APPENDIX - S

Environmental Assessment

APPENDIX - S ENVIRONMENT ASSESSMENT

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APPENDIX - S ENVIRONMENT ASSESSMENT

Chapter 1 INTRODUCTION

In post-independent Sri Lanka, a great effort has been made to increase agricultural production and make the country self-sufficient in food. All five-year plans have emphasised this aspect. Among the strategies that have been proposed and implemented over the years, has been the development of irrigation. In the past 50 years, both new irrigation schemes and rehabilitation of ancient structures have been undertaken; mostly in the dry zone of the country.

The Six-Year Development Programme of the government, 1999-2004, in the section on the irrigation sub-sector, emphasises increasing agricultural productivity by using irrigation water efficiently, integrating resource management, assessing water resource development potential, commercialising small farm agricultural production and handing over the irrigation infrastructure management to its beneficiaries. This project, "Study for the potential realisation of irrigated agriculture in the dry and intermediate zones of Sri Lanka," will attempt to satisfy part of the above objectives in specific geographical locations, through various sectoral strategies, using local raw materials and manpower to the fullest.

From historical times the tank-village ecological system has been the basis for land use in much of the dry zone which has an undulating to rolling landscape with low hills and rock exposures. The lowland, along with the use of the upland, had been an integral system of farming and land use. A characteristic feature is the linking together of a number of small tanks in a cascade, so that the tank at the lower elevation collects the runoff from the catchment and the return irrigation flows of the paddy area above. Paddy cultivation in a particular season is dependent on the rainfall and runoff into the tanks making up the cascade. Unlike in the olden times, tank catchments are often cultivated with seasonal crops. This has caused tank sedimentation and reduced its capacity to provide adequate water for a *yala* season cultivation.

Aspects of natural resource exploitation have contributed to present day environmental ill-effects. One such is the reduction in the tree cover. Another is the inadequate land use planning concerns during the creation of large irrigation schemes and this has brought about varied use-conflicts seen at the present time.

The overall project goals are to improve the agricultural productivity of the rural farm households and to attain the sustainable development of regional agriculture. The project purpose is to increase farmer income and strengthen farmer organisations to include multi-functions.

Chapter 2 PRESENT BIOPHYSICAL CONDITIONS OF PRIORITY SCHEMES

2.1 Climate

The rainfall is distinctly seasonal with the bulk of it falling during October to February. The rest of the months other than March/April, are quite dry, particularly from May to September, when the south-west monsoon, after depositing its rain in the south-western parts of the island, blows over the dry zone as a dry wind, referred to as the *kachan*.

Figure S 2.1 shows the mean annual rainfall of the country over a 30-year period, 1961-1990. Crop production is possible during this period only under irrigation. Given the availability of water, higher yields can be obtained during this dry season, than during the wet season because other growing conditions are more favourable. The inter-monsoonal periods in October/November and March/April, also bring high falls over the entire island. These rains are convectional and are of high intensity and short duration, occurring during the latter part of the day. During October/November there is the possibility of cyclonic activity being experienced, with frequent flooding.

Generally, climatic data maintained at the Field Crops Research and Development Centre at Maha Illuppallama (MI) can be taken as relevant for the Nachchaduwa Tank area. The mean annual rainfall for the priority areas is 1,000-1,500 mm. Rainfall data from MI show a long-term annual average of 1,421 mm. The main source of water to the tanks is rainfall runoff and paddy field drainage.

The mean annual temperature over the Priority areas is 25ºC to 27ºC and the rainy season brings about a drop in temperature. There is some variation however, in daily temperature fluctuations.

Relative humidity remains high throughout the year, from a low 60 in March to a high 90 in December. Evaporation in the Mahananneriya area is about 5 mm per day.

Wind is an important climatic factor because of its influence on evaporation from the water bodies and soil surface, and on transpiration from plants. Wind speeds of between 5 and 15 km/hour have been recorded at MI, the highest being for the month of July.

2.2 Agro-ecological Region

All the priority schemes fall within the DL_1 agro-ecological region associated with the commonly referred to land area, the dry zone (Figure S 2.2). The 75 %

probability of rainfall is 600-700 mm. Water during the north-east monsoon is collected in tanks for a dry season cultivation.

2.3 Geology and Soils

All priority schemes have in common highly crystalline, non-fossiliferous rocks of Precambrian age. Of the three groups that make up these rocks, those of the Vijayan complex are predominant and are a varied group of gneisses, granites and mixtures of the two (Figure S 2.3).

Erosional remnants, also called inselbergs, in the form of rocks, stand out prominently at certain places. These have withstood long periods of erosion, as the major constituent is quartz, which is one of the most indestructible of rock forming minerals. There are also a large number of rocky mounds called turtlebacks and these rocks often form convenient abutments to the small village tanks.

The weathered overburden over crystalline rocks is generally deep but occurs in patches. Water is retained in this zone and is utilised through dug wells that serve the needs of large numbers of people and domestic animals. Some do however, dry up in the long dry season. The introduction of the agrowell concept in recent times, to obtain the water in this zone by power pumps, and its wide geographical distribution, has brought about benefits as well as problems to the farmers.

The Priority schemes are located on the undulating dry zone landscape where the great soil group, Reddish-brown Earths (RBE), predominate. These soils occupy the crests, and the well drained upper and middle slopes and are susceptible to erosion during high intensity rain storms. The lower slopes are imperfectly drained and along with the upper parts of the valley bottoms, are occupied by medium to heavy textured Low Humic Gley (LHG) soils where paddy is widely grown. On the valley floor, along the natural drainage line, is a narrow strip of alluvial soil (Figure S 2.4).

The Reddish-Brown Earths – Low Humic Gley soil association occupies the largest land area of all soil groups. The RBE soils are derived from intermediate and basic Precambrian rocks. The soil structure is weak to moderate. The soils are hard when dry, friable when moist and sticky when wet. The water-holding capacity is low.

The LHG soils, on account of the location in the catena, have a periodically high groundwater table. Gleying is common throughout the profile. The surface soil is a sandy loam or a sandy clay loam beneath which is a sandy clay or clay horizon.

The soils are hard when dry and sticky when wet. The water holding capacity is good because of the high clay content. Alluvial soils are found at the valley bottoms.

Ground water from dug wells is a source of drinking water to large sections of the rural population. Certain areas of the Anuradhapura and Kurunegala Districts have high fluoride levels and in such areas health problems, can arise particularly in children, by drinking such water, unless with adequate precaution.

2.4 Vegetation

The usual climax natural vegetation type in the DL_1 agroecological region, where the Priority schemes are located, is the dry mixed evergreen type. However, nowhere is it extensively found, having been much disturbed over long periods of time for agriculture, timber extraction and settlement. In a typical forest of this type, three canopy levels are evident. The tallest canopy level grows to about 20 m and shows the presence of emergent species. The middle level grows to about 10 m and the under-storey is about 5 m in height.

Figure S 2.5 is a recent vegetation status diagram around Nachchaduwa Tank, where considerable extents of forest had been removed by people and converted into home gardens. In more recent times, the implementation of the Mahaweli Project has been a major cause of deforestation.

Common tree species reported in the disturbed locations are Drypetes sepiara (S: *weera*), Azadirachta indica, neem (S: *kohomba*), Manilkara hexandra (S: *palu*), Diospyros ebenum, ebony (S: *kaluwara*), Chloroxylon swietenia, satinwood (S: *burutha*) and Pterospermum canescens (S: *welanga*).

Along certain river banks patches of riverine vegetation are found where the species composition is somewhat different to that of the dry mixed evergreen forest. This is because of the favourable moist soil conditions throughout the year. Some of the species found growing on the river banks are Berya cordifolia (S: *halmilla*); Terminalia arjuna (S: *kumbuk*) and Tamarindus indicus, tamarind (S: *siyabala*). Riverine forests have useful functions in that river banks are protected from soil erosion, refuges are provided to wildlife, wind protection (windbreak) effects are available for nearby cultivated crops and possible growth of even some of the characteristic wet zone tree species due to advantageous soil moisture conditions.

A variety of plant species inhabit water bodies and some of these have assumed pest proportions. Among the more common species are Nymphaea stellata, water lily (S: *manel*), Nymphaea lotus, lotus (S: *nelum*) and Aponogeton crispus.

Species of grasses and sedges are also found in the interface of land and water that dries out seasonally. Of widespread occurrence is Salvinia molesta that covers many water bodies and is considered a pest.

Five endemic plant species have been reported from around the Nachchaduwa Tank in the wetland site report. These are Anisophyllea cinnamomoides (S: *welipenna*), Diospyros ebenoides (S: *kaluwara*), Memocyclon capitellatum (S: *welkaha*), Vernonia zeylanica (S: *heen bowitiya*) and Willughbhela cirrhifera (S: *kiriwel*).

The Ritigala Strict Natural Reserve (SNR), a protected area under the Fauna and Flora Protection Ordinance, from where the Malwatu Oya feeding Nachchaduwa Tank originates, has a rich plant species diversity, most of which are not found in the usual lowland habitat of the DL_1 agro-ecological zone. For this reason, Ritigala is quite unique floristically and has been the focus of attention of researchers since 1832. It is reported that the SNR has as many as 103 plant species, usually found in the wet zone.

Forest Department data indicate that there are about 480 ha of natural forest in the Tirappane DS Division where the Periyakulama Priority scheme is located. There are also some plantation forests of mixed species and monocultures undertaken by the Department in the last two decades.

The natural vegetation of the Mi Oya basin where the medium scheme of Mahananneriya and the Mahananneriya minor scheme group (cascade) scheme are located, is also much disturbed. Records indicate that only 180 ha of natural forest remain in the Galgamuwa DS Division which is the administrative area for the tank locations. There are however, varying extents of forest plantations of Tectona grandis, teak (S: thekka), Acacia auriculiformis, acacia and Eucalyptus species. The Sangappala teak plantation covers about 2,000 ha.

Forest plantations occupy varying extents of land, where a variety of species have been planted by the Forest Department at different times. Current policy is to seek private sector participation in reforestation. The table below shows the extents of land under forest plantations in the two districts of Anuradhapura and Kurunegala as of 1999.

Area of Forest Plantations (ha)

District	1999
Anuradhapura	5,245.9
Kurunegala	9,974.5

Source: Forest Department

The intimate relationship between forests and agriculture appeasr to be losing ground as the forest extent keeps decreasing each year. Portions of the proposed reserves also get excised regularly to be allocated to other uses, such as village expansion, by the district and provincial administrations.

2.5 Wildlife and Protected Areas

Diverse species of wild animals and wild plants, which together make up the wild biological diversity, are found in the forests, open areas, private lands and water bodies. Most animal families are represented in varying population densities, and because of mobility, are spread over in varying population densities. Many factors determine population dynamics. Plant communities are restricted in their distribution and depend on various dispersal mechanisms for enlarging the geographical spread of individual species.

Limited documentation of the wild biological diversity within the Priority areas has been carried out for purposes of specific scientific and project development uses. Reference in this report to wild species diversity presently found is by no means complete. No attempt is made either, to go into great detail, in listing and/or describing plant and animal species from available documentation, in view of the fact that only a rehabilitation of existing schemes is the project objective and no knew wildlife habitat is being converted to agricultural use.

With the gradual elimination of large extents of the of the natural vegetation for agriculture and settlement, some of the larger mammals such as Panthera pardus fusca, leopard (S: *diviya:* T*: puli*), Cervus unicolor, sambhur (S: *gona*), and Melursus ursinus inornatus, Ceylon sloth-bear (S: *walaha;* T*: karadee*) and the more mobile species of other animal families have been pushed into neighbouring high forests and are not usually come across in the day to day life of a villager.

However, Elephas maximus maximus, elephant; (S: *aliya/atha;* T*: yanei*) that has lost much of its traditional habitat, has chosen to remain in its familiar homeland and fight for its rights! The situation of the man-elephant problem became worse with the implementation of the Mahaweli Project in the 1970s and 80s. The elephant has also been pocketed among cultivated land and settlements in certain parts, around the Priority schemes.

Given this desperate situation, the elephant is in the habit of making regular attacks on crops, property and humans. Farmers are known to have caused injury to animals by using nail boards, wire nooses and by electrocuting. Continuous attack by humans has made some animals very dangerous and these animals are referred to as “rogues.”

Common to most areas are the large mammals such as Sus scrofa, wild boar (S: *wal oora*), Cervus axis, spotted deer (S: *muva*), Macaca sinica, toque monkey (S: *rilawa*), Presbytis entellus, grey langur (S: *wandura*) and Ratufa macroura, giant squirrel (S: *dandu lena*). The toque monkey is endemic. These species are also pests of agricultural produce. Reportedly, the threatened mammal species are the elephant, the leopard and Tragulus meminna, mouse-deer (S: *meeminna;* T*: sarrugu-mann*).

The smaller mammals, reptiles, amphibians and also birds and insects, are common outside forested areas and among habitations. The tanks support a variety of water birds, and also a variety of indigenous and introduced fish species, some of which contribute to the inland fishery.

An endemic crustacean, Cardinia fernandoi, has been reported from the Nachchaduwa Tank. Likewise, two endemic butterflies, Danaus similis exprompta, blue glassy tiger and Euploea core asela, common Indian crow, are also reported from the area of Nachchaduwa. Among the faunal species, some have been identified as threatened, eg. Testudo elegans, star tortoise (S: *tharuka ibba*) and Crocodylus palustris, marsh crocodile (S: *hela kimbula*). A single animal was observed in the Periyakulama Tank.

A large variety of bird species are found in and around the Priority area tanks, believed by some to be nearly 150 species. They include migrant species as well, from Central and Northern Asia, seeking the favourable local conditions during the *maha* season, thereby taking refuge during the northern winter. Two endemic bird species are reported in the Nachchaduwa area; Gallus lafayettii, jungle fowl (S: *wali kukula*), and Pellorneum fuscocapillum fuscocapillum, brown-capped babbler (S: *mudun bora demalichcha*).

Among the animal species reported from the Mi Oya basin, and very likely to be present in the Priority scheme areas, are six endemic mammal species. The endemic species are Crocidura miya, long-tailed shrew (S: *dikwaliga hikmeeya*), Sunucus zeylanicus, jungle shrew (S: *vana hikmeeya*), Macaca sinica, toque monkey (S: *rilawa*), Trachypithecus senex, purple-faced leaf monkey (S: *kalu wandura*), Paradoxurus zeylonensis, golden palm civet (S: *ran hothambaya*) and Vandeleuria nolthenii, Sri Lanka long-tailed tree mouse (S: *kos-eta meeya*). There are a number of threatened species.

There are also reported five bird species, namely, Pycnonotus melanicterus, black-capped bulbul, Pellorneum fuscocapillum, brown-capped babbler (S: *mudun-bora demalichcha*), Ocyceros gingalensis, Sri Lanka grey hornbill (S: *alu kedaththa*), Loriculus beryllinus, Sri Lanka lorikeet, and Gallus lafayetti, Sri Lanka jungle fowl (S: *wali kukula*).

Three endemic reptiles are listed. These are Haplocercus ceylonensis, black-spined snake (S: *kurun karawala*, Dendrelaphis oliveri, Oliver's bronze back (S: *haldanda*) and Bungarus ceylonicus, Sri Lanka krait (S: *mada karawala*). Among the fish species there is one endemic: Clarius brachysoma, walking catfish (S: *magura*).

The highest points of the Nachchaduwa watershed are peaks of the Ritigala SNR, which is a small isolated range of mountains, lying to the south-east of the tank. Ritigala *kanda* (*kanda*: means mountain) bears a legendary, historical and monastic past. It has a number of caves, large boulders and steep rocky precipices. The highest peak is over 1,500 m. No wildlife protected areas are found within the Priority scheme areas.

The elephant population is neither confined to the wildlife protected areas nor to the forest reserves. They are free-ranging over a large section of the northern part of the Kurunegala and southern part of Anuradhapura Districts, travelling long distances, taking shelter during the day in isolated forest patches, and at night, foraging in cultivated upland areas and paddy land. Houses are also attacked because the animals are attracted to the harvested paddy stored in the houses. Salt is another item they are particularly fond of.

The isolated forest patches are a creation of the early Mahaweli planners who allowed these patches of natural forest to remain for the firewood and miscellaneous needs of nearby villagers. The teak plantations of the Forest Department also provide refuges.

While the elephant is the largest of the animals generally seen around, the presence of other large mammals such as the leopard, bear, sambhur and deer, has also been reported from time to time but being shy, they are usually confined to the more remote forests. There is inadequate baseline information on population dynamics.

All these animals suffer from stress due to habitat reduction. The smaller mammals, reptiles, amphibians and also birds, are common outside protected areas and among habitations. However, some of the smaller animals and bird species appear to have adapted themselves to the altered habitat with no visible reduction in population size.

2.6 Water Resources

The main source of water to the Priority schemes is rainfall; from the two monsoons (May to September and November to March), inter-monsoonal convection thundershowers (April/May and September/October) and some

depressional and cyclonic activity during October/Novenber.

Nachchaduwa Tank also benefits from Mahaweli water brought in by the Kalawewa right bank canal.

Surface water use has been practised from the early days. It is that water available in rivers, tanks and ponds. Extensive use of ground water is being used for domestic purposes from the early days and more recently for agriculture, by the construction of agrowells that use the water in the overburden and in the shallow aquifers.

2.7 Agricultural Systems

Command areas of all Priority schemes have been fully developed for agriculture at the present time. The problem is that the full agricultural potential is not being achieved due to one or more reasons. The table below shows the total average land area owned by each household within the command areas and the utilisation for agriculture of each holding, in the three classes of schemes – major, medium and minor, during *yala* 98 and *maha* 98/99. The data have been obtained from the interview survey undertaken in 1999.

The utilisation of land is highest in the major scheme class, where almost all of it is being used. The utilisation is lowest in the minor scheme class, where less than 50 percent is in use. The average for all three schemes is yet low, with nearly half under-utilised.

Due to various constraints, the chief of which is limited availability of water during the *yala* in parts of the command areas, the full potential of agricultural production is not being achieved. For example, the *yala* season paddy cultivation in the Nachchaduwa major scheme covers 62 percent of the area of possible cultivation. Of a 158 ha command area of the Mahananneriya medium scheme, no *yala* season cultivation has been possible.

The performance in the minor schemes is quite poor, with only a single hectare being cultivated in the *yala* season out of a possible 260 ha. Besides problems of water availability, there could be other causes of plant nutrition, that may need investigation.

Average Holding Size per Family in the Three Classes of Schemes and the Extent Cultivated

Category of scheme	Average holding size per family	Extent cultivated per holding
Major	1.79	1.75
Medium	1.77	1.23
Minor	1.34	0.64
Average for all schemes	1.43	0.81

Source: Inventory Survey, 1999

The table below shows the land areas under paddy and other field crops (OFC) during *yala* 98 and *maha* 98/99 in each of the five Priority schemes.

Present Status of Cultivated Crops in the Priority Schemes

Scheme	Paddy	OFC	Total
Nachchaduwa major	4,042.5	17.5	4060.0
Palukadawala major	1,172.9	44.5	1,217.4
Periyakulama medium	88.0	21.7	109.7
Mahananneriya medium	139.0	19.4	158.4
Mahananneriya minor	142.0	20.9	162.9
Total for all schemes	5,584.4	124.0	5,708.4

Source: Inventory Survey, 1999

Chapter 3 CURRENT AND LIKELY ENVIRONMENTAL ISSUES

The environmental issues discussed below are common to all Priority schemes. Some differences are observed in the magnitude of effect. Most of these issues have also been identified and discussed at the Farmer Organisation meetings.

3.1 Land Use Planning

The implementation of the Accelerated Mahaweli Development Scheme (Mahaweli Project) in the 1970s and 80s brought about many ecological changes to large extents of the dry zone. The biggest change came about through a reduction in the natural forest area, which was also wildlife habitat, by its conversion into agricultural systems and settlements. Consequently, displacement of many species of wildlife from their natural habitats took place. .

The elephant has been trapped in an ever reducing habitat that makes it very difficult for the animal to obtain the large quantities of food which it requires on a daily basis, without having to consume farm produce, even paddy stored in houses. In spite of setting up a number of protected areas under the Mahaweli Environment Programme, the problem appears to be increasing in intensity. Quite clearly the present day carrying capacities of the existing habitat in relation to the current elephant population is inadequate.

Inappropriate land use planning at the macro-level has therefore, brought into sharp focus the human-elephant conflict as seen at the present time. At the micro-level too, land use planning plays an important role. The tank-village system of farming that was the basis of settlement of an ancient civilisation, depended entirely upon irrigated agriculture from stored runoff in small village tanks. The entire system was based on numerous ecological linkages that integrated land and water use and human endeavour together with fundamental principles of conservation. These concepts are relevant even at the present time.

The tanks in the Mahananneriya minor scheme group (cascade) do not receive adequate water from runoff, which is derived primarily from individual catchments. This is because the rainfall quickly runs off the catchment because of poor land management and the tanks are silted, and cannot hold the water. Therefore catchment land use and management will be determining factors in the hydrology of the micro-catchment. .

3.2 Soil Erosion on the Rainfed Uplands

Soil erosion is quite common on the rainfed uplands and home gardens. The erosive processes will finally lead to the silting of waterways and tanks particularly the minor village tanks as seen in the Mahananneriya minor scheme group. Continued erosion also depletes soil fertility and reduces productivity, making farming unprofitable. Hence, on eroded farm land, large amounts of inputs are required to keep production at reasonable levels.

Loss of top soil and the exposure of sub-soil makes farming uneconomical. The most visible sign of loss of top soil is the exposure of tree roots. MI workers recognise the loss of top soil in the rainfed uplands as a factor for declining agricultural productivity. They also report that only 50 percent of the production potential of the upland farm is being achieved. The loss of top soil is also associated with other concerns such as depletion of nutrients, organic matter and soil structure. Therefore, land degradation should be recognised as amounting to something more than the physical loss of top soil.

MI studies also indicate that although the total amount of *yala* rainfall is less, the falls are more intensive and erosive when compared to the *maha* falls. The percentage of erosive rain is 70 in *yala* and 50-55 in *maha*. The months of March and September have a high erosion risk. Undulations in the topography are said to make large variations in erosion even within a micro-watershed.

Erosion by water begins with the detachment of soil particles and the subsequent transport by water from the point of generation to the point of deposition. The energy of falling rain drops on a bare soil surface determines the beginning of a series of erosive processes. Other contributing factors are intensity of rainfall, runoff, susceptibility of soils, topography, soil cover and cultivation practices. In this report, the concern is for loss of soil by water, although a limited loss by wind is also a factor during the long *yala* season, when strong drying winds blow across the dry zone from the south-west.

As the Reddish-brown Earths are erosion-prone, conservation measures are required when these soils are used for the cultivation of field crops. The magnitude of soil loss on the well drained, Reddish-brown Earths has been estimated at a few dry zone locations with the help of erosivity values. The table below shows the potential annual soil loss (t/ha) from an open field, 100 m long, on land slopes of 2, 4 and 6 percent at three locations in the Master Plan Study area, namely, Anuradhapura, Galgamuwa and Maha Illuppallama. These are indicative to the Priority schemes as well. The values have been computed using the Universal Soil Loss Equation and the plots had no protection of vegetation at

the time the trial took place. In a real situation, the results can be different on account of the presence of a crop cover or a mulch.

Potential Annual Soil Loss on the Reddish-brown Earths

Location	2 %slope	4%slope	6 %slope
Anuradhapura	27	52	84
Galgamuwa	26	51	83
Maha Illuppallama	25	48	78

Source: P.B.Dharmasena.1992. Rainfall Erosivity and Potential Erosion in the Central Dry Zone. Tropical Agriculturist. Vol.148; pp 111-120.

3.3 Sedimentation of Minor Tanks

Sedimentation of minor village tanks is a serious problem in the Mahananneriya minor scheme group (cascade) made up of the following six tanks – Kallanchiya, Arthikulama, Palumailewa, Ihalagama, Thambarewewa, and Ihala Nanneriya. All tanks show a high degree of sedimentation and hence, a generally reduced storage capacity.

A study carried out in three small village tanks in the Maha Kanumulla small watershed by MI workers has shown that the total volume of sediment deposited in the tanks varied from 23 to 35 percent of the potential tank storage. The rate of sediment generation was 3,200 and 6,000 m^3/km^2/year for two of the three tanks. The impacts of this relate to the degradation of the catchment making it progressively less productive, decreasing storage capacity of the tank and the reduction in the extent of the command area of the command area under a *yala* season cultivation. Section 3.8 also refers.

3.4 Soil Salinity

The salts found in agricultural soils are generated from soil minerals and are carried to the fields in the irrigation water. Sodium and chloride are the dominant ions that make the water in the soil less available to plants. Salinisation can occur when there is poor drainage and the salts are not carried away or when evaporation brings up salts from the lower layers of soil and deposits in the surface layer, as can happen in arid areas. Salinisation can also occur when sea water enters the river systems and move upstream due to changes in river hydrology.

Salt content in water is usually expressed in terms of electrical conductivity (EC). Water quality analytical data so far available does not indicate an excessive salt content in the irrigation water. The data referred to are drawn from the COWI

consult (a consulting company) Anuradhapura water supply study of 1993, routine water analyses of the National Water Supply and Drainage Board (NWSDB), Anuradhapura, and the North Western Province (NWP) water resources development study of 1997. No water analyses have been undertaken during this Study

According to the rapid rural appraisal, 13 percent of farmers in major schemes believed there was a problem of salinity. Localised incidence of soil salinity has been reported from a number of locations. It is primarily due to waterlogging because of the poor drainage conditions.

The localised cases of salinity reported are often from the *yayas* where the field drainage channels have been encroached and the free flow of drainage water prevented. The drainage channel (S: *kunu-ela*) was in the early days an integral part of the *yaya*. It was well maintained so that water carrying excess salts and nutrients was taken away quickly from the *yaya*.

Waterlogging can also be the result of high water use in paddy cultivation. Farmers in Sri Lanka are also known to use irrigation water quite freely as often it is a free resource. Under such conditions crop plants find it difficult to absorb all the required nutrients. The soil oxygen levels are low and toxic compounds may develop in the soil.

3.5 Pesticide Use

Health problems among the farming population from pesticide misuse are always a possibility. In fact in the country as a whole, acute pesticide poisoning is a major health problem. Some of the causes are due to improper handling and storage in the home, when spraying is undertaken without the necessary precautions such as body protection, consuming food and drink while spraying and inadequate personal hygiene on completion of the work. In the Priority schemes paddy is the largest user of pesticides. Considerable amounts are also used in vegetables and tobacco.

Excessive use of pesticides is known to cause a number of adverse effects such as the death of non-target beneficial species in the field, accumulation of residues in the environment and the build-up of pesticide resistance in target species. The resistance of the mosquito in Sri Lanka in recent times, to DDT at first, and then to malathion that replaced DDT, is a good example.

Increase in pesticide use is partly due to reduced efficiency, resulting from ecological changes in the field brought about by repeated heavy dosing. This has

brought about the condition known as the "pesticide treadmill," when pest resurgence and the use of more and more toxic pesticides make pest control uneconomic.

On application, pesticides undergo many changes. Some are broken down very quickly and leave no undesirable effects. Others are more persistent and toxicity levels continue over varying periods of time depending upon many external factors. Sunlight decomposes some chemicals. Some get absorbed by plant parts. Others are washed into the soil and dissolve in the soil solution through which plants may absorb the chemicals. Some chemicals are adsorbed by soil colloids and may be decomposed in the soil due to chemical and biological processes. Some leach downward into surface and ground water or are carried in the drainage water.

In the last few years some of the toxic pesticides such as DDT, aldrin, endrin and dieldrin have been withdrawn. There is at present some control of pesticide use in the country through the Control of Pesticides Act of 1980. The Department of Agriculture approval of pesticides is made after much screening and testing. The new generation of pesticides are much safer formulations, are pest specific and are required in low dosages, when compared to some of the chemicals used many years back.

Preliminary analyses carried out by COWI consult in 1993, of surface and ground water in large paddy tracts of the Anuradhapura District, in connection with a drinking water supply and sanitation study, did not detect any pesticide residues. Residues of carbamates, organo-phosphates, organo-chloro and pyrethroid pesticides had been analysed for, in this study.

Pesticides were also not detected in the water analyses of the NWP Water Resources Project. Here 19 pesticides were tested for.

" Insect pests of most crop plants have many natural enemies whereby an equilibrium situation of the pest population and natural enemies is reached with the pest not being able to reach proportions of large scale infestation. Based on this natural phenomenon, integrated pest management (IPM) methodologies now provide opportunities for minimising pesticide use and increasing profits and making the environment safe."

Agrochemicals are applied to prevent crop losses by insect pests. The Department of Agriculture has estimated crop losses of between 20 and 30 percent of the total yield due to insect damage. The most commonly used agrochemicals are insecticides and weedicides. For example, according to a Department of Census and Statistics, in the Anuradhapura District, insecticides were used in over 70

percent of the sown paddy area during *maha* 1997/98 and *yala* 1998. It is doubtful whether all this amount of chemical was really necessary. The work done on chilli described below confirms these doubts, although the crop is different. Weedicide use was reported to be particularly high in the Anuradhapura District and in System-H.

It is still common practice to see farmers spraying pesticides without the minimum bodily protection, in unsuitable weather and consuming food and drink during breaks in spraying. This is largely due to a lack of awareness.

The table below shows the average pesticide usage in the Nachchaduwa major scheme based on an interview survey of 50 farmers. This scheme had the highest use rate among all the Priority schemes for both *maha* and *yala* seasons.

Average Pesticide Use in Paddy: Nachchaduwa Major Scheme; *Yala* 98 and *Maha* 98/99

Chemical	Form	Unit	*Maha* irrigated	*Yala* irrigated
Weedicide	Liquid	Litre/ha	3.34	3.0
Insecticide	Liquid	Litre/ha	0.67	0.90
	Powder	Kg/ha	0.20	2.20
Fungicide	Powder	Kg/ha	2.50	1.40

Source: Interview Survey, 1999.

In a 1994 study of pesticide use on chilli, MI workers reported some interesting findings that prove that there is indiscriminate use of pesticides. These are:

- The number of pesticide applications were high;
- 46 percent of the farmers used pesticides more than 10 times during the season while some used more than 20 times;
- Farmers are of the opinion that 15-20 applications are needed from field planting to harvesting;
- Higher rates than recommended were used by 56 percent of the farmers;
- Frequency of application is at very short intervals;
- Some farmers applied sulphur even without the presence of mites; and,
- Pesticide application of this nature led to the destruction of natural enemies of chilli pests.

Indiscriminate application has increased the cost of production of agricultural produce and interfered with the balance of nature. More rational use will necessarily bring about reduced cost of production, better incomes and improved environmental quality.

All farmers do not follow the recommendations of the Department of Agriculture. Some of them are in the habit of deciding by themselves on what should be applied. Often farmers are advised by the village boutique keeper. They are also

influenced by propaganda carried out by agrochemical companies, among whom there is much competition.

Hence, the most cost-effective and environment-friendly method of pest management technology available, may not be always used. This is also a reflection on the extension system. Some of the active ingredients in most chemical compounds can lead to environmental degradation when used in excess, by eliminating beneficial insects, fish, amphibians, birds and soil organisms.

Although fears of pesticide pollution of water bodies have been expressed from time to time, pesticide residues in water bodies in the Priority areas have not been detected in recent analyses undertaken in the Nachchaduwa Tank and Attaragalla Tank.

The ill-effects of intensive pesticide use takes place in ways other than polluting of water bodies. They also happen due to careless handling and storage in the home and in the field. For example, children and adults have inadvertently consumed pesticides mistaking for other items of drink because of the similarity of containers used. Often after spraying in the field, the empty containers are carelessly thrown away into waterways. After finishing work the equipment is washed in the canal which is also a source of water to other people.

Very briefly the ill-effects are as follows:

- Acute and chronic poisoning of humans which is a major problem in Sri Lanka;
- Resistance developed by pests to certain chemicals;
- Destruction of beneficial insects and other predators of crop pests in the field;
- Impacts on fish and other aquatic life.

As an illustration of the impacts of all classes of pesticides on humans, the statistics from the Anuradhapura General Hospital are shown below. The results are only indicative. Death (mortality) due to pesticide ill-effects of all classes have been 29, 21 and 21 percent of admissions in the years 1997,1998 and 1999 respectively. Live discharge shows the numbers of affected people (morbidity) who left the hospital after being cured. The places where the patients live were not on record at this office but may be determined by examining the bed-head tickets. It is likely that among the total admissions there were patients also from the two Priority scheme areas of Nachchaduwa and Periyakulama which are not very far away from the hospital. It is also not known whether the cases are effect is accidental or intentional (suicide).

Pesticide Poisoning: Mortality and Morbidity at the General Hospital, Anuradhapura 1997-1999

Year	Total admissions	Live discharges	Deaths	Deaths as % of total admissions
1997	547	387	160	29.2
1998	854	674	180	21.0
1999	758	598	160	21.1

Source: Statistics Division, General Hospital, Anuradhapura

Similar data from the Galgamuwa District Hospital are shown below. The effects are on a much lesser scale. The major scheme of Palukadawala, the medium scheme of Mahananneriya and the Mahananneriya minor scheme group (cascade) are the Priority schemes not very far from the hospital. Being the best equipped in the area, it is likely that the hospital had among its admissions, people from the Priority areas as well. However, the data are again only indicative.

Pesticide Poisoning: Mortality and Morbidity at the District Hospital, Galgamuwa 1997-1999

Year	Total admissions	Live discharges	Deaths	Deaths as % of total admissions
1997	76	70	4	5.2
1998	85	75	10	11.7
1999	71	69	2	2.8

Source: District Hospital, Galgamuwa

Note: Live discharges and deaths should equal hospital admissions. However, serious patients are sometimes transferred to hospitals with better facilities, as happened in 1997, when 2 patients had been transferred.

A reduction in pesticide use is a distinct possibility. This is indicated in the reports of the IPM programme for paddy, promoted by the Department of Agriculture through Farmer Field Schools (FFS). These schools have been conducted in many districts during the last few years. A programme for chilli has also been just introduced.

Some farmers who had participated in IPM training programmes for paddy, interviewed during this Study, reported much satisfaction on following the training class. They have had new information or updated their knowledge on many aspects of paddy cultivation such as reducing the cost of production, improving cultivation techniques and above all, the satisfaction that they are no longer being subjected to a slow poisoning.

3.6 Water Quality

Multiple uses of surface water are common in irrigation schemes. Non-agricultural uses are for washing, bathing and even drinking. However, there are health risks involved. The health risks are possibility of typhoid, cholera, problems due to nitrates and worm infestations. Hence, the need for good quality water places responsibility on project managers.

Water quality is important for irrigation, domestic and recreation purposes. A Sri Lankan Standard has been formulated for drinking water and another is in preparation for irrigation. Few analytical studies of dry zone surface water have taken place and these have been for specific purposes.

Adverse impacts of poor water quality may interfere with the realisation of project objectives, eg. achieving the targeted paddy yield if the water has too much salts. Impacts can also be experienced by people living in downstream areas outside the designated project. Examples of such are, sediment carried in the river and deposited in downstream floodplains, the spread of water weeds and transmission of various diseases. There are also other undesirable chemical elements and compounds that are carried in solution by the rivers that may affect the health of the people and the environment.

Deterioration of surface water quality can take place by the addition and accumulation of toxic substances, sediment, changes in colour, depleted oxygen, bacteriological contamination, agricultural runoff and industrial effluents, amongst others. Agricultural runoff carries with it plant nutrients and pesticide residues, among other constituents such as organic matter and sediment. Agricultural runoff is from non-point sources.

Suitability of irrigation water for crops depends upon several factors. These are, the origins of sources of water, climate, soil and weathering characteristics, and plant tolerance to salt in the soil. These factors interact in determining crop performance. During the flow of water, different soluble salts get dissolved in the water and in excess, can lead to soil salinity when prolonged dry conditions or waterlogging are present. With evaporation, there is capillary movement of water upwards in the soil and dissolved salts may reach the upper soil layers and be left behind as the water evaporates.

The adverse effects of water quality on the soil-plant system depends upon factors such as the total salt concentration in irrigation water, relative proportions of cautions and anions, soil characteristics and crop tolerance. When salinity builds up in the command areas of an irrigation scheme, the effects can also be felt in the downstream command areas of other schemes, using the return flows. Crop yields are adversely affected.

The major chemical components of irrigation water are sodium, calcium, magnesium, chloride, bicarbonate ions, nitrate and potassium. Of those present in small amounts, most do not affect the quality of irrigation water. Selenium, molybdenum and fluoride among these, may be harmful to humans.

When the sodium content in irrigation water is high, it will make soils unsuitable for cultivation because of unsatisfactory physical condition. At high levels sodium is toxic to plants. However, its ill-effects are avoided by high levels of calcium and magnesium in the soil. The sodium adsorption ratio that takes into account the relative proportions of the three elements, is an index for the classification of irrigation water.

Water quality in downstream areas can deteriorate when water leaving a particular irrigation scheme as a return flow after irrigation, rejoins the main stream carrying with it high quantities of the plant nutrients, nitrates and phosphates, and perhaps pesticides. These are the major pollutants that are responsible for the pollution in water bodies. The nitrates and phosphates will cause algal blooms in enclosed water bodies and give rise to eutrophication. In this situation fish life will not be possible due to the absence of oxygen. The dissolved oxygen is used up by the plant decomposing bacteria and therefore oxygen levels in the water will be much reduced or eliminated altogether, when the water smells bad.

Urea and ammonium fertilisers are generally nitrified to nitrates which are not fixed by soil minerals and are carried in the drainage and percolating water. Nitrates as such are not harmful to human health. The ill-effects of excess nitrates occur when nitrates are converted to nitrites by bacteria in the intestine. Nitrites are absorbed into the blood stream and are detoxified by adults. However, babies are unable to do this and nitrites combine with haemoglobin in the blood and reduces the absorption of oxygen by red blood cells. This condition is known as methemoglobinaemia, also called the “blue baby syndrome.”

Increased nitrogen and phosphate levels in tank water, particularly in the small tanks, provide ideal conditions for the growth of water weeds. Beginning with the free floating salvinia and water hyacinth, rooted macrophytes such as lotus, water lilies, grasses and sedges will begin to spread in the tank and finally may cover the entire area making it useless for irrigation and domestic use.

Salvinia molesta, salvinia and Eichchornia crassipes, water hyacinth, are two floating weeds that cause serious problems in small irrigation tanks in particular, canals and even paddy fields. Water weed problems are largely seen in the Mahananneriya minor scheme group (cascade) and to a lesser degree in the large tanks. The medium tank of Periyakulama has an extensive cover of water weeds.

Water weeds grow very rapidly, particularly when large inflows of plant nutrients enter tanks. Salvinia is more common in its distribution and is reported to multiply by division every two days under favourable conditions. Among a variety of other rooted water plants found in the water bodies, Nymphaea lotus, lotus, Aponogeton crispus, Limnophyton sagitifolia, Paspalum mertzii and Nymphaea stellata, water lily, are also common. Some of the sedges are of economic value and provide plant parts for cottage industries.

The economic and social costs of water weed problems can be quite high. The Department of Agriculture has estimated a loss of 2-3 percent of total yield of paddy on account of water weed infestation.

COWI consult work carried out in 1993, concluded that surface and ground water in the Anuradhapura District showed the presence of nitrate, ammonia and phosphate, derived very likely, from high fertiliser use in crop husbandry. Pollutants were more prevalent in dug wells than in tube wells, as to be expected, because dug wells are fed by the upper portion of the ground water aquifer. The wells with high concentrations did not follow a general pattern, supporting the assumption that the anamolous values were not caused by hydrogeological factors. It was also concluded that the nitrate concentration in the Anuradhapura District as of that time, did not pose a health risk. No pesticide residues were detected in this study.

The NWSDB monitors sources of drinking water supply at a number of locations in and around the Priority schemes. The analytical data for Nachchaduwa Tank water, undertaken in 1993 by the National Aquatic Resources Agency (NARA) and NWSDB results in 1999 are presented in Table S 3.1, in comparison with the Sri Lanka Standard for drinking water.

Certain parts of the Nachchaduwa and Periyakulama Priority schemes have high levels of fluorides in surface and ground water. In parts of the country such as the wet zone with a high rainfall, it is believed that the fluorides are easily leached and moved away. Compounds of fluorine are also present in mineral deposits such as fluospars or apatite.

According to the NWSDB, at concentrations of 1.0-4.0 ppm fluorides will cause the discolouration of teeth in children under five years. However, if the concentration is below 0.5 ppm, dental caries will result. While adults are moreor less unaffected healthwise at concentrations when children are affected, skeletal fluorosis can occur in adults when the concentration is between 4-10 ppm.

Analyses carried out for the Asian Development Bank (ADB) Water Resources Development Project in the North-Western Province (NWP), indicated that

surface water (tanks and rivers) and ground water (domestic and agrowells) are of good quality for agricultural use. Nitrates, phosphates and chlorides were well below the maximum desirable levels for drinking water.

No pesticide residues were detected. However, bacteriological tests of ground water showed a high contamination of Eschericia coli, faecal bacteria.

The water quality data for Attaragalla Tank undertaken during 10 months in 1997 are presented in Table S 3.2. This Tank and the Palukadawala Tank are inter-connected and similarity in the water quality can be expected. However, this is only indicative.

However, levels of over 3,000 uS/cm have been reported for the Mahnanneriya area in the wetland site report on the Mi Oya River Basin. The maximum desirable level in the Sri Lanka Standard is 750 uS/cm and the maximum permissible level is 3,500 uS/cm. At farmer meetings the people have confirmed that the water in the dug wells is of poor quality during most months of the year.

3.7 Public Health

Diseases associated with water are of common occurrence in most developing countries where irrigation is practised or where access to good quality water is not available. This is so in Sri Lanka as well. However, it does not mean that all irrigation schemes need experience such ill-effects. There are ways of overcoming these.

Most of the disease causing agents that contaminate water are biological in nature. These include types of bacteria, viruses, protozoa and helminths that enter the human body through food and water. The organisms reach different stages of development within the body and on excretion with the faeces, contaminate water bodies and re-infect people, as many people in rural areas depend upon open water bodies for domestic need. Poor sanitation is largely contributory. The disease causing organisms can survive for long periods in human sewage.

For purposes of classification of water-associated diseases, the World Health Organisation (WHO) cites four classes. These are as follows:

Water-borne: various pathogens contaminate water through infected faeces and urine. Cholera and typhoid are two examples prevalent from time to time in the Priority areas but are easily controlled. Diarrhoeal diseases are mostly responsible for mortality in infants. These are likely to arise in the future too.

Water-washed: this class is common when water is scarce for domestic use. Skin and eye infections are common. Conjunctivitis (eye infection) sometimes

appears in project areas.

Water-based: worm infestations in humans where the parasites use water dependent intermediate hosts to pass part of their lifecycles. These are also common.

Water-related: the vectors responsible for diseases such as malaria, dengue and Japanese encephalitis require water to pass part of the lifecycle. Malaria is the most prevalent disease in project areas and could remain so unless the routine precautions are not taken. The other diseases have also been reported periodically but have not assumed serious proportions. There are over a hundred species of mosquito and they vary in their preference of water. For example, the malaria mosquito requires clean water.

Of all the water-associated diseases, malaria has the most damaging economic impact on the farming population. WHO describes malaria as the "world's most important tropical parasitic disease." The incidence of the disease is greater towards the end of the year when the monsoon begins and creates conditions suitable for the mosquito to breed. Again at the end of the monsoon when reducing rainfall and diminishing canal flow leave pools of water, malaria is common.

A family when affected is likely to lose a season or more of cultivation. Hence, the poor may get poorer. Children are also affected.

Symptoms of malaria are fever, headache, joint pain, shivering and vomiting. If neglected, the disease can lead to death. The disease as caused by Plasmodium falciparum, can be particularly severe. Pregnant mothers are very susceptible to the disease.

The malarial parasites are transmitted among humans by the female anophelene mosquito. The male feeds on plant juices and does not transmit the disease. The parasite develops in the intestine of the mosquito and is passed on to humans when feeding. The parasites are then carried to the liver of the human where they multiply into another stage. After some days the parasites invade the red blood cells and multiply again causing fever and anaemia. The brain and other body organs may also get affected. Diagnosis is by clinical symptoms and blood examination.

A 1997 study carried out in a small tank-based irrigation scheme in the Huruluwewa basin of the Anuradhapura District showed that the total average annual cost per household from the incidence of malaria amounted to about 10 percent of the net household income. Studies have also shown that Japanese encephalitis, which had two major outbreaks in the NCP and NWP in the 1980s,

could be linked to vector breeding in paddy fields.

Of the public health issues, vector-borne diseases are the most prevalent, and of these, malaria stands out as affecting the largest number of the population. It also has its impact on the physical condition of the people and subsequently on the economy, as a result of the number of work days lost and the cost of medication provided. The table below shows the number of admissions to the General Hospital, Anuradhapura during the period 1997 to 1999. Deaths during this period have been less than 1 percent of admissions for each year.

Malaria: Mortality and Morbidity at the Anuradhapura Hospital, 1997-1999

Year	Total admissions	Live discharges	Deaths	Deaths as % of total admissions
1997	1,959	1,940	19	0.97
1998	1,627	1,614	13	0.80
1999	1,438	1,427	12	0.83

Source: Statistics Division, General Hospital, Anuradhapura

In the case of the Galgamuwa Hospital, the admissions for 1997, 1998 and 1991 were 78, 52 and 94. There were no deaths. It is significant that the larger part of the cases were during the fourth and first quarters of successive years when the north-east monsoon is effective.

Malaria control in the country, since its introduction in1923, has had both its successful and not so successful periods. From having brought down its incidence to almost zero level (only 7 reported cases in 1963), there had been an upward trend in the number of cases recorded, with an epidemic occurring in 1967/69. A number of reasons contributed to this situation.

Malaria can reach epidemic proportions if the basic preventive measures are not taken. However, it is reported to be presently on the decline except in the war ravaged north and east of the country.

The periodicity of malaria is primarily associated with weather conditions. Immediately after the onset of inter-monsoonal weather conditions in October, the incidence of malaria peaks. There is another small peak in mid-February, when canal and stream flow reduces and ponding may take place at this time. The tanks also have little water and water releases are therefore not possible.

Defence personnel returning from the north and east act as carriers, as in those areas, little can be done for prevention or control. There are also other interacting factors such as social status of the people; migration from non-malarial areas; design, operation and maintenance of irrigation infrastructure, and geographical location of schemes.

The table below compares the reported cases of malaria in 1997 and 1998 in the North-Western and North-Central Provinces. This data is presented for indicative purposes. The North-Eastern Province is included for purposes of comparison.

Percentage of Malaria Reported by Province; 1997-1998

Province	1997	1998
North-Western	9.5	7.1
North-Central	13.3	8.2
North-Eastern	55.8	62.3

Source: Anti-Malaria Campaign

The main vector is the mosquito, Anopheles culicifacies, although Anopheles subpictus is also a carrier. Two of the malarial parasites are Plasmodium vivax and Plasmodium falciparum. Of the parasites, the former is responsible for about 80 percent of the total cases. The latter however, is more dangerous.

A study on the "Insecticide Resistance in Anopheline Vectors of Malaria," conducted by the Department of Zoology of the University of Peradeniya, in the Galewala area (Matale District), during 1995-98, showed a high resistance to organochlorines (eg. DDT that was used prior to 1977) and organophosphates (eg. malathion has since been discontinued) by the two mosquito species named above. Both chemicals were widely used in Sri Lanka before and were discontinued on account of the resistance developed by the mosquito. The study showed that successful control is however, possible by the use of carbamate and pyrethroid insecticides. The study also indicated that pesticides used in agriculture did not have an impact on the development of resistance in the above malaria vectors.

Snake bite is another problem of frequent happening among farmers and their family members due to the nature of the occupations and the many wilderness areas that are habitat to poisonous snakes. The chances of survival are best when a victim is taken to the nearest hospital as most hospitals are presently well stocked with anti-venom serum (AVS). This may not be the case however, when the patient is taken for local treatment by self-made physicians. The table below shows the snake bite cases admitted to the Anuradhapura Hospital. This is also indicative as not all those who are bitten by poisonous snakes are brought to hospital.

Snake Bite: Mortality and Morbidity at the General Hospital, Anuradhapura 1997-1999

Year	Total admissions	Live discharges	Deaths	Deaths as % of total admissions
1997	583	563	20	3.4
1998	788	773	15	1.9
1999	623	613	10	1.6*

* Data are for the first three quarters only
Source: Statistics Division, General Hospital, Anuradhapura

At the Galigamuwa Hospital the situation due to snake bite death is more satisfactory. In 1997 and 1999, there were no deaths while in 1998, there was one death. The prompt arrival of the patient at the hospital and the availability of the anti-venom serum were attributed to the low death rate.

Some of the poisonous snakes reported are Bungarus caeruleus, Indian krait(S: *thel karawala*), Naja naja, cobra (S: *naya*) and Vipera russelli, Russel's viper (S: *thith polonga*). These snakes are commonly found in most dry zone regions.

Snake Bite: Mortality and Morbidity at the District Hospital, Galgamuwa 1997-1999

Year	Total admissions	Live discharges	Deaths	Deaths as % of total admissions
1997	92	92	0	0
1998	120	119	1	0.83
1999	168	168	0	0

Source: District Hospital, Galgamuwa

3.8 Catchment Degradation

It has been observed that much of the vegetation of the catchments of the Mahananneriya minor scheme group (cascade) has been cleared for upland rainfed cultivation. Crops are grown in both *yala* and *maha* depending on rainfall availability. As generally no soil conservation is practised, eroded soil is deposited in the tanks below, thereby reducing tank capacity. The advantage of runoff collection in the tank is then not achieved as the tank is filled with sediment. No quantification of the sediment deposited in each tank has been made.

MI workers have reported that continuous cultivation of the catchment without adequate soil conservation has caused the degradation of the soil. The soil shows a poor water holding capacity, a low rate of infiltration and a high evaporation rate. They also report that crops have either given very low yields or failed completely on account of inadequate rainfall. Annual runoff from the catchment has been estimated by them to be as much as 40 percent and carries a fairly high suspended load of top soil into the tank below.

During a 10-year study from 1983-1993, MI workers observed an annual sedimentation rate of 2.4 percent in some minor tanks of the Anuradhapura District. Excessive erosion is a reflection on the catchment uses indicating poor agricultural practices. Section 3.3 also refers.

3.9 Deforestation

The Priority scheme areas have lost almost all of the natural forest. The Mahaweli Project has been responsible for a large part of forest loss in the larger dry zone region. Reportedly some 200,000 ha of natural habitat have been converted into agricultural ecosystems during the 1970s and 80s. Other causes of forest loss are legal and illegal logging, and chena cultivation.

3.10 Problems of Wild Animals

Numerous conflicts between man and wild animals have arisen in the Priority scheme areas. There are no wildlife protected areas within or near the Priority schemes. The elephant, moves about quite freely. Its "home ranges" have been drastically reduced by the numerous development schemes that have been undertaken in the past.

Elephants take refuge during the day in patches of forest and at night, move into cultivated lands, and also damage houses in search of stored paddy and salt. Men and women, in the course of their normal day to day work, have often been injured or have even met with their death.

Crop damage by animals is caused by the elephant, wild boar, rock squirrel, monkey, toque macaque, rat, porcupine and a variety of birds. No reliable data of crop damage by wild animals are available.

Snakebite is also a big problem to farming families in most areas. For example there were on the average, over 650 persons admitted per year, to the Anuradhapura Hospital during the three years, 1997-1999. In comparison, only 126 persons per year were admitted to the Galgamuwa Hospital for the same period. The ready availability of anti-venom serum in the hospitals and early arrival of the victim at the hospital after being attacked, has greatly helped to reduce deaths. Section 3.7 on public health provides more data from the Anuradhapura and Galgamuwa Hospitals.

Of the wild animal problems in agriculture, the damage to crops, property and humans by elephants is the most serious at the present time. Indirect effects such as the fear psychosis among villagers and inability to get about their day to day business when elephants have entered the village or nearby areas. One never knows when they would move out. May be in a day; may be in two days. Children cannot go to school and the sick cannot be taken to a doctor or to hospital. This is the real situation in a rural setting. Damage control measures so far adopted by the Department of Wildlife Conservation have not brought about the desired results.

Some farmlands and entire villages are reported to be abandoned on account of elephant attacks. Farmers have often fallen into desperate economic difficulties when crops and property are damaged. Entire families have fallen into similar situations when the head of household, usually the male, meets with an unfortunate death.

Table S 3.3, Table S 3.4 and Table S 3.5 provide information on these aspects during the period 1997-1998. They relate to the Divisional Secretary Divisions of Galgamuwa, Tirappane and Sravastipura which are the local administrative divisions for the Priority schemes selected. The Sravastipura division has been recently created and reorganisation was taking place at the time of field work. Therefore, the information is incomplete.

Wild elephants too have had their share of injury and death, caused by angry farmers resorting to extreme measures in order to safeguard themselves, their crops and property. Nooses, nail boards and trap guns are some of the devices that have been, or are being presently used. Mortality is highest from gunshot injuries, with death taking place sometimes far away and long after the first bullet hit the animal. In the meantime the animal may have been shot at a few more times and suffered over a long period from its infected wounds. Killing of animals for tusks has also taken place.

Present day numbers are too many to be supported by the food and water in the jungle areas they are now forced to live in. For that reason they damage agricultural properties. The human-elephant conflict has far-reaching economic and social consequences and warrants immediate attention. In fact the situation has worsened over the years and is a contributing factor to the poor success from farming in the Proirity scheme areas.

In the *maha,* when water and food are plentiful, the animals disperse in herds of varying number, always led by a female. Single animals, and those in twos and threes are the males that are not part of any herd. In the *yala*, when water and food are both limiting, the tendency is for the animals to move closer to watering places. Receding water lines permit the growth of luscious grasses on the tank beds, as is a feature in the Kalawewa-Balaluwewa Tanks which attract the elephant.

Elephant numbers vary from place to place and from time to time, for they move over large areas in search of food and water, the availability of which is determined by the rainfall and the alternating *yala* and *maha* cultivations. Herds of elephants, made up of adult females, young and sub-adult males, establish their own habitual feeding and watering grounds referred to as “home ranges.”

According to the Anuradhapura Range Office of the Department of Wildlife Conservation, elephant numbers in and around the Priority project areas; estimated at between 260 and 340 are shown below. These are only indicative figures.

Estimated Elephant Numbers by DS Division

Divisional Secretary Division	Estimated Elephant Nos.
Tirappane-Talawa-Nuwaragampalata East	150-200
Galgamuwa	80-100
Giribawa	30-40
Total	260-340

Source: Office of the North-Western Region, Anuradhapura, Department of Wildlife Conservation,

Some compensation is available for human, property and crop damage but it takes much effort and time for the farmer to obtain it. The crop damage by the elephant and wild boar is compensated for by the Agricultural and Agrarian Insurance Board and covers damage before harvest, reported within 14 days of occurrence. The farmer is obliged to bear 20 percent of the loss. Compensation is also available for loss of crop by drought, flood, insects and disease.

Crop insurance is not generally available to those farming under the small schemes. However, if the Divisional Secretary assures availability of water in the tanks for a particular season's cultivation, then farmers can insure their crops. Some compensation for crop damage is also available from the Department of Social Services.

Compensation for loss of life and injury to humans, and damage to property is provided by the Department of Wildlife Conservation under certain arrangements with the Insurance Corporation. The current amounts payable to the closest relative, in the event of the death of a family member are as follows:

- Head of household, Rs.50,000
- Family member over 18 years, Rs.30, 000
- Family member between 10-18 years, Rs.20,000
- Family member under 10 years, Rs.5,000

A maximum of Rs.15,000 is allowed per person for injury. Damage to a house is allowed a maximum of Rs.25,000 and damaged implements and a cycle will receive compensation up to a maximum of Rs.5,000.

3.11 Cultural Aspects

Historic sites, cultural artefacts, places of worship and other places of archaeological interest are scattered all over the dry zone of Sri Lanka. These

cultural assets relate to the ancient civilisation that once was very prosperous. This is the case also in the parts of the Anuradhapura and Kurunegala Disticts where the Priority schemes are located.

Some of these sites are protected and supervised directly by the Department of Archaeology while others are looked after by the incumbents of the temples on site, that often serve as important places of worship and attract people from other parts of the country on pilgrimage. There are also documented sites that are not looked after by anybody. There can also be yet others awaiting excavation as these lie beneath the soil, jungle or under the water in tanks and canals.

As the project is one of rehabilitation of existing irrigation schemes, the fear of damage to archaeological sites will not arise, as might be the case with a new irrigation development scheme clearing virgin or secondary jungle. The nearest regional offices of the Department of Archaeology to the priority schemes are at Anuradhapura and Panduwasnuwara. Both offices have been notified of the proposed project activities. The Anuradhapura office of the Department of Archaeology initiated a reconnaisance survey around Nachchaduwa and Periyakulama Tanks but has not forwarded its findings, although in personal communication, indications are that no threats to existing archaeological sites are expected.

The more important sites around the Palukadawala major, Mahananneriya medium and the Mahananeriya minor are Yapahuwa in the DS division of Maho and Hathikuchchiya in the DS division of Giribawa. Others are smaller sites not directly supervised by the Department. These are at Sangappala (caves and statues), Mangalagala (ruins), Kallanchiya (caves), Nochchiya (old temple and ruins), Buduruwakanda (old temple) and Tammannawewa (caves and image house). In the Galgamuwa DS division there are ruins at Enderagala and Weragala.

The Department stipulates, that in the event of discovering any artefacts, ruins or any other object of archaeological value in the course of project implementation, it should be notified immediately. This requirement shall be complied with.

Chapter 4 ENVIRONMENTAL MITIGATION

4.1 Basic Approach

In the course of field work, certain aspects of diminishing environmental quality have been identified. The development proposals for the Priority schemes are not expected to lead to either the destruction of the environment or to the decrease in its quality from the present state. Rather, there would be an improvement in environmental quality when implementing the project, as the existing issues identified in chapter 3 will be mitigated and new management strategies implemented.

The project will also seek to mitigate those unfavourable effects that may arise during the course of implementation. The active participation of the farmers will be requested to mitigate environmental issues. Awareness creation will take place during training programmes and consensus on solutions will be reached that would in the long-term be economically feasible, environmentally sustainable and socially acceptable.

4.2 Institutional Aspects

A number of institutions have legal responsibility to enforce respective regulations relating to environmental protection and management. In the course of initiating various aspects of economic development, there is also the need to comply with the regulations of the National Environmental Act, and the Provincial Environmental Act in the case of projects within the NWP. There is currently a greater degree of awareness, both among institutions and the people on the need to maintain environmental quality, than the situation a decade ago. However, much remains to be done in order to be satisfied that total environmental quality is very satisfactory.

For purposes of this Study, crop production is concerned with paddy, the group of crops referred to as other field crops, fruits and vegetables. Research and extension centres of the Department of Agriculture, for most of these crops are found around the Priority areas. The largest and best known is the Field Crops Research and Development Centre at Maha Illuppallama, not far from the Nachchaduwa and Periyakulama Priority schemes.

Developing and managing the water resource for irrigation is shared by the Departments of Irrigation and Agrarian Services. The latter is responsible for small tank schemes. Institutional weaknesses are often seen in the inadequacy of

personnel and funding. Training of staff and farmers in conservation aspects needs continuous review and application.

Forestry activities have undergone a transformation from the earlier tradition of merely protecting extents of designated forest areas by the Forest Department, into involving the people in actively participating in growing and caring for trees. People-oriented forestry takes into account the active participation of the people in a variety of forestry activities that can together contribute towards an increase in the overall national tree cover, create a better environment, give households some extra income, provide areas for recreation and even enlist school children in some of the related work.

The Department of Wildlife Conservation has a very large responsibility both in terms of work components and area to be covered. The North-West Region that covers activities in the Priority schemes also, is centred at Anuradhapura. The geographical limits of the Range extend south to Kurunegala, north to Vavuniya, east to Habarana and west to Puttalam. The Region is sub-divided into six divisions. Of these, Wilpattu National Park is almost abandoned on account of security concerns. It is indeed a vast area.

Elephant control by itself requires a specially trained professional staff organised as a single unit, centrally located in the dry zone agricultural region, working long, hard hours and well equipped to meet the demands of the task. The general field staff need to be backed up by adequate research and problem solving to meet the specific needs of this primarily agricultural region. However, in all these aspects there are serious institutional shortcomings that need to be addressed fairly quickly in order to make farming productive and also conserve the elephant in a more meaningful manner.

General environmental matters are dealt with on a provincial basis within the NWP by the Provincial Environmental Authority, having its own law. The Palukadawala major, Mahananneriya medium and the Mahananneriya minor group (cascade) lie in the NWP. The implementation of environmental impact assessment is a special responsibility.

Elsewhere, in the Anuradhapura District, where the Nachchaduwa major and Periyakulama medium Priority schemes are located, the provisions of the National Environmental Act implemented by the Central Environmental Authority are operative. The statutes of both institutions are similar in content. Some of the regulations are delegated to local government institutions for implementation.

As conservation touches upon the work programmes of most development institutions that are resource users, coordination becomes necessary. This is

achieved in a number of ways. Part of the mandate of the CEA and PEA is to coordinate environmental conservation and ensure compliance to the respective statutes. At district level, coordination is effected at the monthly meetings of the District Agricultural Committee and the bimonthly meetings of the District Environmental and Forestry Committee. Parallel committees operate at divisional level as well. Each Divisional Secretariat has the services of an Environmental Development Assistant. He/she is an employee of the CEA but works under the direction of the Divisional Secretary.

4.3 Conservation Plan

An environmental conservation plan for the Priority schemes, involving soil, flora, fauna and water, should attempt to eliminate or mitigate the impacts identified during this Study through practical methods that can be easily adopted by farmers. The Priority schemes will not experience new adverse impacts as a result of implementing the project proposals, if the conservation measures are adopted. This would make the development programmes sustainable.

A sustainable land management system is defined by FAO as follows:

"Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fishery sectors) that conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate and socially acceptable."

4.3.1 Human- elephant Conflict

Resolution of the human-elephant conflict requires the co-ordinated efforts of many – experts of relevant disciplines, a number of institutions and the public – as the problem is spread over large land areas across administrative boundaries, the control of which lies with many institutions. A multi-disciplinary team of people must pool their expertise to prepare proposals to resolve the issues that the people of these areas, particularly the farming community, are faced with.

At the same time the survival of the elephant in its natural habitat has also to be looked at as a national need. A single method of keeping elephants and farmers away from each other cannot be formulated under the present circumstances.

A meaningful resolution of the conflict must take into account not only land

within the five Priority scheme areas under reference in this report, but the larger area of Wayamba and Nuwara-kalaviya as well, where elephant presence is high. The discussion necessarily goes beyond the Priority scheme areas as the elephant moves freely from one area to another. Pushing the problem out of the Priority schemes for the time, onto neighbouring areas, is counter-productive as the problem is bound to continue.

Answers have be found quite quickly to these and other questions as well, that may arise in more detailed discussions of conflict management. Perhaps a number of separate herd movements can be identified within the larger Wayamba and Nuwara Kalaviya Regions.

Some methods of mitigation utilised before, and others being tried presently, that are relevant for discussion in an elephant management programme, are briefly presented below for discussion at an appropriate forum.

(1) Elephant Drives

In 1979, attempts were made by the Department of Wildlife Conservation (DWC) to drive some 170 animals from the Mahaweli-H area into the Wilpattu National Park, lying to the north-west of System-H. Similarly in 1983, about 60 animals were driven from the Resvehera area to the Park. These efforts were unsuccessful as the basic plan of operation was not well prepared. Most of the animals came back to their earlier surroundings. The cost was also very high. Drives of this nature are believed to be impractical at the present time.

(2) Other Methods of Control Undertaken

Those methods undertaken before and also being made use of currently, are immobilisation and translocation to national parks, short-term driving (merely pushing the problem to another area) and the use of fire crackers. Some of these are of doubtful success while others are very temporary in nature and the larger problem always remains.

(3) Baseline Information

A requirement for the preparation of an elephant management plan, is information of a very fundamental nature that relates to animal ecology, socio-economic conditions of the farming communities, habitat conditions, amongst many others. This data are not readily available.

This deficiency is likely to be overcome to some extent by the availability of data from the recently concluded study commissioned by DWC under the Global Environmental Facility (GEF), titled “Ecology and ranging behaviour of wild elephants and human-elephant conflict in the north-west region”. It has been

undertaken by consultants from the University of Colombo. Monitoring herds using radio telemetry by collaring herd leaders, has been utilised to study elephant movement, and a clear picture of at least some of the "home ranges" and herd movements in and around the Priority scheme areas is understood to have emerged. The report is said to be with the Department of Wildlife Conservation.

It would be interesting (and indeed very relevant) to have some assessment of crop losses by wildlife, particularly by the elephant, and determine how much a farm family has lost in terms of production, income and man-days. The social and economic loss to a family on account of permanent injury and death of a member (often death has claimed the head of the family) are also required in a conflict resolution exercise.

(4) Carrying Capacity

Carrying capacity refers to the number of animals a particular habitat can sustain on the basis of available food and water and natural regeneration after a certain period of elephant use.

A number of questions remain for which answers are required in the formulation of a management plan. Some of these, for example are, the ecological status of present day elephant habitats; the number of animals that a particular habitat can support on the basis of the current ecological status; the current elephant numbers above or below the possible carrying capacity and the status, say in 10-15 years time, both of the habitat and the elephant populations.

(5) Land Use Plan

Demarcation of elephant habitat on the basis of a land use plan and recognising the need to grow food, have settlements and to recognise the animal's right to survival, could be a first step in conflict resolution. In the preparation of a land use plan, some trade-offs will be necessary. For example, redefining boundaries of agricultural land and wildlife habitats and the relocation of farming families in critical areas may be necessary.

Or else, are the days of the elephant in this agricultural region over; in that the elephant and man cannot co-exist any more and the elephant has to be removed from the areas altogether? This however, is an extreme situation but is nevertheless presented for discussion. All possible avenues and alternatives need to be examined in conflict resolution.

It was reported that new settlements are being created presently without concern for the ever present elephant problems. The village of Othapaluwa near Reswehera, to the east of Galgamuwa, is one such most recent creation. Another,

Henpitagama, initiated about 20 years ago, has now been abandoned. Unfortunately, the lessons are not learned and this results in a loss of investment, frustations to the people and then people become environmental refugees.

(6) Protected Areas

The Kahalla-Pallekelle Sanctuary (outside the Priority scheme areas but within the larger Master Plan study area) is the only designated protected area at present that offers some refuge to elephants. An evaluation of its ecological status is necessary to determine its role in a future management plan for the whole region. How many elephants can the sanctuary sustain in its present condition? Should the sanctuary boundary be redefined; extended to the Balaluwewa-Kalawewa Tanks and towards Reswehera thereby increasing its land area and restraining a larger number of animals? Should its status be raised to that of a National Park and some relocation of people carried out? The Balaluwewa-Kalawewa Tanks are the most important water source in dry weather, where animals gather in considerable numbers. These questions are raised for debate and discussion.

Protected areas should be easily identifiable by having prominent boundary signs and buffer zones, if possible. Boundary signs and buffer zones are psychological barriers that drive some fear into humans against encroachment. Animals should be discouraged from entering farm land by passive means also; introducing habitat enrichment, watering holes and buffer zones within protected areas. The use of electric fencing can be of benefit under certain conditions. Fences using solar panels are now in common use elsewhere. These fences need to be carefully designed and maintained properly to overcome difficult field conditions.

(7) Reduction in Numbers

Since it is clear that elephant numbers in these areas far exceed the carrying capacities determined by availability of natural food and water, some reduction in numbers is necessary. As reducing numbers cannot be carried out in the manner of African game management because it does not go well with cultural traditions, selected animals may be captured and given over either for domestication by interested and capable people with sufficient funds, knowledge and interest, or translocated to other wildlife parks, supplied to other zoos or reared in orphanages. Transfer of known trouble-making elephants to larger parks is also another aspect of reducing numbers.

(8) Damage Control by Farmers

In a short-term management programme, farmers need to be organised among themselves to minimise or prevent elephant damage as this problem cannot be

solved in a few days. Shortages of family manpower have been identified as a drawback to a greater effort by farmers in damage control in some areas, as only the elderly parents are left at home; the children having gone away for employment. Looking after both field and house is said to be difficult, for animals also attack houses at night.

Too much evening entertainment by the men was also identified as another reason. Negligence of farmers is said to play a part in the damage. The non-involvement of the second generation in agriculture is generally a cause for concern and is a negative factor to achieving better results from farming.

Villagers in all susceptible areas should be trained in reasonable damage control methods that can be adopted by themselves. Thunderflashes are issued to farmers but it is claimed that issues are invariably inadequate. The Department is undertaking this training in certain areas at the present time but should do it as a matter of urgency and increase the coverage of farming areas.

The functioning farmer organisation is a convenient group that can be targeted for training as farmers are organised on the basis of a paddy tract or *yaya*. Farmer knowledge of elephant issues and elephant movements in the area concerned should be constantly updated and they should be supplied with adequate thunderflashes.

Guns have been issued by government in certain villages in the hope that these will be used to frighten animals away. One wonders whether this will actually happen. On the contrary, injured animals will become more aggressive and also dangerous. Guns can also be misused, eg. for killing wild animals for trade in meat and skins. Such activities do take place presently. Some farmers also claimed that guns have been given to the wrong people who have no interest in farming.

(9) Traditional methods

Some farmers mentioned about traditional methods of keeping elephants away, eg. very close planting of a live fence of trees on the farm boundary. The palmyrah palm was one such plant mentioned; that elephants will never attempt going through a very closely planted double row of palmyrah palms.

In the village of Kathnoruwa, farmers of a *yaya* have experimented with the lighting of kerosene oil lamps at night along the boundary to keep away elephants. The lamps are placed within a suitable container covered with red plastic for greater effect and, for protection from wind and rain. They claimed some degree of success but were doubtful about continuing because of the cost of kerosene.

(10) Compensation

The present levels of compensation for elephant damage to crops, property and human injury and death, as indicated in section 3.10, seem inadequate in keeping with today's value of money. More realistic rates of compensation and streamlining the process by eliminating the bottlenecks in its disbursement, should be worked out to enable speedy transfer of money to affected parties.

(11) Advance Warning

It will be useful if DWC field staff can pass on information about elephant movements to farmers in affected Priority areas, as and when there is a likely threat of damage, so that farmers will be warned and adequate preparation can be made to minimise damage.

During the *maha,* when more people cultivate, protection of crops is somewhat better achieved than in the *yala*, when few people cultivate scattered plots and it is difficult to protect these.

Therefore, monitoring of wildlife movements, particularly elephants, by field staff should be an important departmental activity.

(12) DWC Staff Capability

Improvements need to be made to the abilities of DWC field staff to attend to their duties with a greater degree of confidence and responsibility. Provision of technical assistance to field staff should be a continuing exercise. In-service training at regular intervals and field exposure under experienced senior officers are necessary for better delivery of services. More staff postings are needed at strategic places and therefore, more new personnel are required.

The establishment of an "elephant management unit" to operate specifically in the dry zone agricultural production areas and located centrally in the region, should be given careful thought. This was also a recommendation of the Mahaweli Environment Programme that was responsible for the creation of the wildlife parks in downstream Mahaweli areas in the 1980s.

Communication channels need to be established within the Department for effective transfer of information back and forth. Field staff need to be updated with new information regularly.

(13) Database

As information is vital for decision-making, DWC field staff should be trained in collecting and maintaining accurate data on a wide a range of topics, relating not only to elephants but also to all species of wild plants and animals, and habitat

changes, and transfer these upwards at regular intervals for the use of senior management. The subjects may include aspects relating to the ecology of the elephant, its movements, biology of wild animals and plants, damage caused by elephants, injury and death of elephants, human behaviour towards wildlife and extension work undertaken. Data should be collected with as much detail as possible.

(14) Equipment

In order to make the work of DWC field staff meaningful in the larger context, a variety of equipment is necessary and these include vehicles, transmission sets and observation items such as binoculars, amongst others. Means of travel within individual ranges is at present seen as a serious shortcoming and needs to be considerably improved.

(15) Institutional support

Conflict resolution and management requires the active support of other public institutions and responsible private voluntary institutions, having an interest in field level programmes. Good co-ordination, continuous dialogue among contributing institutions and regular review will help achieve set targets.

(16) Co-ordinated Conflict Resolution

Considering the magnitude of the problem, and the short period available for this Study, no effort is made in this report, to find a solution to the man-elephant conflict as that is not possible. What has been attempted is an identification of some fundamental issues for discussion and propose that conflict resolution be taken up without further delay. Therefore, it is suggested that conflict resolution be co-ordinated at senior government departmental level, also involving others who have expertise in disciplines related to the issue.

A convening and co-ordinating role is proposed for the Ministry of Irrigation and Power (M/IP) that is also taking the lead role in this particular Study. A strong co-ordinating leadership is necessary because the problem involves policy-making, decision-making and resource-user co-ordination in the affected land areas. Otherwise there can be unnecessary inter-institutional debate, much confusion and little achievement. It is hoped that the M/IP will provide that leadership. The following could constitute a possible co-ordinating committee:

i) The Ministry of Irrigation and Power, through the Department of Irrigation, has a large interest and investment in the area concerned because of the operation and maintenance of many large and medium irrigation schemes. Continuing elephant damage will frustrate the

farmers, who in turn would fail to achieve national agricultural targets.

ii) The Department of Wildlife Conservation by itself, appears unlikely to be able to find solutions because of its inherent weaknesses.

iii) The Ministry of Mahaweli Development also has similar interests as the Ministry of Irrigation and Power in the areas and has had the benefit of experience in implementing the Mahaweli Environment Programme in the 1980s.

iv) The Ministry of Agriculture and Lands, through the Department of Agriculture, too has a wide ranging interest in the area because it is largely agricultural. It also has responsibility for land through the Land Commissioner's Department and for minor irrigation works through the Department of Agrarian Services.

v) Some universities have undertaken studies on elephant ecology from time to time and are knowledgeable on the issues in question. Others have been associated with special elephant studies, eg. those with the Smithsonian Institute some years back. The sociological aspects also need evaluation for which the universities have the expertise.

vi) There are retired DWC officers with considerable experience whose intimate knowledge of the areas and the particular problem may be availed of.

vii) There are some private voluntary organisations with interests in certain aspects of the issue and may be interested in undertaking specific tasks.

viii) The public of the areas are at the centre of the problem and therefore need to be heard about what they feel about their own problem. They have a wealth of information, experience and the urgent need to find solutions to the problem that they have lived with for a very long period.

4.3.2 Rainfed Uplands

The objective of any farming activity should be sustainable production of food using soil and water, through principles of good agricultural practice. This section considers some of the methods available for maintaining soil fertility in a tank-village system including soil, water and nutrient conservation, for the sustainable production of food. Some of the proposals below are those arising out of scientific research and development carried out at the Field Crops Research and Development Institute at Maha Illuppallama. These can be considered for adoption during the implementation phase.

The principles of good farming are listed below.

i) Selecting land according to its suitability and capability. In so doing, the first steps are taken in controlling soil erosion because consideration of the slope of the land will play a big part in reducing soil erosion in the cultivation of field crops. Slopes up to 25 percent are suitable for seasonal cropping;
ii) Maintaining soil fertility by incorporating organic manures, having adequate crop cover and adopting other appropriate agronomic practices;
iii) Managing runoff through contour cultivation and practices such as SALT and growing multipurpose tree species;
iv) Reducing runoff at the source by reducing the impact of rain drops on a bare soil and improving infiltration;
v) Maintaining good plant cover through practices such as using good seed, correct spacing, pest management, sufficient fertiliser and manure, crop residues and mulching;
vi) Permanently protecting river banks and tank perimeter reservations through legally constituted means;
vii) Adopting systems of forestry, agroforestry and alley cropping on suitable land classes;
viii) Integrating livestock and crop husbandry;
ix) Strengthening extension services;
x) Reintroducing some of the traditional farming practices that have built-in mechanisms of sustainable farming;
xi) Introducing economic incentives such as subsidies for adopting recommended soil and water conservation methods; and,
xii) Undertaking all planning and implementing of agricultural development on a watershed basis as a matter of national policy.

The recommended practices are briefly discussed below.

(1) Traditional Conservation Practices

The small tank-village system is suggested as the appropriate unit of development as adopted in the days of the ancient hydraulic civilisation. Examination of such systems indicate that resource use has had many components contributing as a whole to sustainable development and these appear appropriate even at the present time. The ecological equilibrium between the tank, the upland and the lowland was maintained at optimum levels.

The components of the system as described by MI workers are as follows:

- *weuw pitiya*: the area of the tank which is also the lowest point in the watershed.

- *weuw thavula*: the land area immediately surrounding the water area.
- *gasgommana*: the forest area surrounding the *weuw thavula*; it means a cluster of trees and is grouped into five classes, namely, *maha mukalana* (high forest reserved for hunting and gathering), *mukalana* (for gathering forest produce and sometimes allowed for chena), *landa* (chena after 10-15 years, used for firewood, leafy vegetables, fruit and medicinal products), *athdanduwawa* (vegetation after 25 years of chena) and *hena* or chena (different classes of the *hena* are identified);
- *kattakaduwa*: the land below the tank bund reserved mainly as a safeguard for the bund; consists of three land categories – downstream side of the bund; a marshy land through which the water flows before reaching the fields, where the vegetation has the effect of trapping salts carried in the water, and an upland area; the plant diversity provided many home needs including raw material for cottage industries – as many as 77 plant species have been identified and 27 of these grow in home gardens and in the upland areas.
- *gangoda*: the high ground near the tank and fields where the houses are located.
- *thisbambaya*: the high ground surrounding the houses where the livestock are tethered; where there is protection from wild animals; is also a mosquito trap as it is believed that insects prefer the blood of livestock and hence do not visit the homestead; is a sort of buffer zone for the homestead cluster.

The long-term viability of the village tank was then a primary concern of the entire village community as it was the lifeline for village survival. It is hoped that some of these conservation techniques can be revived when the Priority scheme project moves into the implementation phase.

(2) Land Management

The production potential of the tank-village system has been shown by MI workers to be high and as many as seven possible production avenues have been identified as shown diagrammatically in Figure S 4.1.

These are,

- Rainfed upland farming;
- Agro-based forestry;
- Integrated livestock farming;
- Paddy cultivation;
- Homestead farming;
- Agro-based industry; and,
- Fishery.

It has also been reported that rainfed upland cultivation produces about 80 percent of the grains, vegetables and pulses in Sri Lanka. The current production achievement of less than half the rainfed upland potential is attributed to loss of top soil, depleted soil fertility, weed problems and moisture stress. The extent of the rainfed upland is reported to be about 70 percent of the land area of a minor watershed and the balance being equally shared by the tank and paddy fields.

It has been suggested by other workers that both the small tank irrigated paddy land and the rainfed upland component be considered as a single planning unit, stressing on the importance of agro-forestry in the farming system. This appears practical.

1) Conservation of the small tank catchments

As the small tank catchments are degraded to a great extent, the protection of soil, conservation of water and thereby its fertility, should receive high priority. While conserving soil, the catchment should also generate sufficient runoff to feed the tank. This water enables a *yala* season cultivation of paddy or other field crops. Catchment conservation has a direct influence on the tank hydrology, upland water table and the paddy fields in the command areas.

MI workers in 1992, reported the findings of an experiment carried out to assess the erosion controlling ability of different farming methods, and concluded that graded hedgerows and strip mulches provided the maximum protection to the soil. The results are shown below.

Soil Loss Under Different Farming Methods

Farming method	Soil loss (tonnes/ha)	Erosion coefficient	Percent protection
Chena	14.99	0.435	Nil
Ploughed	12.42	0.432	1
Terraced	8.33	0.260	40
Strip-mulched	1.99	0.087	80
Graded hedgerow	1.28	0.061	86

Source: Dharmasena, P.B. (1992). Soil loss under different farming methods at the Field Crops Research and Development Institute, MI, during *maha* 1989/90

Gliricidia sepium, gliricidia (S: *wetahira*), a leguminous perennial, producing abundant leaf material for use in green manuring or in mulching, is the preferred species to be grown in the graded hedgerow that would divert the runoff during excessive rainfall into protected waterways, to be carried at non-erosive velocities into the tank. Gliricidia is grown at an inter-row spacing of 4 m and 0.5 m within the row. Small ridges of soil are made on the upper side of the hedgerow with a small drain to allow runoff to

flow. Every fifth row is replaced by a strip of grass, 2 m wide and this serves as an added barrier to trap the soil.

In the strip-mulched method, a permanent strip of Centrosema pubescens or Mucuna utilis, 0.75 m width is grown, spaced at 5 m wide contour intervals. The live thickly growing cover, traps moving sediment, provides organic matter and is nitrogen fixing.

What is ideal is a method that would control erosion and at the same time regulate runoff. The rainfall-runoff relationship for the different farming methods tested is shown in Figure S 4.2. The runoff threshold is the amount of rainfall above which runoff is generated. The system of chena farming produces the highest runoff but the associated negative effects of soil erosion in the catchment and transport into the tank below, makes it unacceptable.

It has been reported that the Irrigation Department is having the high flood level (hfl) around major tanks surveyed, to establish a reservation. The Irrigation Ordinance sets apart hfl + 0.5 m on a vertical scale as a reservation. However, these regulations have never been enforced.

The reservations of all tanks - major, medium and minor - should be identified and marked out permanently on the ground to denote state ownership and to discourage encroachment. These reservations should be maintained as "green belts" in the same vegetation type that usually grows in this strip of land. If the vegetation is degraded, steps should be taken to replant.

2) Alley Cropping

Alley cropping is another method that can be adopted to conserve soil and water. In MI trials, two closely spaced double rows of Gliricidia sepium are grown on the contour, at intervals that can vary with the type of crop to be grown in the inter-row space. A small bund of earth is made on the upper side. Even crop residues may be piled up between the two rows of Gliricidia. The Gliricidia is pruned at the beginning of the growing season to allow sunlight into the inter-row space where the crop is being cultivated. The loppings may be used for green manuring, composting or mulching.

3) Sloping Agricultural Land Technology

In the SALT system of farming, tree species, preferably leguminous, are grown on the contour, at an appropriate interval leaving adequate space for the cultivation of crops. The objectives are to control soil erosion, restore soil fertility and produce more food from land that would otherwise be

abandoned because of degradation.

The trees are pruned to allow sunlight and prunings can be used as mulch or green manure. Farm poles, firewood and miscellaneous plant products may also be obtained. Some suitable species for planting are Gliricidia sepium, Acacia decurrens, Flemingia congesta, Cassia siamea, Erythrina lithosperma, Tithonia diversifolia, Calliandra calothyrsus, Albizzia procera and Vetiveria zizanoides (S: *savendra*).

4) Agroforestry

Agroforestry systems combine the cultivation of forest species and tree crops. Multipurpose tree species utilising the multi-storey effect that allows the maximum utilisation of different sunlight intensities filtering through varying canopy levels produce food and other useful items at fairly efficient levels while at the same time providing satisfactory soil cover and fertility maintenance.

The roots pick up moisture and nutrients from different soil depths and the litter fall provides mulch, humus and recycled nutrients. Soil micro-organisms find a beneficial habitat and nutrient recycling is more effectively performed. Thus there is minimum leaching of nutrients beyond the root zone.

5) Home Gardens

The home garden can also be developed on the lines of an agroforestry system and can produce many items of food for family nutrition along with a saleable surplus. As a large number of farmers have the benefit of agrowells, the cultivation of a variety of trees, shrubs and herbs is possible with appropriate soil and moisture conservation methods. Introduced species will also grow well on account of assured soil moisture.

The home garden of the *purana* village was located below the tank bund on high ground, where the benefit of a good water table was utilised. The present day homestead has moved towards the well drained upland where *yala* moisture stress is a limiting factor. Hence, appropriate measures for water conservation have to be adopted for the successful establishment of tree species. MI workers have documented 140 plant species growing in the dry zone home garden.

Some farmers in tropical countries have developed these systems to a very high degree of ecological stability. Sri Lanka's own " Kandyan Forest Garden" is a good example. A case study reported from Kerala, South India,

describes a farmer who had integrated some 60 species of crops, trees and ornamental plants in a garden, as small as 0.4 ha. The species provided as many as 16 uses, with surplus bringing in extra family income. The uses are for food, fuel, timber, medicine, spice, cash, fibre, social, religious, green manure, stakes, poles, snake repellant, cosmetic, mulch and softwood needs.

6) Integration of Crops and Livestock

The integration of plants and animals in various farming system combinations, enable mutual benefits to both forms of farming. Farmyard manure and forms of plant manure when incorporated into the soil sustain soil microbes, maintain soil organic matter levels, improve water holding capacity and soil structure. Soils are also maintained in better physical condition.

7) Firewood Plots

The demand for firewood is very likely to grow in the future as alternate sources of energy such as gas and electricity get more and more expensive. There are many locations that will be suitable for the cultivation of selected species. Such places include the farm boundaries, poorer land classes, degraded land, canal and river banks. Suitable species include Gliricidia sepium, Calliandra calothyrsus, Acacia decurrens, Flemingia congesta, and Cassia siamea.

Besides the provision of firewood, planting trees in these places will also provide the added benefit of protection to the soil, act as windbreaks, modify micro-climate and provide some habitat to small species of wildlife. The growing of firewood can also bring in additional income to rural farmers as it can be sold for urban use. For example, in Anuradhapura town there is a great demand for firewood and there had been a Rs. 450 increase per hand tractor load in the three years from 1997-1999.

8) Stream, River and Tank Reservations

The need to have reservations on the banks of rivers and streams is laid down in the Crown Lands Ordinance but applies only to state land. Ideally, the law should cover all banks whether state or private. This is an important conservation practice and should be included to cover the strip of land above the high flood level of tanks.

The prescribed reserved width on each bank varies depending on the width of the waterway. For water bodies less than 4.5 m wide, a strip of land on each bank, 20 m wide is recommended as the reservation. When the stream

is between 4.5 and 15 m wide, the reservation should be 40 m and for streams over 50 m in width, the reservation should be 60 m.

In summary, if all the conservation measures for erosion control proposed in this section were to be implemented, many agronomic, economic, social and environmental benefits will be brought about. These include the following:

- Physically retaining the top soil within the farm;
- Eliminating sediment movement into streams, tanks and deposition elsewhere;
- Improved hydrological benefits to the tank, paddy land and upland area;
- Better water quality, free of suspended sediment, excessive nutrients and pesticides;
- Low BOD levels;
- More soil organic matter;
- Better soil structure;
- Greater soil micro-organic/soil faunal activity;
- Better nutrient retention in soil colloids and availability to plants;
- Better water infiltration and water holding capacity of soil;
- Availability of miscellaneous items for farm use;
- Dry weather stream flow;
- Improved crop growth and higher yield per unit area of land;
- Reduced cost of production;
- Enhanced productivity and higher income; and,
- Added value to the land.

4.3.3 Soil Salinity

The irrigation water that is supplied presently is free of salt and there is no risk of causing salinity in the immediate future. The isolated cases of salinity are reported from the areas where the field drainage channels have been encroached by paddy farmers and therefore waterlogging has resulted. This needs to be corrected.

In the short-term it is important to recreate the drainage channel (*kunu-ela)* along with its associated reservation and maintain as a permanent feature of the *yaya* to eliminate the instances of salinity so far reported. Permanent boundary markings of the channel reservation will help warn likely encroachers. It is also possible to cultivate salt-tolerant varieties, as salt-tolerant varieties have been bred at the research station at Ambalantota. In the medium-term, soil and water analysis at periodic intervals will be able to indicate poor water quality or localised soil salinity.

4.3.4 Water Quality

Drinking water available to the rural people is mostly from dug wells and open water bodies such as rivers, streams and canals. This is not tested for quality on a routine basis and analytical information is available only from past project studies. Various physical, chemical and microbiological characteristics determine good quality drinking water.

Where purified water is not available to communities, there is a responsibility on government to provide such and conduct routine analytical work on selected dug wells, streams and ponds located at places of high population density. Based on this analytical work, any problems identified should be corrected or alternatives provided to the people. The Mahananneriya area drinking water problem is an example of how the community has been unable to find a solution to a very important problem.

The government has a moral obligation to service these rural communities in areas as important as drinking water. Perhaps the NWSDB should meet this obligation. The laboratory capability of the Board at Anuradhapura has been strengthened through the on-going NCP Rural Development Project, specifically to assist in water quality analytical requirements of the agricultural community living in the region.

If the above community service can be initiated, it would be in the larger environmental interest of the region as early warnings can be obtained on the movement of agricultural nutrients such as nitrates and phosphates, and chemicals as these can also make unusable the sources of rural water supply by setting off undesirable effects. The availability of good drinking water in and around the Mahananneriya medium scheme and the Mahananneriya minor scheme group (cascade) needs to be looked into.

The issue of fluoride in parts of the Priority scheme areas is relevant to drinking water supply, particularly in rural areas. In order to make the water safe for drinking insuch areas, the NWSDB has introduced a simple, low-cost defluoridation filter that can be turned out easily using local raw materials.

According to the Hydrgeological Atlas of Sri Lanka, serpentine, a hydroxyl magnesium silicate, found in Sri Lanka, is known to remove fluoride from water. The Atlas also mentions that villagers have used the seeds of Strychnos potatorum (S: *ingini*) to purify water and perhaps the fluoride is also eliminated. This needs to be scientifically determined.

As the likely problem of high nitrate in the ground water of the Anuradhapura

District has been discussed in the COWI consult study, it would be of relevance to examine the supply of nitrogenous fertiliser to the paddy crop. In both *yala* and *maha* seasons, 260 kg/ha of urea are recommended in all three classes of Priority schemes. This quantity is more than what is being used presently on the medium and minor schemes, by a range of 95-150 kg/ha. Algal blooms are more pronounced in the small tanks. There is little information on ways of reducing nitrate loss from agricultural areas.

However, alternative sources of providing the nitrogen component to the paddy plant may be a very useful research study from the environmental viewpoint. Besides the polluting aspect of nitrogenous fertilisers, the cost of nitrogen supplied to the paddy plant is also very high. In the energy requirement of rice production in the low country dry zone fertiliser is reported to make up 54 percent. Of the above fertiliser recommendation, nitrogen as urea makes up 65 percent of the fertiliser input at a cost of over Rs. 2000.

The adoption of biological methods of salvinia control is suggested, as more recently, it has proved successful at many locations. The coleopteric weevil, Cyrtobagous salviniae, has been used. The adult beetle feeds on the buds of salvinia and the larvae feed on the rhizome of the plant. Physical removal is another possibility. A farmer organisation should be able to remove the weeds in a small tank on a *shramadana* (self-help) basis.

4.3.5 Pesticide Use

Pesticides, though not detected in water analysis work undertaken so far, could be a problem in the future, with increased agricultural activity unless precautions are taken in kinds used, how used and where used. The planned use of insecticide alone in the project implementation stage on a hectare of paddy is 20 kg (carbofuran). Therefore, it is good practice to be informed of the status of chemicals in the water at pre-determined intervals. An initial pre-project analysis of water in each Priority scheme for all environmental parameters has been proposed.

The wide acceptance of IPM methods and farmer education are ways of reducing the quantity of pesticide applied and preventing pollution of water bodies. As farmers in many areas are known to use pesticides indiscriminately, endangering environmental quality and unknowingly increasing their cost of production, there is an urgent need to transfer available technology for the benefit of both farmer and the environment.

IPM focuses on a flexible ecological approach to pest management using a variety of compatible strategies. It takes into account a range of options for pest management and does not do away with the use of pesticides altogether. It offers scope for pesticide reduction by depending more on natural predators of pests such as dragon flies, beetles, wasps, praying mantises, spiders and water bugs, and, pathogens such as bacteria, viruses and fungi. An Agricultural Instructor reported that during a FFS season of three months, 12 beneficial insects and 14 harmful insects were identified in a single *yaya*.

Orderly cultural practices throughout a *yaya* and a thorough understanding of the growth cycle of the crop and the life histories and population dynamics of plant pests are other components that contribute to the success of IPM. Varietal resistance by breeding for pest resistance is also a long-term strategy to be conducted at the same time.

IPM utilises all suitable techniques and methods in a compatible manner, maintaining pest populations at levels less than that causing economic injury. It integrates all suitable management techniques with the natural regulating and limiting elements.

IPM training of farmers is achieved through Farmer Field Schools (FFS), conducted in a selected farmer's field. It is an one day per week outdoor class for farmers, spread over an entire cultivation season, based on learning by seeing and doing. Farmers are trained in the entire agronomy of paddy cultivation and are shown how to establish economic injury levels and economic threshold values. Another advantage of the FFS is that there is farmer to farmer technology transfer.

Economic injury level is the critical population density at which pest damage equals in value the cost of control. Economic threshold value is the density of a pest population above which control measures should be applied.

Programme evaluations have shown that farmers who practised IPM had achieved higher yields/ha than those who did not. This is attributed to the improved after-care in their own fields after the technical knowledge gained at the FFS.

Table S 4.1 compares insecticide use and yield at FFS sites, between two corresponding seasons, 1994/95 and 1995/96 before and after IPM applications in three districts. There had been a significant reduction in insecticide use with IPM methodology. Drought prevented a satisfactory conclusion in the Puttlam District.

Table S 4.2 shows the results at FFS sites with and without IPM during the same season. Here again reduction in insecticide use had been achieved along with yield increases when IPM was practised. At Kurunegala, there was no insecticide

application whatsoever, while a yield increase of 500 kg/ha over the non-IPM plot was obtained.

Another evaluation conducted by the Faculty of Agriculture of the University of Ruhuna, in southern Sri Lanka, in 1996/97, shows that, among many of environmental and economic benefits, farmers who followed IPM methods had obtained gross margins of Rs 31,700 per ha as against Rs 23,800 per ha by those who did not, at the farm gate selling price of Rs 10/kg of paddy.

Traditional methods of insect pest control rely on more on naturally available predators and substances and physical elimination methods. In biological control, common birds play an important part. Some of these are Corvus macrorhyncos culminatus, black crow (S: *kaputa;* T: *kakam*), Coracias benghalensis indica, Indian roller (S: *dumbonna;* T: *kottai-kili*), Acridotheres fristis melanosternus (S: *mynah*; T:*nakanam-patchi*) and Ardeola grayii, pond heron (S: *kana-koka;* T: *kuruttu kokka*). Certain species of fish such as Barbus uneya (S: *thiththaya*) and Aptocheitus dayi (S: *irinala handaya*), frogs and the water monitor are consumers of insect pests.

Spread of water weeds is rapid with high nitrate and phosphate levels. A way to reduce the quantity of fertiliser being used, and therefore also cost of production, particularly in paddy, is by basing fertiliser use on soil analysis. The kinds and quantities of fertiliser to be applied are determined after the soil is analysed, and this service is available from the Department of Agriculture.

4.3.6 Public Health

This section has special reference to malaria control as it has the most damaging effects on the physical well-being, farm productivity and economic prosperity of the farmer households. Malaria can be prevented and also cured. However, prevention is more economical than cure. Preventive methodologies are known and application is what is required. Close public and local institutional co-operation with the Anti-Malaria Campaign (AMC) of the Health Department is to be advocated at all times. This should be followed by effective sanitation and hygiene in the household and within the community.

Studies have shown that when maintenance of irrigation schemes is neglected, increased vector breeding sites are created due to waterlogging, seepage from canals, excess water in the drainage system, reduced canal water velocity and water rotations favouring the propagation of vectors.

There had been a high incidence of malaria in System-C during the early stages of

project implementation mainly due to large settler populations and labour gangs coming from non-malarial areas, who neither knew how to cope with the disease nor had the body immunity against the parasite.

In the Priority schemes, through sub-committees to be set-up within farmer organisations (eg. sub-committee on income generation and social services), efforts should be made to establish and maintain close linkages with the local representatives of the Provincial Health Services to benefit from the anti-malaria programmes. Some of the tasks that should be undertaken by the sub-committee, are updating of knowledge about malaria and other communicable disease prevention among the members, encouraging household sanitation, inviting mobile clinics to the village to take blood films, caring for those needing treatment including pregnant mothers.

A practical difficulty experienced in the field is the lack of co-ordination between institutions responsible for resource use and for maintenance. An example is vector control. The irrigation tanks and canals are controlled and maintained by the Irrigation Department and the Department of Agrarian Services, with hardly any attention being paid to the biological issues that arise within the schemes. The vector control programme is implemented by the Health Department with no relation to water issues and irrigation requirements. Therefore some co-ordination will be useful and may be instituted at the *kanna* meeting at the farmer's level and at Divisional Agriculture Committees at the Divisional Secretary and District Secretary level.

The national programme of the Anti-Malaria Campaign has five main components. These are,

- Detecting cases early and ensuring prompt treatment;
- Adopting selective control methods;
- Forecasting outbreaks and epidemics; and,
- Assessing programme to suit changing needs.

Emphasis is placed on the prevention of the disease rather than on treatment after contracting the disease. A variety of measures can be adopted for prevention. These would either protect against infection or against the development of the disease when infected. For effective control of the disease in those infected, early diagnosis and prompt treatment are essential. Often people neglect treatment and relapses occur, along with development of resistance to anti-malarial drugs.

At an individual level, the following preventive methods are outlined:

- Using permethrin (a synthetic pyrethriod) impregnated bed nets which is very effective;
- Closing windows in the evenings helps reduce entry of mosquitoes into the

house;
- Having mesh covered doors and windows, is effective, though costly;
- Using approved mosquito repellent coils, vapourising tablets, oils and smoke; and,
- Using preventive drugs such as chloroquine but only on the advice of a doctor, as taking such drugs over long periods can have undesirable side effects;

At the community level, the following measures are advocated:

- Residual spraying of houses;
- Inviting mobile clinics for case detection;
- Larviciding by chemicals (eg. temephos) during times of drought when pools of water collect;
- Fogging; and,
- Using larvivorous species of fish in biological control, eg. Poecelia reticulata and Aplocheilus dayi; these species have already been released at many locations.

These preventive methods are components of AMC field operations even at present. What is desired is greater awareness, active community participation and better co-ordination, for desired effectiveness.

4.3.7 Increasing Tree Cover

Some possibilities are indicated in section 4.3.2. Increasing the general tree cover in the project areas is seen largely as one of ecological benefit. Within such a programme, certain areas can be grown to firewood species in anticipation of future shortages. Other potential areas for general tree planting are roadsides, public places, school premises and places of worship.

Planting a variety of species is possible to suit specific locations. A species recently introduced and becoming popular is Khaya sengalensis, african mahogany, suitable for timber.

It should be possible for farmer organisations to establish nurseries with the guidance of the forest Department. There are some financial benefits also in such a venture.

Identified catchment areas also need to be planted to suitable species with the assistance of MI workers. In this instance care should be taken to ensure there is adequate runoff into the tank. During seedling establishment, the most difficult period is during the first one or two yala seasons when the drought makes after-care of field plantings difficult. Suitable methods have to be initiated to minimise field loss of plants such as correct planting time, the use of nurse crops and watering.

Chapter 5 MONITORING

Monitoring has to be undertaken within limitations of availability of finance, manpower and other resources with institutions. It is a continuing activity and provides valuable information to project management on resource changes taking place during and after project implementation. Monitoring to the levels undertaken in developed countries is somewhat of an expensive activity and should not be attempted. What is to be carried out should be simple, economical and practical, so that farmers can be warned of the need to be mindful of the changes taking place.

With the current trend towards transferring certain aspects of resource use to the users, ie. farmer organisations, the involvement of the farmers themselves in monitoring resource changes becomes very relevant. This is also a very cost-effective way of initiating the monitoring process into project management. Hence, farmer training classes should also include components of simple methodologies by which farmers would be able to identify visible resource changes or environmental effects.

For example, sedimentation of the tanks takes place because there is erosion occurring somewhere in the watershed. Poor growth of the paddy crop at the lower end of the *yaya* could be related to salinity because there is waterlogging due to encroachment of the drainage channel. Hence, before rushing into expensive analysis of the water, restoring the drainage channel to serve the intended purpose, will mitigate the problem.

5.1 Elephant Damage

Monitoring elephant movements by DWC staff, with the assistance of the farmers will provide at least two needs. Firstly, farmers in nearby farming villages can be warned about likely paths of travel of the animals. Secondly, the DWC will gather data about elephant movements, elephant ecology and likely "home ranges." Data such as these are necessary for preparing or modifying management plans at little or no cost.

5.2 Soil Erosion

Erosion losses of soil, particularly on flat land, will not be easily visible unless very advanced. However, on sloping land, the formation of rills and sediment movement over short distances will be the first signs. It is also the time to assess the situation and take preventive action. At this stage the problem can be easily corrected by adopting simple agronomic practices. But the presence of gullies shows an extreme erosive process and this situation requires complicated and often costly corrective measures.

Therefore, farmers should be on the look out for the early warning signs of sheet and rill erosion, identify the causes and take the necessary remedial measures. This is the simplest cost-effective method of monitoring that can be undertaken at the farmer level.

5.3 Salinity

The basis for all agriculture is water, the quality of which has to be within limits of acceptability in order not to cause undesirable effects on human beings, livestock and the environment. A national standard for drinking water is available and one for irrigation water is in preparation.

As salinity is usually associated with irrigation schemes, it would be advantageous to have baseline information for each scheme being implemented. The availability of such information will enable assessing changes taking place subsequently. If the changes are undesirable, then the necessary corrective management decisions can be taken.

Farmers' observations and crop performance should be the guidelines to further analytical work. Farmer organisations should ensure that drainage channels and reservations are cleared of all encroachments, deepened where necessary and free flow ensured at all times. Farmers have indicated that where drainage channels have been encroached upon, salinity has developed. Hence, this should be a priority in a management plan. The canal reservation markings should remain in place at all times.

5.4 Water Quality

Water in a free flowing state as in rivers and canals, and in a static state as in enclosed ponds, can deteriorate due to natural causes or man-induced causes. Monitoring for water quality can take place at two levels; the institutional and farmer levels. The former can be routine or specific. Routine water quality analyses in irrigation water does not take place. However, routine analyses takes place in the case of drinking water supplies, when the NWSDB monitors its supply sources. Nachchaduwa Tank is one such source. The Board also examines the high fluoride content peculiar to parts of the Priority schemes.

The larger interest in good quality water is for domestic and drinking purposes. Knowledge on the presence of nitrates, phosphates and pesticides are particularly important. Some involvement of the NWSDB is proposed in areas where the community has to depend entirely on dug wells and open water bodies.

However, with project implementation, agricultural production is likely to intensify with higher levels of inputs and therefore, the likelihood of nutrient and chemical pollution. Quantification would be possible, but to assess to what degree the changes have taken place, and over what period of time, a knowledge of what the situation was before project implementation, is required. This is possible only if data are available indicating the status before the project began. Towards this need, baseline analyses of the Priority watersheds are proposed. It is not feasible to have continuous monitoring of irrigation water. Salinity was discussed in section 5.3.

As there are many users of water, co-ordination becomes necessary in order to avoid overlap and also to ensure optimum use of scarce manpower and materials. This co-ordination is proposed at the District Agricultural Committee, constituted of all district resource managing agencies, that meets monthly.

5.5 Public Health

Monitoring farmer's health condition is important from the aspect of farm productivity as ill-health will reduce the ability to perform hard farm work, increase cost of production by having to hire outside labour, reduce potential family income and also increase national cost on health care.

Correct nutrition and preventive measures against certain diseases, are the basis of remaining healthy and being able to make a meaningful contribution to family and national welfare.

Within each family, perhaps the mother, should be responsible for looking after family health. The combined efforts of all households will contribute to a healthy community. This is a convenient point at which to assess the impacts of irrigation on health and the environment.

At the community or village level, the responsibility to ensure good health is best co-ordinated at meetings of village leaders. A suitable focal point is the sub-committee level of the Farmer's Organisation – the sub-committee on income generation and social welfare. As the women will play a major role here, it is a suitable forum to discuss community health matters. As there will also be training programmes convened by sub-committees, education on individual family matters of health may also be taken up here.

Aspects to be focused on will be household sanitation, controlling vector-borne diseases (malaria, dengue and Japanese encephalitis), family nutrition, primary health care, drinking and irrigation water, and pesticide poisoning through careless handling in the home and field.

Malaria control should be given special importance as it is a disease that can have serious social and economic implications because of its long-term deteriorating effect on family health – from farmer output in the field, through impacts on pregnant mothers to attendance at school.

These aspects are also the concern of government departments at all administrative levels from the village upwards. There are village-level health workers with whom the sub-committee should maintain regular contact, invite to its meetings and obtain the maximum benefit by way of knowledge and facilities.

The issue of pesticides is of particular importance because of accidental use in the home, in suicide, irresponsible handling and storage in the home and in the field, and pollution of soil, air and water. The adoption of IPM by farmers can be an initial indicator relating to reduction in pesticide use. Here again the subject should be one for discussion at sub-committee on income generation and social welfare and at DAC meetings.

Health and environment is also one of the concerns of the International Water Management Institute (IWMI) based in Colombo. The institution has a study programme on disease vector control with Sri Lanka as one of the study areas. Research into some aspects of specific problem areas take place, eg. reduction of vector breeding sites, high levels of pesticide poisoning and multiple uses of irrigation water. As there is usually a delay in research findings reaching the intended beneficiaries, the project management should attempt to obtain the new findings of research and initiate relevant implementation.

5.6 Tree Cover

Increasing the tree cover may be monitored in several ways. One is the actual field planting - the number of seedlings planted during a particular season or year. Another is the area covered - on a watershed basis or any other designated unit, eg. roadsides, places of worship and schools. The number of farmer organisations that have established nurseries is another indicative measure.

Field planting is easy. Maintenance until establishment in the field is difficult under the unfavourable *yala* conditions. Some replacement will then have to be undertaken. An annual evaluation of field survival rate will also indicate the extent of replacement required.

Chapter 6 REVIEW OF IEE

Basically, the objectives of the project are to help rural farming households to achieve targets of more profitable agriculture and higher standards of living through rehabilitation of irrigation infrastructure, more efficient use of water with participatory management and improvement of support services, including credit and marketing.

Of the environmental issues identified in chapter 3, one problem stands out as of great significance to the continued success of farming in the Priority schemes. That is the human-elephant conflict. It has, over a long period of time, continued to frustrate the farming community by destroying in just one single night, the hard work of a couple of months (eg. damage to paddy or upland crops in the field or paddy stored in the house). The hard work of a few years (eg. damage to banana or young coconut) can also be damaged in a single night. A lifetime's effort also comes to an end when a house is damaged. Farmers have even paid with their lives or have been injured in the course of getting about their daily work.

Hence, it is suggested that the issue of the human-elephant conflict be resolved in a lasting manner. It is not possible to lay down guidelines for the resolution of the human-elephant problem at this stage of the Initial Environmental Examination (IEE) due to lack of adequate information and the need to discuss the subject with a number of institutions. Therefore, the human-elephant conflict needs to be studied in depth as a separate issue.

In the case of all other environmental issues listed in chapter 3, initial corrective measures and subsequent good management can bring about a more sustainable level of agricultural production. There is no need therefore, to subject these to a detailed environmental impact (EIA) assessment. These are easily mitigated through the different management options which the project will recommend and implement. Some of these issues include problems of field drainage, surface and ground water quality, catchment degradation and silting of minor tanks.

For example, the establishment and maintenance of the *yaya* drainage channel should eliminate the isolated occurrences of salinity. The preliminary water quality analysis to be conducted at the beginning of the project will be an indicator of irrigation and drinking water quality. This will then serve as the baseline reference against which future analytical data (during implementation) will be assessed. The presence of salts, nitrates, phosphates and pesticides will be indicated through this analysis. These are the major polluting constituents of water that will cause problems later if left unattended. Corrective measures are not too difficult to implement.

The degradation of the rainfed upland can again be arrested and the situation corrected through a series of agronomic practices that are very simple and implementable by the farmers. The research work that has been carried out at MI will provide the required

mitigating methodologies. The adoption of good household sanitation, and co-operation with the anti-malaria campaign can minimise the incidence of malaria and other public health issues.

Resolution of the human-elephant conflict however, requires more baseline field information than is presently available, in relation to animal ecology and a quantification of losses incurred by farmers on account of attacks. It has not been possible to undertake an exercise of this nature within the mandate of this study.

Preliminary field inquiries within the Priority schemes, by talking to farmers, wildlife field officers, and the GEF study consultant, discussions at PCM workshops and looking into records of damage, have led to the conclusion that a detailed investigation of the problem is necessary to find ways and means to a lasting solution. Hence, an EIA on the human-elephant conflict is recommended.

TABLES

Table S 3.1 Comparison of Water Analysis of Nachchaduwa Tank with the Sri Lanka Standard for Drinking Water

Parameter	Unit	NARA analysis 1993		NWSDB analysis 1999		Sri Lanaka Standard	
		min.	max.	min.	max.	minimum desirable	maximum permissible
Temprature	^{o}C	26	32				
Conductivity	uS/cm	207	623	260	360	750	3,500
pH		6.83	8.11	7.4	8.2	7.0-8.5	6.5-9.0
Dissolved oxygen	mg/l	3	9.4				
Total alkalinity	mg/l	24	130	80	130	200	400
Total hardness	mg/l as CaCO3	60	198	84	115	250	600
Calcium	mg/l	12.8	32.9				
Magnesium	mg/l	2.9	32.1				
Total iron	mg/l	0.08	1.98	0.5	0.15	0.3	1
Anmoniacal N	mg/l	0.01	0.93	0.2	0.6		0.06
Nitrate N	mg/l	0.04	2.32	0.9	7.5		10
Nitrite N	mg/l	0	0.1				0.01
Phosphate	mg/l	0	0.03	0.07	0.26		2
Chloride	mg/l	2.5	8.5	24	96	200	1,200
BOD	mg/l	3	19				
Organic matter	mg/l	2	10				
Turbidity	NTV	5	35	8	50	10	20
Sulphate	mg/l		9			200	400
Fluoride	mg/l					0.6	1.5

Table S 3.2 Water Analysis of the Attaragalla Tank

Month	pH	EC (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (^oC)	Phosphate (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Chloride (mg/L)	Alkalinity (mg/L)	Total Hardness (mg/L)
1 January	8.40	0.36	33	1.4	29.0	0.000	-	0.007	75	30	140
2 February	-	-	-	-	-	-	-	-	-	-	-
3 March	8.10	0.43	10	2.2	29.0	0.000	0.009	0.014	80	40	160
4 April	7.53	0.51	48	6.7	32.0	0.171	1.371	0.032	55	10	120
5 May	-	-	-	-	-	-	-	-	-	-	-
6 June	8.60	0.41	10	6.2	34.0	0.220	0.245	0.007	75	10	110
7 July	8.50	0.42	10	7.0	29.0	0.021	0.138	0.018	70	20	140
8 August	7.20	0.50	20	8.0	28.0	0.025	0.203	0.017	95	20	170
9 September	7.70	0.65	140	5.7	29.0	0.013	0.116	0.038	210	10	250
10 October	8.00	0.63	80	6.2	31.0	0.104	0.132	0.045	140	30	230
11 November	6.20	0.48	10	5.7	31.0	0.024	0.000	0.022	95	20	150
12 December	7.90	0.24	10	3.8	28.6	0.030	-	0.007	5	20	60

Source : NWP Water Resources Development Project ,1997

Table S 3.3 Human Elephant conflict in the Galgamuwa D.S. Division

Around Palukadawala Major, Mahananneriya Medium and Mahananneriya Minor Schemes.

(i). Human Deaths

Year	Total for the year	Village	No/Age/Sex	Remarks
1997	5	Embalegama	1/-/M	-
		Meegalewa	1/-/M	-
		Sangappala	1/-/M	-
		Liyannagama	1/-/M	-
		Mahagalkadawala	1/-/M	-
1998	6	Mahananneriya	1/-/M	-
		Wetakoluwagama	2/12/Children	Getting too close to injured animal
		Walawaswa	1/-/M	-
		Wegedera	1/-/M	-
		Meegalewa	1/-/M	-
1999	6	Mahananneriya	1/-/M	
		Usgala – Siyambalangamuwa	1/-/M	
		Porothukadawala	1/-M	
		Galkiriyagama	1/-/M	
		Medagama	1/-/F	
		Palukadawala	1/-/M	

Source : Department of Wild Life conservation, Meegalewa

(ii). Wild Elephant deaths

Year	Total for the Year	Village	No./Age/Sex	Remarks
1997				
1998	3	-	1	-
		Galkiriyagama	2	-
1999	-	-	-	-

Source : Department of Wild Life conservation, Meegalewa

(iii). Property Damage (House)

Year	Total No. reported for the year	Value as estimated by owner (Rs)
1997	23	286,160
1998	75	1,483,861
1999	43	712,294

Source : Department of Wild Life Conservation, Meegalewa

(iv). Crop Damage : requests for compensation

Year	No. of requests	Remarks
1997	168	Compensation paid rarely exceeds Rs. 1000
1998	203	-
1999	Not available	-

Source : Social Services Officer, Divisional Secretariat , Galgamuwa

Table S 3.4 Human–Elephant conflict in the Tirappane DS Division 1997 to 1999

Around Periyakulama Medium scheme

(i) Human deaths

Year	Total for the year	Village	No./Age/Sex	Remarks
1997	2	Ittikattiya	1/-/M	Killed in the home
		Kanumullegama	1/-/M	Killed in the field
1998	1	Pudukulama	1/-/M	Killed in the field
1999	-			

Source: Department of Wildlife Conservation, Beat Office, Ittikattiya

(ii) Wild elephant deaths

Year	Total for the year	Village	No./Age/Sex	Remarks
1997	1	Eruwewa	1/-/M	Gun shot injuries
1998	1	Periyakulama	1/-/M	Gun shot injuries
1999	2	Perimiyankulama	1/-/M	Gun shot injuries
		Elupethawewa	1/-/-	Gun shot injuries
	1	Ethungana	1/-/F	Killed for tusks

Source: Department of Wildlife Conservation, Beat Office, Ittikattiya

(iii) Property damage (house)

Year	Total for the year	Village	No.of incidents	Estimated value (Rs). Totaled for the year
1997	2	Ittikattiya	2	8,500
1998	15	Ittikattiya Periyakulama Pudukulama	8 6 1	134,000
1999	1	Pudukulama	1	8,150

Source : Department of Wildlife Conservation, Beat Office, Ittikattiya.

(iv) Crop damage

Compensation is paid by the Social Services Officer attached to the Divisional Secretariat. It has not been possible to obtain a breakdown of payments.

Table S 3.5 Human-elephant conflict in the Sravastipura DS division* 1997 to 1999

Around Nachchaduwa major tank

(i) Human deaths

Year	Total for the year	Village	No/Age/Sex	Remarks
1997	2	Alutwewa	1/43/M	-
		Madawalagma	1/-/M	-
1998	nil	-	-	-
1999	6	Thuruwila	1/53/M	Killed in the field
		Aluthpunchikulama Nachchaduwa	1/-/- 4/47,17,26,5/F,F, M,M (all of one family)	- Killed in the home

Source: Department of Wildlife Conservation, Range Office, Anuradhapura.

(ii) Wild elephant deaths

Year	Total for the year	Village	No/Age/Sex	Remarks
1997	Nil			
1998	1	Thuruwila	1/-/-	Gunshot injuries
1999	3	Galkulama	1/-/-	Gunshot injuries
		Ittikulama	1/-/-	Gunshot injuries
		Bulupethawa	1/-/-	Gunshot injuries

Source: Anuradhapura Range Office, Department of Wildlife Conservation.

* This is a newly created Divisional Secretary Division in1999 by redefining the boundaries of other Divisions. Hence, it has not been possible to obtain all the data, due to the transfer of material from the old offices to the new office had not been completed at the time of the Field Study.

Table S 4.1 Pesticide Usage and Yeild at FFS sites before and after IPM

(Comparison between two corresponding seasons)

FFS sites / Distric	No. of Pesticide Applications		Cost of Pesticide (SLR/ha)		Yield (Kg/ha)	
	Before 94/95	After 95/96	Before 94/95	After 95/96	Before 94/95	After 95/96
Anuradhapura	5	2	5,500	2,500	5,000	4,000*
Kurunegala	5	2	3,800	1,600	4,356	4,715
Matale	6	2	4,220	1,280	3,235	3,322
Puttalam[+]	-	-	-	-	-	-

Table S 4.2 Pesticide Usage and Yeild at FFS sites with and without IPM

(Comparison during the same seasons)

FFS sites / Distric	No. of Pesticide Applications		Cost of Pesticide (SLR/ha)		Yield (Kg/ha)	
	IPM	UFP	IPM	UFP	IPM	UFP
Anuradhapura	2	5	2,500	5,500	4,000	4000
Kurunegala	0	2	0	1,600	4,868	4,366
Matale	1	5	640	2,580	4,173	4,156
Puttalam[+]	-	-	-	-	-	-

Notes for both tables

FFS : Farmer Field Schools
No. of Pesticide Applications : Insecticide and weedicide applications during a season
Before/After : Maha season of 94/95 and Maha season of 95/96 respectively
Yield : Wet weight yield
* : Affected by drought
[+] : Abandoned due to drought
IPM : Integrated pest management methods adopted
UFP : Usual Farmer Practices

Souce : Result of IPM Farmer Field School. FAO, IPM Programme, Sri Lanka. June 1996

FIGURES

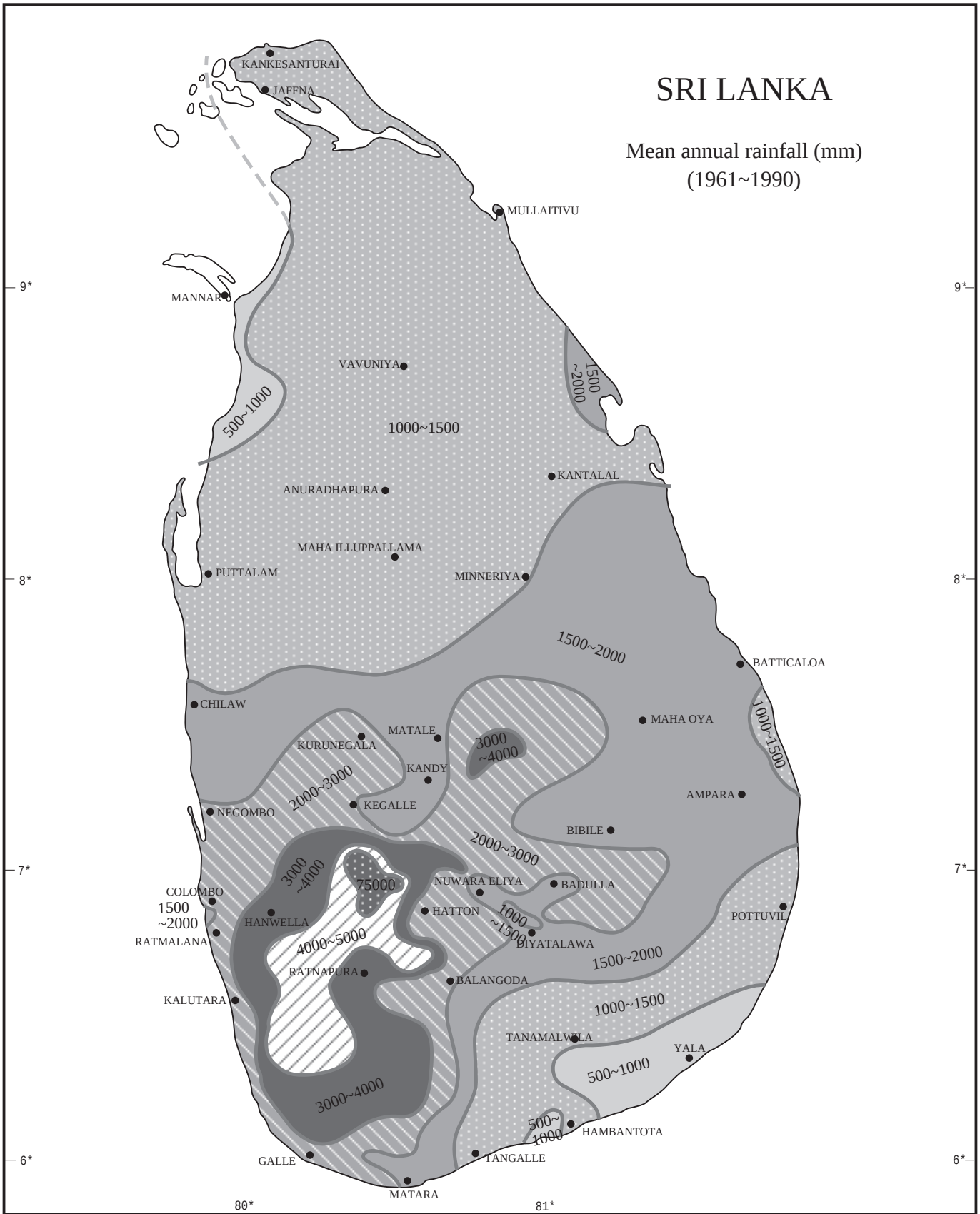

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Figure S 2.1

Sri Lanka : Mean Annual Rainfall
(1961 - 1990)

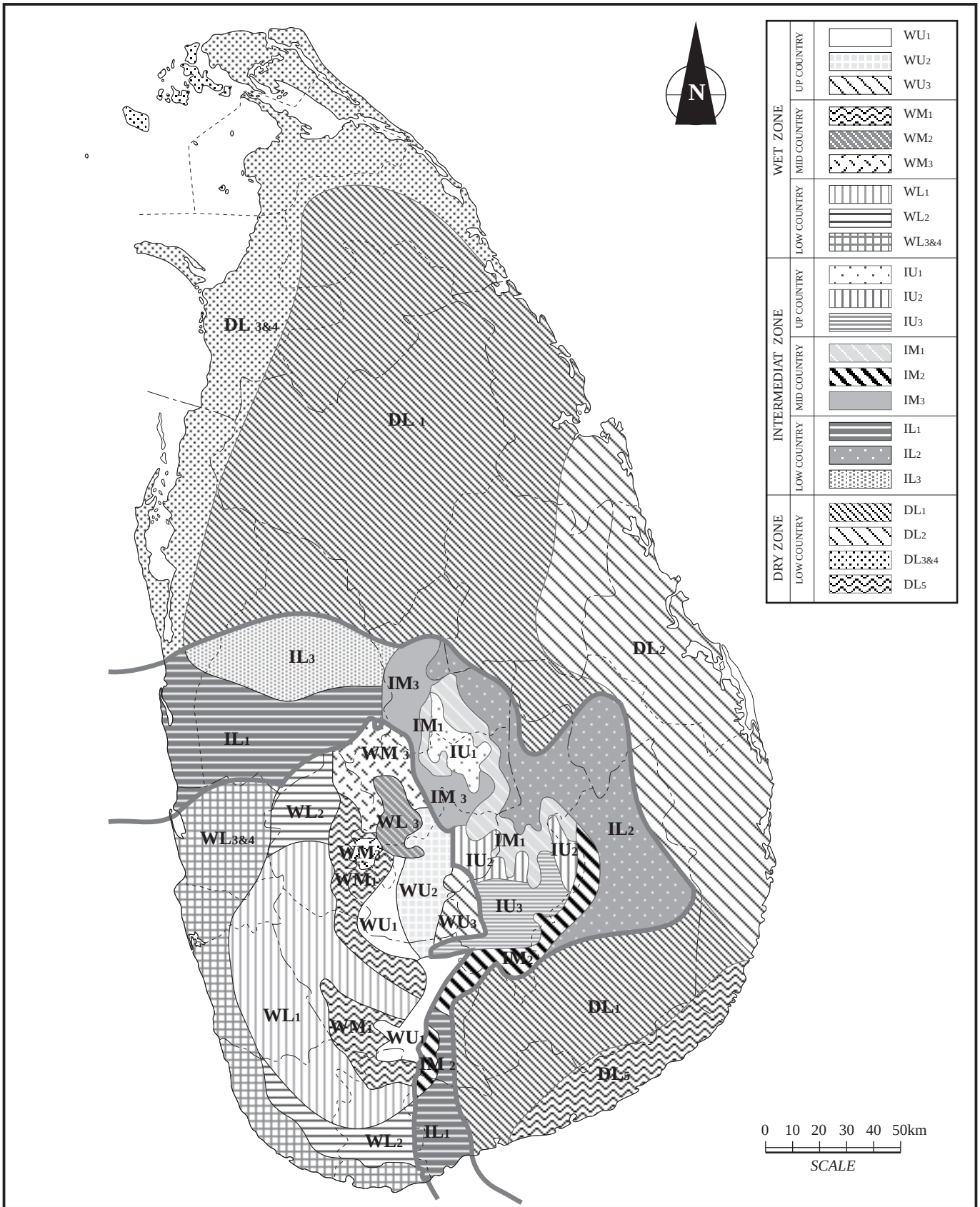

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Figure S 2.2

Agro-ecological Zones of Sri Lanka

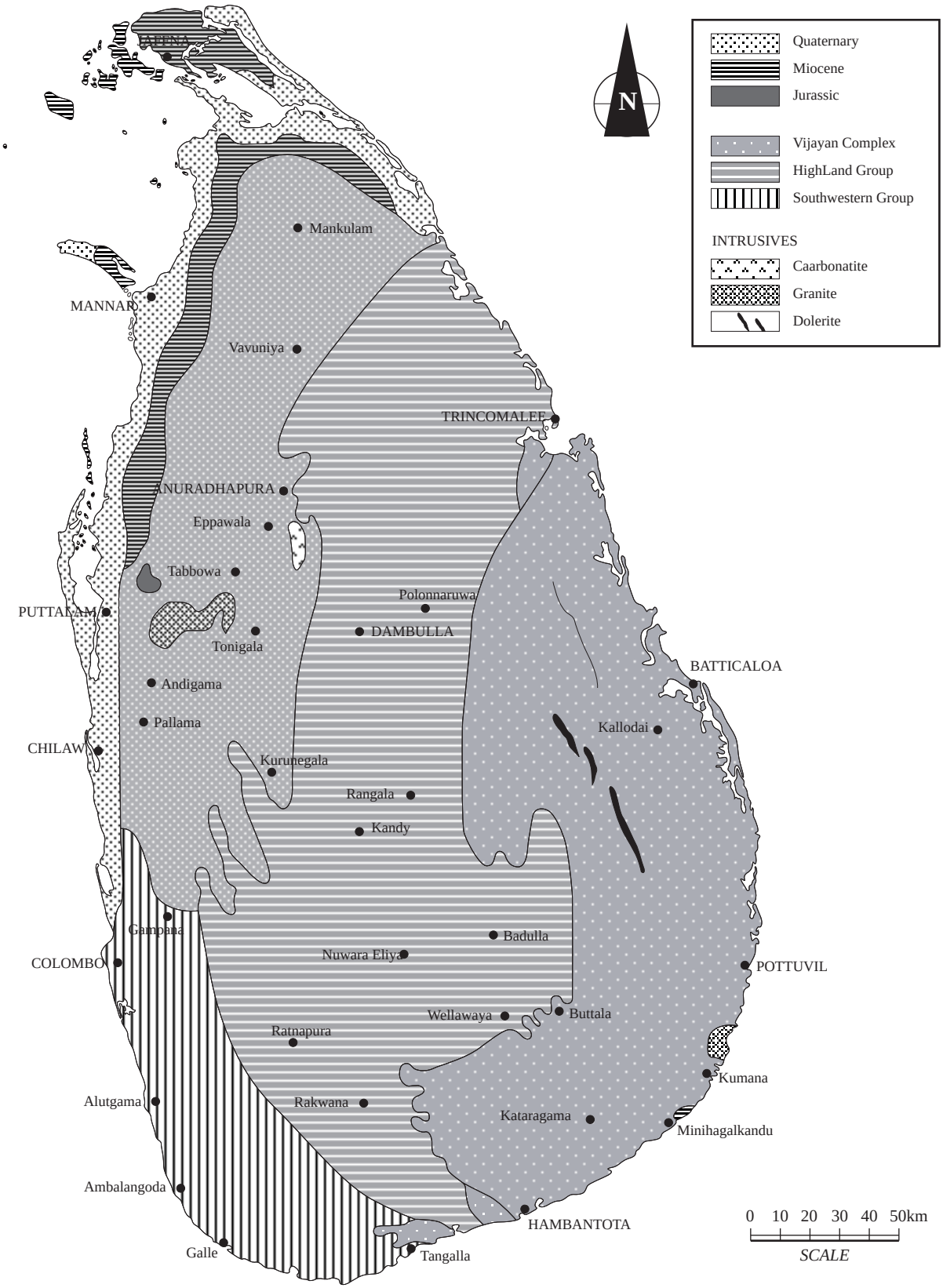

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Figure S 2.3

Geology fo Sri Lanka

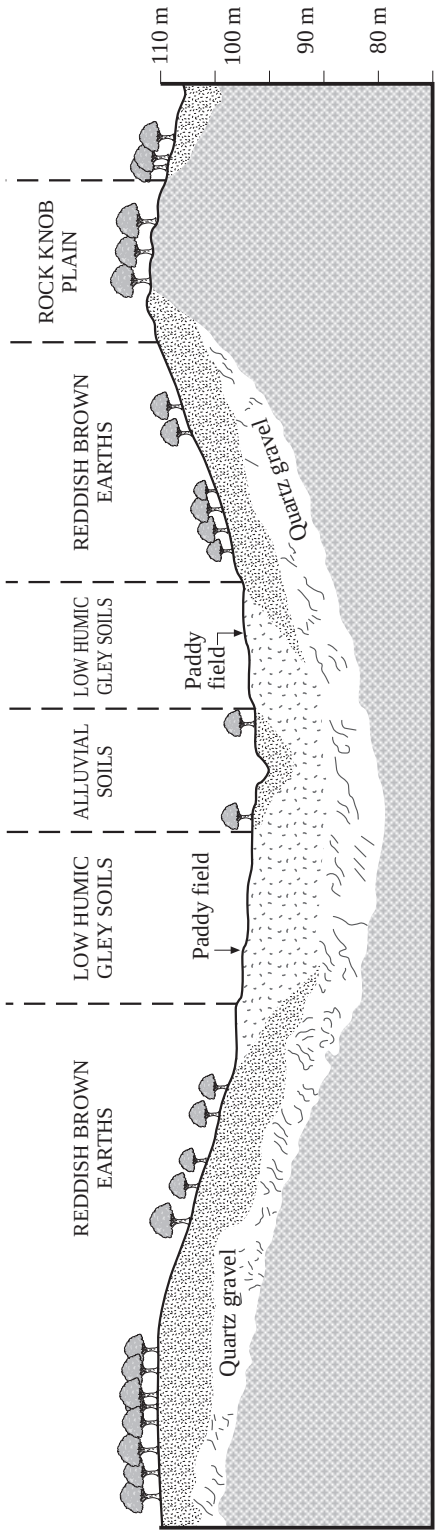

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Figure S 2.4

Reddish - brown Earth - low Humic Gley Soils Association

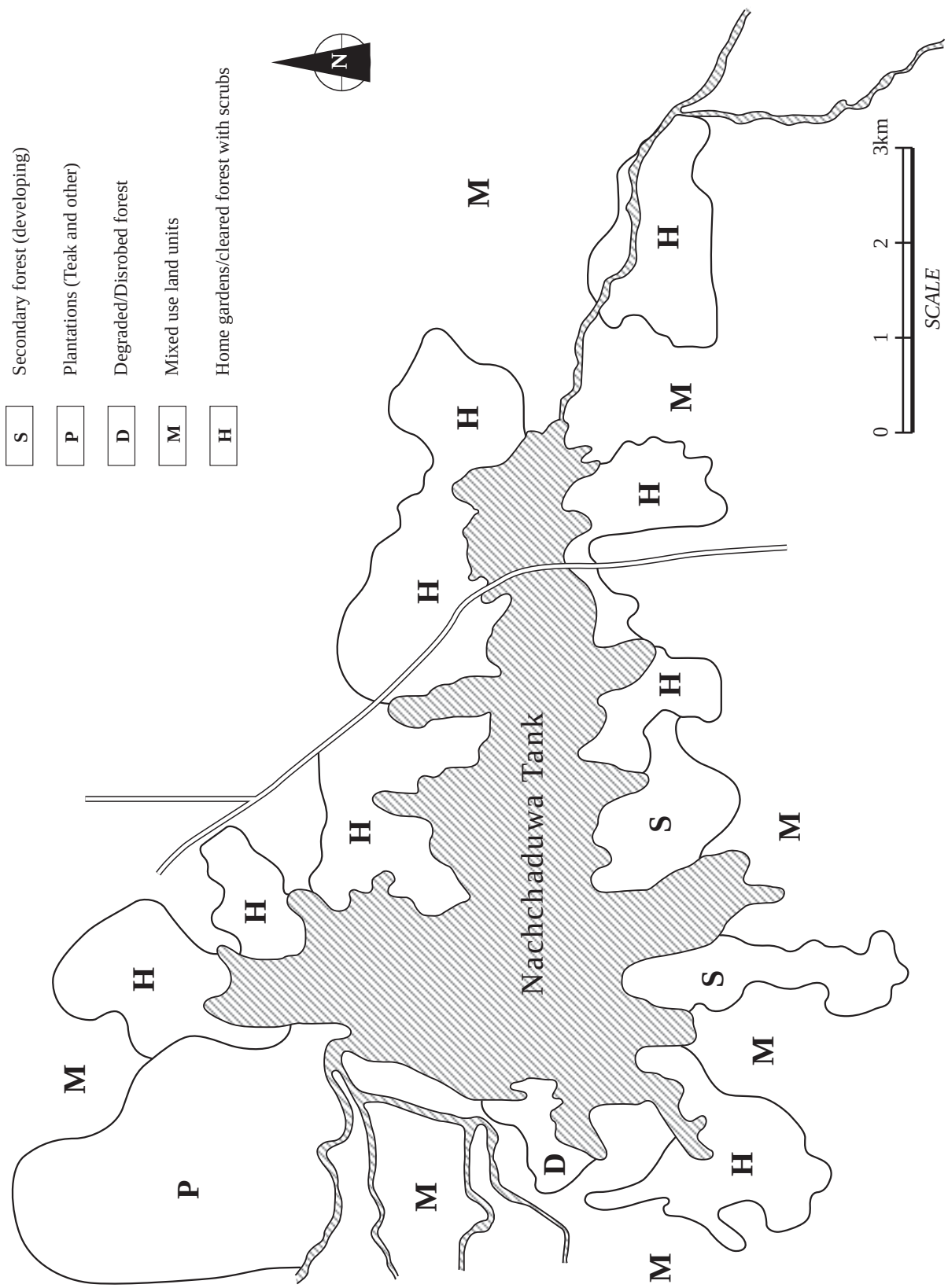

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Figure S 2.5

Deforestation around Nachchaduwa Tank

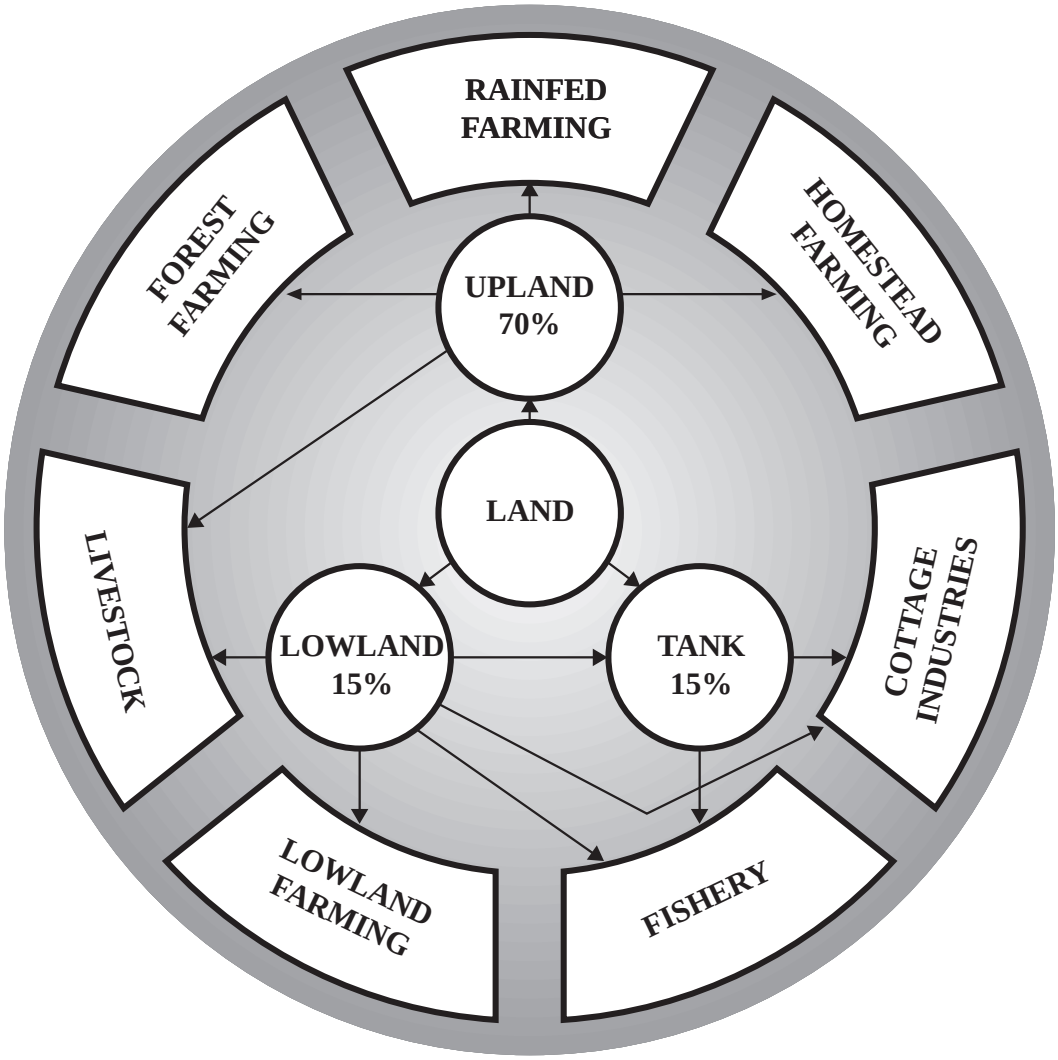

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Figure S 4.1

Agricultural Opportunities of Land Use in a Tank-village System

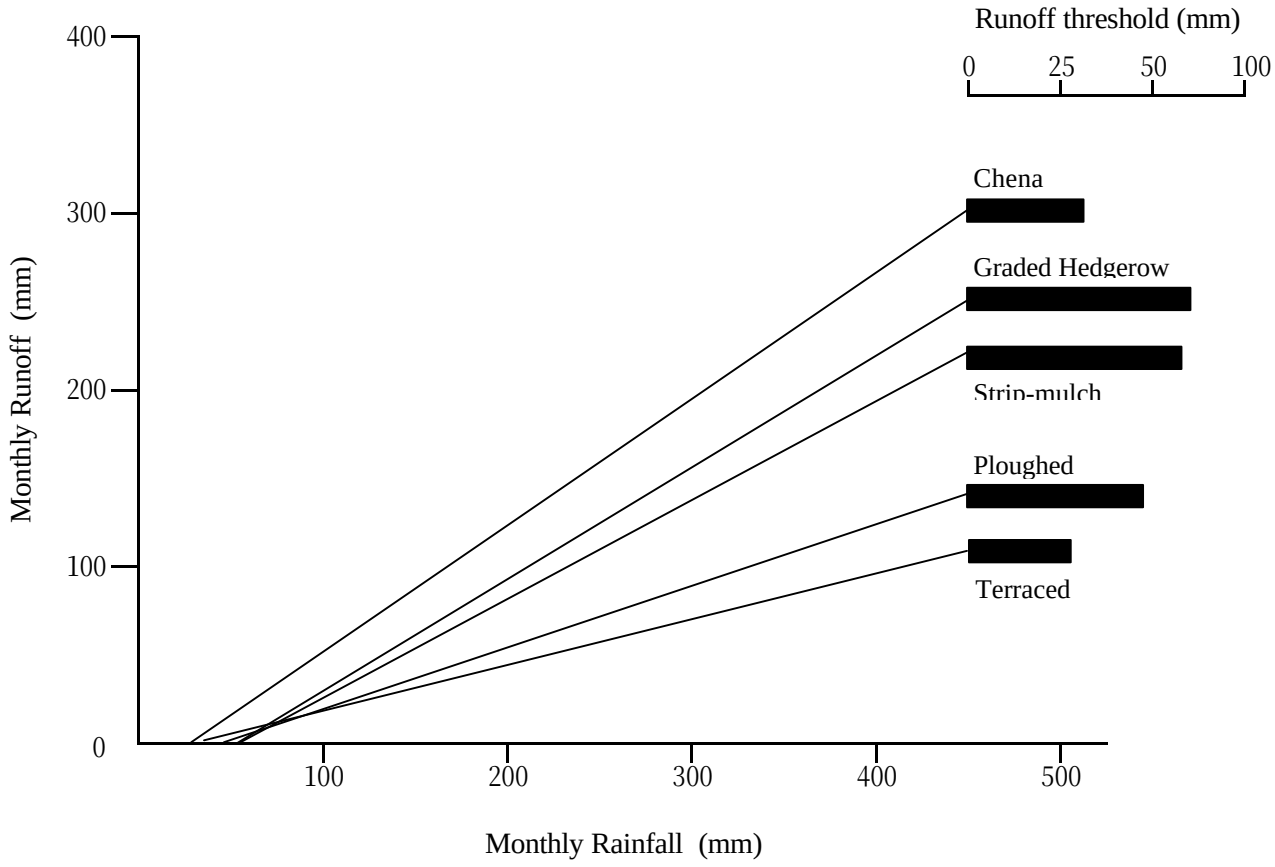

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Figure S 4.2

Rainfall-runoff Relationships and Runoff Thresholds for Different Farming Systems