second only to the Somawathie in the region. The faunal richness of Wasgomuwa and its environs is enhanced by the availability of riverine forests (along the Mahaweli Ganga) which are the preferred habitat of many endemic species.

Taking into consideration the habitat requirements of endemics and the welfare of endangered species, Wasgomuwa and its environs are considered to be a high-quality wildlife habitat. In this regard, the government's decision to preserve the present Wasgomuwa Reserve for wildlife conservation instead of developing it for agricultural use is endorsed. Preservation of the reserve, to a certain degree, offsets some of the losses of other high-quality wildlife habitats which will result with implementation of the Accelerated Program.

It is recommended that the present reserve status of Wasgomuwa be transferred to that of National Park in order to ensure more active protection of the area and to stimulate more public participation and concern for conservation in the area. The new park should also be extended to the northeast to allow for a natural merger with the Mahaweli Ganga Conservation Park along the river floodplain. In addition, it is recommended that the park be expanded to the west up to the Kalu Ganga (Refer to Figure E-1 and E-4 for localities and boundaries).

It is further recommended that the enlarged Wasgomuwa Park be expanded substantially by various appropriate reserve designations to the north, west and southwest (Figure E-4). These would include the following:

- The area bounded on the east by the Hasalaka-Hettipola road, on the west by the Amban Ganga, on the south by the Knuckles Range and on the north by the enlarged Wasgomuwa Park itself;

- The area north from the Amban Ganga just west of Elahera and east of the Kandy - Habarana road to form a linkage with the Kaudulla Reserve; and

- The area north of the enlarged Wasgomuwa Park through the forest which lies west of Parakrama Samudra to form a link with the Minneriya Giritale Sanctuary.

These new reserve areas would allow for continuity of fauna and flora over an extensive area without producing conflicts with proposed agricultural development. Significantly, this reserve system would provide two links between the Wasgomuwa and Hurula Parks in addition to that between Wasgomuwa and Somawathie, and similarly between Somawathie and Hurulu (Figure E-4). This can, to some degree, compensate for losses to natural habitats and isolation of others as a result of the proposed development.

Ideally, in terms of wildlife conservation, the high-quality habitat region in the northern part of System C (Figure E-1) should also be included within an expanded Wasgomuwa National Park. This is supported by the following features of the area in question:

- The area is a natural habitat for many endangered and endemic species;

- The area probably contains more wildlife in terms of diversity and numbers than any other area, excepting perhaps the northern part of the Somawathie, that is presently considered for development within the project area. Therefore, the problem of displaced animals will be considerably reduced if this area is left in its natural state;

- The faunal abundance of this area is partially attributable to ideal habitat conditions and partly to the crowding of animals displaced by earlier agricultural expansion that moved northwards from Mahiyangana along both banks of the Mahaweli Ganga. Therefore, continued agricultural expansion in this area may seriously overload the carrying capacity of the existing Wasgomuwa Reserve. Moreover, it will further aggravate potential crop damage and the human-wildlife conflict; and

- The expansion of Wasgomuwa to the east would permit a linkage with the new Maduru Oya National Park.

On the other hand, not developing this area would result in a conflict with the proposed cultivation of more than 8,000 hectares of land and a corresponding loss of potential crop and homestead income returns of about Rs.162 million per year. Furthermore, without this development, the feasibility of implementing both Systems C and B would be questionable, since the two systems share the costs of construction for delivery and irrigation infrastructure (some of which is already being built). Thus, settlement opportunities may be lost for more than 100,000 families. This would have a significantly adverse effect in terms of the socio-economic requirements of the country and considering government commitments to preserve other high-quality habitats as well as the opportunities to substantially expand wildlife reserves in general, it is suggested that the development of this specific area to meet human needs is

preferential to its maintenance for wildlife conservation. In this regard, it should be noted that this area is very likely to be substantially encroached upon in the immediate future before any reasonable protective measures could be initiated.

Taking this into consideration, a few additional mitigation measures can be evaluated with respect to the development of the northern portion of System C. One is the Jungle Corridor requested by the Department of Wildlife Conservation along the Kuda Oya to allow for animal movements between the Wasgomuwa Reserve and the Maduru Oya National Park.

An analysis was made of the requirements and costs for implementing the proposed Kuda Oya Corridor. In order to establish any effective corridor, the following inputs are necessary:

- The width of the corridor should be five kilometers, consisting of the actual corridor path and protected on either side by a buffer;

- Each buffer zone should be one-half kilometer of agro-forest and one-half kilometer of grazing area;

- On the margin of the grazing area, a jeep track/fire line is required;

- The corridor path can be enhanced with water supplies and thinning or seeding where necessary; and

- It should be monitored by a game warden with game scouts every six kilometers.

The Kudu Oya corridor would displace about 3,000 hectares of paddy plus 1,700 of settlements in System C as proposed in the Accelerated Program. The capital costs for developing the corridor would be about 3.9 million rupees and recurrent costs are about 100,000 rupees (Details of these costs are presented in TOPIC REPORT M: ECONOMICS). The opportunity cost of agricultural production foregone would be around 54 million rupees per year. The corridor could not be justified on the basis of quantifiable costs and returns.

Information collected by TAMS field surveys indicates that this corridor does allow for animal movements, although it does not completely satisfy the area requirements of the unique and abundant fauna living in this high-quality habitat. A corridor itself would not provide a suitable alternative to maintaining the entire high-quality habitat. The reduction of the total high-quality habitat to the corridor size would benefit a few more far ranging species, such as elephants, but would not allow substantial gene flow between reserves for all of the relatively unusual fauna and flora. Also, the corridor would pass through an area of intensive agricultural activities; the actual prevention of encroachment into what is suitable land for cultivation would in the long term be very difficult. Thus, for many reasons, the proposed corridor does not appear to be practical nor feasible.

Finally, a mitigation measure which appears more feasible and would particularly benefit endemic fauna in the region, would be to include the riverine forests and rocky outcrops bordering the Mahaweli Ganga in System C within the Wasgomuwa National Park. This could include the area which would have been

inundated by the Rotalawela Reservoir, which with the large surplus of water storage available from other reservoirs, may no longer be required. The park could extend into System C in some places for perhaps several kilometers due to the dendritic nature of the proposed cropping patterns.

Establishment of the Hurulu National Park and Kaudulla Reserve

These recommendations involve the establishment of two wildlife reserves to the west of System D, i.e., outside the project area. Once established, these areas would help to increase the accommodation of animals displaced from System D. These proposed areas are tentatively designated as the Hurulu National Park and Kaudulla Wildlife Reserve.

The Hurulu National Park could be established by connecting the Hurulu-Anaolundawa Man and Biosphere Reserve with the Naval Headworks Sanctuary through the broad patch of forest on the western side of Kantalai Tank. Establishment of this park should not prove difficult since a large proportion of it already exists as protected areas. Furthermore, in view of the rapid decline of Sri Lanka's forest cover, it is recommended that all natural forests which lie intermingled with paddy lands to the west of the proposed Hurulu Park be given an appropriate status which affords them full protection. Indeed it is urged that the destruction of natural forests and its effect on human welfare be treated as a more critical issue than even the problem of displaced animals.

In order to allow for continuity of fauna and flora between the proposed Hurulu Park and the Minneriya-Giritale Sanctuary, a second wildlife reserve is recommended. It is advised that this reserve be established in the area bounded by the road from Minneriya to Habarana to Alut Oya and a line drawn from Alut Oya to the northern tip of the Kaudulla Tank and thence to Minneriya (Figure E-4).

The southern half of the proposed Kaudulla Wildlife Reserve includes the existing Gal Oya Forest Reserve. This was one of the areas in which elephants did extensive damage to teak in 1977. Since then Eucalyptus has been planted in the areas that suffered damage. Eucalyptus as is well known inhibits the growth of most other plants and therefore, will further deplete the food requirements of the large number of elephants found in this area. This may lead to a repeat of the 1977 episode. Therefore, it is recommended that the planting of Eucalyptus be stopped in this area so that natural regeneration could proceed without hindrance and provide food for the elephants which reside here.

Maduru Oya National Park

The Department of Wildlife Conservation has proposed the establishment of the Maduru Oya National Park in the catchment of Maduru, Ratkinda and Ulhitiya Oyas and the retention of an elephant corridor south of Maduru Oya into the Gal Oya National Park. The basis of these proposals are endorsed, but two additional recommendations are made as follows.

It is recommended that the southern and southeastern boundary of the proposed park be extended to as close to the Mahiyanganga - Padiyatalawa - Maha Oya road as possible, and the eastern and northeastern boundary be extended to include a substantial portion of the Omunugala Forest Reserve.

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Further, it is proposed that the area forming the upper catchments of Rambukkan, Maha, Maduru and Ulhitiya Oyas be established as a wildlife reserve. This would provide greater safety to animals and more extensive connection between the proposed Maduru Oya and Gal Oya National Parks than afforded by the establishment of a corridor between these reserves. This would effectively merge the Gal Oya and proposed Maduru Oya parks as one extensive wildlife reserve. This area between the two parks could be designated as a Conservation Park. This recommendation is largely derived from and supports findings of the present investigations by the Canadian International Development Agency as part of the Lower Uva Regional Planning Study. The maintenance of this park would protect the catchments of the proposed Galloda Aru, Maha and Rambukkan Reservoirs without precluding any future potential development downstream from these reservoirs.

Nelugala Corridor

The Nelugala Corridor was established in order to protect one of the known paths of intensive elephant movement to and from the riverine forests of Maduru Oya. Such habitat types are essential to elephants during the dry season. Therefore, destruction of paths leading to these areas would cause food shortages and other serious problems to elephants.

The existing Nelugala Corridor presents a land use conflict with proposed agricultural development within System B. About 2,500 hectares of land within the corridor are suitable for rice cultivation.

The retention of the corridor in its entirety has been recommended by the Department of Wildlife Conservation (De Alwis 1978). In addition, suggestions have been made to extend the present corridor southwards to form a linkage with the Maduru Oya Park.

The present corridor is neither patrolled nor maintained. An estimate of the capital costs to fully develop the corridor (including the southern extension) which would involve enrichment, guard housing, jeeps and buffer zones is about 16 million rupees (See TOPIC REPORT M: ECONOMICS). Recurrent costs will be about Rs.396,000. Returns of about Rs.1.9 million annually could accrue due to grazing and forest harvesting of the buffer zone. In addition, a conservative estimate of 35% reduction in crop losses can be expected along areas through which the corridor will pass. This would represent a total savings (over six years) of about Rs.15.3 million. Consequently, capital costs for the corridor would be recovered by the anticipated quantitative returns. However, in order to fully justify the corridor, the opportunity costs of crops foregone must be balanced against the social value of conserving wildlife. This cost will probably be about 40 million rupees per year. The engineering costs of this proposed corridor, including the opportunity cost of crops foregone, are being more accurately developed by ACRES and will appear in their final feasibility report for System B.

In any event, for the corridor to be effective, proper maintenance and strict monitoring will be required. If these commitments cannot be made, the corridor would not sufficiently protect wildlife or cropland. At present, the corridor is not protected, and substantial portions of it have already been converted to cropland. In addition, some settlements have appeared within the corridor boundaries. Encroachment pressure in the corridor is expected to further increase especially after project implementation. The corridor would

then, as with the proposed corridor in System C, be bounded by intensive agricultural activity. Protection from encroachment would become increasingly difficult especially as second generation families would be seeking any available land suitable for crops. Consequently, the corridor may prove effective in the short term, but over a long period its maintenance is probably not feasible.

It is recommended that the corridor be maintained at least as a temporary measure. Its permanence may not be so essential since a trade-off may be possible by further extending the Somawathie into the east. It is suggested that this area be investigated in detail to determine if enrichment or other measures could be implemented to provide suitable wet season grazing habitat as a replacement for the Nelugala Corridor. A study of this nature would involve a range management specialist, wildlife management/ecological expertise and perhaps a water resources engineer. The study could be coordinated by the Department of Wildlife Conservation. Wet and dry season surveys should be made of vegetation and animal movements in the region and specific enrichment recommendations should be made including their costs and designs. The study would cost about Rs.1.6 million.

An additional compensation which should be considered would be the preservation of the northern part of the Somawathie which is now planned for development. Preservation of this area and perhaps some other forested areas north of Somawathie may be a suitable exchange of wet season grazing habitats.

EXPANSION OF NATIONAL PARK ADMINISTRATION AND WILDLIFE MANAGEMENT CAPACITY

An enlarged wildlife reserve system would automatically require an expansion of the infrastructure capacity of the Department of Wildlife Conservation. This expansion would also be required to deal with any future wildlife problems related to the proposed agricultural development. Since the present administrative and wildlife management capacity of the above department is considered inadequate even to contend with the existing situation an extensive expansion of this department is recommended for the future. Recommendations along these lines are given below, and are in accordance with the main elements of the existing infrastructure.

Recommendations for Strengthening Upper Level Staff

At the administrative level it is recommended that the Director be supported by five deputy directors, each of whom will undertake one of the following major tasks:

- General administration;
- Wildlife management and field research;
- Veterinary research;
- Park planning; and
- Law enforcement

The Director and his deputies should be based in Colombo and among other duties, be responsible for all policy decisions and regional activities of the department.

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The recent move by the department to decentralize the administration is endorsed, but it is recommended that four administrative regions be set up instead of the three that exist now. The activities of these regional offices would come under the purview of the Deputy Director, General Administration (Figure E-5). Furthermore, it is recommended that the department's activities be expanded by establishing a captive research program and a Wildlife Management and Training Institute under the Deputy Directors of Veterinary Research and Wildlife Management and Field Research, respectively. In order to supervise the activities at the four regional offices, the Wildlife Institute and the captive research program, it is recommended that six senior Assistant Directors be appointed (Figure E-5). To cope with the expanded program of work of the department it is estimated that a minimum of 15 assistant directors should be appointed (Figures E-5 thru E-7). This excludes the teaching and research staff at the Wildlife Institute who should be recruited (at the assistant director level) according to the needs of the Institute as it develops. Three of the assistant directors (i.e. park planning, general administration and law enforcement) will be based at the Colombo office, while most of the others should be based in the outstations. The responsibilities of the upper level staff are indicated by their designations given in Figures E-5 through E-7.

In summary then, it is recommended that the present upper level staff of seven be increased to at least twenty-seven. This increase is urgently needed, but may not be immediately possible because of a lack of qualified personnel and facilities for appropriate training. Therefore, it is recommended that the department recruit suitable candidates and send them abroad as soon as possible for training (Figure E-7).

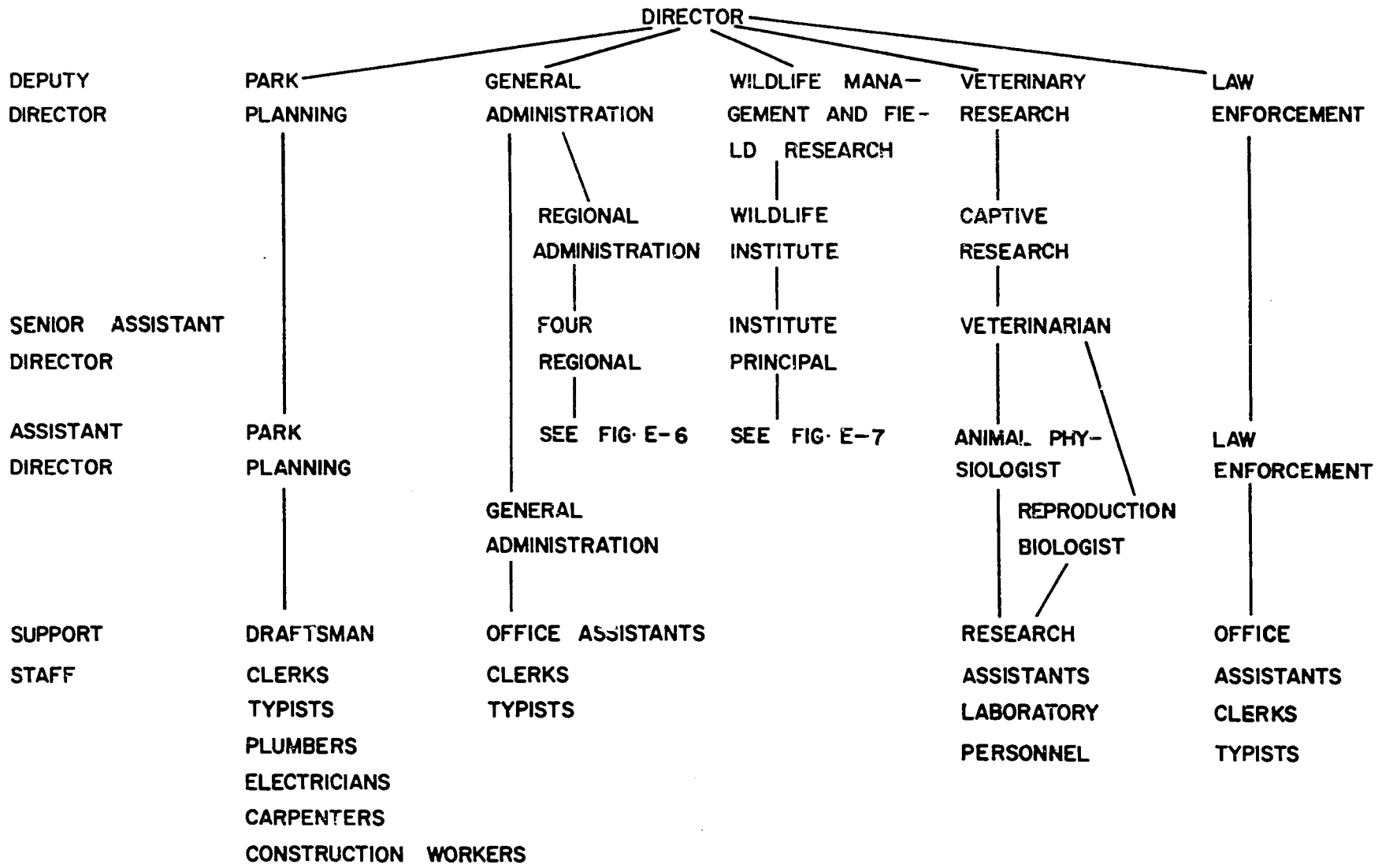
Wildlife Management and Park Planning Team

Among the upper level staff, wildlife management and park planning are the two fields in which technical expertise is most urgently needed. In order to fulfill this immediate need while trainees are abroad, it is recommended that an appropriate team be set up under the Department of Wildlife Conservation. This team would serve to harmonize and coordinate the establishment of the proposed national park/reserve system with the proposed agricultural expansion scheme. Therefore, this team should be functional during the construction of the infrastructure for agricultural expansion.

The major objectives of the Wildlife Management and Park Planning team should be as follows:

- Prepare site specific guidelines for integrating the proposed wildlife reserve system with the development of agricultural areas in the project area so that human-wildlife conflict will be reduced;

- Prepare Master Plan for infrastructural development and management of the proposed wildlife reserve system. These plans should include details of construction of roads; building for offices, staff and visitors; and a program for habitat improvement and the establishment of buffer zones;



RECOMMENDED STRUCTURE OF THE DEPARTMENT OF WILDLIFE CONSERVATION

FIGURE E-5

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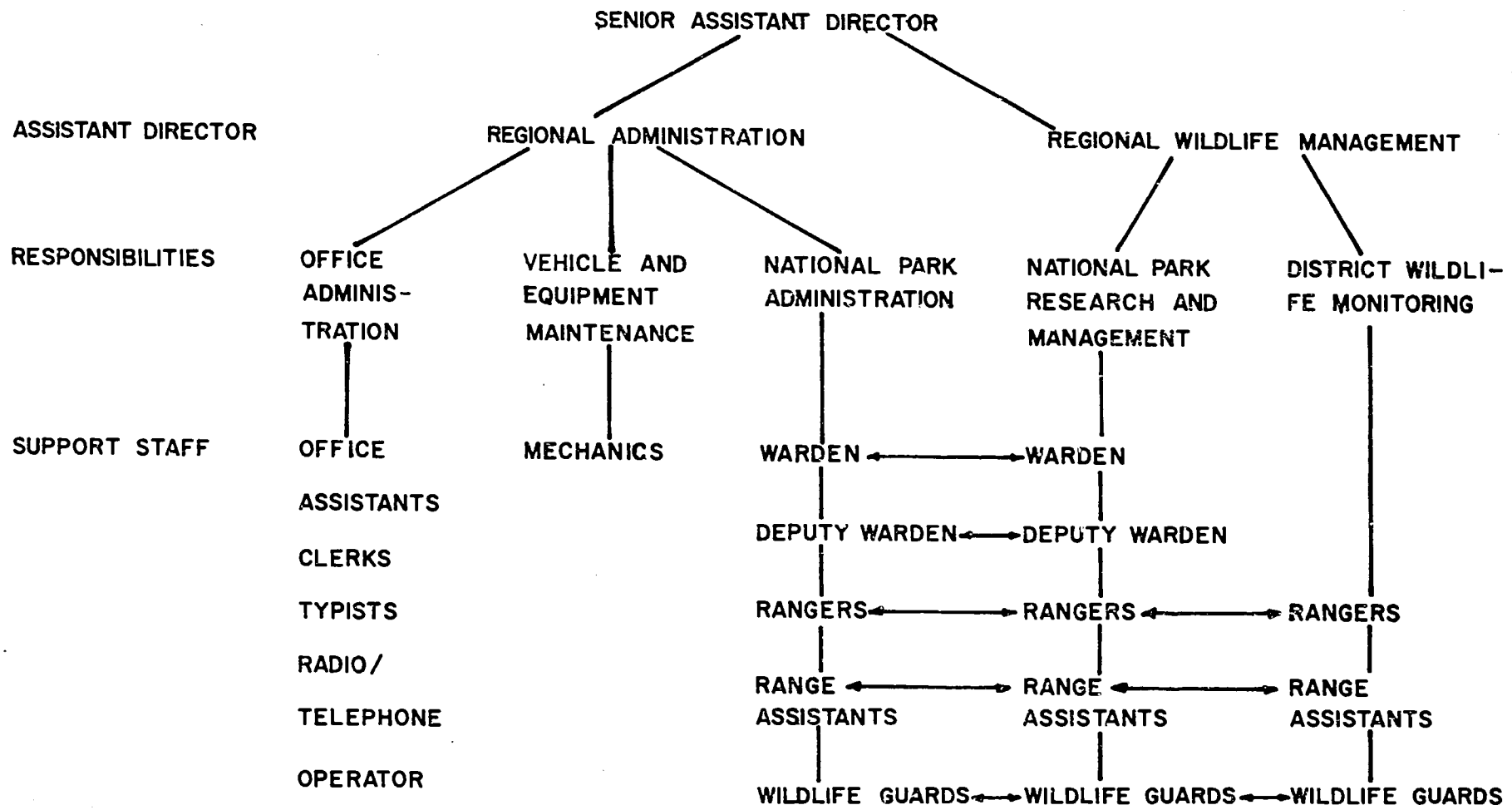
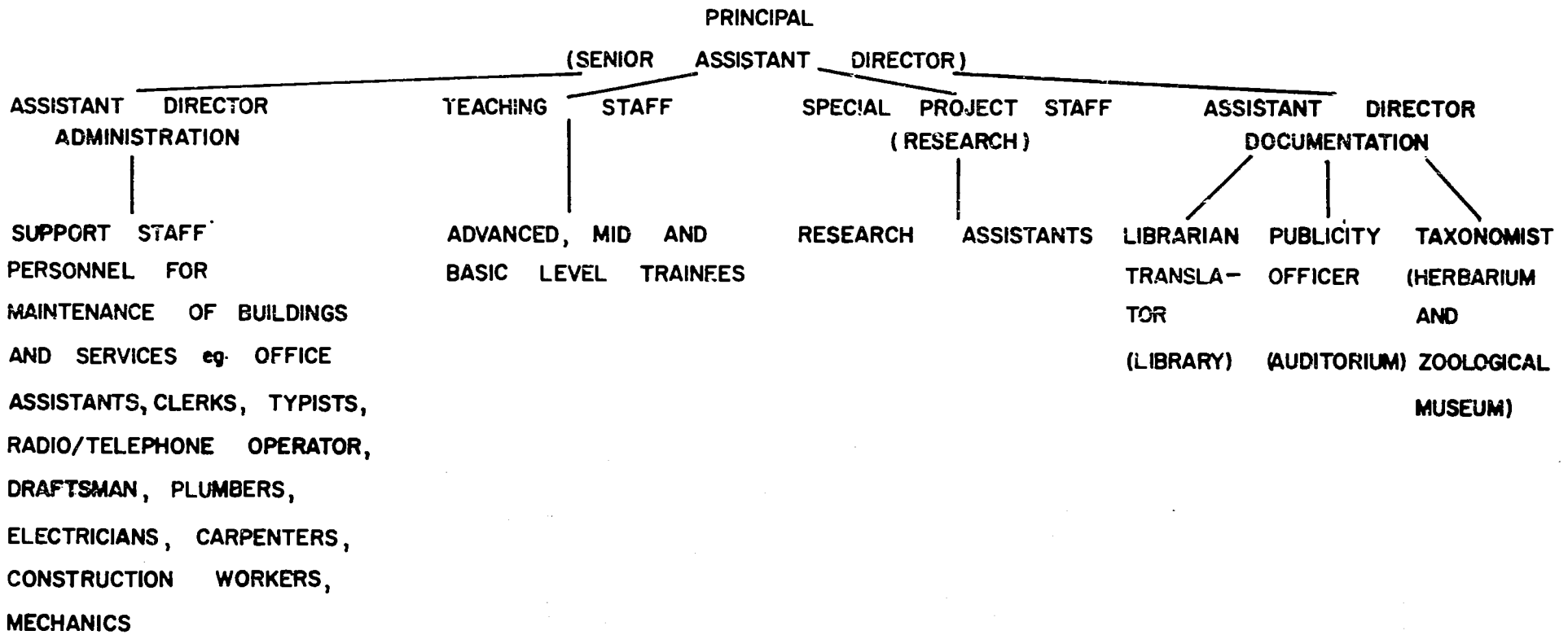


RECOMMENDED REGIONAL INFRASTRUCTURE
OF THE DEPARTMENT OF WILDLIFE CONSERVATION
FIGURE E-6



RECOMMENDED INFRASTRUCTURE FOR THE WILDLIFE MANAGEMENT AND TRAINING INSTITUTE

FIGURE E-7

- Prepare a tourism coordination plan and redesign tourist flows to reduce tourist pressure on existing national parks;

- Monitor and maintain habitat quality within the wildlife reserve system by analyzing interactions between wildlife populations and habitat conditions;

- Monitor the movements of wildlife, particularly elephants, in the boundary areas of the proposed wildlife reserve system and in areas under the proposed agricultural scheme; and

- Develop the technical capacity and guidelines to capture and transport selected species of wildlife whenever necessary.

It is envisaged that the following personnel would be required for the above tasks which will take about three years for completion.

Department's Team	Man-Years
Wildlife Management Biologist	3
Wildlife Ecologist	3
Planning Economist	3
Veterinarian	3
Park Planner	2
Civil Engineer	2
Sociologist	1
Range Manager	0.5
Hydrologist	0.5
Aircraft Pilot	3
Total = 10 people	21

In addition to the department's team it is recommended that a wildlife ecologist and a wildlife management biologist be hired to teach courses at collaborating universities for about three years. These personnel should also develop the research and training curriculum for the proposed Wildlife Institute (see below). Thus in the future, the department could depend on the university system as well as the Institute for qualified personnel.

Due to the lack of qualified local personnel the positions of wildlife management biologist, wildlife ecologist, park planner and range manager may have to be filled by expatriates. However, it is recommended that these expatriates have Sri Lankan counterparts (Figure E-8). Other positions in the wildlife management and park planning team could be filled by suitably qualified Sri Lankans.

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It is recommended that the above personnel have the use of an aircraft (e.g. Cessna 185) for aerial surveys of wildlife populations and the proposed national parks. The aircraft could later be used for anti-poaching activities and for monitoring animal movements outside natural parks. The wildlife management and park planning team will also require approximately six four-wheel drive vehicles, radio telemetry equipment, camping gear and animal capture and transport equipment.

With the immediate focus of major development in the Mahaweli area, it is recommended that a park design planning study be conducted for the new and expanded parks related to the Accelerated Program. This will permit direct integration of the proposed wildlife reserves with agricultural development planning. This study should be integrated with national wildlife planning policies and should have a terms of reference including the following:

- Establish management guidelines for the Somawathie National Park, Wasgomuwa National Park, Muduru Oya National Park, Hurulu National Park, Kaudulla Reserve, Mahaweli Ganga Conservation Park and other conservation parks;

- Delineate park boundaries on 1:20,000 or larger scale land use maps;

- Identify specific potential conflict areas where intensive agriculture would border a park. Detailed buffer zones for these areas would then be proposed;

- Conduct detailed habitat/vegetation analysis in order to recommend specific localities for habitat enrichment and to provide estimated carrying capacities for larger mammals, especially elephants, in the respective parks;

- Recommend population management and related techniques for particular species as needed;

- Design infrastructure needs for park administration, tourism development and related management;

- Recommend staffing requirements, maintenance schedules and monitoring for each park; and

- Estimate costs and benefits for each park development.

This study should be conducted in cooperation with the MA, MDB, and the Department of Wildlife Conservation. The expertise required would include disciplines involving park planning, range management and economics. The study would last about one year and cost about Rs. 4 million.

Recommendations for Strengthening Regional Infrastructure

The regional offices mentioned earlier are in the process of being established, and there is much to be done before they are functional and effective (Figure E-6). As an initial step it is recommended that a building complex be constructed to accommodate the following aspects of regional administration:

- Regional office;

- Vehicle and equipment maintenance unit;

- Storage of heavy equipment;

- Living quarters for the senior assistant director and two assistant directors; and

- Living quarters for field personnel attached to the regional office.

It is also recommended that each regional office:

- Be linked to the central office of national parks through a radio communications network;

- Be equipped with typewriters, photocopying machines, drafting material and other accessories required for efficient regional administration;

- Possess a complete cadre of support staff;

- Provide each of the upper level staff with a four-wheel drive vehicle (i.e., 3 vehicles/regional office); and

- Include in its equipment list about four tractors and one bulldozer for construction and habitat enrichment work, as well as equipment and vehicles for capture and transport of wildlife.

A senior Assistant Director would be in overall charge of the regional office, and this office should emphasize administration as well as wildlife management. These two areas will be under separate Assistant Directors, but their responsibilities will overlap in the national parks and other wildlife reserves (Figure E-6). Outside the wildlife reserves the Assistant Director of Wildlife Management should have his own support staff to deal with wildlife problems in the districts, while the Assistant Director of Administration should have a separate staff for office and vehicle maintenance work.

Strengthening the Infrastructure of National Parks and Other Reserves

As indicated in Figure E-6, the administrative unit of each national park should be strengthened by a research and wildlife management unit. These two units would be separate entities but their staff should be given the opportunity of broadening their experience by working in both units at different times. It is also recommended that all field personnel working in national parks and other wildlife reserves be given appropriate training in the proposed Wildlife Institute.

The head office of each national park should have the following features:

- Sufficient personnel to cope with tourist inflow, administration and wildlife management;

- Vehicle maintenance unit capable of handling minor repairs and a store room;

- Living quarters for all of the Park's head office personnel;

- A building with basic biological research facilities (e.g. a herbarium and a well equipped zoological laboratory);

- Four-wheel drive vehicles for each of the Wardens and Deputy Wardens; and

- Radio communications links with regional offices and the central office.

As under the present system, guard posts should be established at the periphery of national parks and if necessary within them. Guard post personnel will be responsible for anti-poaching activities and patrolling the national parks. It is recommended that a guard post be provided with one person for approximately each 12 square kilometers of national park under its purview. Furthermore, in order to be effective as an anti-poaching unit there should be no less than six persons to each guard post, e.g. one ranger, two range assistants and three wildlife guards. However, guard posts should not consist of more than about nine people because it would make the guard post too dispersed to be effective. It is recommended that each guard post have for its use:

- One four-wheel drive vehicle and driver;

- One motor bicycle, if necessary;

- Field radio telephones;

- Firearms;

- Binoculars, telescopes and compasses; and

- Camping equipment including tents, ground sheets, camp-cots, cooking utensils, pressure lamps, head lamps flashlights, water canteens, back pack and rain capes.

It is recommended that the guard post infrastructure, vehicle and equipment support outlined above be also used for patrolling wildlife reserves other than national parks. In these areas too each guard post should have about six people and be responsible for approximately 75 square kilometers of wildlife reserve.

Wildlife Management and Training Institute

The establishment of this institute would fulfill a greatly felt need for training in wildlife ecology and management in Sri Lanka. Because of the lack of training, the department's field personnel, who are excellent observers, have not possessed a conceptual framework to which they could relate their field information. Consequently, a good deal of extremely useful information is lost,

and interpretation of what remains is often difficult. A period of training at the Wildlife Institute would help immeasurably in rectifying the above problem and assist greatly in decision making processes. Another major impetus for the creation of this institute is generated through the demands placed on the department for dealing with the problems created by the large scale removal of natural habitat under the Accelerated Mahaweli Development Program. It should be further noted that the Wildlife Institute could contribute substantially towards the implementation of the National Wildlife Conservation Policy.

The major objectives of the Wildlife Institute would be to:

- Train basic and mid-level staff in wildlife ecology, wildlife management and other expertise necessary for wildlife conservation;
- Provide upper level staff with facilities for wildlife research;
- Continue the adaptive wildlife management and research programs initiated by the park planning and management team;
- Assist in the capture and transport of wildlife whenever necessary; and
- Monitor wildlife habitats and populations and advise the central office on policy decisions.

Institute's Trainee Curriculum and Wildlife Management Program - It is recommended that the trainee curriculum of the institute comprise basic and mid-level courses and cater to the students with 7th to 12th grade qualifications. The basic level course should include subjects such as principles of wildlife ecology and wildlife management, field techniques and data collection, law enforcement, equipment use and maintenance motor mechanics and bush craft. This course may be conducted over a period of nine to twelve months. The mid-level course should be offered with more intensive training in the above subjects as well as in research methodology, data analysis, survey and map work and park administration. This course may be 18 to 24 months in duration. The Wildlife Management and Research Program of the Institute would essentially be a continuation of some of the work initiated by the wildlife management and park planning team. The scope of this program would widen with the identification of wildlife problems by the department. Candidates with mid-level training could work as research assistants in this program, and it is recommended that they be registered as candidates for a university diploma.

Personnel of the Institute - A senior assistant director should be appointed as Principal of the Institute (Figure E-7). Under him there would be assistant directors for administration and documentation. All teaching and research staff would also be considered assistant directors. The medium of instruction at the Institute necessitates that the teaching personnel be Sri Lankans The teaching staff could be selected from the qualified Sri Lankan personnel returning from abroad and from those trained at the local universities by expatriates (Figure E-8). Visiting lecturers may be necessary to teach special courses such as surveying and law enforcement. It is preferable that the regular teaching personnel possess post graduate qualifications. Wildlife management and research personnel should also possess similar qualifications or considerable field research experience. Because of the lack of pertinent literature in the national language, a translator should be included in the personnel of the documentation center.

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Building Complex for the Proposed Wildlife Institute - It is recommended that the Wildlife Institute be established as a self-contained unit with modern conveniences. Buildings for training, research, administration and documentation, as well as facilities to accommodate approximately 90 trainees and staff related to the Institute should be made available.

The Administration building should include the following major features:

- Fully equipped office for general administration;
- Offices for Institute Principal, Assistant Directors and Teaching and Research Staff;
- Conference Room;
- Radio communications room;
- Visitor center; and
- Staff recreation room.

The Training and Research building should include:

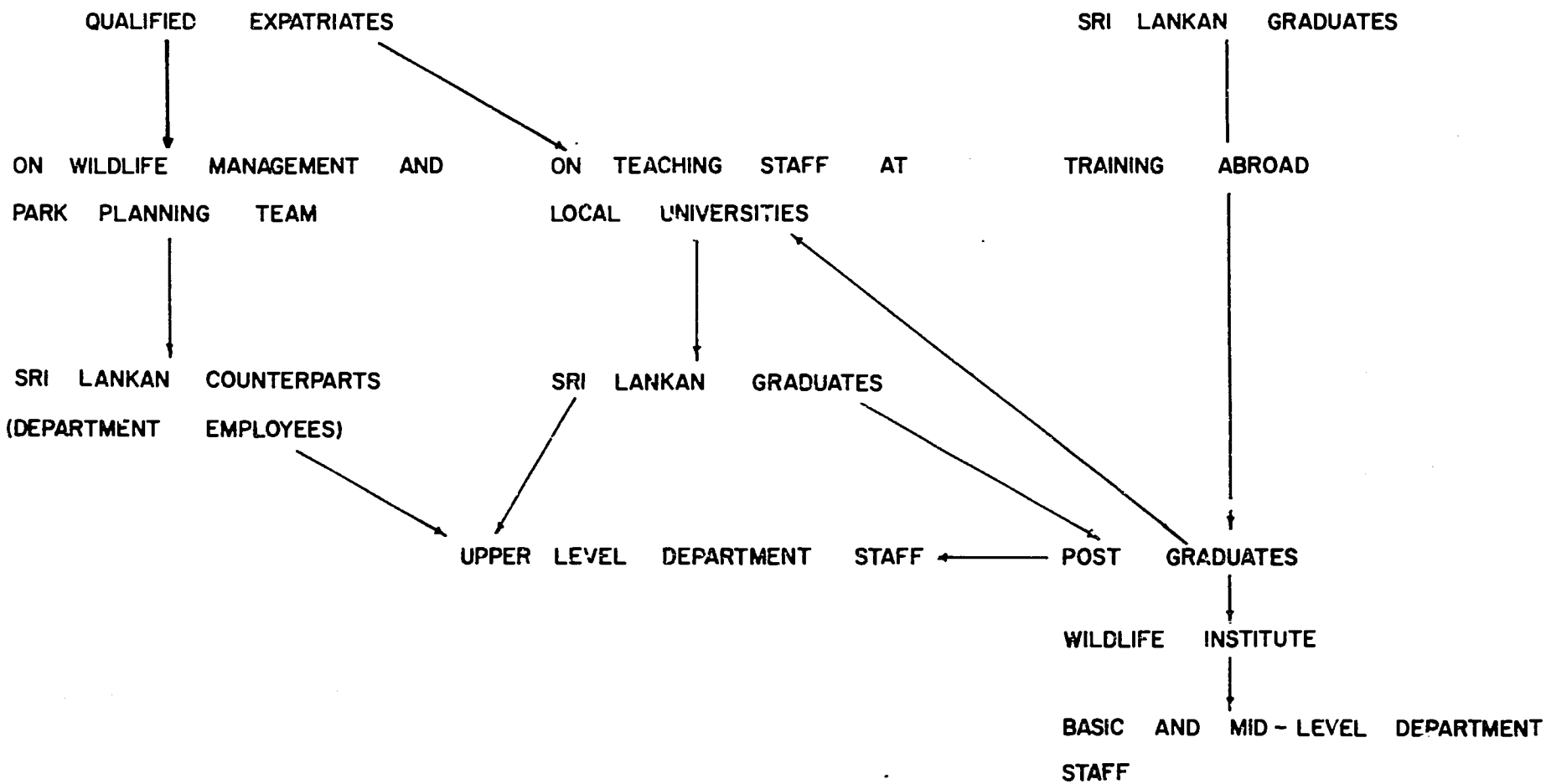
- Three lecture halls to accommodate approximately 30 trainees each;
- Three laboratories with preparation rooms, each designed and equipped for basic chemical analyses (soil and water quality), veterinary and biological studies respectively; and
- Offices for laboratory personnel and research assistants.

The Documentation Center building should include:

- Fully equipped auditorium to accommodate approximately 200 people;
- Film and book library and reading room;
- Appropriately designed herbarium;
- Zoological Museum;
- Offices for Documentation Center Staff; and
- Fully equipped photographic room.

In addition, the building complex for the proposed Wildlife Institute should include:

- Living quarters for all senior and junior staff;
- Living quarters for visiting personnel;



SOME SHORT TERM AND LONG TERM STRATEGIES FOR TECHNOLOGY TRANSFER TO THE DEPARTMENT OF WILDLIFE CONSERVATION

FIGURE E-8

- Dormitories for trainees equipped with minor cooking facilities, baths and toilets;

- Mess Hall Complex complete with fully equipped kitchen, canteen, dining hall, recreation room and toilets;

- Room for storage of equipment; and

- Vehicle repair shop.

Equipment and Vehicle Requirements of the Wildlife Institute - Given below is a partial list of equipment that will be required by the administrative office, laboratories, documentation center and trainees of the Wildlife Institute. Other equipment including that required by the research staff may be identified as the need arises.

1.	Office Equipment	- typewriters, photocopying machines, drafting tables, drafting equipment, calculators, radio-telephone.
2.	Laboratory Equipment	- Standard laboratory equipment such as microscopes, hand lenses, dissecting instruments and trays, measuring cylinders, beakers, chemicals as well as accessory equipment like freezers, refrigerators and ovens.
3.	Equipment for the Documentation Center	- Overhead projector, slide projector, movie projector and sound system, projection screen, photographic development, processing printing and enlarging equipment, movie film splicing and editing equipment, fully equipped mobile audio-visual units.
4.	Equipment for trainees	- Binoculars, telescopes, tents, ground sheets, compasses, camp-cots, camp furniture, back packs, rain capes, cooking stores, cooking utensils, pressure lamps, head lamps, portable generators, walkie-talkies, water canteens.

Initial vehicle requirements of the Wildlife Institute may necessitate the purchase of about six four-wheel drive vehicles and one thirty-passenger bus for the use of the senior staff and trainees.

OTHER IMPORTANT RECOMMENDATIONS

Some of the recommendations made in this section facilitate the integration of the actions proposed above with the agricultural expansion program. Other recommendations serve to arrest certain existing trends which are undesirable for wildlife conservation and human welfare.

Buffer Zones

It is recommended that the proposed wildlife reserve/corridor system be buffered to minimize conflicts arising from crop damage by wildlife. This can be accomplished by establishing zones for livestock grazing, fuelwood plantations and human settlements between wildlife reserves and areas of intensive agriculture. Each of these zones should be at least one kilometer wide to be relatively effective as barriers separating the centers of wildlife activity from the foci of intensive agriculture. It would be preferable to establish the grazing area next to the wildlife reserve and the fuelwood plantation next to the settlement so that a gradient of decreasing human activity is established towards the wildlife reserves.

Canal Construction and Development Infrastructures

The proposed plan for development indicates that irrigation canals may be constructed within the proposed and existing wildlife reserves. This is considered a dangerous situation for the security of wildlife and natural habitats. Therefore, as the first option it is recommended that construction plans be reviewed, and revised if possible, so that canals (particularly major canals) are built outside wildlife areas. If this is not possible then provisions should be made to include adequate crossing places for wildlife. Across major canals these may be provided by taking irrigation water under bridges approximately 15 m wide. At present the exact locations of these bridges cannot be given because of a lack of site specific information on animal movements. However, a bridge every kilometer of the canal within the wildlife reserve may suffice. These bridges should simulate natural conditions as far as possible and should be no higher than the ground level of the surrounding area.

Even with the provision of bridges, considerable numbers of animals can be expected to move to the canal water to slake their thirst and to cross between banks. This would be particularly frequent when water levels are low in minor as well as major canals. Therefore, it is recommended that the banks of canals have very gradual slopes so that they offer very little resistance to animal movement. It may be necessary to line all or parts of the canal with concrete, but the more gradual the bank slope is, probably the less need there would be for concrete lining. In any case, it is recommended that regular patrols be undertaken along canals for maintenance work and for the prevention of illicit encroachments. This task should be delegated to or supervised by the Wildlife Department personnel. It is also recommended that if canal construction takes place within wildlife reserves, it should be done under strict supervision to prevent the unnecessary destruction of wildlife habitats.

Phasing of Development

During the initial phase of development there will be a great disruption as wildlife habitat is removed, but it is essential that the proposed wildlife reserve system not be isolated. Connections should be maintained between the wildlife reserves and the areas that are being developed. In some circumstances it will be necessary to phase development so as to reduce the chance of isolating wildlife in habitat pockets. This will necessarily be determined on a zone to zone basis.

During the process of development it should be remembered that the proposed wildlife reserve system within the Accelerated Project Area is a minor portion of the total area of what is now essentially a vast area of good wildlife habitat. Consequently, it should be recognized that the proposed wildlife reserve system cannot contain the majority of displaced animals and further, that care must be taken to not supersaturate, i.e., exceed carrying capacity by attempting to force excess numbers of displaced wildlife into the system. Supersaturation of a reserve by large herbivores can be expected to result in habitat damage. Therefore, it is recommended that the speed and method of project implementation be regulated, in order to minimize the impact on the environment.

During the initial stages, development should be phased so that its rate of progress will enable at least some capture and translocation of animals to the extent technically possible. During later stages, when development approaches the periphery of wildlife reserves, the speed and scope for habitat enrichment activities within wildlife areas should dictate the rate of progress of development. The term capture as used in this report involves traditional and scientific methodologies and not poaching. Furthermore, it is strongly recommended that the welfare of wildlife, especially endangered species, be monitored through all phases of development so that the proposed plans could be modified whenever necessary.

Habitat Encroachment

Wildlife mitigative measures and agricultural development plans for the Accelerated Mahaweli Development Program have not yet been integrated or finalized. However, within this area the State Timber Corporation is causing a great deal of damage to wildlife habitats and the environment. It is recommended that this agency terminate its activities immediately in the Somawathie Sanctuary and its environs. A controlled clearing program needs to be implemented (see TOPIC REPORT D: FORESTRY). Furthermore, measures proposed by the government to prevent chena cultivation and illicit burning and felling of timber should be effectively implemented without further delay.

Conservation Education Program

The present shortage of fuelwood and timber (see TOPIC REPORT D: FORESTRY), power, natural forest cover and other resources clearly indicates the immediate need for a large scale program for conservation education and awareness. The scope of this program should be wide and address itself to all aspects of natural resource conservation as it relates to human welfare. It should be designed to reach people from all walks of life in the cities, towns, as well as rural areas. It is recommended that this program be coordinated by the proposed Department of Conservation Education under the Natural Resources Coordinating Agency. It is also recommended that conservation education be made part of the science curriculum of primary, secondary and university teaching courses. This would necessitate the involvement of the Department of Education in the conservation awareness program.

Riverine Forests

Riverine forests are the preferred habitat of many endemic species and an essential habitat to elephants during the dry season. In addition, these habitats play an important role in preventing soil erosion. Therefore, it is advised that all riverine forests not mentioned in the earlier recommendations be protected. This includes the riverine forests along Maduru Oya and on the

right bank of Hungamala Ela, as well as others. Narrow strips of at least 200-500 meters of natural vegetation should be left along riverine forests. Forests along tanks and reservoirs should also be protected. These habitats as well as small patches of forest located in and out of command areas could be developed as part of community development and conservation education programs. They could be "adopted" by neighborhood schools and other community institutions and maintained by the Department of Wildlife Conservation personnel. Their value could be enhanced by creating passive recreation areas and nature trails with informative signs identifying local wildlife.

Upgrading the Status of Wildlife

All wildlife of Sri Lanka enjoy a certain amount of protection, but it is recommended that their status be periodically reviewed and updated. This is especially important with respect to endemic and endangered species. Any species threatened with local extinction should be immediately included in the endangered species list, and appropriate steps should be taken for its protection. The present critical status of elephants and leopards indicate that they require special protection. It is recommended that these two species be declared national monuments, and severe penalties be imposed for their destruction.

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APPENDIX E-I

Objectives of Wildlife Field Study Program

Endemic Species

1. Compare past and present distribution of endemic species within project area.
2. Assess relative abundances, microhabitat preferences and range of microhabitats used by endemic species.
3. Assess impact on endemic populations through environmental change within project area.

Endanagered Species

1. Estimate elephant density and distribution in System B and C of project area.
2. Group size and composition of elephant herds.
3. Home range size of elephant herds and seasonal use of habitat.
4. Migatory patterns of elephants within Systems B and C with special emphasis on movement between Wasgomuwa Strict Natural Reserve and proposed Maduru Oya National Park.
5. Estimate elephant damage to agricultural crops and plantation forest.

Villu Fauna

1. Estimate relative abundances of terrestrial vertebrate fauna using villus and water courses particularly in System A.
2. Seasonal changes in the use of selected villus by terrestrial vertebrates.
3. Food habits of terrestrial vertebrates using villus and water courses.
4. Assess the degree of dependence of different terrestrial verte-

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brates using villus and water course.

4. Assess the degree of dependence of different terrestrial vertebrates on villu systems.

Agricultural Pests

1. Compare relative abundances of known agricultural pests in disturbed and undisturbed habitats.
2. Estimate abundances of probable competitors of agricultural pests in disturbed and undisturbed areas.
3. Assess habitat preference, food habits and seasonal changes in diet, mortality rates and factors and movement patterns of agricultural pests.
4. Estimate damage to agricultural crops by pests.
5. Recommend methods of control of agricultural pests.

APPENDIX E-II

List of Resident and Migrant Birds Located in the Accelerated Mahaweli Program Area

Resident Birds

PODICIPEDIDAE	
Podicepts ruffcollis capensis Salvadori	Little Grebe
PELECANIDAE	
Pelicanus philippensis philippensis Gmelin	Grey Pelican
PHALACROCORACIDAE	
Phalacrocorax carbo sinensis (Shaw)	Indian Cormorant
P. fuscicollis Stephens	Indian Shag
P. niger (Vielillot)	Pigmy Cormorant
Anhinga rufa melanosgaster Pennant	Indian Darter
ARDEIDE	
Ardea cinerea rectirostris Gould	Eastern Grey Heron
A. purpurea manilensis Meyen	Eastern Purple Heron
Ardeola grayii (Sykes)	Pond Heron
Butulous ibis coromandus (Boddaert)	Cattle Egret
Egretta alba modesta (J.E. Gray)	Eastern Large Egret
E. intermedia intermedia (Wagler)	Median Egret
E. garz etta garzetta (Linnaeus)	Little Egret
Nychicorax nycticorax nycticorax (L)	Night Heron
CICONIIDAE	
Ibis leucocephalus (Pennant)	Painted Stork
Anastomus oscitans (Boddaerts)	Open-bill Stork
Ciconia episcopus episcopus (Boddaert)	White-necked Stork
Leptoptiles javanicus (Horsfield)	Lesser Adjutant

THRESKIORNITHIDAE	
Threskiornis melanocephala (Latham)	White Ibis
ANATIDAE	
Dendrocygra javanica (Horsfield)	Lesser Whistling-Teal
Nettapus coromandelianus c. (Gmelin)	Cotton-Teal
ACCIPITRIDAE	
Elanus caerulus vociferus (Latham)	Black-winged Kite
Haliastur indus indus (Boddaert)	Brahminy Kite
Accipiter badius badius (Gmelin)	Ceylon Shikra
A. virgatus besra Jerdon	Besra Sparrow-Hawk
Spizaetus cirrhatus cirrhatus (Gmelin)	Crested Hawk-Eagle
Lophotrorchis kienerii kienerii (E. Geo.)	Rufous-bellied Hawk-Eagle
Ictinaetus malayensis perniger (Hodg.)	Black Eagle
Haliaectus leucogaster (Gmelin)	White-bellied Sea Eagle
Ichthyophaga ichthyaetus plumbeicepts (Baker)	Grey-headed Fishing-Eagle
Spilornis cheela spilogaster (Blyth)	Ceylon Crested Serpent-Eagle
PHASIANIDAE	
Coturnix chinensis chinensis (L)	Blue-breasted Quail
Perdicula asiatica ceylonensis	Ceylon Jungel Bush-Quail
Galloperdix bicalcarata (Forst.)	Ceylon Spurfowl
Gallus lafayetti Lesson	Ceylon Jungle Fowl
Pavo cristatus Linnaeus	Common Peafowl
TURNICIDAE	
Turnix suscitator leggei Baker	Ceylon Bustard-Quail

RALLIDAE	
Amaurornis p. phoenicurus (Pennant)	White-breasted Waterhen
Gallicrex cinerea cinerea (Gmelin)	Water-Cock or Kora
Porphyrio porphyrio poliocephalus	Purple Coot
JACANIDAE	
Hydrophasianus chirurgus (Scopolis)	Pheasant-tailed Jacana
ROSTRATULIDAE	
Rostratus b. bengalensis (L)	Painted Snipe
CHARADRIIDAE	
Vanellus indicus lankae (Koelz)	Ceylon Red-wattled Lapwing
Charadrius alexandrinus seebohmi	Ceylon Kentish Plover
RECURVIROSTRIDAE	
Himantopus himantopus ceylonsis	Ceylon Black-winged Stilt
GLAREOLIDAE	
Glareola lactea	Indian Little pratincole
CAPRINULGIDAE	
Camprimulgus macrurus aequabilis	Ceylon Jungle Nightjar
d.casiaticus eidos Peters	Ceylon Common Nightjar
APODIDAE	
Collocalia fuciphaga unicolor	Edible-nest Swift
Apus affinus singalensis Mad.	Ceylon White-rumped Swift
Cypsiurus parvus batasiensis Gray	Indian Palm-Swift
HEMIPROCNIDAE	
Hemiprocne longipennis coronata	Indian Crested Tree-Swift
TROGONIDAE	
Harpactes fasciatus fasciatus	Ceylon Trogon

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ALCEDINIDAE	
Ceryle rudis leucomelanura Reich.	Ceylon Pied Kingfisher
Alcedo atthis taprobana Klein.	Ceylon Common Kingfisher
Pelargopsis capensis capensis (L)	White-breasted Kingfisher
Halcyon smyrnensis fusca (Boodaert)	White-breasted Kingfisher
MEROPIDAE	
Merops l. leschenaulti Viellot	Chestnut-headed Bee-Eater
M. orientalis ceylonicus Whistler	Ceylon Green Bee-Eater
CORACIIDAE	
Eurystomus orientalis	Broad-billed Roller
Corasias bengalensis indica L	Indian Roller
UPUPIDAE	
Upupa epops ceylonensis Reichenbach	Hoopoe
BUCEROTIDAE	
Tokus griseus singalensis (Shaw)	Ceylon Grey Hornbill
Anthracoceros c. coranatus (Buddaert)	Malbar Pied Hornbill
CAPITONIDAE	
Megalaima z. zeylanica (Gmelin)	Brown-headed Barbet
M. flavifrons (Cuvier)	Yellow-fronted Barbet
M. haemacephala indica	Crimson-breasted Barbet
M. rubricapilla rubricapilla	Small Ceylon Barbet
PICIDAE	
Micropternus brachyurus jerdoni	Rufous Woodpecker
Dinopium benghalensis psarodes	Ceylon Red-backed Woodpecker
BURHINIDAE	
Esacus magnirostris recurvirostris	Great Stone-Plover
LARIDAE	
Stern albifrons albifrons Pallas	Little Tern

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COLUMBIDAE	
Treron pompadora pompadora (Gmelin)	Ceylon Pompador Tree-Pigeon
T. bicincta leggei Hartert	Ceylon Orange-breasted Pigeon
Ducula aenea pusilla (Blyth)	Green Imperial Pigeon
Streptopelia chinensis ceylonsis	Ceylon Spotted Dove
Chalcophaps indica robinsoni	Ceylon Broze-winged Dove
PSITTACIDAE	
Psittacula eupatria eupatria (L)	Alexandrine Parakeet
P krameri manillensis	Southern Rose-ringed
P. c. cyanocephala (L)	Blossom-headed Parakeet
P. calthropae (Blyth)	Layard's Parakeet
Loriculus beryllinus	Ceylon Lorikeet
CUCULIDAE	
Clamator j jacobinus (Boddaert)	Pied Crested-Cuckoo
Cuculus varius ciceliae (Phillips)	Ceylon Hawk-Cuckoo
Surniculus lugubris stewarti Baker	Ceylon Drongo-Cuckoo
Eudynamys s. scclopacea (Linnaeus)	Indian Koel
Ehopodytes viridirostris (Jerdon)	Blue-faced Malkoha
Phaenicophaeus pyrrohocephalus	Red-faced Malkoha
Centropus sinensis parroti	Southern Coucal
STRIGIDAE	
Otus bakkamoena bakkamoena Pennant	Ceylon Collared Scops Owl
Bubo nipalensis blighi Legge	Ceylon Forest Eagle-Owl
Glaucidium r radiatum (Tickell)	Indian Jungle Owlet
Bubo z. zeylonensis (Gmelin)	Ceylon Brown Fish-Owl
Ninox scutulata hirsuta (Temm.)	Indian Brown Hawk-Owl

TIMALIDAE	
Pellorneum fustoeapillum babaulti (Wells)	Brown-Capped Babbler
Pomatorhinus schisticeps holdsworthi	Ceylon Scimiter-Babble:
Dumetia hyperythra phillipsi	Ceylon White-throated Babbler
Rhopocichia atriceps siccatus	Ceylon Black-fronted Babbler
Chrysomma sinensis nasalis (Legge)	Yellow-eyed Babbler
Turdoides affinis taprobanus Ripley	Common Ceylon Babbler
MUSCICAPIDAE	
Muscicapa tickelliae jerdoni (Hold.)	Tickell's Blue Flycatcl
Rhipidura aureola compressirostris	White-browned Fantail-Flycatcher
Monarcha asurea ceylonensis (Sharpe)	Ceylon Azure Flycatche:
SYLVIIDAE	
Cisticola juncidis cursitans (Franklin)	Fantail Warbler
Prinia hodgsonii pectoralis Legge	Franlin's Prinia
P. Subflava insularis (Legge)	White-browed Prinia
P. sylvatica valida (Blyth)	Ceylon Large Prinia
P. socialis brevicauda Legge	Ceylon Ashy Prinia
Orthotomus s. sutorius (Pennant)	Ceylon Tailor-Bird
TURDIDAE	
Copsyshus saularis ceylonensis	Southern Magpie-Robin
C. malabaricus leggei	Ceylon Shama
Saxicolodies fulicata leucoptera	Ceylon Black Robin
PARIDAE	
Parus major mahrattarum Hartet	Ceylon Grey Tit
SITTIDAE	
Sitta frontailis frontalis Swainson	Velvet-fronted Nuthatch

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MOTACILLIDAE	
Anthus novaeseelandiae malayensis	Indian Pipit
DICAEDAE	
Dicaeum agile zeylonense (Whistler)	Thick-billed Flowerpecker
NECTARINIIDAE	
Nectarina zeylonica zeylonica (L)	Purple-rumped Sunbird
N. lotenia lotenia (L)	Loten's Sunbird
N. asiatica asiatica (L)	Purple Sunbird
Denarocopus maharattensis mabarattensis	Yellow-fronted Pied Woodpecker
D. nanus gymnopthalmus (Blyth)	Ceylon Pygmy Woodpecker
ALAUDIDAE	
Mirafra assamica affinis (Blyth)	Indian Bushlark
Eremopterix grisea (Scopoli)	Ceylon Finch-Lark
HIRUNDINIDAE	
Hirundo daurica hyperythra (Blyth)	Ceylon Swallow
ORIOLIDAE	
Oriolus xanthornus ceylonensis Bonap.	Black-headed Oriole
DICRURIDAE	
Dicrurus caerulescens insularis	White-bellied Drongo
D. paradiseus ceylonicus	Racquet-tailed Drongo
ARTAMINDAE	
Artamus fuscus Vieillot	Ashy Swallow-Shrike
STURNIDAE	
Temenuchus pagodarum (Gmelin)	Brahimy Mynah
Acridotheres tristis melanosternus	Common Mynah
Gracula religosa indica (Cuvier)	Common Grackle

CORVIDAE	
Corvus splendens protegatus Madrasz	Ceylon House Crow
G. macrorhynchos culminatus Sykes	Black Crow
CAMPEPHAGIDAE	
Hemipus pictus leggei Whistler	Ceylon Pied Cuckoo-Shrike
Tephrodornis pondicerianus affinis	Ceylon Wood-Shrike
Coracina melanoptera sykesi	Black-headed Cuckoo-Shrik
Pericrocotus flammeus flammeus	Ceylon Little Minivet
P.c. cinnamomeus	Ceylon Little Minivet
IRENIDAE	
Aegithina tiphia multicolor (Gmelin)	Common Iora
Chloropsis aurifrons insularis	Gold-fronted Chloropsis
C. cochinchienensis jerdoni	Jerdon's Chloropsis
PYCNONOTIDAE	
Pycnonotus m. melanicterus (Gmelin)	Black-capped Bulbul
P. cafer haemorrhousus (Gmelin)	Red-vented Bulbul
P. luteolus insulae (Whist & Kin.)	White-browed Bulbul
Hypsipetes indicus indicus (Jerdon)	Yellow-browed Bulbul
H. madagascariensis humii	Ceylon Black Bulbul
ZOSTEROPIDAE	
Zosterops palpebrosa palpebrosa (Temm.)	Small White-Eye
PLOCEIDAE	
Passer domesticus indicus	House-Sparrow
Ploceus philippinus philippinus (L)	Bays Weaver
P. manyar flaviceps Lesson	Striated Weaver-Bird
ESTRILDIDAE	
Lonchura striata striata (L)	White-backed Munia
L. punctulate punctulata (L)	Spotted Munia

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L. malacca malacca (L.)	Black-headed Munia
L. malabarica malabarica (L)	White throated Munia

Total number of resident species seen = 154

Migrant Birds

ANATIDAE	
Anas querquedula	Garganey
Anas acuta	Pintail Duck
ACCIPITRIDAE	
Pernis ptilorhynchus ruficolis	Honey Buzzard
Circus aeruginosus	Marsh Herner
Circus melanolencos	Pied Herner
PANDIONIDAE	
Pandion haliaetus haliaetus	Osprey
MUSICAPIDAE	
Musicapa latirostris	Brown Flycatcher
Musicapa m muttui	Layard's Flycatcher
Musicapa parva submbra	Kashmir Redbreasted Flycatcher
SYLVIIDAE	
Acrocephalns dumetorum	Blyth's Reed Warbler
Phylloscopus magnirostris	Large Billed Warbler
Phylloscopus nitidus	Green Tree Warbler
LANIDAE	
Lanius c. cristatus	Brown Shrike
MOTACILLIADAE	
Motacilla caspica caspica	Grey Wagtail
Motacilla flara thunbergi	Grey Headed Yellow Wagtail
Motacilla indice	Forest Wagtail

CHRADRIDAE	
Tringa stagnatilis	Marsh Sandpiper
Tringa totanus eurhinus	Eastern Red Shank
Tringa nebularia	Green Shank
Tringa glareola	Wood Sandpiper
Tringa ochropus	Green Sandpiper
Tringa h. hypolencos	Common Sandpiper
Capella stemura	Pintail snipe
Calidris ferruginea	Curlew Sandpiper
Limosa limosa melanuroides	Black Tailed Godwit
Scolopax rusticola rusticola	Woodcock
Charadrius dubins curonicus	Little Ringed Plover
Charadrius mongolus atrifrons	Lesser Send Plover
Plurialis dominica fulva	Asiatic Golden Plover
LARIDAE	
Chlidonias hybrida indica	Indian Whiskered Tern
MEROPIDAE	
Merops superciliousus philippinus	Blue-tailed Bee-eater
HIRUNDINIDAE	
Hirundo rustica guthuralis	East Asian Swallow
CUCULIDAE	
Clamator coromandus	Red Wing Crested Cuckoo
Cuculus m micropterons	Indian Cuckoo
Caconiqutis merulinus passerinus	Plaintive Cuckoo

Total number of migrant species seen = 35

Source: TAMS Wildlife Survey Team

APPENDIX E - III

Endemic Vertebrates Found Within the Mahaweli Accelerated Program Area

AMPHIBIANS

Family	-	RHACOPHORIDAE
1		*Polypedetes cruciger*
Family	-	CAECILIIDAE
1		*Ichthyophis* sp. (at least one species)

REPTILES

Family	-	GEKKONIDAE
1		*Calatodactylus* sp.
2		* *Gymnodactylus frenatus* Gunther
3		* *Geckoella vakhuna* Deraniyagala
4		*Hemidactylus depressus* Gray
5		*Cnemaspis podihuna* Deraniyagala
Family	-	SCINCIDAE
1		*Dasia haliana* (Haly et Nevill)
2		*Anguinicephalus deraniyagalei*
3		*Anguinicephalus hickanala*
Family	-	AGAMIDAE
1		*Calotes liocephalus*
2		* *Calotes ceylonensis* (Muller)
3		* *Otocryptis weigmanni* Wagler

SERPENTOID REPTILES

Family	-	ANILIIDAE
1	*	Cylindrophis maculatus
Family	-	ELAPIDAE
1		Bungarus ceylonicus
Family	-	BOIDAE
1		Pseudotyphlops philippinus
2	*	Rhinophis oxyrhynchus (Schneider)
Family	-	COLUBRIDAE
1	*	Chrysipelea taprobanica Smith
Family	-	VIPERIDAE
1	*	Trimeresurus trigonocephalus (Sonnini et Latrelle)
Family	-	TYPHLOPIDAE
1	*	Typhlops sp (at least one species)

BIRDS

1	*	Galloperdix bicalcarata (J.B. Forster) Ceylon Spurfowl
2	*	Gallus lafayetti Lesson Ceylon Jungle Fowl
3	*	Psittacula calthropae (Blyth) Emerald-collared Parakeet
4	*	Loriculus beryllinus (J.B. Forster) Ceylon Lorikeet
5	*	Megalaima flavifrons (Guvier) Yellow-fronted Barbet
6	*	Pellorneum fussocapillum (Blyth) Brown-capped Babbler
7	*	Phaenicophaeus pyrrohocephalus (Pennant) Red-faced Malkoha
8		Zoother sploptera (Blyth) Spotted-wing Thrush

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MAMMALS

* *Macaca sinica*	Toque Macaque
* *Presbytis senex*	Purple-faced Langur
Paradoxurus ceylonensis	Golden Palm Civet

FISH

Barbus fitteya	Cherry Barb
Barbus bimaculatus	Two Spot Barb
Garra lamta	Stone Sucker
Belontia signata	Leaf Lates
Barbus srilankensis	Sri Lankan Barb
* *Labeo fisheri*	Mountain Labeo
Barbus cummingi	Cummings Two Banded Barb
Channa oreintalis	Smooth Breasted Snake Head

* Presence of these species within the Accelerated Mahaweli Program Area were confirmed by sightings made by the wildlife field survey team.

Addenda

The wildlife field survey team has located the following additional endemics within the Accelerated Mahaweli Program Area.

AMPHIBIANS

Bufo atukoralei

Rana (Hylarana) gracilis

REPTILES

Sphenomorphus fallax

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APPENDIX E-IV

Financial, Technical, and Infrastructure Capabilities of The Department of Wildlife Conservation, Sri Lanka

1) Budget 1979

Salaries	Rs.2,844,000 =	45.6%
Travel	300,000	
Supplies	305,000	
Maintenance	150,000	
Utilities	90,000	
IUCN Membership	3,000	
Capital Equipment	764,990 =	12.3%
Permanent Structures	1,784,000 =	28.6%
Total Budget	Rs.6,240,990 =	$390,061

2) Wildlife Reserves

Status	No.	Area (Sq.miles)
National Parks	5	1,175.45
Intermediate Zones	2	139,29
Strict Natural Reserves	4	234.47
Nature Reserves	1	12.20
Jungle Corridor	1	40.00
Sanctuaries	45	799.63
Total	58	2,401.04 Sq.miles

3)

Field Personnel Job Description	No.	Minimum Education Qualifications
Park Wardens	5	10th Grade
Deputy Park Wardens	4	10th Grade
Rangers	34	10th Grade
Range Assistants	81	8th Grade
Wildlife Guards	288	7th Grade

No. of field personnel stationed in National Parks = 266
No. of field personnel stationed in other Wildlife preserves = 156

4) Vehicle Pool

Description	No.
4-Wheel drive jeeps	29
Tractors	8
Motor bicycles	3
2-Wheel tractors	2
Bus	1
Saloon car	1 loaned by the Ministry of State

Source: Department of Wildlife Conservation

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