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9. ABSTRACT

This report is the result of a coolaborative effort between the consultants and officials of the Department of Irrigation to fulfill the intent of USAID Regulation 16: 1)"...to strengthen the indigenous capabilities of LDCs to appreciate and evaluate the potential environmental effects of proposed development projects ..." and 2)"...to ensure that the environmental consequences of proposed AID-financed activities are identified by AID and the host country..". Environmental concerns are defined in terms of specific project activities and affected environmental systems. Methods used to make assessments of the significance of environmental impact are discussed. Recommendations are made for project changes, future study, and program development aimed at both impact mitigation and the development of local capacity for analysis and impact evaluation. The Rambukkan Oya Development Project involves development of intensive, year-round irrigated agriculture in an area of 12,700 acres which will be supplied with water stored in three reservoir tanks. Two types of environmental change are involved. The first is the physical change associated with construction of works such as tanks, irrigation ways and roadways, as well as with land use changes such as land clearing and agricultural development. The second type of change is the continuing input of the resident human population. This input varies with changes in the environment and altered socioeconomic conditions. Adverse impacts on public health, soils and agricultural practices, water, flora and fauna, energy, stream flows and agricultural runoff are considered. Recommendations emphasize the interrelationships between regional environmental systems, different regional land uses, and the proposed project area land use.

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ENVIRONMENTAL ASSESSMENT

of the

RAMBUKKAN OYA DEVELOPMENT PROJECT

prepared for the

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
Bureau for Asia,
Office of Technical Resources (ASIA/TR/SDP)
Washington, D.C. 20523

and for the

DEPARTMENT OF IRRIGATION

of the

GOVERNMENT OF SRI LANKA

by

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1.0 SUMMARY

1.1 Introduction

This document is an environmental assessment of the Rambukkan Oya Development Project in Sri Lanka. This project involves development of intensive, year-round irrigated agriculture in an area of 12,700 acres which will be supplied with water stored in three tanks (reservoirs). The United States Agency for International Development is the principal donor assisting in the financing of this project. This report is the result of a collaborative effort between the consultants and officials of the Department of Irrigation to fulfill the intent of USAID Regulation 16: 1) "...to strengthen the indigenous capabilities of developing countries to appreciate and evaluate the potential environmental effects of proposed development projects..." 2) "...to ensure that the environmental consequences of proposed AID-financed activities are identified by AID and the host country..."

The focus of the effort which resulted in this report was guided by environmental concerns identified in discussions with various officials of the Department of Irrigation. This report attempts to define these concerns in terms of specific project activities and affected environmental systems. This summary section outlines the methods used to make assessments of the significance of environmental impact and provides a list of major project impacts. Following this list is a subsection that gives recommendations for project changes, future study, and program development aimed at both impact mitigation and the development of local capacity for analysis and impact evaluation.

Originally, this project included only the development of the lands under the command of the Rambukkan Oya tank; however, the project as currently constituted includes the development of lands under the command of tanks on the Rambukkan Oya, Maha Oya, and the Gallodai Aru, all of which supply contiguous irrigation command areas that drain into the Mundeni Aru. The designation in the text of "Rambukkan Oya Project" refers to the entire regional project and not just the tank and command area of the Rambukkan Oya drainage.

1.2 Proposed Project

The purpose of the project is the development of intensive, year-round agriculture on 12,700 acres by the management of the water resources of the three major tributaries of the Mundani Aru, which lie in east central Sri Lanka. The project involves the following specifications:

1) Three storage tanks (reservoirs) will be constructed on the Rambukkan Oya, the Maha Oya and the Gallodai Aru.

2) All these tanks will have an earthen dam, spill-way, outlet works, canals leading to agricultural areas, barrages in streams etc.

3) A maximum of approximately 15,000 acres will be inundated during the wet season at full supply level in the storage tanks.

4) Roadways will be constructed in all areas.

5) Approximately 12,700 acres, the command area, will be irrigated for year-round cultivation of paddy and upland crops.

6) Social and physical infrastructure will be provided in the command area.

7) Approximately 5,080 rural families will be settled in the command area.

1.3 Methods of Impact Analysis

This subsection serves as a guide to the main body of the report and presents a logical basis for determination of the impacts of subsection 1.4 and the recommendations of subsection 1.5.

There is a high level of awareness about environmental problems in Sri Lanka among a wide variety of persons of different interests. Much of the data upon which this report is based are developed either from the previous efforts or in conjunction with the ongoing efforts of many of these persons. While this document shares many of their concerns, it is written from a perspectives that is different either from project planners, who are interested primarily in the project area by itself, or from other interested groups, who have specific concerns about particular environmental changes, such as the alteration of wildlife habitats, changes in water quality, soil loss and siltation, etc. This report takes a broader systems view of project related environmental changes.

The work leading to this report was performed concurrently with a study of the environmental impacts of Stage II of the Mahaweli Development Project. That work was organized so that background and general environmental data essential to impact assessment of rural development projects were collected and presented in the four appendices of the Mahaweli Stage II Environmental Assessment. It is necessary to refer to that report, which is being issued simultaneously, for the analysis presented in this report.

A large scale development project such as the Rambukkan Oya involves two types of environmental change. The first is the physical change associated with construction of works such as tanks, irrigation ways, and roadways, as well as with land use changes such as land clearing and agricultural development. These physical changes usually take place over a short period of time and radically alter the point of environmental equilibrium from its former state.

The second type of change is the continuing input of the resident human population. This input is not constant but varies in response to changes in the environment and to altered socioeconomic conditions. The long range stability of the regional environment depends on the new equilibrium established by the feedback relationships developed between the new population, its new activities, and the new environmental setting.

The description of the human population characteristics which are important for assessing environmental impacts covers a variety of needs and activities that result from the increase of population and the institution of intensive agriculture. Data on rural demography, consumption habits, energy needs and human behavior used for the immigrant population in the Rambukkan Oya Project are based on censuses of rural populations and on surveys conducted in conjunction with the Mahaweli environmental assessment. Reference to the appendices of that report will be necessary for a quantitative evaluation of the population needs.

The following list of sensitive environmental systems affected by project activities were studied in order to compare the project with alternatives.

1) Water. The changes of the water regime in the project area that are a result of the project were examined in terms of their consequences for public health, particularly malaria, and for the assurance of a safe domestic water supply.

2) Soil. The potential for erosion and siltation as a result of changed agricultural practices and land clearing was determined.

3) Biological systems. The potential for fisheries development in the new tanks was determined. The sensitivity of the region's wildlife to project development was considered.

4) Regional energy needs and resources. Both the post-project capacity of the region for production of renewable energy resources and the needs of project area residents for energy were determined.

1.4 Unavoidable Adverse Impacts and Mitigation Measures

The following list of adverse impacts constitutes a summary of the changes in the project area which have detrimental effects either on the human environment or on the long term stability of the total environment. The list's arrangement corresponds to sections of the text in which these impacts are discussed in a context of both positive and negative effects. Reference to these sections of the main body of the text is necessary to give the perspective needed for an evaluation of the seriousness of the impacts.

Mitigation measures whenever possible and feasible in the context of national economic priorities and design constraints of the project are given for each of the following adverse impacts. Other mitigation measures are discussed in the corresponding sections of the text.

Public Health (see section 4.1)

1) The incidence of malaria will increase in the first few years of the project life. New breeding habitats for malaria-bearing mosquitoes will be created as an inevitable consequence of the start of a new irrigation system. This increase can be largely prevented by diligent attention to areas where inadequate drainage leaves standing water suitable for mosquito breeding and by a program of house to house spraying for malaria mosquitoes.

2) The incidence of water-bourne disease will increase in the project area. As the population density, and with it the proximity of people in the new homestead areas increases, poor sanitation practices will lead to fecal contamination making epidemics of diseases such as cholera, typhoid, polio, etc. likely. Mitigation measures follow naturally from the improvement of local infrastructure. Health care will become more available and accessible in the region, than before.

3) There will be an increased risk of pesticide poisoning. With the introduction of new varieties and greater quantities of agrochemicals to the project area, it is likely that accidental contact with poisons will occur. The number of these accidents can be minimized by clear warning labels on all pesticides as well as by thorough instruction in pesticide use and safety precautions by agricultural extension workers. Health care personnel should be trained in recognition and treatment of pesticide poisoning in the field.

Soils and Agricultural Practices (see section 4.2)

4) Soil will be lost by erosion from areas irrigated by the project. The lands to be brought under the command of the three project tanks are now subject only to shifting cultivation in upland areas and to paddy cultivation in lowland areas. With year-round cultivation of upland areas, soil losses of up to ten to fifteen tons per acre are anticipated. This loss can be controlled by careful layout of the slopes of fields as well as by the use of crop rotations that give the soil protection from erosion by heavy rains.

5) Land clearing in the catchment area of the three project area tanks will lead to siltation of those tanks. The project settlers will create an increase in the local need for firewood. Regional development that is stimulated by project development may lead to an increase in the number of chena cultivators in the region. If either increase results in land clearing in the catchment areas of the three tanks, then the rate of siltation of these tanks could increase by a factor of ten or more over that presently anticipated. Land clearing can be prevented by the institution of reserve status for all forest lands in steeply sloped areas, particularly those highland areas over 400 feet in elevation that are contained within the catchments of the Maha Oya and Rambukkan Oya tanks.

Water (see section 4.3)

6) In some areas the level of the water table will rise to within a few feet of the soil surface leading to waterlogging and possible salinity build-up. Water table rise is an inevitable consequence of large-scale, year-round irrigation systems. The most effective check on salinity build-up is the high rainfall of the wet season that naturally flushes out salt accumulations. Where waterlogging is a problem special drains or an occasional dry fallow period may be required.

Flora and Fauna (see section 4.4)

7) The variety and number of small mammals and birds living in the project area will decline as a result of habitat loss. There is no mitigation measure possible for this inevitable consequence of land clearing for agricultural development; however, substantial areas of the same scrub jungle habitat will remain in the region.

8) Project development will increase the conflict between agriculture and large mammals such as elephants and wild swine. The command area portion of the project will become a complex agricultural unit very susceptible to damage from the region's elephants. The conflict can be eased by the creation of a buffer zone between the irrigated area and the known ranges of elephant herds. The buffer zone could be an intermediate land use such as grazing areas for cattle or plantations for firewood and other forest products.

Energy (see section 5.1)

9) There will be a loss of local resources of energy as well as an increase in the local demand for energy. Previously the entire region was locally self-sufficient for the majority of its energy needs. Now the command area portion of the project will become completely dependent on a supply of energy from outside. The most likely source for energy will be the cutting of firewood in adjacent areas. The only mitigation measure possible is firewood silvaculture in regions adjacent to the project area.

Stream Flows (see section 5.2)

10) The flow regime of the Mundeni Aru will be altered by the storage of wet season runoff. The reduction in annual total flow will alter the salt and fresh water cycle of the Batticaloa lagoon, with possible adverse effects on the lagoon fishery.

Agricultural Runoff (see section 5.3)

11) The amount of nitrates and pesticide residues and breakdown products in drainage water from the project will increase with possible adverse effects on Batticaloa Lagoon fisheries. The nature and degree of the effect depends upon the kinds and quantities of pesticide used. Mitigation measures include safety precautions in handling, storage, use, and disposal of pesticides, and control at a national level of the kinds of pesticides imported. The institution of integrated pest management programs involving use of biological pest controls can reduce the total amount of pesticides used. The assessment of long term effects of widespread pesticide use requires a monitoring and study program such as described in sections 5.3 and 1.5.

1.5 Recommendations

The Rambukkan Oya Project is the first effort at large scale development in the region. Aside from serving as a pattern for the future development of two neighboring river drainages, it will be a stimulus for economic and social change in the region. The direct environmental impacts of the project are easier to predict than the impacts of project stimulated growth and change in areas surrounding the project area. Nonetheless this regional growth has a potentially more profound influence on environmental stability than the project per se.

The Rambukkan Oya Project will become the main regional focal point for markets and infrastructure. Because the project will develop essentially all of the regional water resources, there will be no other vehicle available to planners to shape regional development. Thus it is necessary that the goals of the project be made commensurate with the goals of regional development.

Alternatives to development of the project as currently designed need to be evaluated in the context of a regional master plan. The extent and nature of regional environmental change will depend upon the facility with which the project is integrated into projected patterns of regional land use.

The following list of recommendations emphasizes the interrelationships between regional environmental systems, different regional land uses, and the proposed project area land use. The recommendations are grouped in three categories focused around the traditional areas of concern of natural scientists, social scientists, and planners; however, effective use of these recommendations can only be made by management officials who are appreciative of the interdependency of environmental problems and the interdisciplinary approach needed to attack them.

Physical and biological systems

1) The quality of domestic water taken from wells should be systematically analyzed in a continuing program. The development of such data will allow standards for well design and location in relation to human habitations and irrigation ways to be established.

2) The soil loss from cultivated fields should be measured under actual growing conditions. Understanding of the interrelationship between soil loss and agricultural practices is essential for maintenance of long-term productivity.

3) A comprehensive pesticide program leading to integrated management of pesticide use is needed. It would involve: monitoring of pesticides in the environment; record keeping of pesticide use in the project area; institution and monitoring of safety practices; research on the

research on biological controls as components of an integrated pest management program.

4) The dependency of the Batticaloa lagoon fishery on the fresh water input from the Mundeni Aru needs to be determined.

5) To allow a maximally productive fishery the vegetation on the floor of the three tanks needs to be removed completely or at least in strips wide enough for nets to be used.

Relationship of the human population to the environment

1) A program of preventive medicine for new settlers immigrating to the project area should include vaccinations and instructions in sanitation techniques appropriate for living conditions in the homestead areas. It should include instruction of farmers in the safe handling of hazardous agrochemicals as well as training of paramedical personnel in diagnosis and treatment of pesticide poisoning.

2) Project area health care and agricultural extension services should be integrated into the regional infrastructure.

Land use and the environment

1) The development of local renewable energy sources is crucial to supplying the energy needs of project area residents without either a drain on the national energy resources or adverse effects from overharvesting of firewood from scrub jungle areas. The economics of silvaculture for firewood should be examined both in small marginal areas within the project area as well as in adjacent areas.

2) The practicality of buffer zones between the project area and conflicting land uses such as nature preserves should be explored. These areas may supply fuel, serve as grazing land for livestock, or perhaps a source of wild buffalos and elephants for draft animals.

3) Agricultural research on chena (shifting) cultivation is needed. As water is the limiting resource for development of the region, rainfed agriculture will continue to have widespread importance. Ways of achieving increased productivity in chena agriculture without severe environmental degradation need to be identified.

4) The land exposed by seasonal drawdown of the tanks constitutes a potentially large (approximately 10,000 acres) resource. The environmental effects of land uses in this zone need to be studied. Grazing or cultivation of trees tolerant of seasonal inundation may be compatible with development of tank fisheries.

5) The seriousness of the threat of tank siltation from erosion in highland areas contained within the tank catchments may warrent reserve

status for these areas to prevent land clearing for either chena cultivation or for firewood.

2.0 ACKNOWLEDGEMENTS

Interest in environmental matters is widespread in Sri Lanka. The depth of that interest was amply attested to by the time so generously given by officials of the Department of Irrigation in cooperating with this study. Mr. Lochi Gunaratne of the Department of Irrigation worked closely with the consultants in the work leading to this report. The direction taken by that work was guided by concerns identified in discussions with him and other officials of the Department of Irrigation. Many of the ideas expressed here are the contribution of Mr. Gunaratne and others in the Department of Irrigation. However, as the final draft of this report was completed in the United States the responsibility for data and opinions contained therein rest with the consultants, as there was no opportunity to check the final draft with the Department of Irrigation.

A special thanks to Mr. Denlie Peiris, secretary, and Mr. Sunimal Herat and Mr. Sinnathamby Siuapatham, research assistants.

3.0 ENVIRONMENTAL SETTING

3.1 Geology and Soils

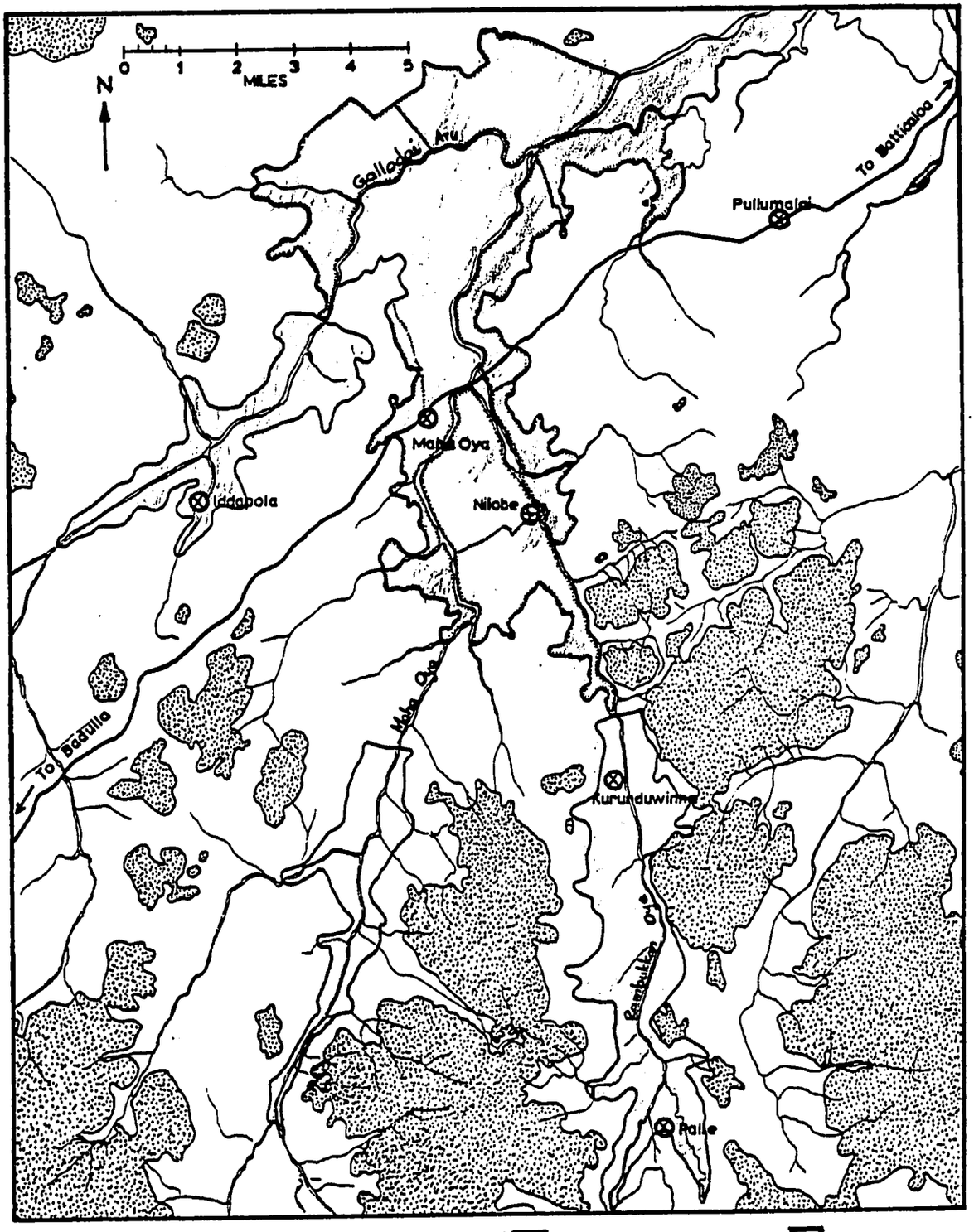
The topography of the project area is shown in figure 3.1.1, and is characterized by an undulating plain with slopes ranging from one to six percent over most of the area under the command of three project tanks. To the south of the command areas are a number of upland areas ranging in elevation from four hundred feet to over 2800 feet. These areas have much steeper slopes than the command area of the tanks. The valley floors which will become the tank beds are intermediate between the gently rolling plains of the of the command areas and the steep highlands. The lower elevations in the project area are an erosion plain in which the underlying metamorphic rock formations have become overlain with alluvial sediments. The parent rock is predominantly gneiss.

The hydrogeologic conditions in the project area are not felt by planters in the Irrigation Department to be adequate for development of ground water resources for anything but wells of low capacity, less than five gallons per minute, for domestic water supply. This opinion is based on extrapolation from other dry zone areas as the project area has not been surveyed for ground water resources. However, thermal springs occur within the project area. These springs have been surveyed by Fonseka et al. (1969). The spring at Maha Oya is typical of others in the region in that it has a high mineral content, is slightly basic, and seeps from the ground with no appreciable pressure head. The existence of these springs indicates deep circulation of ground water. If these deep aquifers could be tapped, then a relatively stable source of domestic water free of contamination from human waste or agrochemicals could be developed for the project area.

The soil in the project area which is suitable for agricultural use falls into four basic categories: 1) reddish brown earth soils, 2) low humic gley soils, 3) immature brown loams, and 4) alluvial soils. All of these soil groups are poor in nitrogen and phosphorous and will require an intensive input of fertilizers to be productive. The low humic gley soils are found in the valley lowlands and are more poorly drained than the other soil groups. Along the river flood plains are recent alluvia which are also poorly drained. The low humic gley and alluvial soils will be used for paddy culture cultivation, and the other soils for upland crops.

3.2 Climate and Rainfall

The climate of the project area is tropical and is dominated by two monsoons or periods of rain. The average monthly rainfall amounts are given in table 3.2.1 and show a pattern more or less typical of the dry zone of Sri Lanka. From March to mid May is the first inter-monsoon; mid May to September is the southwest monsoon, or yala season; October to November is the second inter-monsoon season; and, December to February is the northeast monsoon, or maha season. In normal years the two monsoon seasons together constitute seven and one half months and the two inter-monsoons account for the remaining four and one half months. The potential evapotranspiration exceeds the rainfall in all of the dry season and occasionally even during the wet season in dry years.



HIGHLAND AREAS OVER 400 FT. ELEVATION COMMAND AREA TANKS

RAMBUKKAN OYA PROJECT AREA

FIGURE 3.1.1

Table 3.2.1

Rainfall

Month	Periya Aru	Inginiyagala
Sept.	4.00"	4.42"
Oct.	8.32	13.03
Nov.	12.81	7.47
Dec.	16.67	14.18
Jan.	13.81	8.93
Feb.	4.39	6.16
Mar.	3.88	3.91
Apr.	4.48	4.21
May	3.67	10.60
Jun.	1.90	0.13
Jul.	2.23	3.33
Aug.	3.23	5.88
Total	79.39	81.24

One important characteristic of rainfall at low elevations in Sri Lanka is the frequency of occurrence of heavy storms. These heavy storms have important consequences for soil erosion, both in agricultural areas and in the catchment areas of the rivers which supply the water for irrigation. Figure 3.2.1 shows the variation of the intensity of rainfall of storms with altitude. An area at a higher elevation although receiving the same annual rainfall, will suffer less erosion because the rain does not fall at such high rates. As the entire catchment area of the three rivers supplying the irrigation project are below three thousand feet in elevation, they will be exposed to frequent, heavy and erosive storms.

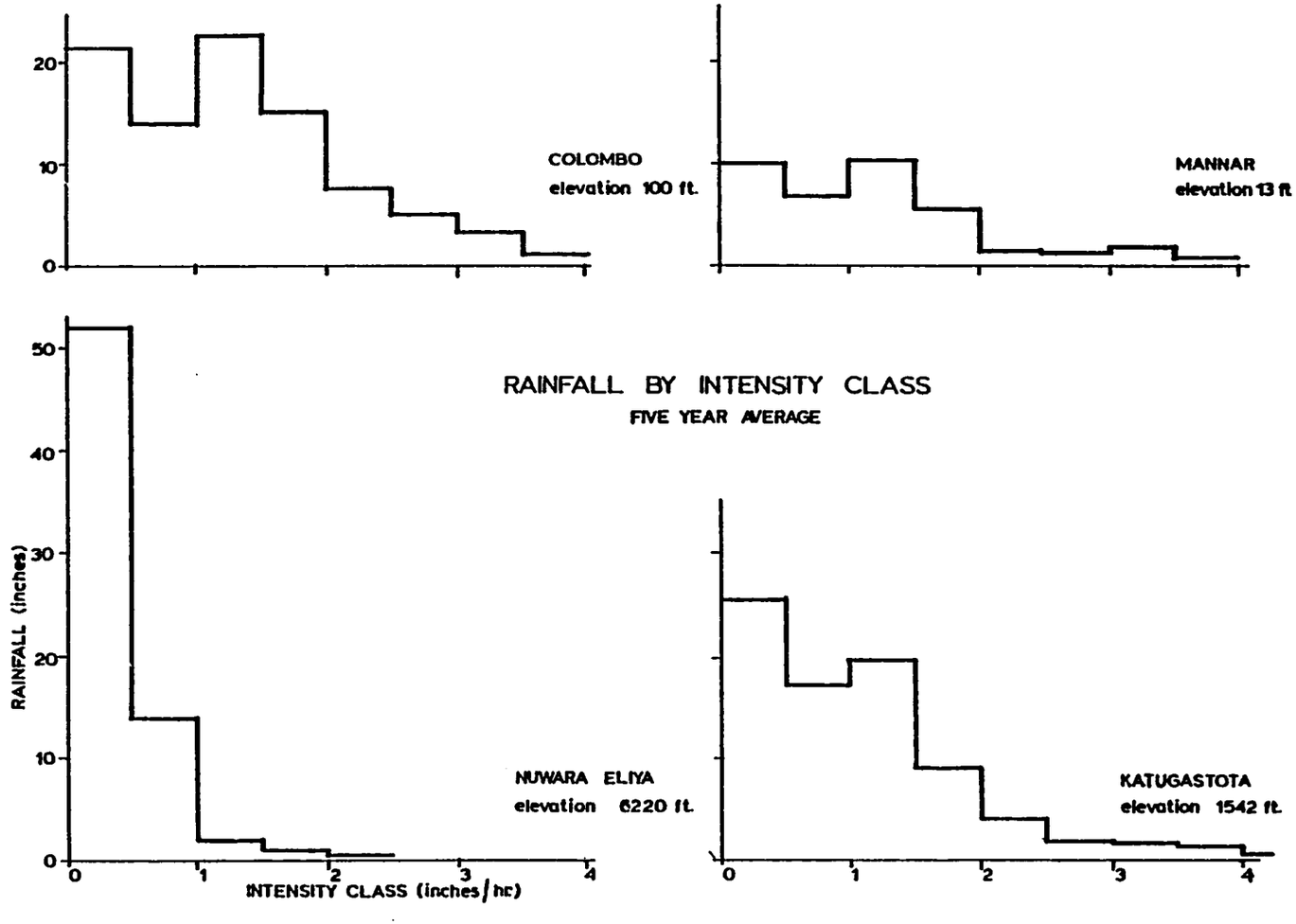

RAINFALL BY INTENSITY CLASS
FIVE YEAR AVERAGE
COLOMBO
elevation 100 ft.
MANNAR
elevation 13 ft.
NUWARA ELIYA
elevation 6220 ft.
KATUGASTOTA
elevation 1542 ft.
RAINFALL (inches)
INTENSITY CLASS (inches/hr)
0
10
20
30
40
50
1
2
3
4

FIGURE 3.2.1

3.3 Present Land Use

This section is based on the following sources of data: A survey of land use and socio-economic conditions and present infrastructure made by the Department of Irrigation in May of 1977; a reconaissance by the consultants in June of 1977 which was focused primarily on the Rambukkan tank and command areas; Forestry Department statistics on teak plantations contained within the project area.

In the project area most farmers have practiced shifting cultivation or chena. Also within the project boundaries are paddy fields, either rainfed or supplied by small village tanks. Table 3.3.1 gives a breakdown of agricultural land use as determined by the Department of Irrigation survey. Undoubtedly many farmers practice both chena and paddy cultivation as is traditional in many parts of the dry zone.

Important crops in chenas and the project area are chillies, maize, bananas, pulses and citruses such as limes are also grown. Once a week there is a market in Mala Oya at which crops are sold and trucked by lories as far as Colombo.

A small chena plot near the dam site on the eastern side of the Rambukkan Oya was inspected and the chena cultivator interviewed at some length. This chena plot is representative of others in the Rambukkan Oya valley. It is now in its second year after having been cleared in August of 1975. The two main crops in the chena are maize and bananas. Maize was harvested the first year and at least four varieties of banana were bearing. The farmer's criteria for selection of the site of his chena field were quality of the soil, absence of rocky outcrops, proximity of drinking water and a covering of mature jungle scrub. The chena had been covered with large trees as evidenced by the number of dead tree trunks still standing or lying on the ground in excess of two feet in diameter.

The chena land was cleared as a result of the cooperative activity among the chena farmers. After clearing the cultivator and his family managed the plot on their own. Their primary labor inputs were the removal of weeds three times a year using a mammoty and watching the chena to protect it from encroachments by animals, particularly wild swine and elephants. The chena cultivator said that there had been paddy cultivation in the Rambukkan Oya valley as recently as ten years ago, but that a number of dry seasons had forced local farmers to rely almost exclusively on chena cultivation which had proven to be a more reliable form of agriculture.

This chena is typical in that the crops grown are the dominant ones in chenas throughout the area. It is also typical in that the land was cultivated for only two years after clearing.

Inferences about the stability of the chena cycle can be made from two sources: one, the density of people in a given area and, two, the percent of land suitable for chena cultivation that is under cultivation at any one given period of time. As a rule of thumb, a density of less than 20 persons per square kilometer is considered to be supportable by the natural fertility as utilized in the chena cycle. Secondly, if a twenty

Table 3.3.1

Current Population and Land Use

I. Rambukkan Oya

Tank Area

Village	Number of Families	Paddy Lands (Acres)	Upland & Chena (Acres)	% of Land in Chena
Kurundiwinna	45	19	85	
Damanegama	17		30	
Idam bowa	1			
Nelliyadda	38		86	
Total	101	19	201	4.

Command Area

Pollebedda	31(14)*		49.5	
Nilobe	77	66	165	
Akulobe	15			
Bora Pola	75	42	300	
Baticalaw	20			
Badiokka	6	60	3	
Ellara	2	100		
Kudunila	4	60	4	
Total	230	328	521.5	12

II. Maha Oya

Reservoir Bed Area

Warapitiya	40		20	
Kirawanabaliya	4		4	
Total	44		24	1

* (Number of families of Vedda origin)

Command Area

Village	Number of Families	Paddy Lands (Acres)	Upland & Chena (Acres)	% of Land in Chena
Tempana	8		16	
Wewaudakanatta	20			
Tapalpola	15			
Maha Oya	58	56	190	
Unuwatura	23	47*		
Koowinna	17			
Hinguragama	9			
Ambelanda	22	25*	100	
Weeradiya	15	30*	125	
Tekkawattha	15	35*	50	
Total	202	481	193	15

III. Gallodai Aru

Tank Area

Mudagala	35		175	
Iddapola	125		612	
Total	160		787	17

Command Area

Gallodai Bogam				
Oya Road	75		180	
Begama Oya	15			
Total	90		180	4

year cycle is the norm, then something on the order of ten percent of the land suitable for chena cultivation should be under chena at any one time. In the Rambukkan Oya area both of these statistics can however, be misleading for several reasons: 1) the presence of extensive highland areas (See figure 3.1.1) which are unsuitable for chena cultivation as currently practiced in the Rambukkan Oya area. 2) the greater natural fertility of alluvial soils along the margins of the Rambukkan Oya itself. 3) the unknown percentage of farmers resident in the areas affected by the project, either in the tank or the command area, who have chenas outside that area and conversely the unknown number of non-residents who have chenas within the project area. Nonetheless the density estimates of table 3.3.2 support the notion that chena cultivation is stable in the Rambukkan Oya area. Further evidence for the stability of the chena cycle comes from a series of aerial photographs made in June of 1977 by the consultants. These aerial photographs covered 2,500 acres both within and without the project area. Of these 2,500 acres something less than 10% of the land was under cultivation, or had been recently cleared. Unfortunately there are no other aerial photographs available for the last twenty years with which to compare this figure. All these data are consistent with the notion of a stable chena system existing within the Rambukkan Oya Valley.

In the two other portions of the project area available evidence indicates that local chena cultivation is also stable. However, in these other areas paddy cultivation is much more common and a few small village tanks allow for its stability in some places. Teak plantations managed by the Forestry Department are also found in the Gallodai Aru area.

Table 3.3.2

Present and Future Population of Project Area	Acreage	No. of families Present	No. of families Proposed	Present Population (Persons/acre)	Proposed Population (Persons/acre
Rambukkan Oya					
-Tank area	7000	101	-	0.09	-
-Command area	4500	230	1800	0.31	2.4
Maha Oya					
-Tank area	3700	44	-	0.07	-
-Command area	3200	202	1280	0.38	2.4
Gallodai Oya					
-Tank area	4900	160	-	0.20	-
-Command area	5000	90	2000	0.11	2.4
Total tank area	15600	305	-		
Total command area	12700	522	5080	0.25	2.4
Total area	28300	827	5080	0.18	2.4

4.0 ENVIRONMENTAL IMPACT RECEPTORS

4.1 Public Health

The public health impact of the Rambukkan Oya tank and settlement project centers around three areas of concern: 1) alteration of the habitat of disease vectors, primarily that of mosquitoes; 2) contamination of drinking water supplies, primarily with human waste, but also with agro-chemicals; 3) transitional problems associated with the resettlement of people. The impact of the Rambukkan Oya project will be examined in terms of these three areas both as it may improve the level of public health or crease public health problems.

4.1.1 Insect vectors

Mosquitoes in Sri Lanka are vectors of at least three diseases: malaria, dengue fever and filariasis. In Sri Lanka the only proven vector of malaria is *Anopheles culicifacies*. At least eight other species which are known to be vectors in other parts of the world are also found in Sri Lanka, but as yet all examinations of these eight species have proved them to be free of malaria. *A. culicifacies* typically breeds in small temporary pools along water courses during drought conditions. These pools are usually free of vegetation and are shallow and temporary. The gravid female requires an open water surface free of vegetation for egg laying; therefore, this species is known to breed only at the edges of paddy fields. The larval development period in Sri Lanka may vary from 14 to 25 days. Thus the duration of these small pools must be in excess of that period to serve as suitable breeding places for *A. culicifacies*.

The mosquito *Aedes aegypti* is the vector for dengue fever and hemorrhagic fever. This mosquito is a container breeder usually found only in pots, cans, tins, old rubber tires and the like. It is very common around human habitation and may occur in natural containers, such as hollows in tree trunks. In Sri Landa *A. aegypti* is found primarily along the coastal belt because there the human population density is greater and climatic conditions are more favorable for breeding.

The *Culex* mosquito is the vector for filariasis. This, the common house mosquito, is chiefly confined to breeding sites in the vicinity of human habitations. The incidence of filariasis has been decreasing in Sri Lanka in recent years. Filariasis occurs principally along the coastal belt, probably a result of the high human population density along the coast as well as the breeding preference of the *Culex* mosquito.

The public health problem created by malaria in Sri Lanka is severe. Over five hundred thousand cases are reported per year, and the actual total is clearly in excess of that figure. A nation-wide malaria control program is planned with its primary focus centered around house spraying four times per year. A similar program was terminated in 1964 when the total number of reported cases of malaria in Sri Lanka was less than twenty. In the past five years malaria has returned throughout the island and in epidemic proportions in the dry zone. The proposed islandwide malaria control program will

involve house to house visits by teams of spraymen using malathion as the primary pesticide of choice. No broadcast spraying of breeding areas is planned. In the past house to house spraying was sufficient to reduce the incidence of malaria to the above cited low figure. It is anticipated that the contemplated program will achieve a similar level of success. As the environmental effects of this program have been recently investigated by a U.S.A.I.D. team, Gerberg and Willcox, this report will examine only the public health problem caused by malaria in the Rambukkan Oya project area and will focus on the likely changes in the pattern of malaria infection brought about by the project.

4.1.2 Alteration of insect vector habitats

As previously stated the project will have significant effects on the habitats suitable for the breeding of mosquitoes. These effects derive from the following project related changes; a large increase in acreage of open water for a greater portion of the year; a rapid increase in the density of human population within the project area with a concomitant increase of breeding places for household mosquitoes; an increased use of broadcast pesticides on agricultural lands; the immigration into the area of people who are less resistant to malaria because their previous residence was in malaria free areas in the wet zone; a change in the ratio of domestic animals to the human population; and lastly, on the positive side, an increase in the availability and accessibility of health care.

It is difficult to predict the effect of the introduction of year-round irrigation on malaria mosquito breeding habitats. One opinion maintains that the improvement of drainage from paddy fields that is necessary for intensive irrigation will reduce the surface area of standing water and thus decrease mosquito breeding areas. On the opposite side, others claim that the introduction of a greater volume of water into an area will very likely create numerous small incidental problem areas such as seepage areas around canal and tank bunds. Borrow pits resulting from the construction of irrigation works will also increase the number of small but perfectly adequately sized breeding habitats. It is clear that during the first few years of such a large scale project there will be such problem areas. This is an inevitable consequence of the necessity to prove out a complex system by operation. No one can predict whether or not a small transient pool of water will occur in a given locale as a result of large scale irrigation. Such discoveries are only made empirically, and it will take time to take corrective measures to eliminate these habitats. Thus, while the area may ultimately show a decline in breeding habitats, there will almost certainly be a period during which they will increase.

The availability of suitable breeding habitats is not the only controlling factor determining the population dynamics of malaria mosquitoes. A rapid influx of settlers into the area will increase the number of mosquitoes simply by increasing the number of sources for a blood meal. There are two other consequences resulting from the increase in the human population in the area that can alter the life cycle of malaria mosquitoes. Both derive from the change

in the ratio between the human population and the population of domestic and wild animals which also serves as a source of blood meals for Anopheles culicifacies. If in a given area the ratio of human sources of blood to animal sources of blood is low, the probability that a mosquito will make two successive blood meals from a human is reduced. On the other hand, a population of A. culicifacies that can derive much of its food from non-human sources is less affected by malaria control programs centered around the household. The project will increase this ratio, which will increase the mosquito's dependence on humans, thereby increasing the probability of human to human transmission. However, the mosquito will become more vulnerable to malaria control programs centered around human habitations.

The second effect related to this change in ratio between human and animal populations is the possibility that mosquito species which at present do not carry malaria could become vectors if their customary source of blood meals were taken away. This has happened in settlement areas in Africa and presumably reflects the change from an essentially non-human feeding population to one dependent on humans when its preferred source of blood from wild or domestic animals was removed. There is almost no way to predict this change and it is clearly something that should be watched for carefully during the course of settlement.

The introduction of pesticide use on a large scale in habitats which are known breeding grounds for mosquitoes will likely bring about resistance in these mosquitoes over time. The malaria control program recognizes this and has therefore banned the use of malathion throughout Sri Lanka for at least the period of the control program. This decision reserves malathion for exclusive use as a house spray. However, the widespread use of many varieties of pesticides will undoubtedly also affect animals such as predacious mosquitoes and aquatic insects which serve as natural controls to the mosquito population. Thus if a resistance breakthrough is achieved by one population of mosquitoes then the possibility exists that there could be a population explosion because the natural controlling feed back on their reproduction represented by predators would have been rendered ineffective. The malaria control program has reserved fenitrothion as a backup pesticide in the event that malathion resistance develops. Even this precaution would be ineffective should mosquitoes develop cross-resistance to fenitrothion from exposure to other pesticides. This phenomenon has been observed in areas in which insect populations have been exposed to a wide variety of pesticides sequentially over a long period of time (Sawicki, 1975). In the case reported, house flies had acquired cross-resistance to malathion from previous exposure to other pesticides.

4.1.3 Water borne disease

There is a high incidence of water borne disease in the project area. Project area public health statistics on common water borne diseases such as polio, hepatitis, cholera, and enteric fever, are shown in table 4.1.1. The statistics, which are for areas larger than the project area can be used only to indicate the presence of these diseases in the project area as well as in the region. All of these statistics are highly inaccurate and often grossly underestimate the true incidence of these diseases. Mild cases are not presented to health authorities or are not positively diagnosed. In the

Table 4.1.1

Reported Cases of Disease in Jurisdiction of Batticaloa Superintendent of Health Services

	1974	1975	1976
Polio	13	12	5
Enteric Fever	112	110	75
Viral Hepatitis	91	61	103
Population	579,000	597,000	616,000

Reported Cases of Disease in Jurisdiction of Vallachchenai Medical Officer of Health*

	1974	1975	1976
Cholera	10	8	0
Malaria	9,946	16,378	8,190
(Reported percent of positive tests)	(35%)	(51%)	(41%)
Population			120,000

*The jurisdiction of the Batticaloa S.H.S. is comprised of 4 sub-jurisdictions, of which the Valachchenai M.O.H. is one.

case of amoebic dysentery, many of the residents have built up resistance to or at least tolerance of, the parasite and rarely seek medical treatment. While the extent of water borne disease is difficult to assess, it is clear that there is a high level of such disease, probably stemming from two human behavioral characteristics. One is that very few latrines are in use. The common method of sanitation is to walk several hundred feet away from the dwelling place. The other characterisitc is that very few poeple in the project area boil water before drinking it. Farmers frequently drink from irrigation waters when they are working in the field.

The Rambukkan Oya scheme will have several influences on domestic water quality. There will be a rapid increase of population, allowing a greater chance for disease to spread. There will be more centralized sources of domestic water. If a particular water source should become contaminated with a pathogen, a large number of people will be affected. As the population in the area increases, the supply of cheaply available firewood for boiling of water will decrease. This will be a transient problem that should be corrected as the infrastructure builds up, allowing for efficient transportation of fuels into the area.

On the other hand, the project will clearly have some positive benefits for the public's health. The health care delivery system will be expanded making services more available and accessible. At the same time there will be an increased opportunity for education in elementary sanitation, and perhaps most important, the project will provide water wells as a source of drinking water. The design of wells can be made to conform to high standards and their location can be kept away from sources of contamination.

It cannot be too strongly emphasized that health education and health care services must be provided as early as possible. Further, a regular program of monitoring of domestic well water for the presence of pathogenic organisms should be undertaken. In the past such monitoring has been done only in response to epidemics and not in anticipation of epidemics. Emphasis should be placed on an effort to ensure that all immigrants to the area are properly immunized against communicable disease.

4.1.4 Effect of the introduction of agrochemicals

The effect of the introduction of fertilizers, pesticides and weedicides on water quality is discussed in section 5.3; however, direct relationships between the use of agrochemicals in the project area and public health problems are discussed in this section. For example, one consequence of nitrate leaching by both irrigation water and rain water will be in the buildup of nitrates in the subsoil waters. In other parts of the world this has led to nitrate contamination of well water. In Sri Lanka this result is seen in intensively cultivated areas in the northern part of the island around Jaffna. While nitrate concentrations in surface drainage water and in tank water may have some beneficial effects towards increasing the fertility of these waters, nitrate buildup in ground water can present a public health problem. It has been found that nitrate concentrations in excess of 10 parts per million in drinking water can have serious consequences for infant health. Apparently such nitrate levels have no adverse effect on adults or older children.

Similarly the concentration of pesticide breakdown product residues may also increase in shallow wells that are used for domestic water supplies. The potential that this contamination presents as a public health problem is not well understood. None of the chemicals which have acute toxicity to man survives long enough under field conditions to reach any source of domestic water. On the other hand, those farmers who drink from drainage ways in the field may be exposed to harmful levels.

The breakdown time of pesticides are several orders of magnitude shorter than the time for percolation of the water from fields down to the watertable and thence to wells. The use of poorly located temporary wells during the transition period before the project is fully developed can lead to water contamination--especially in extremely shallow wells which are only a few feet deep and are adjacent to unlined irrigation canals. Under normal conditions these irrigation waters do not carry pesticide in them as they come more or less directly from tanks and main canals and not from drainage ways. However, if many farmers wash their spray equipment in the nearest available source of running water, this practice could lead to incidents of contamination of these shallow wells. This lack of proper safety precautions points to the necessity for a national code of labelling of all agrochemicals. Further, effective instruction in application techniques should be required especially in areas where use of a maximum amount and a maximum variety of agrochemicals is anticipated.

Because the sources of domestic water in the project area are shallow and because there is a great deal of percolation water carrying leachate from cultivated fields through the watertable, it will be necessary to monitor the quality of domestic water on a regular basis. A watch should be maintained both for longterm changes in water quality and for accidental, transient pollution. A regular program of monitoring the baseline parameters of water quality from wells needs to be started as soon as possible so that the full impact of intensive agriculture on water quality can be appreciated. In addition these data from domestic wells should be integrated into an overall program concerned with subsurface water flow as influenced by both the quantity and quality of irrigation water in the area.

4.2 Soils and Agricultural Practices

4.2.1 Siltation and erosion

Erosion is a major threat to the long term maintenance of agricultural output through loss of topsoil. Aside from the loss of valuable topsoil, erosion also increases the silt load of drainage waters which leads to clogging of drainage ways, silting up of tanks (reservoirs), and alteration of aquatic flora and fauna.

The potential of a particular plot for erosion depends on six factors: 1) the pattern and amount of rainfall, 2) the erodibility of soil, 3) the slope gradient, 4) the plot's length down slope, 5) the cropping management, or the effect of vegetative cover, and 6) erosion control measures. In any given situation the first two factors are given and are not the result of man's activities. The second two are also physical variables, but they can be altered by terracing. The last two factors are a direct function of agricultural practices.

The equation which gives soil loss of a particular plot of land is the product of the above factors. As a result of empirical observations (Beasley, 1972), ranges of values have been assigned to these factors, with, for example, the contribution of the intrinsic erodibility of different soil types ranging over a factor of 15.

The effect of vegetative cover, which ranges over a factor of 100, and the combined effect of slope gradient and length (factor range: 60) are more important determinants of potential erosion than rainfall (factor range: 30) or erosion control practices such as contouring (factor range: 10). Extreme values of factors for either vegetative cover or slope characteristics can lead to significant erosion in spite of moderate values of other factors. When forested land is cut and converted to agricultural land, the maximum protection afforded by forest cover is lost. This change, which is necessary for agricultural development, will be examined in terms of its implications for soil stability in the project area.

There are two areas of major concern associated with the Rambukkan Oya project. One is the increase in the rate of erosion that will occur as a result of agricultural development and the other is the effect of siltation that will result from the erosion. Both these effects have to be seen in contrast to the background of current levels of erosion and siltation. To see the effect of current levels requires an examination of traditional practices.

4.2.2 Traditional agricultural practices and erosion

As chena cultivation is the only traditional method of cultivation in the project area (see section 3.3), the erosion potential resulting from chena practices will be examined in detail. The first important fact to note about chena cultivation and erosion is that traditionally chena land lies fallow for a period of approximately twenty years. Thus significant

erosion can occur only during the two or three year period of cultivation. The second important fact to note about chena cultivation and erosion is that the land is, in fact, not cultivated.

The chena cycle commences with brush clearing followed by its burning, after which, and with the onset of rains, the crop seed is broadcast sown on the bare soil. No ploughing, turning of soil, or other disturbance to the soil surface is made except perhaps scratching with a mammoty (hoe). This practice helps to preserve the soil organic matter by keeping it from exposure to the air and also presents a less erodable surface to the impact of the first heavy seasonal rains. With the onset of rains, both the crop seeds and weed seeds sprout quickly and provide cover to protect the land from erosion. The farmer does not begin to weed for several weeks at which time the crops have grown enough to afford protection to the soil from rainfall. Thus the period of susceptibility to the erosive impacts of rainfall is brief and is confined to the period between the clearing of the land and the first growth of crops and weeds.

The second season and the third season, if there is one, are even less likely to suffer erosion because the growth of weeds is much greater in the second and third seasons and in fact it is this growth of weeds which eventually discourages the farmer from continuing cultivation of the chena. At this point after two or three seasons of cultivation the chena is abandoned and the natural successional sequence takes place. If allowed to progress for the full duration of the twenty year cycle a thick scrub jungle grows up.

There will be no chena cultivation within the confines of the project area boundaries. However there will continue to be chena cultivation in adjacent areas. This chena cultivation will be affected by the project in a number of ways. These chena farmers will be exposed to a variety of new agricultural techniques appropriate for the intensive, irrigated cultivation of the upland areas within the project area. There will be a strong temptation on the part of these farmers to adopt some of these techniques for the same crops grown under rainfed conditions in their chenas. These chena farmers will also be subject to competition for chena lands from two sources: 1) the residents of the project area who prefer to cultivate some chena and who have the time, and 2) the project dropouts, some of whom would move to the nearest region where they can return to their traditional agricultural practices.

The result of the introduction of new techniques in the chena together with the competition from an increased density of chena farmers can lead to changes in the chena system that will have important consequences for erosion and soil stability. One inevitable result of the increased denstiy of chena farmers will be a decrease in the fallow period.

If a significant number of project farmers dropout and revert to chena, then the effect of their chena cultivation centers around three questions: 1) Will the dropouts increase overutilization of chena lands? 2) Where will they practice chena - will lands now thought unsuitable be cultivated? 3) What new techniques will be employed by chena farmers to cope with decreased yields?

The factors contributing to a decision to dropout are: 1) a failure to realize the expected productivity of irrigated land 2) unwillingness on the farmer's part to accept the risks associated with intensive agriculture 3) faulty perception of these risks 4) the farmer's lack of the managerial skill necessary to coordinate the complex timing of various inputs 5) the availability of land suitable for chena cultivation.

It is difficult to predict the number of farmers, both native and immigrant to the project area, who will dropout or who will fail to adapt completely to sophisticated intensive agriculture; however, it is expected that their number will be considerable. If many of them are native to the area, then it is likely that they will attempt to resettle in areas as similar to and as close to their native lands as possible. The closest available approximation to such lands is adjacent to the project. If many of the dropout farmers settle there, the scrub jungle will be liable to significant overutilization with resulting land degradation - especially in the highland areas south and east of the project.

If the chena farmers in the areas surrounding the project area are confronted by decreased productivity as a result of these changes it is likely that they will try to compensate by employing new techniques. Various agrochemicals which will become abundantly available as a result of the intensive agriculture in the project area will likely be tried. Whatever other effects these agrochemicals have one sure effect will be to increase both the intensity and the duration of cropping. This change by itself will lead to greater problems with erosion. The use of herbicides for weed control will reduce the quick invasion of weeds and will also lead to increased erosion. Further it is possible that the natural successional sequence may be altered by the use of agrochemicals thus decreasing the benefit derived from a fallow period. Another factor which will serve to increase erosion is the location of the chenas in areas of greater slope.

Very little attention is being paid to the current problems of chena farmers. Understandably more effort in agricultural experimentation is focused on cultivation systems that produce higher yields per acre by the intensive use of agrochemicals and highly refined genetic varieties which possess a higher fertilizer response. While greater yields are important to the chena farmer, maximum reliability of a minimum yield level is the traditional goal of the chena farmer. If chena cultivation remains a significant land use, then it will undergo change from its traditional form. It seems only prudent that agricultural research be employed to assist the chena farmer in this transition period so that there is a minimal likelihood of land degradation.

4.2.3 Soil loss during land preparation

The preparation of land for intensive agriculture under irrigation is a three step process: 1) removal of forest vegetation, 2) laying out the pattern of fields and irrigation channels and 3) grading of the fields to produce the optimum slope for the crops to be grown. Erosion, both sheet and gully can occur during land clearing if it is not carefully done and if

attention is not paid to the possibility of heavy rain when the land is in a vulnerable condition. Removal of trees can disrupt the soil surface and induce gully formation. Gully erosion can occur in the sides of freshly cut canals before the canal banks are protected with vegetation or are lined. In general, erosion from these sources is transient mainly because weedy vegetation quickly grows in before the rainy season is much advanced; however, if the topsoil is removed, the volunteer weed growth is insufficient to protect the steep sides of a canal cut.

Grading operations can cause an important erosion problem. If the grading is not careful to restore the topsoil (approximately six inches) to an even depth, then sheet erosion can quickly produce spots bare of topsoil. This result has already been observed in areas where machine grading was used. The resultant "thin" spots show up as areas with very poor crops or even bare ground, which, without protection of vegetative cover, can erode further. While this erosion may produce a temporary, local problem, it is of small impact compared to the potential for long term loss of topsoil from upland areas.

4.2.4 Longterm erosion potential

When upland fields are laid out, they are graded to a constant slope, whose value is a compromise between the need to have adequate control over the flow of irrigation water over the field and the desire to minimize erosion. If the soil were not so well drained, then virtually flat terraces could be used for upland cultivation; however, a reasonably rapid flow of water over a field is needed to ensure even and efficient wetting of the upper layers of soil over the entire surface of the field and to prevent water logging in any portion of the field. The minimum slope necessary to have adequate control has been set by the project engineers at 0.5° to 1.0°. A slope greater than 1.5° is felt to lead to excessive erosion. One estimate of the eroison likely even under this narrowly defined range has been made by Lewis (1975).

Lewis' estimate is examined in the Mahaweli environmental assessment and the conclusions reached there should apply here as well. However, it is difficult without precise knowledge of a number of additional variables to make a prediction of the annual expected soil loss on the basis of this one experiment. Although soil loss is clearly dependent upon slope, it is more heavily dependent upon the vegetative cover, as well as organic matter left on the soil surface from a previous cultivation. It is also strongly dependent upon the statistical frequency of heavy erosive rains. Nonetheless an approximate outside figure of soil loss can be estimated based on the rainfall data that is known for the area -- see table 3.2.1. There should not be more than a ten to fifteen ton per acre per year loss of soil under the proposed growing conditions. It must be emphasized however that this figure is highly approximate and can easily vary by a factor of three or more depending upon the following factors: One, the control that is exercised by the surveyors when slope gradients for the furrows are laid out. Two, the rotational sequence of crops that are grown and the cultivation techniques. Three, the probability of occurrence of heavy erosive rains at seasons when fields are in

a fallow condition. All three of these variables can be minimized by proper management of the cultivation. And, if erosion and attendant siltation become a problem either because of the loss of topsoil or because of siltation problems in drainage ways, then corrective soil conservation measures can be taken. Nonetheless this level of erosion represents a substantial increase over current levels of erosion in the area for the reasons outlined in section 4.2.1.

4.2.5 Siltation of Project Area Tanks

It is difficult to estimate the erosion resulting from land clearing in the catchment area of the three project area tanks; nonetheless, as this soil loss leads directly to siltation of the tanks, it is important to place limits on the problem.

The Rambukkan Oya tank has a dead storage volume of 2500 acre feet (see table 4.2.1). Independent calculations made by the Department of Irrigation and by an A.I.D. survey team (Richardson and Corey, 1976) indicate that this dead storage volume could accommodate the silt load of catchment runoff for at least 100 years. These estimates assume an average of 1.7 ton per acre per year of soil loss from the catchment area. While this figure is a liberal estimate for siltation from a forested catchment, it is conservative if substantial land clearing occurs in the catchment area. Present land use in the catchment area (see section 3.3) is chena cultivation. As the chena cycle is currently twenty years, only approximately ten percent of the land is under cultivation at any one time and hence susceptible to soil loss.

If the number of chena cultivators in the catchment area of the three tanks increase or if the project area energy needs are met by firewood taken from the catchment area, then a substantially greater percentage of the catchment areas of these three tanks will develop potential for erosion. As approximately half of the catchment areas of the Rambukkan Oya and the Maha Oya tanks are highland areas with steep slopes, such a spread of chena cultivation or firewood gathering could lead to high rates of soil loss in excess of fifteen tons per acre per year. In this case the one hundred year lifetime for the dead storage of the Rambukkan Oya tank would be decreased to something on the order of ten to twenty years. While the Maha Oya tank would be similarly affected, the Gallodai Aru tank is less susceptible to the siltation resulting from land clearing, because its catchment area contains only approximately 14% highlands.

Table 4.2.1

Specifications of Project Area Tanks

	Total Storage (Ac - ft)	Dead Storage (Ac - ft)	Catchment Area Mi^2	% Highland in Catchment
Rambukkan Oya	40,000	2500	50	53
Maha Oya			82	55
Gallodai Aru	78,000	6000	86	14

4.3 Water

None of the land in the Rambukkan Oya project area has been irrigated previously, therefore the direct impacts of the Rambukkan Oya project will stem from the irrigation of land for the greater part of the year during two growing seasons. Consequently:

1) The volume of ground water both in storage and moving through the ground will increase.

2) The quality of surface drainage and subsurface waters will be altered by the wide scale use of fertilizers, pesticides and weedicides.

The first change is the subject of the following sections, which explore the effect of additional water by examining the management system by which water flow is controlled. The second change is examined in sections 4.1 and 5.3.

4.3.1 Irrigation water management

In order to obtain a clearer picture of the change brought about by the trans-basin movement of water it is necessary to look at the water regime of representative crops during each of the two growing seasons. Figure 4.3.1 shows the water cycle in the Rambukkan Oya area in schematic fashion. This cycle can be used for any of the crops anticipated for the project area. It will be examined for two cases in order that estimates of the magnitude of each of the flows indicated in the diagram can be made. The first is paddy, the most water consumptive crop grown during the maha season. The second is an upland yala crop of chillies. Reference to table 4.3.1 and the accompanying figure will serve to identify the water flows between the different comparments of the system.

This systems should be thought of as a unit field supplied at the upper end by irrigation water and drained at the lower end. Water moves on to the surface of the field via the irrigation turnout and moves through the subsoil of the field by a gravity induced sub-surface flow. The values shown in the table are estimates based on the World Bank analyses of crop water requirements and irrigation efficiencies. The actual values will vary greatly with rainfall, irrigation management, farm management, soil permeability, height of watertable, depth of water bearing subsoil and the condition of the crop. Nonetheless these estimates are useful to highlight two points:

1) There is a great deal more percolation from flooded paddy cultivation than there is from upland cultivation. This is in spite of the lower permeability of lowland soils compared with upland soils.

2) In both cases there is more subsurface flow down slope of the field than there is flowing into the unit field from above the slope. This means that during the season the watertable will become progressively higher as a result of the greater amount of water coming into the subsoil. Figure 4.3.2 illustrates this result.

WATER FLOW IN IRRIGATED AGRICULTURE

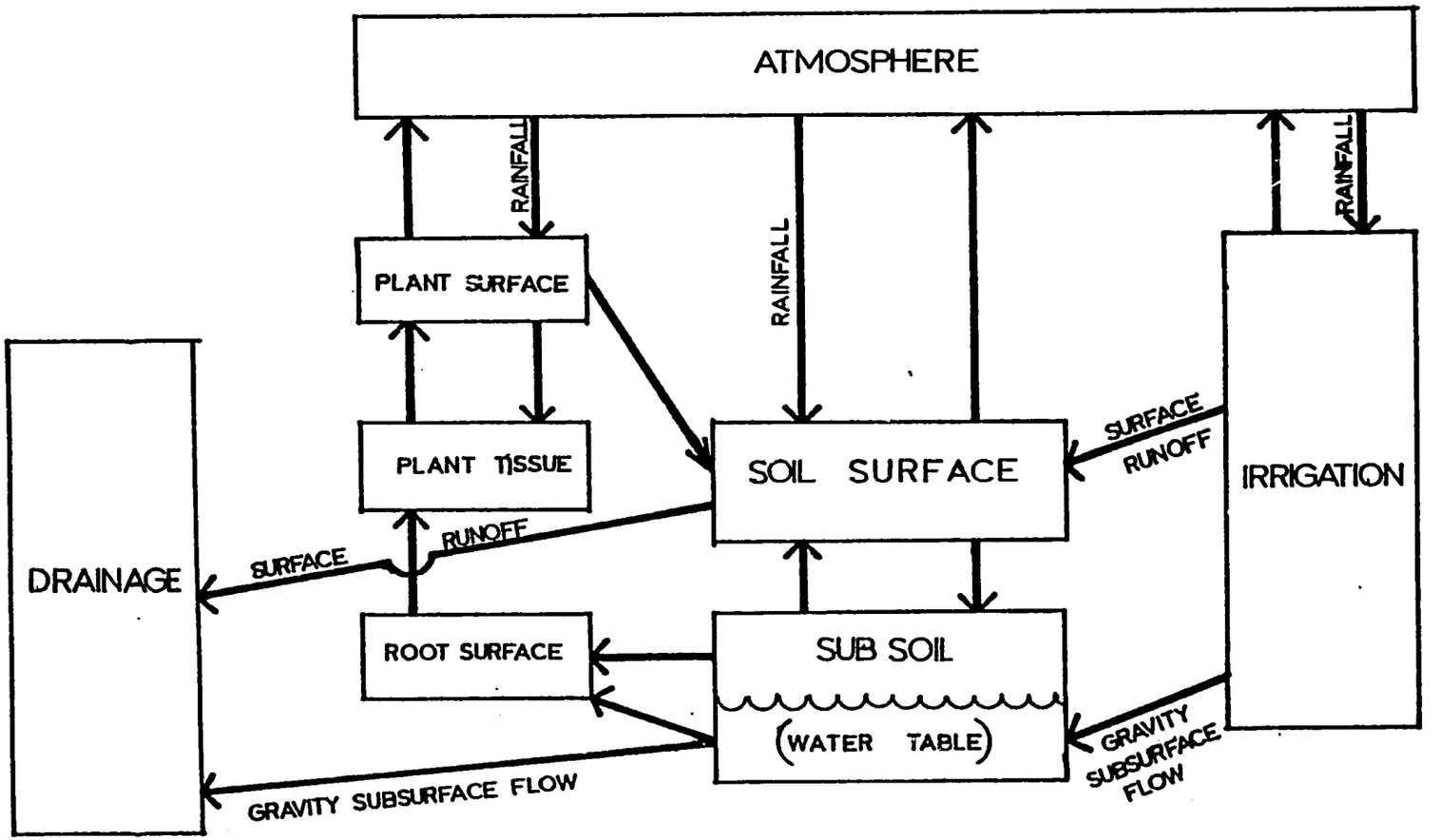


FIGURE 4.3.1

Table 4.3.1

Total Water Movement During One Season of Cultivation

Direction of Movement	Water Depth in cm.	
	Lowland Paddy Maha Season (155 days)	Upland Chillies Yala Season (180 days)
1. Effective Rainfall	50	25
2. Evapotranspiration	81	57
3. Subsurface Flow From Irrigation Channels Into Subsoil	44	32
4. Percolation Loss to Water Table	65	29
5. Surface Supply of Irrigation Water	133	97
6. Surface Drainage Runoff	37	36
7. Subsurface Flow	109	61

Note: 1 & 5 are inputs to soil surface; 2,4 & 6 are outputs.

3 & 4 are inputs to subsoil; 7 is output.

Source: Adapted from World Bank Analysis of Irrigation Water Needs.

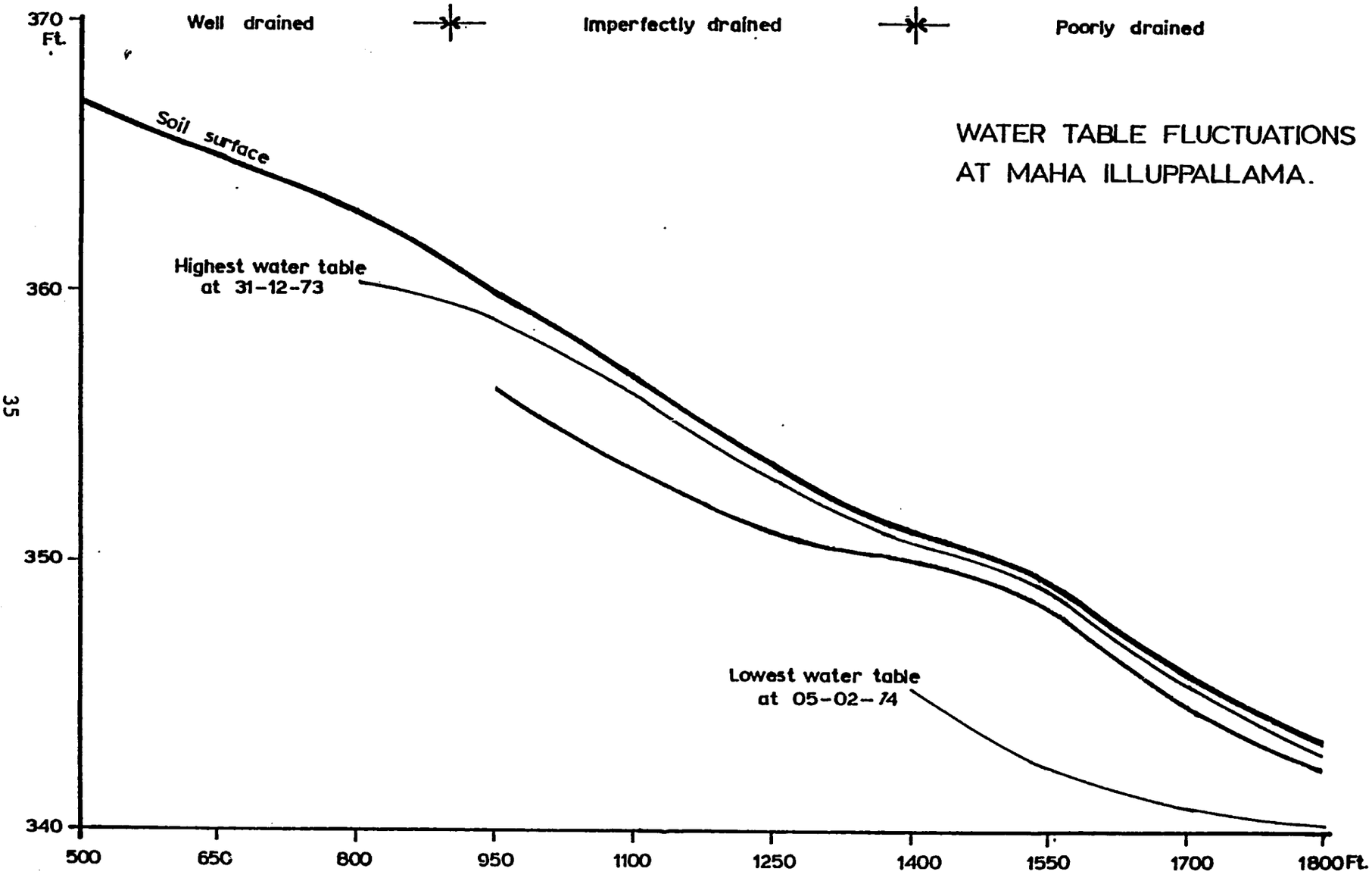

WATER TABLE FLUCTUATIONS
AT MAHA ILLUPPALLAMA.
Well drained
Imperfectly drained
Poorly drained
Soil surface
Highest water table
at 31-12-73
Lowest water table
at 05-02-74
370 Ft.
360
350
340
500
650
800
950
1100
1250
1400
1550
1700
1800 Ft.

FIGURE 4.3.2

The rise of the watertable under irrigation is a well-known effect. There are several consequences of this rise that have important consequences for agriculture. One is water-logging of the soil resulting in loss of soil structure. Secondly, as the watertable rises closer to the surface it also moves up the slope thus fields which once were suitable for upland cultivation now become suitable only for paddy. Since paddy itself contributes a greater amount of water to the watertable, it is likely that a shift to paddy cultivation on these soils would push the watertable further still up the slope. Thus from the point of view of agricultural planners control of the watertable is of vital importance. In the case of the Rambukkan Oya project strict control and management of water will be necessary to prevent this kind of rise. Even so it may require an occasional yala fallow period in which no water is used on the upland soils at all thus allowing the watertable to subside to a lower level.

4.3.2 Ground water and salinity buildup

In many areas of the world where continuous irrigation systems have been introduced, the buildup of salts in the soil has become a problem. Salt buildup through time can reach levels which either inhibit crop yields or prevent the growth of crops altogether. Even when the irrigation water supplied to the fields is of low salinity this phenomenon occurs. And, once salt has built up in the soil it is very difficult and costly to remove. This section examines this process and assesses the likelihood of salinity buildup in the Rambukkan Oya project area.

When irrigation water is supplied to a field the water table rises as described in the previous section. If the watertable rises to within 1½ meters of the soil surface then a significant amount of water flows directly from the watertable by capillary action to the soil surface where it evaporates. This is in contrast to the usual flow of subsurface water (see figure 4.3.1) which is either through the subsurface layers or through the roots of plants to the atmosphere by the process of transpiration. When water evaporates directly from the surface of the soil, salts which were dissolved are depositied on the surface layers of the soil. This process occurs only druing relatively dry seasons when the potential for direct evaporation is high. The rate of buildup is increased by high watertables, moderate or high amounts of dissolved salts in irrigation waters, high winds, low humidity and long dry periods.

Salinity buildup is not expected to be a major problem by irrigation planners in the Rambukkan Oya project area, primarily because the high seasonal rainfall (see table 3.2.1) is expected to flush salts annually from the soil. Moreover, the areas where the watertable is close to the surface fields are likely to be under paddy cultivation rather than upland crops. The only problems that could arise in areas of paddy cultivation would be from a lack of drainage which would allow the irrigation water to stand and evaporate in place thus leaving a coat of salt on the soil surface. This problem in most areas can be corrected by the improvement of drainage ways.

The ultimate solution to the problem of salinity buildup depends on control of the height of the watertable. However, in some areas with a chronic problem other measures are possible. For example the evaporation potential can be reduced by the provision of tree plantings as windbreaks. These could be particularly effective in the project area because of the dry, high velocity winds which sometimes occur during the dry season. Unfortunately the requirements for the layout of fields for adequate control of irrigation water often do not allow the planting of windbreaks of a proper orientiation to the prevailing wind thus this mitigating measure is limited in application. Nonetheless in areas where the orientation of irrigation ways allows it should be tried. Another use of tree plantings is to control the watertable in limited problem spots. For example eucalyptus plantings have very high rates of transpiration and can be used to lower the watertable efficiently.

The most efficient way to deal with problems of salinity buildup is control of the watertable height by control of the irrigation water applied to the fields. If the volume of irrigation water is no more than is needed for crop growth, then it is unlikely that ground water buildup will become a severe problem; however, if irrigation waters are wasted then ground water buildup is an inevitable consequence in many areas. An efficient and accurate system of regulating and measuring the flow of water into fields is appropriate since water is the limiting resource in the Rambukkan Oya project, not the land.

4.4 Flora and Fauna

The pattern of land use in the Rambukkan Oya region is described in section 3.3. In summary here the area presents a mosaic which is the result of a low density stable land use characterized by chena cultivation. The climax vegetation is a result of the chena successional cycle. The scrub jungle which results after a twenty year or more fallow period is a dense mixture of species characteristic of the dry zone scrub jungle of Sri Lanka. Conspicuous among these species are emergent trees of the species *Manikara hexandra* and *Chloroxylon swietenia*. This forest type and associated types of scrub are described in detail by Fernando, 1968. There are many local variations in this pattern that are characteristic of exposed rocky slopes or alluvial soils along river flood plains. There have been no detailed vegetation surveys of either the project area or the area destined to be flooded by tank construction. If studies are carried out, it would be appropriate to examine the successional sequence of plants and animals that follow upon the abandonment of a chena.

The project area when surveyed by the air or from aerial photographs presents a mosaic of patches of vegetation that is the direct result of chena cultivation. This mosaic supports a complex variety of animal life. Interviews with local residents reveal that elephants and wild swine and deer of various species are common in the project area. Leopards are also frequently reported and bears are also known to inhabit caves in the rocky highland areas and south and southeast of the project. This abundance of animal life is not surprising in that the project area is only a few miles north of the Gal Oya National Park and presents much the same habitat as is found within the park. Further there are no roads or conflicting land uses that would prevent the free movement of animals from the park area into the project area.

There are a few small tanks within the project area which are the result of a local effort to improve local very small irrigation systems. Neither of these tanks have proved very useful for agriculture; however, they support a varied avian fauna that is typical of the tank habitat in Sri Lanka. Conspicuous in this fauna are species such as cormorants, anhingas, fishing owl, terns, sea eagles, brahminy kites and in the winter a variety of ducks. Other conspicuous members of the avian fauna include two species of the hornbill, racket-tailed drongo, bee-eaters, the paradise fly catcher, a trogon and several woodpeckers.

4.4.1 Within the project area

The effect of the Rambukkan Oya scheme will be to convert the command area from scrub jungle characterized by chena cultivation, to intensive agriculture with few, if any, sizeable areas of natural vegetation remaining. Without question both the number and variety of animal and bird species found in the project area will decrease as a result of the reduction in habitat.

No large mammals will remain in the project area because of their incompatibility with intensive land use. The population of birds and

small mammals will also be reduced. However, many species of both birds and small mammals are tolerant of the frequent disturbance to their habitat that comes from chena cultivation. Thus many of these species will be found in and around the borders of the project area as they are adapted to a mosaic of land uses. Other less tolerant species which require larger tracts of scrub jungle will not be found within the project area.

The population of some species of animals usually considered agricultural pests, will increase as a result of the project. For example the number of crows and small birds which are destructive of rice at various stages will increase as their food becomes more available. Rats and other small rodents will likely become a sufficient nuisance to warrant control programs in the project area.

Major changes in animal populations in the project area will be brought about as a result of the construction of three medium sized storage reservoirs or tanks. As these three rivers go almost completely dry during the dry season they have very small year round populations of fish. In some small pools along the rivers are found carp and catfish. These fish are taken in very limited quantity by some area residents. As there are only a few very small tanks in the entire region, the development of these three tanks will inject not only a completely new habitat but also affect the animal populations that utilize adjacent habitats. The tanks themselves constitute a potential fishery resource which is discussed in the section 4.4.3. The species of birds associated with tank habitats will also become more common in the project area.

In the areas actually flooded by the tanks there will be a loss of riverine habitat. The strip bordering the rivers on the flood plain will cease to exist unless the suggestion proposed in section 5.2 is followed. This vegetation is important as a means of stabilizing the river banks during floods and, if retained for that purpose, will continue to provide riverine habitat in the command area.

These tanks will undergo the extreme annual fluctuation in water level that is characteristic of tanks in the dry zone of Sri Lanka. A complex community of plants and animals has become associated with this man-made habitat in its thousand year existence in Sri Lanka. As no agriculture is contemplated within the watershed of these tanks beyond chena cultivation, the input to these tanks should not be appreciably affected by agricultural run-off. The tank communities should be relatively secure from the effects of pesticide residues. In fact, the catchment runoff is likely to be so nutrient poor that the development of a productive fishery in these tanks will require an input of nutrients as discussed in section 4.4.3. The greatest danger to these tanks is represented by siltation resulting from erosion in the watershed. This threat is discussed in section 4.3.

As the tank waters will be the source of water for irrigation as well as a potential fishery resource, it is strongly recommended that a program of monitoring basic water quality parameters of tank waters be instituted as soon as the tank waters begin to fill behind the new dams.

4.4.2 Outside the Project Area

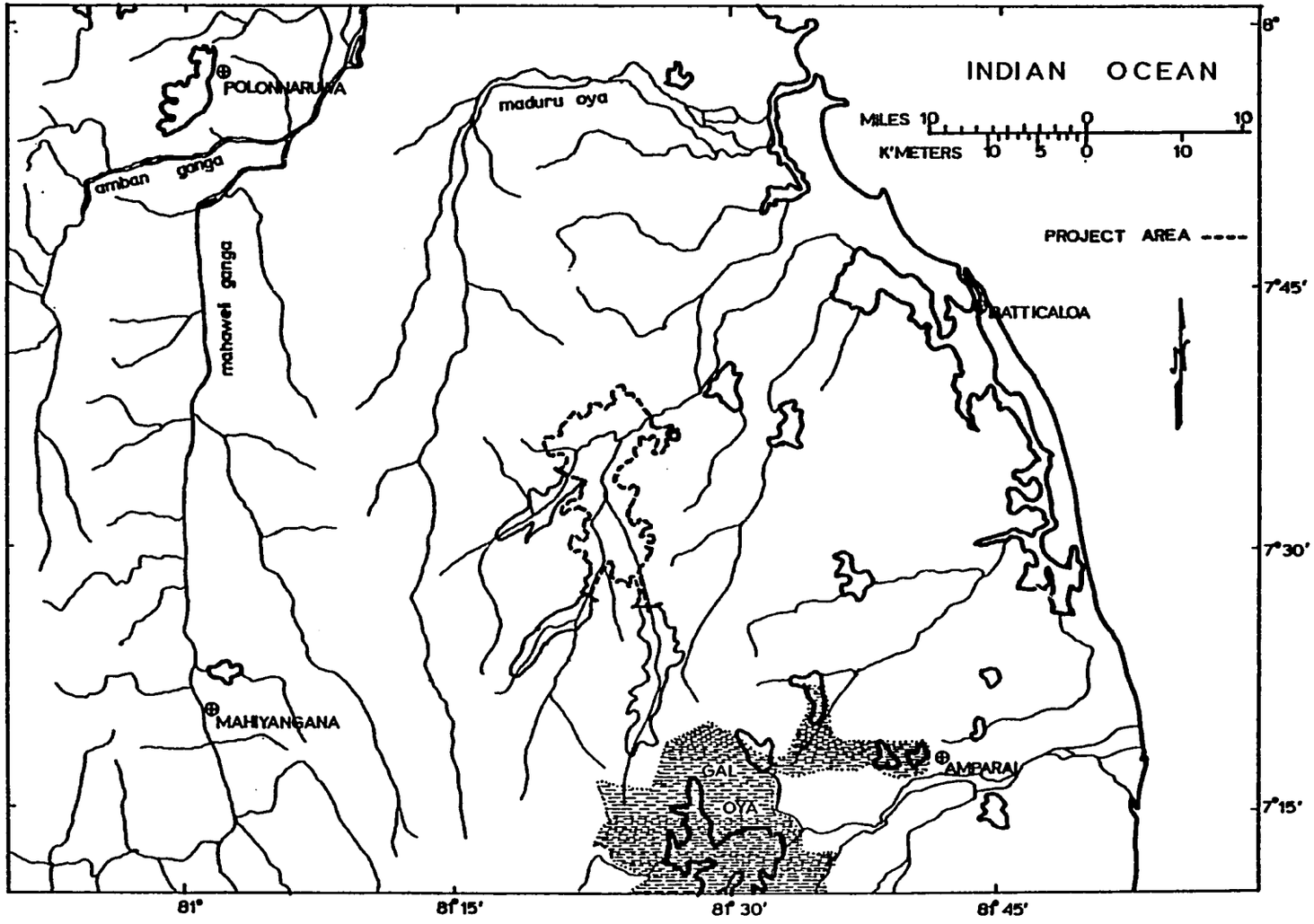
South of the project area is one of the three major national parks of Sri Lanka. Gal Oya National Park extends approximately twelve by twenty miles with an area of approximately 240 square miles, including associated sanctuaries. The relationship of Gal Oya to the project area is shown in figure 4.4.1. The park surrounds a large tank, Senanayaka Samudra.

The park is noted for its large elephant population which was surveyed by McKay (1973). McKay estimates that there is a population of several hundred elephants that make regular use of park lands as well as adjacent areas. These elephant herds roam freely across park boundaries at different seasons of the year in search of food. At particular seasons the large open savanna-like areas along the shores of Senanayaka Samudra are noted for concentrations of up to one hundred elephants at a time. It is not clear whether park herds roam as far north as the project area, although it is not unlikely that the herds occupying the northern part of Gal Oya Park are found from time to time in the sourthern part of the project area, particularly in the vicinity of the proposed tank on the Rambukkan Oya.

The catchment areas of the three project area tanks are included within the proposed elephant reserves shown in figure 4.4.2. These elephant reserves are designed to include the known ranges of large herds of elephant and to connect these ranges insofar as possible with "corridors". The purpose of these corridors is to allow for movement of elephant herds whether seasonal in response to extreme dry periods. These seasonal movements of elephants are not well understood, and there is no direct evidence to support the commonly held notion of long range migration of herds. Nonetheless, if such migrations occur then the routes north from Gal Oya Park would most naturally be through the valleys of the three rivers of the project scheme.

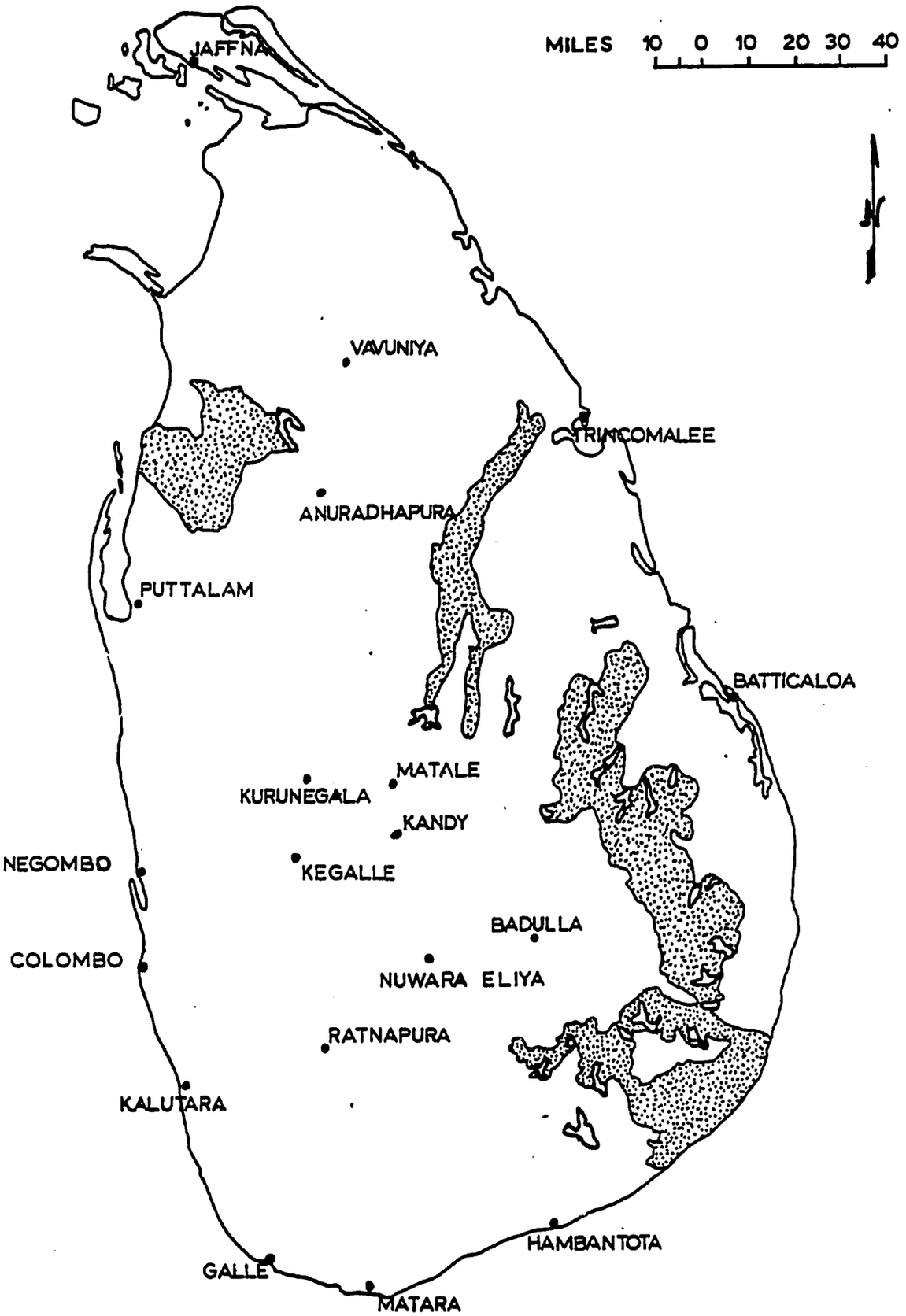
Elephants are considered a nuisance by both paddy and chena cultivators within the project area. The elephant population of the project area, although less dense than the populations of Gal Oya Park, constitutes a major problem for cultivators. In chena fields a nightly watch is maintained to ward off wild swine and elephants. In the Rambukkan Oya valley a chena plot is raided by elephants almost weekly. The project will exacerbate this conflict between agriculture and wild elephants in three ways: 1)the institution of agriculture in the command area will provide a source of food tempting to elephants; 2) the irrigation ways, dikes, fields and crops will be more sensitive to damage by large wild animals; 3) the construction of three large tanks will provide an attraction for elephants in a number of ways. The presence of year round water, as well as the usual thick growth of grasses in the drawdown area of the tanks will both provide resources for the local elephant populations.

There appears to be no easy way to mitigate the conflict between agriculture and elephants. It is possible as suggested by Hoffman (1972)



THE PROJECT AREA IN RELATION TO GAL OYA NATIONAL PARK

FIGURE 4.4.1



PRESENT AND PROJECTED ELEPHANT PRESERVES.

FIGURE 4.4.2

that buffer zones could be created between intensive agricultural areas and elephant preserves; however, the layout of the command area does not readily allow the creation of an effective buffer zone. Perhaps grazing lands around the tanks could serve as an intermediate land use. Or perhaps plantations for firewood or forest products could serve as a buffer, although teak plantations appear to be extremely susceptible to damage by elephants.

4.4.3 Tank fisheries

In rural areas in Sri Lanka fish is the most important source of protein in the diet. The per capita consumption of fish in rural areas ranges from eight to twelve kilograms per year (appendix A, Mahaweli Environmental Assessment). The second major source of protein in the rural diet is eggs of which four to six kilograms per capita per year are consumed. In the average diet fish, whether fresh or preserved, constitutes approximately half of the protein.

The importance of further development of tank fisheries is recognized by the planners of multi-use water development projects. This attitude has not always been so positive as it was illegal until twenty-five years ago to fish in irrigation supply tanks. Over the years this attitude has changed and fresh water fishing is now an important commercial activity in many of the larger tanks in Sri Lanka. In medium sized tanks and in very small village tanks fishing on a smaller scale has become increasingly important as a source of food for the farmers living around those tanks.

As there are no natural lakes in Sri Lanka, there are few native species which are adapted to a lake habitat. Consequently, when exotic species were introduced to tanks in the late sixties the productivity of these waters was increased many fold. The fish that have given the largest boost to production of these waters are the various species of *Tilapia*, such as *Tilapia mossambica*, *T. melanopleura* and to a lesser extent *T. nilotica*. Of secondary importance are species of *Labeo*, *Puntius* and the common carp. All of these species grow rapidly in tank waters and can reach harvestable size in a few months, a time span short enough to permit their utilization in tanks with extreme seasonal fluctuations in water level.

So far the Fisheries Department of Sri Lanka has emphasized the development of large scale commercial fisheries in the larger tanks. Within recent years there has been an effort to develop small and medium sized tanks as local community resources. The Fisheries Department believes that the fisheries in fresh water tanks of all sizes can be increased by a factor of two within the next five years. To achieve this goal in medium sized tanks such as those in the project area will require community management of the tank resources and cooperation with stocking programs of the Fisheries Department.

Since smaller tanks decrease in volume during the dry seasons to such an extent that they are incapable of carrying over a substantial population of fish, the fishery in these tanks is therefore based on a yearly cycle that begins with stocking. To produce a maximum yield requires the addition of nutrients either in the form of fertilizers or plant material to increase the productivity of the tank ecosystem. As the tank level drops during the dry season community cooperation becomes essential for the successful harvest and processing of the concentrated yield of fish over a short period of time.

Table 3.3.2 shows the acreage of the three tanks proposed for the project area and the project area population that will benefit from the proposed fishery. Table 4.4.1 shows a projection of yield of these three tanks based on estimates supplied by the Fisheries Department of Sri Lanka (Mendis, 1977). With even the conservative development forecast for 1985, the fishery should yield 25 kilograms/capita/year.

To achieve this projected yield will require both community management of the tanks and a program of analysis of those tank conditions which are relevant to the management of the fishery. As there are no facilities close to the project area capable of sampling and analyzing algae, plankton, benthic organisms or the nutrient concentrations within the tank, it is suggested that a small facility be set up in the project area to serve this purpose.

Table 4.4.1

Projected Annual Productivity of Project Area Fishery

Tank	Full Supply Area (hectare)	1980 Yield* (metric ton)	1985 Yield* (metric ton)
Rambukkan Oya	2000	50	250
Maha Oya	1500	40	200
Gallodai Aru	2000	50	250
Total	5500	140	700
Assumed Catch		50 kg/ha	250 kg/ha
Potential for Local Consumption		5 kg/capita	25 kg/capita

*Assuming 1980 is the first year after project completion.

5.1 Energy

The demands of the project area for energy are an important impact of development. Energy demands directly affect the environment in a number of ways. If energy demands are met by firewood, then areas of natural forest vegetation can be overexploited. If demands are met by petroleum based fuels, then a non-renewable resource is being committed. If energy demands are met by hydroelectric power, then stream ecosystems are being altered.

In order to understand the energy impact of the Rambukkan Oya project it is necessary to understand both the energy economy of Sri Lanka as well as the energy demand within the project area. The energy economy of Sri Lanka as well as a review of the potential sources of energy available within the country is discussed in Appendix B of the Mahaweli Environmental Assessment. This section will examine the transition of the project area from a self-sufficient autonomous region in terms of its energy needs to an energy consuming region that will require a net importation of energy. Throughout the following discussion constant reference will be made to Appendix B which describes the energy sources and requirements of rural areas in general.

5.1.1 Future energy demands within the project area

The energy demands of the project area come from the requirements of the settlers for cooking, lighting, boiling water, personal and commodity transport, drinking water distribution, agricultural land preparation, manufacture of fertilizers, harvesting and processing of crops, and retail and service activities. Table 5.1.1 gives a summary of the project area energy requirements for the major categories of energy use for the next twelve years. These estimates are derived from data presented in Appendix B and Appendix C of the Mahaweli Environmental Assessment.

For each activity that requires energy there is a choice of fuel sources if more than one fuel source can be used to meet that need in the foreseeable future. The requirements in terms of each fuel source are calculated based on the efficiency of that fuel source for that particular activity. A table of energy equivalents in Appendix B gives relative efficiencies for different fuels for different purposes. All of the projections are based on per family use figures which are calculated in the following manner:

1) Cooking - Cooking requirements are estimated to increase at 1% per year. This increase is meant to reflect an increasing caloric intake in the average project area diet.

2) Boiling water - The energy need to boil water is based on the assumption that all drinking water is boiled now and through 1990. Actually very few families boil water except for tea.

3) Lighting - Lighting requirements are expected to double from an average of 1½ lamps per family in 1980 to 3 lamps per family in 1990. The equivalence between kerosene and electricity for lighting is based on a ratio of one kerosene lamp to one 40 watt bulb.

Table 5.1.1

Energy Demands for Project Area

	1975	1980	1985	1990
Cooking				
-kerosene (million gallons)	1.7	2.2	3.0	3.3
-electricity (Gwh)	127	160	220	238
-LPG (million lbs)	10.6	13.3	18.3	19.8
(million cu ft)	210	270	370	400
-firewood ('000 tons)	52-73	66-92	90-126	98-137
-paddy husk ('000 tons)	120-220	150-280	220-390	230-410
-biogas (million lbs)	18	23	31	34
Boiling water				
-kerosene (million gallons)	0.44	0.56	0.77	0.84
-electricity (Gwh)	18	23	32	34
-LPG (million lbs)	3.1	3.9	5.4	5.8
(million cu ft)	62	78	108	116
-firewood ('000 tons)	12-17	16-22	22-30	23-30
Lighting				
-electricity (Gwh)	1.1	1.9	3.3	5.2
-kerosene (million gallons)	0.32	0.57	1.0	1.55
Land preparation				
-diesel	0.1	0.4	0.5	0.6
Personal transport				
-diesel (million gallons)	0.03	0.04	0.1	0.2
Crop transport				
-diesel	neg.	neg.	neg.	neg.
Project area population-families	24,500	29,250	37,950	39.350

Note: Alternative energy sources for most uses are given; the quantities for each source are calculated as if 100% of the energy required for a particular use all came from that one energy source.

4) Land preparation - The calculation of fuel requirements for land preparation is based on the amount of fuel necessary to prepare one acre of land or 3.3 imperial gallons for two plots of a one acre field. An average of 0.2 gallons for transport to and from the field is added to this figure.

5) Personal transport - The primary mode of personal transportation in the project area today is walking, with the bullock cart and bicycle of secondary importance. For long trips bus service is the only mode available. Present demand for bus transportation is estimated to be 360 passenger miles per family per year. This low figure reflects the fact that most long trips are for legal or business purposes and are made by only one member of the family rather infrequently. Nonetheless this estimate should approximately double by 1990 due to the improvement in bus service, to the addition of new highways and to the greater affluence of the farmers. With the advent of intensive agriculture there will be a greater need for more frequent trips by a farmer to attend to business related to his crops. Since virtually all long distance personal transportation is by bus, the only fuel included in the estimate is diesel fuel.

6) Crop transport - Energy requirements for transportation of crops are much less than for land preparation primarily because paddy, the main crop is transferred to the nearby village co-op from where it is redistributed both locally and to more central markets. The transport of cash crops is also only to local markets and boutiques. There the crops are purchased by traders and trucked by lorry to more central markets such as Batticaloa and Badulla. While the requirement for diesel fuel for lorry transport could be considered as part of the energy requirements for the project area it is more likely that the necessary fuels would be supplied in the major market cities rather than locally in the project area.

7) Community services - The energy requirements of retail and community services are expected to grow dramatically over the next twelve years primarily because of the increasing affluence of local residents. However as most of these energy needs will be confined to central principal villages, they are not considered in the estimates of per family use in the project area.

8) Fertilizer - The energy demand for fertilizer production similarly was not considered because most fertilizers are imported and only formulated locally.

The project area energy demand by use is shown in figure 5.1.1 to the year 1990. This graph is a summary of the above discussion and is presented in terms of gigawatt hour equivalents based on table 5.1.1. As the two major fuels are firewood and kerosene the gigawatt equivalent figure for cooking with either kerosene or firewood was used for all other uses. This figure was chosen for the purposes of graphical illustration. Reference to Appendix B will give the exact gigawatt equivalents for each use. For example, if lighting were from electric lamps rather than from kerosene lamps, the greatly increased efficiency of electricity would reduce the energy demand for lighting to a very small fraction of that shown in figure 5.1.1. However, as this substitution is unlikely in the next twelve years,

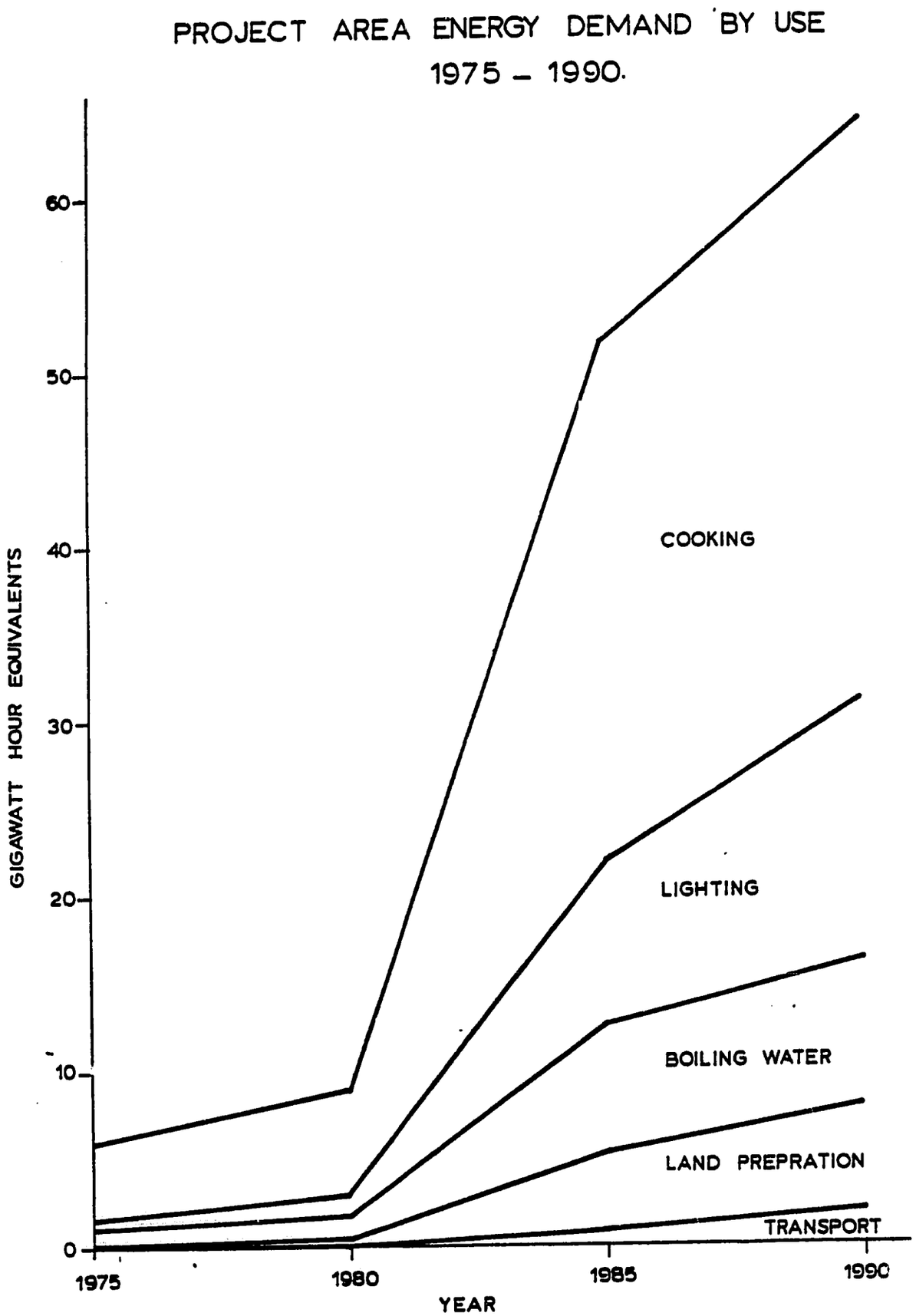

PROJECT AREA ENERGY DEMAND BY USE
1975 – 1990.
GIGAWATT HOUR EQUIVALENTS
60
50
40
30
20
10
0
COOKING
LIGHTING
BOILING WATER
LAND PREPRATION
TRANSPORT
1975
1980
1985
1990
YEAR

FIGURE 5.1.1

kerosene is used as the probable source of fuel for lighting requirements.

The energy required for boiling water is the theoretical maximum amount if everyone boiled all their drinking water. Now virtually no one in the project area does. Thus to obtain a true picture of the amount of energy use this component should not be included; however, it is included from 1975 to 1990 as a means of estimating the increase that would occur if boiling water were to become common.

5.1.2 Future sources of energy for the project area

In theory the project area energy requirements could be met by a number of different sources or by a combination of sources. In practice the supply of fuel from each source is severely restricted. The development of intensive agriculture within the project area affects both the need for energy and the potential sources of energy. This section examines the possible and probable sources of energy for the project area and how these sources will be constrained by project development.

1) Electricity - In Sri Lanka which produces a great amount of hydro-electric power, it is tempting to think that all energy needs can be met by the use of this source. While this is indeed possible, there is very little likelihood that the capital expense for rural electrification can be met any time within the next ten to fifteen years. Not only is the cost of transformers, substations and distribution lines prohibitively expensive, but electric appliances for cooking and other uses are also beyond the means of even moderately affluent farmers.

2) Biogas - Another possible energy sources comes from the biogasiciation of animal waste and crop residues. While this source is clearly theoretically sufficient to meet most of the project area's energy needs, it too requires a high level (although less than electricity) of capital expenditure. It also requires the introduction of unfamiliar technology at the village level. But perhaps the most crucial requirement for effective use of biogas is the land for raising the bullocks and water buffalo to produce the necessary manure. Although crop residues can be used in a mixture with animal manure for generation of biogas, the carbon to nitrogen ratios of animal manure are required for effective gas generation. Unfortunately the prospect for biogas use in the project area is poor because planners have already made a strong commitment to mechanical power over animal power for land preparation and cultivation. Thus it is unlikely that biogas will be able to supply more than a fraction of the total project area energy needs even with maximal development of locally available resources.

3) Kerosene and other petroleum based fuels - Kerosene will in the next ten years become increasingly important as a general purpose fuel for project area needs. It will continue to be the exclusive fuel used for the lighting requirements of the project area and will begin to be used for cooking and boiling water, needs which are now met in the project area by firewood. Diesel fuel and to some extent gasoline will also be increasingly

demanded by the project area residents for land preparation and transport. Thus the use of petroleum based fuels will increase dramatically in the project area. Unfortunately there are limitations on the supply of petroleum based fuels to the project area. The international market price of crude oil will continue to increase at a rate greater than the market price of project area products. An increase in project area use of petroleum based fuels is dependent on continuation of government subisdization of the price of these fuels.

4) Firewood - The primary alternative to kerosene is firewood, which can be used for cooking and boiling water. Most of the increase in project area energy needs will be met either by kerosene or firewood. Unfortunately firewood is the fuel whose supply is most affected by the project development. Currently all cooking in the project area is by the use of firewood, almost all of which is obtained locally through individual labor. In the future within the project area there will be few useable sources of firewood left. Most firewood that will be used in the project area will be supplied by a market system from sources outside the project area. The supply of firewood and problems associated with its transportation and distribution are discussed in the following section. This section deals only with demand forecasts for firewood or for its substitute kerosene.

Figure 5.1.2 shows two scenarios of the way future energy demands may be met. These scenarios are explained in table 5.1.2 and reference to both the figure and the table will clarify the bases for the projections.

Scenario A represents continuation of the use of firewood exclusively for cooking. The increase in the amount of firewood necessary for cooking reflects directly the increase in the number of families in the project area. In this scenario kerosene continues to be used for lighting as at present, and its increase relates to the increase both in the number of families and in the number of lamps burned by each family. An increase in the number of lamps burned from one per family in 1975 to three per family in 1990 is perhaps conservative in view of the findings of the survey reported in Appendix C of the Mahaweli environmental assessment. Moreover, this use of kerosene cannot be substituted in the foreseeable future by any other energy source. In figure 5.1.2 kerosene is also shown used for boiling water. This need is valid only if project area residents change their present habit of not boiling water. If the price of kerosene goes up radically or if the government subsidy in kerosene price is removed it is still unlikely that firewood use would be much greater. In that case it is likely that most families would accept the risk of not drinking boiled water until and unless a water borne epidemic occurs.

Scenario B represents an increasing use of kerosene in the project area. It is likely only if the market price of kerosene does not increase drastically.

The actual use of various fuels is very difficult to predict even a few years in advance. For example Scenario B might be followed for the first five or six years of the project life at which time, if extensive firewood silvaculture in areas adjacent to the project area has been developed a shift to Scenario A could gradually occur as a result of the increasing supply of firewood from this source. The scenarios are intended only to give a range of possible fuel requirements in the project area and to serve as a guide for energy planners.

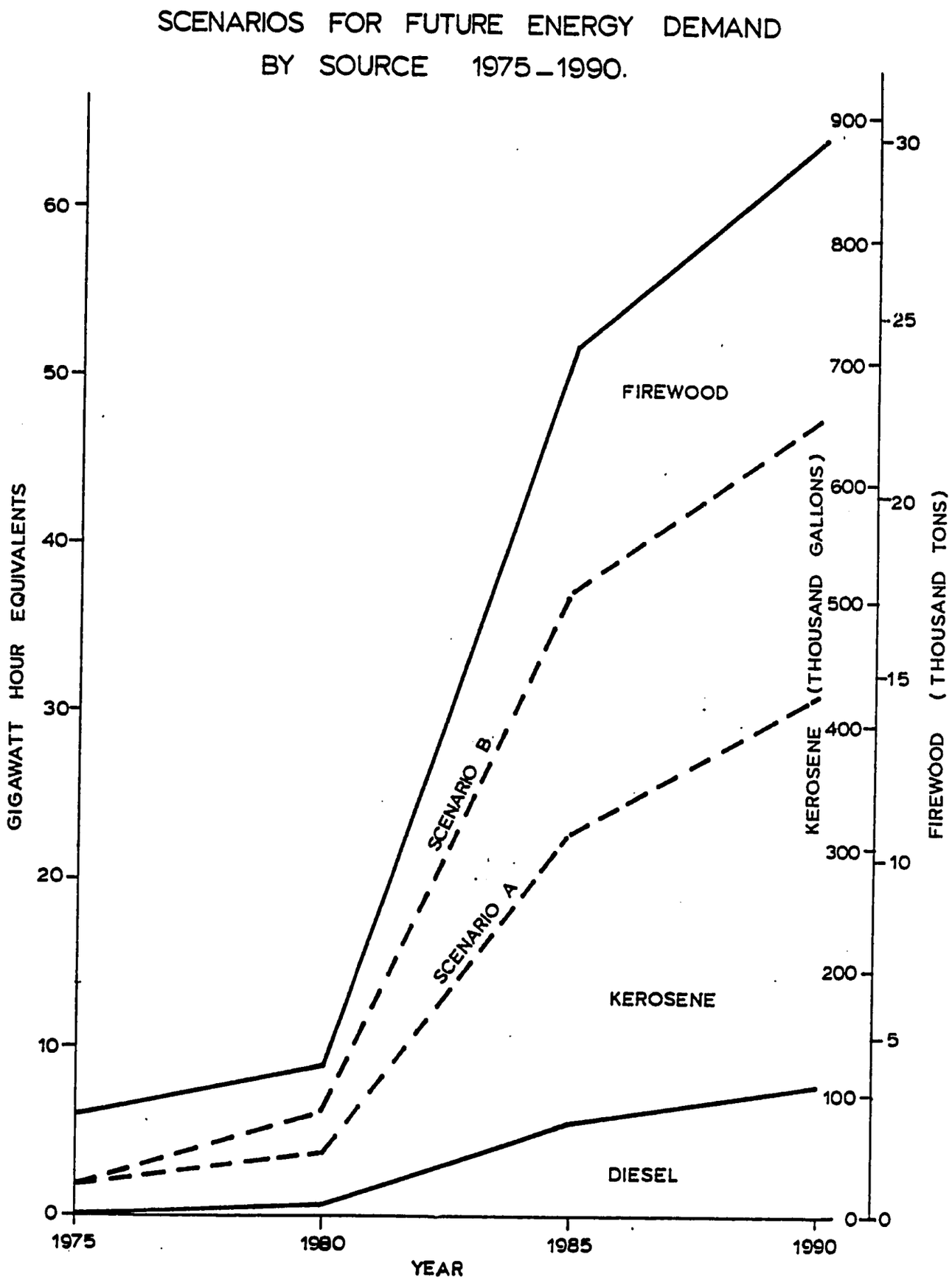

SCENARIOS FOR FUTURE ENERGY DEMAND
BY SOURCE 1975_1990.
GIGAWATT HOUR EQUIVALENTS
KEROSENE (THOUSAND GALLONS)
FIREWOOD (THOUSAND TONS)
FIREWOOD
KEROSENE
DIESEL
SCENARIO B
SCENARIO A
YEAR
0
10
20
30
40
50
60
100
200
300
400
500
600
700
800
900
5
15
25
1975
1980
1985
1990

FIGURE 5.1.2

Table 5.1.2

Scenarios for Future Energy Demand

Year	1975		1980		1985		1990	
Scenario	A	B	A	B	A	B	A	B
Kerosene consumption								
-cooking ('000 gallons)	-	-	-	38	-	200	-	225
-lighting('000 gallons)	9.1	9.1	23	23	130	130	200	200
Total	9.1	9.1	23	61	130	330	200	425
-boiling water ('000 gallons)	14	14	18	18	100	100	115	115
Firewood consumption								
-cooking ('000 tons)	2.5	2.5	3.1	1.4	17	6.8	20	7.8
Diesel ('000 gallons)	neg.	neg.	9.1	9.1	77	77	110	110

Scenario A: Kerosene used only for lighting; firewood used for all cooking
Scenario B: Kerosene used for lighting and half of cooking; firewood used for half of cooking requirements.

Consumption rate:
-lighting: 13 gal kerosene/lamp/year
-cooking: 71 gal kerosene/family/year for 1975
inflated 1%/year after 1975

Assumptions: lamps/family: 1975, one; 1980, 1.5; 1985,2.0; 1990, 3.0

5.1.3 Firewood and land use

The previous section presents two scenarios for the future demands the project area will make on the two principal energy resources likely to be used in the region, kerosene and firewood. Scenario A calls for the maximal use of firewood in the project area to supply all cooking needs. This scenario would require 15,000 tons of firewood per year in the project area by the year 1990.

This amount of firewood could be supplied by a plantation. The estimates of silvaculture output range from three to six tons per acre per year on a sustained yield basis. In the dry zone of Sri Lanka it is not likely that maximum yield could be realized as growth does not occur year round as it does in the wet zone. Thus the lower figure of three tons per acre is a more accurate estimate of the feasible yield under plantation conditions. With the maximum yield of six tons per acre some 2500 acres of land for firewood silvaculture are required; with a low yield twice this or 5000 acres are required.

This amount of acreage can be set aside in a number of ways. One large plantation could be managed to supply the entire needs of the project area or there could be a combination of smaller plots within the project area and a large plantation outside the project area. The last alternative is to supply firewood from a remote region. If one or a small number of plantations are planned, then the question of location becomes critical for two reasons. 1) the plantation needs to be as close as possible to the project area to minimize transportation costs. 2) the plantation needs to be located in an area where there are few conflicting land uses such as a nature preserve. The layout of the plantation should also conform to the following requirements for efficient operation: Proximity to road access for easy transportation of firewood to the project area, contiguous boundaries for easy and efficient management as well as for the protection of firewood from theft, and location in an area where expansion is possible as future needs arise.

Reference to the map in figure 3.1.1 shows that there are few areas to the south or east of the project area that fit the above criteria; however, areas north and west might serve. There are a number of teak plantations (not shown on the map) in the area now that might be converted as they are harvested.

The economic analysis of the location and operation of firewood plantations can be altered by a number of factors. One is the consideration of multipurpose plantations. This is the traditional approach of the Forestry Department whose plantations for teak are used for construction, cabinetwood and firewood. However, the firewood yields for a multipurpose plantation are manyfold less than from a plantation designed for the exclusive purpose of firewood production.

The price of petroleum based fuel, either diesel, kerosene, or gasoline, is very likely to increase dramatically in the next ten to fifteen years. If this happens the competitive price of firewood will also increase serving to raise the profit margin. However at the same time the transportation cost, especially over long distances, will increase. Before any final decision about the location and size of plantations is made, a careful analysis should be made of the range of possible economics of operation.

In the Rambukkan Oya area are a number of highland areas (see figure 3.1.1) which are covered with scrub jungle except for an occasional rock outcrop. If energy needs of settlers are not planned for, then it is very likely that these highland areas will become a ready source of firewood. If extensive cutting occurs, then the resulting erosion could lead to heavy siltation of the three reservoirs.

5.2 Stream Flows - Effect of the Project on the Downstream Flow Regime

The Rambukkan Oya project will store the wet season runoff of the three rivers which are tributary to the Mundeni Aru. The stored water will be used for irrigation of paddy and upland crops during both the maha and yala seasons. All the drainage from the irrigated area will be returned ultimately to the Mundeni Aru. The following is a list of four major effects which will result from the alteration of the Mundeni Aru flow imposed by the construction of three storage tanks.

1) A decrease in the flow of the river during the wet season. The volume of flood water in the Mundeni Aru will be decreased as the storage capacity of the reservoirs are filled. The three project tanks are designed to contain a large portion of the average wet season runoff. Nonetheless, as there still will be years in which flood waters beyond the tanks' capacity will be discharged down the Mundeni Aru drainage, the stream side vegetation below the three dams should be preserved as much as possible. The vegetation stabilizes the river banks during periods of high water as well as protects project area inhabitants.

2) An increase in the dry season flow. The flow rates of the three tributaries approach zero during most dry seasons and indeed have been known to go dry altogether. With drainage from lands being irrigated year-round the Mundeni Aru will have a year-round flow.

3) A decrease in the overall yearly flow. As evapotranspiration exceeds rainfall for at least seven months of the year, the storage of water will increase the total evapotranspiration both from the tanks and from the irrigated areas. Thus the total yearly stream flow will be substantially less than before.

4) The annual salt/fresh water cycle of Batticaloa lagoon will be altered. The Mundeni Aru is one of the two major watersheds draining into the northern arm of Batticaloa lagoon through an anastomosing network of tidal waterways. This brackish lagoon undergoes a yearly cycle, becoming more fresh during the wet season and more salty during the dry season. As the net yearly flow from the Mundeni Aru is decreased so is the amplitude of the annual salinity change. If this alteration is drastic, it could affect the well developed fishery, primarily for shrimp, that is carried on in the lagoon.

5.3 Agricultural Runoff

The Rambukkan Oya project will bring about a number of changes in the water regime of the project area. Many of these changes relating to the increased volume of water are discussed in section 4.3; however, a special problem is presented by runoff water from agricultural lands. This drainage will contain agrochemicals in new variety and in greater quantity than previously found in the area. These agrochemicals have potential impact on: 1) the biota of receiving waters as well as animals making use of those waters. These impacts are discussed in section 4.4. 2) the public health. This impact is discussed in section 4.1.4. This section discusses the changes in runoff waters and the steps necessary to monitor potential problems.

5.3.1 Receiving waters

The waters receiving the input of agricultural runoff are the field drainage ways and the Mundeni Aru, which drains the entire project, and the ocean. Water quality in Sri Lanka is poorly studied. Only in urban and industrial areas where tanks and streams receive quantities of sewage or pollution have tank waters been regularly monitored. In tanks in agricultural areas most data collection has been concerned with water quality parameters that are important for agricultural use. Table 5.3.1 gives water quality parameters for major tanks in Sri Lanka that are used primarily for irrigation.

The following three sections describe the changes in runoff expected as a result of the increased use of agrochemicals in the project area. The last of these sections proposes an outline of a monitoring program to assay these changes as well as changes thereby induced in tank and drainage water ways. This monitoring program will aid the efforts to increase the productivity of tank fisheries as well as allow monitoring of wasteful or careless use of agrochemicals in the project area.

5.3.2 Fertilizer use

The Rambukkan Oya project represents a shift from traditional agriculture with a low level of input to capital intensive agriculture with high inputs of agrochemicals, water and labor. The use of fertilizers will become more frequent and heavier.

It is clear that even without the project that there exists a trend toward increased use of fertilizer. This trend follows from the increased use of high yield varieties of rice and other crops which are more responsive to fertilizers than previous varieties. Since these new varieties, in most areas, will give higher yields even without fertilizer input, there has been a widespread shift to their cultivation even when the farmer has very little money to invest in agrochemicals. With the widespread establishment of these varieties the use of fertilizer soon follows as the farmer becomes more sophisticated and more prosperous. There has been and will continue to be an

Table 5.3.1

Laboratory Analyses of Water Samples

Tank	Conduct umho/cm	Na Meq/l	Ca Meq/l	Mg Meq/l	Ca+Mg Meq/l	SAR
Kalawewa	436	1.5	1.4	1.3	2.7	1.4
Huruluwewa	367	1.2	1.2	1.2	2.4	1.1
Nachchaduwa	344	1.2	1.1	1.0	2.1	1.3
Nuwerawewa	506	1.8	1.6	1.6	3.2	1.5
Maha Willachchiya	508	2.1	1.3	1.5	2.8	1.9
Giant's Tank	665	2.9	1.5	2.4	3.9	2.1
Pavatkulam	555	2.3	1.3	1.9	3.2	1.9
Vavunikulam	237	0.8	0.7	0.7	1.4	0.9
Iranamadu	224	0.9	0.7	0.7	1.4	1.0
Kantalai	218	0.4	0.9	0.8	1.7	0.4
Minneriya	240	0.4	1.2	1.1	2.3	0.3
Parakrama Samudra	221	0.4	1.1	0.8	1.9	0.4
Unnichchai	76	0.2	0.2	0.1	0.3	0.3
Rukam	78	0.3	0.2	0.2	0.4	0.5
Senanayaka Samudra	80	0.2	0.3	0.3	0.6	0.3

evolution of agricultural practices toward the greater use of fertilizer and other agrochemicals. Even in traditional purana villages agrochemicals are beginning to be used.

The limit of fertilizer use is determined by its economics which are subject to international market price variations and government price control. At least for the foreseeable future, fertilizer use in the project area, as discussed in Appendix D, will increase manyfold. However, while it is also certain that the amount of fertilizer contained in agricultural runoff will increase, the exact quantities depend on four factors:

1) The form of application.

2) The solubility of the chemicals used.

3) The time of application, especially relative to hard erosive rains which can wash the fertilizer away before it can be absorbed into the crop plants.

4) The amount of fertilizer.

It is the aim of efficient agricultural management to minimize the amount of fertilizer lost to useful purpose in runoff; however, in the project area farmers have limited experience with the application of fertilizer in the amount required. Undoubtedly there will be both errors by individual farmers leading to high, transient runoff loss as well as errors from inexperience of extension workers. The first few years of the project will probably see more fertilizer runoff than later years as experience is gained in more effective application techniques.

There have been no studies of the amount of nitrogen contained in agricultural runoff in Sri Lanka. The only figures come from temperate zone experience. In North America agricultural runoff contains from 2-10 kg of nitrogen per hectare per year. These figures are more than twice the content of runoff from forested land. The appropriateness of this estimate to conditions in Sri Lanka is highly questionable; nonetheless, the runoff will contain significant amounts of nitrogen in forms that are readily assimilated by organisms in receiving waters.

The chemistry of the soil in the project is such that phosphates are rapidly fixed (see section 4.4.3) and thus little if any soluble phosphates are likely to be found in runoff. However, it is possible that significant quantities of phosphate will find its way into receiving waters through erosion of soil containing bound phosphate. Control of phosphate runoff is therefore largely a control of erosion and siltation.

5.3.3 Pesticide and weedicide use

The use of pesticides and weedicides in the project area will become more intense and more widespread as a result of implementation of the project scheme. There are four principal reasons why there will be an increase in the use of these agrochemicals:

1) More land area will be brought under cultivation for a greater portion of the year.

2) Many of the new high yielding varieties of rice as well as other crops are more susceptible to the attack of various pests, either insect or disease. For example the new shorter, more densely leaved varieties of rice provide a more humid and more sheltered microclimate that is more suitable for the breeding of some rice pests. Further, widespread planting of the same variety of a crop plant encourages the rapid spread of a pest or disease that is particularly adept at preying on that variety.

3) There will be a longer breeding season available to pests with the institution of a two crop system. In the dry zone of Sri Lanka many insects suffer a dieback during the dry season. With the institution of year round irrigation the annual dry season will have less effect on the population of these pests and thus greater levels of pesticide application will be required.

4) There is a need to protect the greater initial capital investment required for intensive agriculture. A farmer who has made a substantial investment in cultivation on one crop will be reluctant to see that investment destroyed by pests. In the past farmers were more likely to cultivate a variety of crops in a variety of situations so that the likelihood of complete failure from pest attack was minimized.

While many of the pesticides used in Sri Lanka have residues and breakdown products with significant environmental effects, the primary concern in the project area revolves around compounds which are toxic to humans through contact poisoning. A secondary concern exists for those compounds which are toxic to fish. Those compounds which by themselves or through their breakdown products are capable of causing long term environmental effects are of less concern to project planners. Nonetheless there has been a tendency to use less of chlorinated hydrocarbons and more of organophosphates and carbomate pesticides. Table 5.3.3 lists all of the agrochemicals that were imported into Sri Lanka in 1975. The great variety of these chemicals compounds the problems of project planners and managers who are concerned about the proper use and proper safety precautions in field applications.

The environmental effects of pesticides and weedicides are many and various ranging from acute poisoning of non target animals to the concentration of long lasting residues up through the food chain and ultimately affecting the reproductive success of higher order predators. Other effects of wide scale, long term pesticide use are alteration of the indwelling fauna in soils, including invertebrates other than insects. Fish kills and the alteration of aquatic communities are common features of contamination of receiving waters with runoff from agricultural lands on which pesticides are used. Low level long term human consumption possibly also has effects on health although there is much debate on this subject. Undoubtedly all of these effects will occur in the project area either on an acute or chronic basis. Already there is evidence of some of these effects. Table 5.3.4

shows the result of examination of market vegetables in 1973. Although most of the residues were well within accepted limits, their presence at all indicates a growing problem which can only be exacerbated by the implementation of intensive agricultural projects such as the Rambukkan Oya scheme.

As new varieties and quantities of pesticides are introduced into the environment of the project area a monitoring program needs to be established. The primary needs to which this program should be addressed are public health and the environmental consequences of pesticide use. The relevant data which have been collected in temperate zones need confirmation in tropical areas where factors such as higher rainfall and more intense sunlight alter breakdown chemistry and transport through the environment.

5.3.4 Monitoring program

A monitoring program needs to be instituted to follow the changes of various environmental systems resulting from a sudden increase in the amount of pesticide and fertilizer use. These systems include the soil, water ways, assemblages of plants and animals, and lastly human health. The following four phases of the monitoring program are proposed as an outline of components sufficient to answer the above needs.

1) Environmental monitoring. The presence and concentration of pesticides and nutrients in receiving waters should be monitored in a systematic fashion. Drainage ways and the ultimate recipient of all agricultural runoff in the project area, the Mundeni Aru should be monitored. In addition residues and breakdown products of pesticides and herbicides should be looked for in soil that has been exposed to these agrochemicals. Similarly pesticide residues on foodstuffs exported from the project area should also be checked.

2) Record keeping. The quantities and varieties of agrochemicals applied within the project area should be accounted for. It is expected that with the greater amount of record keeping by the farmer and extension workers that it should be possible to assemble accurate figures of the use of agrochemicals.

3) Safety program. An effective safety program should have four phases: 1) uniform labelling of all poisonous chemicals; 2) institution of and instruction in safety procedures; 3) periodic inspection of the actual use of poisonous chemicals; 4) ability to respond quickly to investigate incidents of poisoning.

4) Research on pesticides in the environment. Agricultural research stations should expand their current research programs on the use of pesticides and on the occurrence of various breakdown pathways under field conditions. Much of this work is already under way at various agricultural research stations; however, the research topics being pursued need to be broadened to include these environmental questions.

Table 5.3.3

Agrochemicals Imported in 1975

Insecticides

Name	Metric Tons	Liters
Aldrin 25% EC	-	2,389
Aldrin Dust 2.5%	12½	-
BHC Dust 10%	250	-
BHC 20% EC	-	2,955
BPMC 50% EC	-	17,616
BHC 6% Granules	10½	-
Carbaryl 85% WP	10	-
Carbofuran 3% Granules	100	-
Carbophenothion 20% EC	-	5,683
Chlorfenvinphos 24% EC	-	2,273
Chlordane 40%	-	568
Chlorpyriphos 40% EC	-	11,365
Dizinon 10% Granules	14	-
Diemethoate 40% EC	-	8,128
Dometon-S-Methyl	-	2,614
Endosuphan 35% EC	-	12,956
Fenthion 50% EC	-	15,911
Formothion 25% EC	-	1,705
Methamidophos 60% EC	-	11,501
Methomyl 90% WP	5	-
Methomyl 18%EC	-	14,775
Isoprocarb 50% WP	3½	-
Monocrotophos EC 60%	-	24,094
MPMC 30% EC	-	1,023
Bufencarb 20% EC	-	4,660
Omethoate 50% EC	-	4,546
Parathion 50% EC	-	11,479
Phenthoate 50% EC	-	227
Pirimiphos Methyl 50% EC	-	8,810
Primiphos Methyl 2% Dust	5	-
Phoxin 50% EC	-	1,137
Propoxur 3% Granules	25	-
Propoxur 20% EC	-	6,819
Quinalphos 20% EC	-	3,410
Sulphur WP 80%	14	-
Trichlorphon 50% EC	-	5,683
Persthprinw 25 % EC	-	1,137
Surmiedin 25% EC	-	227

Fumigants

D.D. Soil Fumigant	-	11,365
Methyl Bromide	12½	-

Fungicides

Name	Metric Tons	Liters
Antimucin	-	455
Benemyc 50% WP	3	-
Brunolium Plantarium	-	227
Candarsan	-	227
Captan 50%	4½	-
Copper Oxychloride 50% WP	19	-
Cuprous Oxide 50% WP	33	-
Captafol 80% WP	4	-
Captafol 4F	-	1,818
Chlorothalonil 75% WP	6	-
Complex-Dithiocarbamate	11½	-
Folpet 50% EC	¼	-
Flyomal	-	455
Fomao	-	455
Ediphenphos 50% EC	-	1,137
Kasugamycin 2%	-	227
Maneb 80% WP	11½	-
Mancozeb 75% WP	11½	-
Mema 6% EC	-	227
Memol	¼	-
Propineb 70% WP	12½	-
RMA 1% Dust	5	-
Sulphur Dust 80% or above Dust	100	-
Thiram 80% WP	¼	-
Zineb 80%	1	-

Herbicides

Alachlor 40%	-	3,410
Pipersphos & Dimuthametryn 3.3% Granules	¼	-
Benthiocarb 6% Granules	12½	-
Butachlor 5% Granules	12½	-
Dalapon 85%	8	-
Diuron 80%	4¼	-
Glyophosate 35%	-	2,273
Linuron 50%	¼	-
MCPA 3% Granules	5	-
MCPA Solution containing 40% Active Na or K Salt	-	116,832
Metribuzin 70WP	3	-
Methbenzthiazuron 70% WP	3	-
MSMA 70% Solution	10	-
Nitralin 75% WP	33/4	-
Paraquat EC containing 200-240 grams A.I./Liter	-	72,963

Herbicides

Name	Metric Tons	Liters
Propanil EC containing 40% EC	-	59,098
Sodium Chlorate 40% WP	5	-
Simazene 50% WP	1	-
2,4,D 50% WP	-	909
2,4 5-T 50% EC	-	68
2,4 Dioc 3% Granules	2½	-
2,4 D Sodium Salt	4½	-

Acaricides

Dioofol MF 42% EC	-	4,546

Others

Coumaris 1% (Compound)	3½	-
Chlorophacinone 0.25%	-	205
Coumatetralyl 0.75%	2½	-
Metaldehyde Powder or Pellets	5	-
Aluminum Dichloride Tablets	140,000	-
Sufaetant	-	2,273

Table 5.3.4

Chlorinated Hydrocarbon Residues Found on Market Vegetables in 1975
Maximum level found (ppm)

	DDT	Endrin	Dieldrin	Aldrin
Carrot	0.14	0.02	nf	0.07
Beetroot	0.13	0.01	0.02	0.09
Cabbage	0.29	0.34	nf	0.23
Bean	0.01	nf	nf	nf
Leeks	0.02	nf	nf	0.06
Knolkhol	0.23	nf	nf	0.12
Brinjal	2.40	0.41	0.01	0.04
Potato	0.05	nf	nf	nf
Green chilli	0.08	nf	nf	0.01
Dried chilli	0.21	nf	nf	0.02
Ripe chilli	1.30	nf	nf	0.01
Onion	0.40	0.03	-	0.05
Cigarette tobacco	0.25	nf	nf	0.01

6.0 COMPARISON OF ALTERNATIVES

The Rambukkan Oya project is the first extensive and coordinated development in the region. From Senanayake Samudra to the south to the Mahaweli development areas to the north a distance of over fifty miles, the region is without a major irrigation system. The Rambukkan Oya development will affect this region both as a pattern for future development of other irrigation schemes and as a stimulus for change in the remaining areas of the region. Project alternatives therefore must be considered in the context of regional environmental change.

There are at least two other large scale development projects contemplated in the same region. Both are of a similar area and complexity as the Rambukkan Oya project. One is in the Maduru Oya drainage to the west and north of the project area, and the other is in the Magalavatavan Aru drainage to the east of the project area. With full development of these two rivers the acreage under year-round irrigation in the region would approximately double over that contemplated for the Rambukkan Oya project. The pattern for development of agriculture and infrastructure that is set by the Rambukkan Oya project will likely be followed in these other projects.

Development of the Rambukkan Oya will influence the region by the creation of an expanded local market for regional resources such as firewood, draft animals, and food such as animal protein, not produced in the project area. The introduction of new techniques and inputs for agriculture as well as the presence of agricultural extension services will indirectly affect indigenous agriculture. The need to supply protein to the project area will stimulate the local fishing industry in the tanks created for the project as well as increase the need for grazing lands for cattle. The need for draft animals will increase both for cultivation and for transportation. The need for firewood will increase as well as the need for transportation to carry it a greater distance than before. Many of these regional changes such as the need for firewood or for grazing lands for animals will influence the pattern of land use in the areas surrounding the project area.

As the future of this entire region is dependent upon the Rambukkan Oya development, the planning and execution of the Rambukkan Oya project becomes an important tool that can be used to shape and stimulate regional development, if, and only if, the potential regional influences are appreciated in advance. If these demands on the region are planned for in an overall regional development plan with careful attention paid to the pattern of land use, then the regional impact of the project can be accommodated.

One focus for regional planning should be the interface between the project and the agricultural activities of the surrounding region, which are mainly chena farming. How will the project area infrastructure be responsive to the needs of the surrounding region as they are affected by project development? Chena cultivation in the surrounding region is stable at present; however, a significant increase in population density could shorten the present 20 year chena cycle so that the stable equilibrium upon which continued productivity is dependent would be threatened. Can the project area agricultural extension infrastructure respond to the needs of chena farmers in the surrounding area so that the equilibrium is preserved in the face of increasing demands on the system?

To aid chena farmers may only be possible if an effective program of agricultural research into the chena cycle is carried out. Questions which need to be asked include: What are the alternatives for increasing yield without decreasing the period of the chena rotation cycle? What is the utility of pesticides and weedicides in chena farming? And, what are viable alternative land uses in chena areas?

Because of the dominance of chena farming in the region, changes in the chena are potentially more influential on the region's environment than changes in the project area itself. Since regional water resources are limited, the acreage that can be put under irrigation from stored water is strictly limited. Nonetheless, the project by its intensive nature will become the regional focus and will be a natural point of dissemination of change in rain-fed agriculture.

There are only two alternatives to the development of virgin lands for the implementation of the national priority for the increase of agricultural productivity:

1) The introduction of improved technology, higher inputs, and more extension service to lands already under intensive cultivation.

2) The introduction of year-round cropping with improved water control in lands that are already under irrigation. This implies more effective use of, and greater storage capacity of the available water resources. Of these three alternatives, only the development of virgin lands allows for the replacement of significant numbers of people from areas of high population density to areas of low population density. All of these alternatives involve substantial environmental change.

The three alternatives for the project area are: 1) the project as presently proposed, 2) the same project in another location, 3) another project different in design, and 4) the no project alternative. The second of these alternatives is apparently not feasible from a water-management point of view as the location of storage areas and command areas could not be moved more than a few miles from the designed location.

No Project Alternative

The no project alternative does not rule out regional development as there are other ways in which the region's economy and productivity could be stimulated. It may be possible to increase the yields from chena farming and rain-fed agriculture by the introduction of extension services and limited inputs of agrochemicals if a research program on productivity in chena farming is implemented. However, without a focal point for change the region will continue with a very slow rate of change for some time. Unless an effective program for improvement of rain-fed cultivation is introduced into the area, there will be a very gradual deterioration of yields as the population increases. The long term environmental effects of the no project alternative are difficult to assess in the context of the dry zone of Sri Lanka as no program for the improvement of chena farming has been developed as yet in Sri Lanka.

Less Dense Development

The development of the Rambukkan Oya project is not like a seed crystal in a saturated solution that precipitates regional change. Rather it is more like an ink drop in water that will affect the region inversely with distance from the project area. This diffuse effect will be centered around the project area itself. Therefore, the primary effect of a less dense option for development will be to bring about change in a wider area to a less intensive degree. Presumably, it is technically feasible to develop the Rambukkan Oya area by placing a string of smaller storage tanks up and down the length of the river and producing strings of irrigable areas corresponding to those tanks. The following differences in environmental effects can be reasonably predicted on the basis of this spacial arrangement.

A less dense option would improve the distribution of infrastructure throughout the region. For example, health care would be more accessible to the regional population with a less dense option than it would be with the project option. Conversely, the provision of a more widespread infrastructure for health care, agricultural extension service and other services would be more expensive and more difficult to coordinate on a regional basis.

Alternative for less dense development would not make the same degree of an irreversible committment of land resources as would the project, thus a number of planning options for future land use are retained.

The alternatives would be the same in terms of the impact of an increased use of agrochemicals within the region. However, with a less dense option the downstream tanks would receive agrochemicals in the runoff from areas of cultivation upstream. This would not be true in the project option. Similarly, there would be a greater likelihood of siltation of the downstream tanks with the less dense option. The less dense option would most likely have a greater effect on wildlife, particularly on elephants, as it would necessarily more widely spread development that is incompatible with large mammals.

In summary, the extent to which the project or an alternative will affect the regional environment depends upon the care with which development is coordinated with a regional plan. The limiting resource in the region is water and the amount of land that can be brought under intensive year-round cultivation is therefore also limited. The choice of location for this land is probably less important for environmental considerations than the stimulus that the project development will present to the region. This stimulus is guided by the interface between the project and the surrounding area that is provided by the economics of local markets and the accessibility and influence of project infrastructure on regional inhabitants.

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S. Maheswaran	Director of Irrigation
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W.R.A. Perera	Conservator of Forests
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Addenda

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The cover illustration is a woodcut of a Capsicum plant reproduced from:

> Theatrum Botanicum: The Theater of Plants or, an Herball of a Large Extent. Collected by John Parkinson, London, Printed by T. Cotes, 1640.

This English herbal gives the following description of the pepper's properties:

> "... the whole huske but especially the seede, being of so hot and fiery a taste, that it enflameth and burneth the mouth and throate, for a long time after it is chewed, almost ready to choake one, that carelessly taketh much at a time thereof:..."

The copy used for the illustration is in the Pre-Linnean Collection of the Library of The Academy of Natural Sciences, Philadelphia, Pennsylvania.