APPENDIX VII-3
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ANNEX VIII

ENVIRONMENTAL ASPECTS

ANNEX VIII

ENVIRONMENTAL ASPECTS

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1. INTRODUCTION

The Kingdom of Cambodia is an agricultural country with a predominant rural base. Over 85 % of the people live in the countryside. This has been so for centuries past and will continue to be so for the forseeable future as well. What was once a sound economy and a glorious culture,that sustained a contended nation, has over the years – part of it being recent history – undergone untold trials and tribulations of many wars. These wars have undoubtedly brought her people much misery and economic ruin, the effects of which are currently evident.

It is a strong-willed Cambodia that is today attempting to "rise from the ashes" and it is towards this end that this project – integrated agricultural and rural development – also focuses itself. Given the determination of the government and the generosity of the international community, the obstacles are not insurmountable. In the larger context, what is presently most relevant is the assurance of a stable political climate.

Cambodian agriculture, has since early times, largely depended on irrigation. It was between the tenth and thirteenth centuries – what was the Angkorian period – that the nation flourished and the irrigation works constructed during this period, had much to do with this prosperity. Evidence of such is found in parts of the country. Quite unfortunately,irrigation and agricultural progress like everything else in the country, has had its ups and downs during the last two or three decades.

1.1 Project Objectives

Poor rural infrastructure and low-level technology are mainly responsible for the current uninspiring performance of the country's agricultural sector. Ironically, agriculture is the one sector on which the large majority of people depend for a living; yet it has been unable to make a favourable impact. In the national reconstruction programme agricultural receives hihg priority. In spite of the large area under paddy – 85 to 90 % of the country's arable land – the average paddy yield of 1.5 tonnes per hectare is one of the lowest in the Southeast Asian region. This scenario is characteristic of both the project area and the country as a whole.

Much of the paddy in the project area is grown under rainfed conditions and only limited irrigation facilities are available. Irrigation is necessary to raise a dry season crop and also to provide supplementary soil moisture during periods of moisture stress in the rainy season, as often happens due to unpredictable weather patterns. The indigenous paddy varieties however, although admirably suited to prevailing conditions, do not give an adequate yield and cannot wholly satisfy the increasing demands of a growing population.

A variety of other crops are also grown but productivity is generally low. Livestock, often poor producers, are raised in fairly large numbers throughout the project area. But pigs,cattle and poultry are readily encashable. For this reason they are seen as an insurance against dire financial need. With all its inherent disadvantages agriculture continues to be the mainstay of employment in the rural area; other alternative forms of employment being very limited. Family income is consequently inadequate to meet basic needs and the standard of living is therefore,necessarily low among the large majority of rural people.

The master plan study has helped focus attention on two selected areas referred to as the priority areas in the two districts. These include 1,950 ha in Kandal Stung and 1,600 ha in Tonle Bati.

Hence, the primary focus of the project – in the areas of Kandal Stung and Tonle Bati – is on provision of irrigation water through a rehabilitated regulator and canal network. Likewise, drainage will also be improved. Irrigation and drainage when effectively provided, complemented by adequate agricultural inputs of the right kind, at the right time, will pave the way to increased paddy production, crop diversification and higher all-round productivity.

These initiatives will be further enhanced by appropriate environmental management measures throughout the project area, eventually leading to sustainable development. A variety of socio-economic measures are also being recommended. Details of these proposals are discussed in relevant sections of the main report and also in the accompanying annexes.

1.2 Scope of Annex

This annex focuses on the environmental implications of the proposed project, both in terms of adverse and beneficial impacts. The pages to follow begin with a brief exposure of Cambodia's new institutional framework for environmental protection and management, along with the major areas that are likely to be considered in a future state policy on the environment.

The major natural ecosystems of the country are briefly introduced and national environmental concerns are analysed. The present conditions of the priority area are discussed in so far as these have a bearing on the quality of the environment. Apart from the existing and modified natural systems, cultural and recreational aspects are also highlighted.

The field work undertaken during the current study period is then described in relation to environmental protection and management issues that are current or are likely to occur in the event of the project being implemented. Very often, data have not been forthcoming as much as desired and this has made analyses somewhat difficult. In such instances parallels are drawn with similar situations elsewhere. A series of recommendations are made, intended at arresting environmental issues identified during the study and enhancing those that are currently not producing the desired benefits.

2. COUNTRY ENVIRONMENTAL PROFILE

2.1 Institutional Organization

Cambodia has an abundance of important natural resources, eg. land, forests, fishery and water. These can, if rationally harnessed, serve the needs of the relatively small current population and future generations as well. In the past two decades, any pretensions to good management had to be put aside due to the unsettled conditions, when institutional capability, administrative ability and jurisdiction of the then central governments, were either seriously challenged or were subject to extraordinary political influence. This does not however, mean that there was rampant over-exploitation of the country's resources. In fact there was the opposite tendency, except in certain provinces where government control was totally absent.

The extensive bombing of the first half of the 1970s contributed partly to the destruction of the forests, animal life and people. A bleaker period in history is the 1975-79 period, when all institutional capability broke down and thousands of people paid dearly with their lives. This also included the field of education, when neither schools nor the only university functioned.

It was a case of starting from nothing when government changed in 1979. More than resource conservation, the priority was to get the administrative machinery in place. It was only after the Paris Peace Accord in 1991, and the nationwide election which followed in 1993, that the pieces began to fall into place. However, a long, difficult road lies ahead.

Having recognised the importance of the environment as a key factor in the economic development process, the present government created the Ministry of Environment in July 1993. In November 1993, the Ministry was transformed into the State Secretariat for the Environment, with a clear mandate for formulating environmental policy, instituting environmental legislation and regulatory requirements, undertaking environmental planning, initiating environmental impact assessment, supervising environmental education, and taking responsibility for overall coordination of environmental protection and management. Daunting tasks no doubt for a fledgling institution with no experience whatsoever. However, the Secretariat has gathered a nucleus staff and has initially embarked on a programme of capability building, with the assistance of the donor community. Other programme components such as the preparation of draft legislation forwisely, could benefit the current rehabilitation effort. However, this requires a strong executing and monitoring capability within the confines of the State Secretariat for the Environment, which is yet to be developed.

The Secretariat which is headed by a Secretary of State, has an Under-Secretary, and three Directors as the senior executive staff. It has five main technical departments under a single Director, while a second Director is responsible for administration. The current cadre position is shown in the organogram at Figure 1. The technical departments are:

a. Environmental planning, water management and land use;

b. Nature conservation and protection;

c. Pollution control, reduction and prevention;

d. Legal affairs; and,

e. Education and communications.

The role and responsibilities of the State Secretary are briefly set out as follows:

(1) Nature Protection:

a. rehabilitation, preservation, protection, conservation and amelioration of the quality of the rural and urban natural environment, including air, soil, sub-soil, forests and biodiversity, rivers, sea and the sea bottom;

b. elaboration, coordination and application of national policies to water management;

c. supervision, planning and development of national systems on the protected areas including the protection of the terrestrial environment, wetlands, seashore, wildlife and flora; and,

d. protection and management of susceptible multipurpose areas not included in a national system, particularly wetlands, sloping basins and the seashore.

(2) Environmental Policies

a. coordination of policies relevant to the environment; participation with competent ministries in determining policies and legislation on water resources, management of forest and rural land, exploitation of natural resources, cultural assets, urbanisation, transportation, industrial development, energy and tourism; and,

b. elaboration and planning policies for development in relation to the quality of the environment including preparation of strategies for financing and investment for the environment.

(3) Legislation and Environmental Norms

a. elaboration of environmental norms pertaining to environmental quality;

b. revision and upgrading of laws and regulations relating to environmental quality;

c. promotion of the participation of the Kingdom of Cambodia in environmental conventions and at international meetings; and

d. creation of a controlling mechanism with necessary resources to implement laws and regulations.

(4) Environmental Evaluation

a. collection of data and analysis; and

b. initiation, coordination and supervision of studies on evaluation of environmental impacts.

(5) Environmental Education and Public Information

a. preparation and presentation of programmes and materials on the environment to inform and sensitize all sectors including all levels of government, private sector and general public; and

b. preparation and presentation of viewpoints of other ministries and preparation and development of training programmes on the integrated use of natural resources and protection of the environment.

The Secretary of State for Environment is an ex-officio member of the following national committees:

a. land use and urbanisation for Phnom Penh and the provinces;

b. investment;

c. rehabilitation and development; and,

d. National Mekong Committee.

Participation at deliberations of these committees at such senior level provides opportunities for the submission and safeguarding of environmental concerns by consultation, compromise and consensus, whenever development objectives cut across narrow sectoral and departmental boundaries, as they often do. This also will hopefully ensure that parochial sectoral interests are not pursued at the expense of long-term sustainability of the resource base.

Another step forward has been the creation of the Environmental Assessment Commission, comprising senior officials representing the following ministries:

a. Agriculture, Forests and Fisheries;

b. Industries, Mines and Energy;

c. Public Works and Transport;

d. Culture and Fine Arts;

e. Education;

f. Health;

g. Tourism; and

h. Secretariat of Rural Development

The Commission is chaired by the Prime Minister and the vice-chairman is the State Secretary for Environment. It is expected to pave the way for inter-ministerial co-ordination.

2.2 National Policy

At present, the country lacks an environmental policy. It does not also have sectoral policies in the major natural resource fields. The damage and inaction of the past two decades demands a concerted rehabilitation effort with priority for setting up the institutional frame-work, and provincial and sectoral capabilities. One of the key policy goals of the government is an integrated policy for environmental protection and management. In the present context, preparation of such a policy is no easy task. However,the beginnings have been made, shortcomings recognised and,efforts are underway to face the new challenges. Policies, legislation, education, guidelines and controls are all part of a package of initiatives being worked upon.

In the current efforts at formulating an integrated environmental policy, emphasis is being placed on four areas, as these are considered to be of importance in the current develop-ment climate. These include:

a. environmental legislation: there are no laws,regulations or standards to manage either the environment or the exploitation of natural resources;

b. environmental impact assessment: with a likelihood of rapid investment in the near future, government finds itself lacking the capability to screen proposals for the content of environmental stability,and impact assessment is seen as one of the tools available for ensuring balanced development;

c. environmental education: government acknowledges the importance of education to achieve desired goals, particularly as there is little appreciation of the need to use resources rationally; and

d. inter-agency coordinating mechanisms: to avoid conflict among users of resources and to ensure that ecological principles are honoured by those competing for scarce resources, government sees the urgent need to pave the way to consultation, compromise and consensus.

2.3 Major Natural Ecosystems

2.3.1 Natural Forests

The country is blessed with a rich and varied forest ecosystem. It is one of Cambodia's main assets, with more than half of the country still covered by forest. The forest wealth has not been inventoried and accuracy in geographical distribution is yet to be ascertained. It has been reported that in the early 1960s more than a third of the country (6.75 million hectares) was covered by evergreen forest while another third was covered by deciduous forest. The deciduous type is said to be the largest undisturbed unit in the Asian region and perhaps, in the whole world. Inundated forests accounted for about 700,000 ha and mangroves for another 100,000 ha. A total of more than 13 million hectares, representing 73 % of the land area was believed to be under forest at that time.

The forest cover map produced in 1992 by the Mekong Committee, gives up-to-date information and is being improved upon. It is based on 1991/92 landsat TM imagery (Table 1). On this basis 11.2 million ha or 62 % of the land area is under forest. Grassland, shrub land and water bodies are not included in this computation. Of the eight forest types, evergreen forests predominate with 4.8 million ha, followed by deciduous forests spreading over 4.2 million ha. The diversity of forest types also include pinus (Pinus merkusii) forests. No systematic inventory work has been carried out since the 1960s, when the total standing volume was believed to be 820 million m^3.

Over the years natural forests have been exploited for a variety of reasons and such deforestation has had impacts on other important economic sectors, besides overall ecological consequences. It is believed that the annual forest cutting had been between 50,000 and 100,000 ha in the three decades from the 60s to the 80s. Of the 19 provinces, four have lost much of the forest cover, while Kandal and Takeo provinces have no forests at all. In the early 1960s, each of these provinces had about 10-15 % forest cover. No reliable information however,is available on forest depletion.

The forests in the southeastern parts of the country have been particularly vulnerable because of proximity to large population centres and therefore have been subject to increasing pressure. Some of the reasons for deforestation are commercial logging, fire, firewood gathering, charcoal making, conversion to agriculture and, by no means the least contributory, the long and protracted war in the region – during which time heavy bombing caused a great deal of physical damage. On the all important river banks too, the forest has been largely eliminated.

Afforestation began in 1985. Progress so far has not been satisfactory for a variety of reasons, chief of which are insufficient funds and staff. Consequently the survival rate at the end of one year has been somewhat poor. Poor weather, and pests like the rabbit, have also contributed to failure. The highest degree of success, measured at the end of the first year, is reported to be around 70-75 % in Takeo, Kampot, Preah Vihear and Svey Rieng provinces.

From 1985 to 1993, the area planted has been 5,600 ha, at an average of 620 ha per year. In 1993, the planted area was 640 ha. While the logged areas have not been taken up for

reforestation, departmental programmes have been concentrating on afforestation. The species used have been mainly preng kyal (Eucalyptus camaldulensis) and Acacia auriculiformis. Other species used include dipterocarps, trasek (Peltophorum ferrugineus), maysak (Tectona grandis) and varieties of fruit. Some enthusiastic NGOs are participating in afforestation programmes in a number of provinces.

The environmental effects of deforestation are varied. For example, depletion of the flooded forest has impacted on the lucrative fishery in the Great Lake. After cutting the trees, the people turn the land into paddy. No studies have been undertaken to measure the scale of impacts.

The production of timber increased from 19,000 m^3 in 1981 to 200,000 m^3 in 1988. It has not been possible to obtain the rates of recent and current logging but is believed to be more than in 1988. Aside from this,there is illegal logging taking place,and also unaccounted logging in areas outside government control.

Another disturbing feature is that the firewood demand is met almost exclusively from the national forest estate. Part of the timber is also turned into charcoal to meet the growing urban demand. The demand for firewood is estimated at 6-8 million m^3 annually. In the city of Phnom Penh, people mainly use firewood, while other forms of energy are also used in urban centres, eg. electricity, gas and sawdust.

In the southeast of the country,deforestation has given rise to extensive soil erosion. In 1992, flash floods created large scale damage in many parts of the country and estimated to have cost millions of dollars.

The 20-year period of the war gave a new slant to the pattern of 1975-79, logging continued at a rapid pace but there were no exports of timber. In the period following, exports resumed and since the late 1980s, there has been accelerated logging, largely through government granted concessions.

A forestry policy is contemplated by government, incorporating components for the sound utilisation of the forest estate which will hopefully lead to sustainable production. These include reforestation, afforestation, watershed protection, legislation and, urban and rural forestry for aesthetics, firewood,soil conservation and fodder.

2.3.2 Wildlife

The diversity of flora and habitat across the country, ranging from sea level mangrove swamps,through flood plains and inland wetlands,to mountains and rugged valleys, provide opportunities to an equal diversity of animal life. There is every likelihood that species hitherto not recorded, may be discovered in the future. The tragic story of the country's recent history unfolds again when documentation is sought. The gaps correspond largely with political turmoil and invariably fresh beginnings are being made presently. However, the unknowns are many and comprehensive surveys of wildlife have not been carried out.

Among the known animal species, some are believed to be rare and endangered. Of the endangered species reported in the country are the pileated gibbon (Hylobates pileatus), kouprey (Bos sauveli), banteng (Bos banteng), elephant (Elephas maximus), Sumatran rhinoceros (Didermocerus sumatrensis), gaur (Bos gaurus), clouded leopard (Neofelis nebulosa), leopard(Panthera leo), bear and tiger (Panthera tigris).

Sitings of the kouprey in recent times are reported to have been less than 20. These rare animals inhabit the difficult mountain regions that separate Cambodia, Laos and Vietnam. Hence they move back and forth between countries, and coordinated conservation programmes are necessary in an effort to make safe what could well be their last refuge.

Other forms of the larger mammals are wild water buffalo (Bos bubalus), brown-antlered deer (Cervus eldii), Schomburgk's deer (Cervus porcinus), common barking deer (Cervus muntjak), wild boar (Sus scrofa) and sambar (Cervus rusa). The Mekong river system is believed to be home to the Irrawady dolphin(Orcaella brevirostris), the Chinese white dolphin (Sotalia chinensis), and the black finless porpoise (Neophacaena phocanoides).

The Great Lake (Tonle Sap-inundated forest ecosystem) is known to support populations of rare and threatened bird species such as the greater adjutant stork (Leptoptilos dubius), white-winged wood duck (Cairina scutulata) and the masked finfoot (Heliopais personata). Likewise,other important wetland areas such as the Mekong-Bassac river system and those in the flood plains, although lacking in data, are worthy of study and inclusion in a national conservation programme. The institutional responsibility for the management of the Tonle Sap-inundated forest ecosystem is not clear.

Inadequate information on the status of wildlife of the country is a disadvantage to the formulation of management strategies. The larger animals have been under threat due to poaching, illegal trading across international borders, habitat reclamation and land mines.

There is an ongoing trade in living wildlife, wildlife products and game meat in Phnom Penh and in the provinces. It is also known that certain living species and wildlife products are transported across international borders to satisfy foreign demand. For example in China, parts of the tiger are increasingly sought after. Shops in Phnom Penh openly sell leopard skins, tiger parts and those of other animals also, some of which are used in traditional medicine. Legislation is not yet in place to counter this trade and, in the meantime depletion of the wildlife resource continues. The government has however, placed a ban on hunting of some of the the mammals mentioned above, and also the greater mouse deer (Cervus tragulus). Enforcement, is undoubtedly a losing battle with the meagre resources available.

On November 1, 1993, King Norodom Sihanouk issued a decree committing a total land area of 3.4 million ha, making up 19 % of the country,into a system of protected areas. This indeed is a far-reaching step in nature conservation and if managed effectively, these areas should be a proud asset to the Cambodian heritage. The management of the network rests with the Directorate for Nature Conservation of the State Secretariat for Environ-ment. The proposed protected area system is made up of four categories. These are:

a. national parks: for nature conservation, research, education and conservation;

b. wildlife sanctuaries: for nature conservation and research;

c. protected landscapes: for cultural and scenic assets preservation, research and recreation; and,

d. multiple-use areas: for nature preservation and sustainable development.

2.3.3 Fishery

The unique aquatic habitats of the country, created by its peculiar physiography and hydrology, are home to a rich and diverse complement of fish and a variety of other organisms, most of which are useful in providing dietary protein. There are believed to be nearly 300 recorded species of fish, belonging to 50 families.

Fish provides 90 % of the nation's protein. The consumption of fish and fish products in 1991, was estimated to be between 13-16 kg per capita; much lower than the 25 kg per capita in 1970, estimated in a Mekong Committee study. For comparative purposes, the study also revealed that consumption in neighbouring regions was as follows: Laos – 10.2 kg; North East Thailand – 11.5 kg and South Vietnam – 20.8 kg.

On a national basis, the equivalent of 180,000 tonnes would have met the above consumption pattern. Of this, 107,000 tonnes were believed to have come from artisanal fishermen, 53,000 tonnes from family fishing and the balance 20,000 tonnes from the marine catch. Cage culture also contributes in a small way, particularly around Phnom Penh. There was a phenomenal decline in the catch during the 1970s, with consumption dropping to an estimated 10 kg per year. The inland capture fishery yet plays an important role providing about 70 % of the total production.

Being in the lower flood plain of the Mekong, much of the country is subject to partial flooding that brings about a range of environmental benefits. The hydrological cycle determines patterns of fish migration. The flood water may be on the land, in some places for as long as six months, depositing suspended and dissolved materials. Flooding releases nutrients from the soil, vegetation and organic debris. This feature brings about close links between agriculture, forestry and fishery.

However, fishery management is weak and knowledge scanty, and these weaknesses prevent the full potential of the resource being utilised in a sustainable manner. New irrigation and drainage canals constructed in the latter half of the 1970s have changed drainage patterns. Seasonal inundation of the flood plain has been seriously interfered with, and with that, fish access to the flood plains for spawning. Sedimentation has reduced capacity in water bodies and also brought about other undesirable effects.

In terms of biological productivity, the Great Lake along with its associated inundated forest is one of the richest ecosystems in the country. Its contribution to the fishery is very special. The hydrology itself is unique; when, in the months of July and August, the flow in the Mekong river reverses itself and moves up the Tonle Sap river. The lake then overflows onto the adjacent inundated forest, providing excellent spawning and nursery grounds for many species of fish that move upstream at this time of the year. The adults occupy a variety of niches in the inundated forest and elsewhere, as these provide them with ideal conditions to raise their young. Unfortunately much of the inundated forest has been thoughtlessly destroyed and the land converted to paddy fields. Intensive fishing has also been a factor for depletion. As the floodwaters recede, the fish move back into the rivers. Therefore, protection of spawning grounds of fry and fingerlings is an important tool of conservation.

The government has adopted a number of measures for sustainable development of the resource. Among these are the enforcement of a close season from June to September, banning the use of explosives and, protection to certain species. While artisanal and industrial fishing is prohibited during the close season, family fishing is permitted.

2.3.4 Wetlands

There has been recent interest shown in Cambodia's wetlands. As wetlands are defined in many ways, creating confusion sometimes, the definition adopted by the "Convention on Wetlands of International Importance Especially as Waterfowl Habitat" (The Ramsar Convention) is cited.

Wetlands are:

> "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh or salt, including areas of marine water, the depth of which at low tide does not exceed 6 m."

The two main wetland areas in the country are the Tonle Sap along with its inundated forest and grassland system at its periphery, and the riparian strip along the Mekong river. The former is believed to cover over one (1) million ha at the peak of inundation. These are highly productive ecosystems, and the Tonle Sap in particular, needs to be rehabilitated on a priority basis. Information on wetlands is inadequate and data scanty, as hitherto, no systematic

studies have been conducted. It is only quite recently that a start has been made to inventorise and study the ecological relationships of the component parts in the larger systems that are being identified. Tree species of the inundated or flooded forest include reng phnom (Barringtonia acutangula), sama (Terminalia chebula), Amelia asiatica and krabao (Hydrocarpis anthelminthica). These forests and the associated grasslands support herbivores like the elephant, deer and buffalo, among others.

2.3.5 Coastal Ecosystems

There are coastal mangrove and watershed forests that contribute to the stability of the shoreline and near-shore seas. These are believed to contain endemic and rare plants and animals. In economic terms too, these natural systems are important as mangroves undeniably sustain the coastal fishery. However, mangroves are being destroyed for shrimp farming and charcoal production.

2.4 Major Environmental Concerns

The country is presently free of any serious environmental degradation. The resource base is yet intact in many respects. However, the current speed and manner of exploitation of certain resources warrant a close review vis-a-vis conservation practices, so that future generations will also be beneficiaries, having the right and priviledge to utilize resources for their needs. Forestry, gem mining and pesticide use, need to be looked at closely. Unfortunately, in the first two instances, a part of resource exploitation is in districts of the country where government control is almost lacking. Discussed below are a few areas which have the potential for causing serious environmental damage unless appropriate checks and balances are instituted without delay for control and management.

2.4.1 Biodiversity

Legislation is not available to effectively protect the country's wildlife heritage, or for that matter any other resource. There is also little information on population densities, migration patterns and, hardly any on the status of endangered and threatened species, as listed in IUCN's Red Data Book. Such information is absolutely necessary for the preparation of management plans for conservation of the wide range of ecosystems. Responsibility for wildlife protection has recently been shifted to the State Secretariat for Environment, while there also exists a Wildlife Protection Office within the Department of Forestry and Wildlife, which earlier had the mandate. This makes lines of authority unclear.

2.4.2 Deforestation

The lack of forest inventories has prevented forest harvesting on a sustainable basis. It is reported that in the last 30 years, the country has lost more than 2 million hectares of forest. Accurate data on deforestation are not available but the area being felled is believed to increase year by year. In parts of the country where government control is not possible, logging takes place without any restriction. Illegal logging is thought to be 2-3 times that of government logging. Some of the forest land, for example, the inundated forest around the Tonle Sap, has been converted into paddy. This is ecologically detrimental to the fishery, which economically is worth more to the country – accounting for about 60 % of commercial fish production – than the paddy which replaced the forest.

2.4.3 Fishery

Of concern is the ecological damage to the Great Lake caused by the destruction of the inundated forest and sedimentation. Varying estimates have been made on the reduction of the inundated forest; eg.from a million ha in the 1960s to 360,000-460,000 in the early 1990s. Deforestation destroys spawning and feeding niches of the many varieties that migrate when the water flow reverses upstream and inundates the forest. The consequent erosion deposits sediment in the lake – estimated to be 4 cm/year – thereby reducing its depth and volume. Gem mining in Battambang is also said to be a reason for the siltation of the lake. Siltation is also a major environmental issue affecting most rivers and canals.

Construction of canals for irrigation and drainage, especially during the latter part of the 70s, has caused widespread interference with patterns of seasonal inundation, thereby interfering with adults reaching spawning grounds.

Numbers of some species have declined to levels causing concern. In order to help conserve, four species are protected and catching is forbidden. These are: trasok (Parharbus jullieni), tbork (Tenualosa thrbaudeaiai), kla (Damioides mievolepis), reach (Pangasius gigas), and kulriang (Catlocarpio siamensis). However, in practice it is difficult to effectively enforce the ban.

2.4.4 Pesticide Use

Pesticide use in Cambodia is reported to be little, particularly in wet season paddy. Farmers do not consider insect pests as a major problem; hence its low use. But those who use, seem to be doing so quite indiscriminately. A range of pesticides are freely available in the local markets; and among them, some extremely hazardous chemicals. There is currently no legislation to control import, distribution and use of these chemicals. Both government and the private voluntary organisations have expressed concern at the manner in which pesticides are being imported and used.

Consequently, government is studying draft legislation to control the import, distribution and use of pesticides. Apart from imports through the government-owned Central Company of Agricultural Materials, pesticides are also brought into the country by the private sector, on a license from the Ministry of Commerce. Most of the government imports are on the basis of gifts from friendly countries and some kind of control is possible as a result. In addition there is considerable inflow of stocks across the borders between Thailand and Vietnam and it is here that ethical aspects seem to be set aside.

2.4.5 Land Mines

Land mines and unexplored bombs are a grave threat and danger to displaced people who are now making efforts to settle down after having spent long periods in refugee camps outside the country. The masterplan study area is reported to be free of this danger. An estimated 6-10 million mines are said to be in the country, where an estimated 40 % of the arable land is mined.

Inadequate in-country technology on mine defusing has been met by a favourable international response and efforts are now under way to make areas safe. Training and equipping of nationals in mine clearing are also being undertaken.

3. PRESENT CONDITIONS OF MASTER PLAN STUDY AREA

3.1 Natural Environment

3.1.1 Biodiversity

(1) Natural Forests

There are no natural forests remaining either in the masterplan study area or in the rest of the provinces of Kandal and Takeo, where the project is to be located. The natural forests have given way to settled agriculture and human settlements, and the study area in its entirety, is presently a man-made farming ecosystem, with rice as the predominant crop. It can also have far reaching economic implications; for example, timber and firewood cost more in the study area presently, than they did a decade ago. Both products are unavailable in close proximity and have to be transported from far.

The absence of natural forests deprive the people of the usual minor forest produce such as fodder, resins, medicinal herbs and honey. Effects which are difficult to quantify, for example, the contribution of forests in the hydrological regime and in erosion prevention, will not be experienced.

(2) Wildlife

With the loss of forest habitat, animal forms that inhabited the forest, largely disappeared. Presently the larger forms of wildlife are not found in the project area. Bird life also is very sparse. Numerous species of fish and other forms of life provide the much needed protein to the local people. However, their numbers too are said to be diminishing.

The present biodiversity of the study area can be seen in three very broad categories. These are: firstly, the predominant rainfed and irrigated paddy monoculture; secondly, the uplands which include home gardens and bare land, also used for grazing and thirdly, the aquatic systems.

The paddy fields are cultivated as often as weather, finances and labour permit as the farmers' is for rice security. Associated with paddy cultivation are the usual complement of weeds, insects, arthropods, reptiles, amphibians, birds and mammals. On the whole most of the larger animal forms are conspicuous by their absence. But some of these are pests of the paddy crop,eg.the rat.

On the home gardens there is an interesting diversity of herbs, shrubs, creepers and trees. Some of these such as seasonal vegetables and permanent tree crops are economically important. The commenest tree in the landscape is the sugar palm (Borassus flabellifer), often found growing on paddy field bundsin most parts of the study area. It is of considerable economic importance. Coconut (Cocos nucifera) is widespread but its full economic potential does not seem to be exploited. Eucalypts and acacias are also commonly seen on canal banks, field bunds and home gardens. On the whole, throughout the study area, here is much potential for increasing the tree cover, both in density and diversity.

The present wildlife species in the project area is minimal; there being no species of importance. This is due to the absence of jungle areas and also due to depletion by poaching, as people consume a variety of wild organisms to satisfy their protein needs.

(3) Wetlands

Being in the flood plain of the Mekong, the study area is influenced by the hydrological regime of the river and its tributaries. The varied aquatic habitats have many plants, both floating and submerged, some of which are items of food, while others can be considered more as weeds. The submerged edges of lakes and those areas with poor drainage, often have large extents of phka chouk (Nelumbium nelumbo). The floating weed, kaplok (Eichornia crassipes), is by far the most common and chokes canals and most small water bodies. Romchang (Nymphea stellata), is also very common. However, there are no wetland systems of the significance of the Great Lake Tonle Sap. On the seasonally inundated plains surrounding Cheung Loung lake, reng phnom,(Barringtonia acutangula) is a common tree species. Wherever the drainage is poor elsewhere, associations of hydrophytic plants are seen. Table VIII-2 gives a list of hydrophitic plants around Cheng Loung and Tonle Bati lakes.

A waterbody of fair size is the Tonle Bati lake at the southeastern tip of the Kandal Stung area. Outside the eastern boundary of the project area is the much larger Cheung Loung lake into which the Tonle Bati river flows, having some distance before, passed through the Tonle Bati lake.

Both the Tonle Bati and Cheung Loung lakes have had marshy areas at the lake fringes some years ago. It is clear that what would have been extensively covered by typical hydrophytic vegetation, has now given way to paddy cultivation. The lands on the lake fringes get annually inundated for varying periods of five to eight months in the year. The benefits to the people, therefore accrue from the waterbody, and not from the hydrophytic vegetation and animal life that such vegetation usually supports.

(4) Fishery

There is little documentation of fish species diversity, population dynamics, biology, migration, and other scientific data. Rivers, streams, canals, lakes and perhaps paddy fields provide opportunities for artisanal and family fishing. As fish is an important source of dietary protein, fishing will continue to hold its place as an important economic activity. Success or failure in the industry will depend on the hydrological regime and the interplay of several environmental factors. The annual flooding of the flood plain is of fundamental importance to the success of artisanal and family fishing.

The fish catch in Kandal province fluctuated between 10,800 tonnes in 1987 and 10,500 tonnes in 1993, peaking to 14,000 tonnes in 1991. The lowest during this period was 7,200 tonnes in 1989. Generally, with the annual inundation, fish move upstream and onto the submerged land which may be irrigable or non-irrigable land, where they spawn and the fry grow into fingerlings in these sheltered temporary habitats until it is time to move back into the river. Some get trapped in ponds and streams.

Two groups of fish are identified. These are the "white" and the "black" fish. The former live in rivers and larger streams and spawn in the inundated areas during the rainy season. The species indicated below are among others reported to be found in the Prek Thnot river.

The largest family, Cyprinidae, belong to "white" group and included are the giant carp, kul riang (Catlocarpio siamensis), now legally protected from being fished, proul (Cirrhinus microlepis), chkork (Cyclocheilichthys enoplos), proloug (Leptobarbus hoeveni), dagkteg (Macrochirichthys macrochirus), kaek (Morulius chrysophekadion), kahe kraham (Puntius altus), chrava moul (Rasbora dusonensis), and ling (Thynnichthys thynnoides).

The catfishes ka ok (Arius caelatus), kagn chos kadoug (Heterobagrus bocourti), pra (Pangasius micronemus), por pruy (Pangasius sanitwongsei), kes (Kryptopterus apogon), kramam (Ompok bimaculatus) and klang hai (Wallago dinema) are also reported.

The "black" fish essentially live in the swamps and backwaters exhibiting the ability to live under conditions of low oxygen, some acidity and salinity. This group includes deap (Channa micropeltes), photoc(Channa striata), kragn (Anabas testudineus), and kanthor (Trichogaster pectoralis).

Migration of fish is a little documented phenomenon. Lateral and longitudinal migration are two aspects that have been identified. The former instance involves the "black" fish which move about during flood time, while in longitudinal migration the "white" fish move over varied distances along rivers and streams.

Evidence of degradation of the fishery habitat is frequently seen. Briefly, some of the issues are as follows:

a. changed patterns of canals;

b. reduced seasonal inundation and impeded access to spawning grounds by the new canal network created during 1975-79;

c. silted rivers and canals;

d. increased water temperature; and,

e. over fishing.

3.1.2 Soils and Land Use

Soils in the master plan area have been classified into seven soil units. The most extensive unit is cambisols, on nearly 40 % of the land area. Of the total master plan area of 18,200 ha, 9,800 ha or 54 % are said to have good agricultural soils and 8,400 ha or 46 % of the land area very poor for agriculture.

Thirteen land units have been identified. Land use classes are identified on the basis of the FAO classification. These are five in number and are briefly as follows:

S1: Highly suitable, having no significant limitations to sustained crop production, but with one limiting factor at a moderate degree of severity allowable ;

S2: moderately suitable but having two limitations at moderate degree of severity which will reduce production levels and/or increase production costs;

S3: marginally suitable, having three or more limitations at a moderate degree of severity that will make crop production marginally economical;

N1: unsuitable because of one type of limitation at a high degree of severity that makes correction uneconomical under existing knowledge; and,

N2: unsuitable with severe limitations, usually two or more at a high degree of severity that preclude sustained production.

The topography varies from a generally flat to a rolling landscape but there are areas where levees of different ages are elevated – some active and others relict. Not all areas are subject to flooding.

Uplands are only slightly elevated but are flood-free and lie outside the command area. Soils have a high permeability. These lands mostly support vilages while a part are under-

utilized and here cattle graze. In the Kandal Stung area of the study upland areas extend over 344 ha or 14 % of the land area and in Tonle Bati these cover 147 ha or 8 % of the land area.

In summary, the distribution of upland land is as below; the details of which are in the annex on Soil and Land Use of this report.

Land Use Type	Mapping Unit	Area (ha)	%
Kandal Stung			
Upland/grazing land	U	130	5
Villages	V	214	9
Sub-total (i)		344	14
Tonle Bati			
Upland crop fields	U	36	2
Villages	V	91	5
Grazing land on hillocks	H	20	1
Sub-total (ii)		147	8
Total of (i) and (ii)		491	22

Paddy fields on gently sloping land cover 389 ha (16 %) and 449 ha (25 %) in Kandal Stung and Tonle Bati districts respectively. In Tonle Bati 36 ha of upland are used for growing seasonal crops.

Upland land exists in several stages of plant succession and these are sufficiently disturbed to prevent communities from attaining fully mature climax communities in the forseable future.

(10) Soil Fertility

All soils are formed on deep alluvial deposits. There is no hard rock. Saline soils have not been encountered but some limited areas had evidence of sodic conditions at about a metre depth.

Soil analyses have been carried out to determine soil fertility. By and large soils are devoid of problems such as salinity, alkalinity and acid sulphate conditions. However, they are of low fertility, particularly poor in nitrogen and phosphorus, and deficient in organic matter. In phosphorus deficient situations, the supply of nitrogen has little or no effect. The cation exchange capacity is low, as are exchangeable bases.

The most fertile soils are those along rivers and around lakes, where annual inundation leaves behind nutrient-rich sediment. These soils are grown to paddy when the flood waters recede and produce fairly satisfactory yields.

(2) Soil Erosion

Although not widespread, soil erosion occurs in the project area in varying degrees and is one of the environmental issues to be concerned with and addressed. As the land is generally flat or only gently sloping, and the paddy fields are terraced and bunded, erosion would be minimal on paddy land. However, sloping land grown to other crops without adequate measures for soil conservation, are erosion prone. Some of these lands have bunds but these are not so well designed to arrest soil movement. Also, in land preparation, bunds and furrows made up and down the contour, do little to minimise water and soil movement and can lead to subsequent gulleying. On the more sandy soils however, there would be greater infiltration and less runoff.

Soil erosion of extensive proportions is taking place along most canal and river banks. Vegetative protection of the canal and river banks is limited in the extreme. Some canal banks

have scattered clumps of bamboo; others mixed vegetation, while eucalypts have been planted along limited lengths of certain canals. Sedimentation causes silting of canals, reduces capacity and interferes with the fishery. Erosion also occurs at road embankments and road shoulders. This has even caused sediment deposition on adjacent paddy fields.

Along the rivers, the riparian vegetation has long been removed in most places. Shorn of its stability, river banks keep on collapsing, widening channels, raising bed levels, increasing the frequency of flooding and interfering with water flow and fishery. The riparian vegetation when present would also be habitat for limited wildlife species which are known to positively contribute to pest control in the adjacent agricultural fields. As it is, this benefit is not to be expected. Riparian vegetation also acts as filters to nutrients moving in drainage or sub-surface flows, thereby minimising that amount entering water bodies, which in-turn would and minimise possible eutrophication. Riparian vegetation also acts as fish refuges.

(3) Land Degradation

The masterplan study area does not as yet have major problems of land degradation. Saline, alkaline and toxic soils are not found. Large scale dumping of urban waste is also not happening. What is of significance in respect to sustainable resource use, is bank erosion taking place on the canal and river banks. Generally canal banks have not been protected either by lining or by vegetation although some do have bamboo, eucalypts and mixed vegetation which provide a degree of slope stability.

Sediment generated by eroding banks can have on-site and off-site effects. On-site, when irrigation is the objective, the effects will be a reduction of the capacity of the water-course and interference with water flow. Water levels will be lowered, water temperature will rise and the suspended sediment load will increase. The last, will impact upon the respiratory mechanism of fish, when gills get coated with finer particles of sediment. Suspended sediment deposited off-site will cause similar effects. Another effect is ponding, which is likely to occur when water flow in canals is impeded and this can give rise to mosquito breeding and the spread of vector-borne diseases.

In the long-term, when soil is not farmed in keeping with its suitability, degradation will be evident. In addition to the factors discussed above, depletion of soil organic matter, breakdown of soil structure, and excessive use of fertilizer and agrochemicals, will in a cumulative manner, contribute to a degraded soil. In such a situation subsequent farming will be a costly undertaking.

3.1.3 Surface Water Resources

Surface water is found in rivers , streams, canals and ponds – natural and artificial. It serves a number of uses, ranging from irrigation, to domestic and livestock needs. The fishery supported by these water bodies is a key socio-economic factor in the daily life of thousands of people, as on it depends a part of the nutritional needs. Hydrophytic plants also supply part of the nutritional needs of man and animal. During the dry season except in the main river, water levels recede in almost all other water bodies to the point of drying. Drinking water becomes difficult in most areas during this time, particularly in Bati district. The main source of drinking water however, is ground water.

3.1.4 Water Quality

Water through present in abundance during most months of the year, hs to be looked at from the aspect of quality. Good quality water is one of the key factors leading to the health

and well-being of humans and livestock. Several competing uses have to be met from available sources. These are:

i) Irrigation

Provision of irrigation water to the project area is basic to every other objective, for without it no further economic and social benefits can be achieved. Quality of irrigation water is reflected mostly in its salt content.

ii) Domestic Use

Good potable water is fundamental to healthy living. One of the project objectives, discussed in another section is to supply good quality drinking water.

iii) Industrial Uses

Firstly large quantities are required for most of the light industries, eg: hotels, restaurants and hospitals. Water for the above uses is obtained from surface water bodies such as rivers, streams, canals and ponds or from underground sources such as dug wells and deep wells. Except for the major rivers and deep wells, most of the other sources dry up during the dry season. Analysis of well water have shown mostly satisfactory quality except for a high iron content at a few isolated locations.

The study benefitted from the recent work of consultants who were engaged in the Prek Thnot Reservoir environmental study. Of relevance to this study, were their analyses of water in the Prek Thnot and Tonle Bati rivers, ie. at Kompong Tonl and, at the bridge over the Tonle Bati river on road no. 2 and just before the river enters the Cheung Loung lake. These sites, along with some additional sites, have been again sampled at the end of June and July, 1994, in order to compare changes. Water quality has been quite satisfactory. There are no point sources of pollution. Being a agricultural area, agricultural runoff could be the only polluter if at all. Results are presented in table VIII-3.

3.2 Man-made Environment

3.2.1 Farming Ecosystems

In tropical climates, soil organic matter gets burnt up very rapidly and regular replenishment, as a means of maintaining soil fertility becomes increasingly important. Apart from providing a range of physical, chemical and biological benefits, soil organic matter also enables efficient utilization of nutrients supplied through fertilizers.

Under practices currently adopted in the master plan study area, the complementary nature of crop and animal husbandry and linkages between different farming components are not being exploited as much as would have been desirable, in order to achieve integrated nutrient cycling. Livestock – cattle, poultry and pigs – being reared in large numbers, more productive use can be made of dung, urine and bedding by adopting simple, inexpensive techniques. Animals and poultry are at present mostly on free range, thereby depriving the use of dung and urine for crop husbandry. Even when tethered dung and urine are not collected in very many cases.

Livestock feed – pasture and fodder – are in short supply in most areas and people are seen transporting bundles of grass all the way from Phnom Penh, where it is cut from waste lands and sold to those in need. The non-irrigable upland areas and the bunds of the fields are not being put to optimum use, although these provide opportunities for growing short-term crops and fodder grasses.

Paddy occupies the most favoured position in the cropping calendar. Being the staple food, the main desire of farmers is to achieve rice security. Rainfed cultivation is possible over most of the study area, but is very limited. Often supplementary irrigation is even required during the wet season, to tide over dry spells. The wet season yield is low; averaging 1.2 to 1.5 ton/ha. However, with dry season irrigation, a yield of 2.5 ton/ha is not uncommon.

Paddy soils are generally poor in nitrogen and phosphorus. Fertilizer use is not widespread. Though not in adequate amounts, because of limited availability, farmyard manure is used as a basal dressing before transplanting and also, quite extensively at the nursery stage. Subsequent fertilizer applications generally are urea at 20 kg/ha, and compound fertilizer (16:20:0) at 80 kg/ha. Financial considerations rather than agronomic need, determine mineral fertilizer use.

The use of manures seem to hold promise in improving soil fertility although there are a few associated technical problems to be resolved. Trials conducted by the Cambodia-IRRI-Australia Project suggest that by ploughing-in a crop of snau (Sesbania rostrata) before transplanting, a yield increase of 40 % can be expected.

Pesticides are usually not used, particularly in wet season paddy, as pest damage is low. Sometimes outbreaks of the brown plant hopper, warrant pesticide use in the dry season. A variety of pesticides are freely available in the market.

Apart from the limitation of moisture, shortages of good seed material, credit and draught animals also act as constraints to expanding the area presently under paddy. The use of quality seed alone is believed to be able to oncrease yield by about 10 %.

Apart from the limitation of dry season soil moisture, shortages of labour and draught animals, also appear to act as constraints to expanding the area presently under cultivation. Increased productivity from paddy land depends upon many factors including good quality seed, improved soil fertility, water management, pest control and support services such as research, extension and input supplies. The availability of quality seed alone is believed to be able to increase yield by about 10 %.

Besides wet season paddy, a wide variety of seasonal crops are grown. These include chek (Musa paradisiaca), sandaek dey (Arachis hypogea), tobacco, mungbean and other bean varieties, pot hawai (Zea mais), gourds, tubers, trau (Colocasia esculenta), penh pah (Lycopersicon esculentum), melon, peppers and vegetables. The home gardens support tree crops such as svay (Mangifera indica), trabaek (Psidium guajava), khnal (Artocarpus integrifolia), ankie dey (Sesbania grandiflora), lahong (Carica papaya), citrus species, krasang (Feroniella lucida), tiep khmae (Anona squamosa) and dong (Cocos nucifera). Sugar palm (Borassus flabellifer)is an important cash crop and is commonly seen on the bunds of paddy fields.

Though not well organised, livestock rearing which basically is a family activity, is popular and is widely practised. Livestock provides the farmer with a means of overcoming unforeseen family cash needs. Pigs and poultry are favoured. Cattle are used exclusively in paddy land preparation. Procuring feed is always problematical. Household leftovers and crop residues are also utilised. Straw is held over after harvesting to feed the cattle. Treated with urea, it is a cheap source of feed. Pasture land in the villages is not developed. Grass is cut from wherever available and often brought from far. Cattle, unlike other forms of livestock, are mostly tethered or grazed nearby. Therefore, numbers of livestock reared in each household are determined mainly by availability of feed. Given access to adequate pasture, fodder and feed, animal husbandry can be of greater economic benefit.

3.2.2 Home Gardens

There are over 10,000 households in a population of over 50,000 people who live in the master plan study area. Each household possesses a house and a garden of variable extent; sometimes over a hectare. This land is flood-free, unirrigable and provides the farmer space to grow trees, vegetables, keep cattle and, raise pigs and poultry. At times, a fish pond may be part of the activity. In the Kandal Stung area, the total area planted to upland crops in 1989 was 92 ha. It is likely that this area has since increased.

Most home gardens do not appear to be utilized optimally. A better garden in the study area, on about three-quarter hectare had a total of 20 plant species (Table VIII-4), a pair of draught bulls, four pigs and some poultry. The bulls were grazed along the roads and also stall-fed with straw. The pigs and poultry were on free range during the day but had no regular place of bedding at night. The excreta of the bulls was put into a pit for composting but the urine was lost as the stall floor was not cemented.

A typical home garden in the project area, on about three-quarter hectare, had a composition of plants made up as follows:

dong (Cocos nucifera), thnaot (Borassus flabellifer), reussey, bamboo species, sloek krey (Cymbopogon citratus), papaw (Carica papaya), trabaek (Psidium guajava), svay (Mangifera indica), krasang (Feroniella lucida), tiep khmae (Anona squamosa), mon (Morus alba), kor (Ceiba pentandra), ankie dey (Sesbania grandiflora), kravann (Popowia diospyrifolia), svay chanti (Anarcardium occidentale) as tree crops; damlong mi (Manihot esculenta), damlong chiva (Ipomea batatas), trap veng (Solanum melongena) and a number of leafy types as vegetables; and moteh hael (Capsicum annum), romiat (Cucurma domestica) as condiments.

The ecologically effective storeyed forest physiogaphy which can be applied in an upland agricultural ecosystem is not to clearly seen. The boundary fence is not fully utilised to growing multipurpose trees.

Much of the produce of the garden is used by the family of four, while the saleable amounts are small and includes the pigs as the main component. This farmer had a compost pit and appeared to be fairly well versed in good agricultural techniques. However, his knowledge of pest control was poor. He was using folidol without quite knowing its ill effects. He had picked up the idea of using this insecticide from another farmer. The container was labelled in the Thai language and he could not read the instructions. He figured out for himself the dosage.

Firewood is a problem to this farmer, as it is to most people of the study area. The home garden provides a fair amount and the balance is procured from elsewhere. The hearth though, is not one that is energy-efficient.

3.2.3 Agrochemical Issues

What is set out below is a review of available information relating to agricultural pest control and pesticide use in the study area, and the status of current agrochemical use in the country.

It is widely reported that pesticide use in agriculture, particularly in wet season paddy cultivation, is of a restricted nature. This is because damage due to pests is low. But there appears to be a lack of farmer knowledge on pests, chemicals and environmental interactions. A range of toxic chemicals are available in the market and can be purchased without restriction.

A recent survey conducted in Srey Ampal area by the Chamcar Daung Agricultural Institute, revealed that farmers have a poor knowledge of the principles of plant protection. In this instance, 73 % of 60 farmers interviewed, could not distinguish a pest and, 58 % could not

distinguish a predator. The decision to spray is usually based on mere observation of insects in the field, irrespective of whether they are harmful or beneficial. Economic threshold levels are also not considered. Therefore it can be inferred that farmers need to be trained and an effective extension service be established.

A recent taxonomic survey conducted at Kap Srau, brought to light the abundance of natural enemies of insect pests in paddy fields indicating that the ratio of natural enemies to pests is nearly 2:1. The possibilities for natural control therefore appear to be encouraging.

The ongoing Cambodia-IRRI-Australia Project reports that in the four provinces of Kampot, Prey Veng, Svay Rieng and Takeo, the phytophages amounted to less than 40 %, while the beneficials and scavengers made up more than 60 %. A large proportion of the pests happened to be parasitised. However, if pesticides continue to be applied indiscriminately, valuable populations of predators and scavengers already established in the field, will be eliminated and the natural predation eliminated. Build-up of pest resistance will necessarily follow.

Surveys conducted during this study at Chba-ampov market in Phnom Penh, and at smaller outlets elsewhere, indicated the availability of a wide range of chemicals (Table VIII-5). Most products had labels in foreign languages which the farmers cannot understand. Very few had labels in Khmer. The shopkeepers had hardly any knowledge about the chemicals they sold, which included two classified by WHO as "extremely hazardous" – folidol and mevinphos – and placed in class 1a of The WHO Recommended Classification of Pesticide by Hazard.

On an initiative taken by the Cambodia-IRRI-Australia Project, 22 samples of pesticides, collected from Phnom Penh and Kandal province, were analysed in Australia recently. The results showed that,

a. only five samples contained the strength of the active ingredient claimed on the packing;

b. seven samples were below strength but had more than half the quantity of active ingredient claimed; and,

c. ten samples had extremely low concentrations or none at all.

Thus, apart from the country losing valuable foreign exchange by importing sub-standard products; farmers, already burdened with high costs, were further reducing their profit margin, exposing themselves to ill-health and death, eliminating useful predators in the field which would otherwise have accomplished a large degree of control at no cost, endangering the environment and ecological balance, and enabling a build-up of pest resistance. Unless appropriate policy decisions are taken soon, it may well be that the country will get caught up in a vicious cycle – pesticide application, often excessive – resistance build-up – use of more toxic chemicals – to counter increased pest resistance.

A variety of ill-effects have been reported. These include poisoning of humans and livestock, decline in fish stocks and reduction of predators. No data however, are available. Most people handling spray equipment in the field, neither wear protective clothing nor adopt other precautionary measures. The study survey showed that 90 % of farmers did not take precautions when storing, spraying or washing containers after use. The Ministry of Agriculture, Forestry and Fisheries does not have legislation to control the import, distribution and sale of pesticides.

A national Integrated Pest Management (IPM) programme is now underway and some interesting and encouraging results have been obtained in its preliminary work relating to paddy cultivation, suggesting that the use of pesticide can be drastically reduced, if not totally

eliminated. The study survey showed that 96 % of farmers had no knowledge of either integrated pest management or its benefits.

3.2.4 Irrigation and Drainage

To provide for the most effective management of water resources of the masterplan area, it is necessary to oversee the water balance of the larger Prek Thnot river basin, including those proposals for the Prek Thnot reservoir further upstream. The essential components of this study have taken cognisance of this.

The water of the Prek Thnot river is presently used for irrigation upstream of the Tuk Thla and Kompong Toul regulators. These schemes are at Roleng Chrey, O'Krang Ambel and Dangkor. Therefore the river regime has been altered before. Consistent river flow measurements are not available for the Prek Thnot and no data at all for the lower part.

The proposal to continue with the dam construction further upstream at a future date will have a bearing on the project considered in this study.

A careful assessment of water availability vis-a-vis upstream users becomes necessary in extending project benefits to entire masterplan area.

Installation of gates at Tuk Thla and Kompong Toul have reportedly interfered with the upstream migratory patterns of certain fish species. However, the Department of Fisheries is unable to provide accurate information population dynamics and migratory patterns of fish in the river.

Due to faulty design and poor maintenance, the irrigation network in the two districts is not functioning efficiently. Canal banks and embankments are heavily eroded and smooth flow is not possible due to faulty bottom levels. Hence water can stagnate. The structures are often in a state of disrepair.

Sedimentation of canals interferes with smooth waterflow and induces ponding when water flow is weak. Other contributory factors are weed growth and fish fences. These situations promote mosquito breeding and irigation schemes are particularly vulnerable to the incidence of vector-borne diseases. The area does not report such diseases as schistosomiasis. Malaria and dengue are found in the country.

The storage in the Tonle Bati lake forms and important and necessary feature in irrigating the fields of the Bati district.

3.2.5 Firewood

Energy is required by a variety of end-users – households and industry, both large and small scale. For the large majority of the Cambodian people – nearly 95 % – firewood is the chief source of domestic energy and, will continue to be so for the foreseeable future. It has been estimated that the current national demand for firewood is 6-8 million cu m per year. Generally the bulk of the firewood is obtained from natural forests and relatively little from home gardens. Mature stands of replanted firewood forests are not available for harvesting and would not be available in the next decade even; hence the dependence on natural forests.

It should be noted that natural forests also provide industrial energy, eg. for brick and tile factories. In the Bati district there are two such factories – one in the village of Tonle Bati, manufacturing bricks and tiles, and the other, in the village of Orung, manufacturing bricks only. The former obtains its firewood requirement from Kampot province, while the latter is supplied from Kompong Speu province. In both instances good quality hardwood was being supplied, which indeed is a waste of a valuable resource. The factory at Orung producing only

bricks, uses on the average 40 m^3 per month and 480 m^3 per year. The current cost is Riel 18,750 m^3 (US$ 7.50) and it reflects an increase of more than 150 % over that of January 1993, ie. in the space of 18 months.

The inference is that the resource is under threat and depleting, perhaps in the face of competing demand, one of which is commercial timber extraction. Domestic firewood demand in this area is met from the Phnum Thma forest reserve area not very far away, although the reserve itself has been almost totally deforested. The situation is so severe that people are even removing plants that have attained a height of only a metre.

In some provinces all the natural forests have given way to other human needs and firewood has to be brought from a distance. For example in Phnom Penh, the firewood demand – which is not only for domestic cooking, but has uses in hotels and small industries as well – is met by transporting from the provinces of Kompong Speu and Kompong Chhnang. The annual demand is estimated at 100,440 m^3 of firewood and 35,200 m^3 of charcoal. The Department of Forestry and Wildlife estimates that 52 % of energy required in Phnom Penh, is supplied by firewood, 12 % by charcoal, 4 % by gas and 32 % by electricity, oil or sawdust.

3.3 Social and Cultural Aspects

3.3.1 Cultural Assets

On the banks of the Tonle Bati Lake, 40 km from Phnom Penh, within the project area, is the Ta Prohm temple complex; its origins dating back to the 7th century (Fig. VIII-2). However, not long afterwards, the structure was completely destroyed but was rebuilt in the late 12th century by King Jayavarman 7th (1191-1218). The value of the complex is complemented by the adjacent recreation area on the banks of the Tonle Bati Lake. The complex as it stands today is in a state of disrepair and needs to be restored.

A number of reasons have contributed to the collapse of the ancient civilization, among them, the many wars waged during different periods of Cambodian history. Direct hits by artillery have caused much damage. During these encounters, temples were often used as refuges by warring fractions. People also evacuate areas of war and then there is nobody to take care of the temples, which is yet another reason for decay. Looting and vandalism have also contributed to the current situation. Even today looting is rampant as there is a lucrative market for treasures outside the country.

Like most Khmer temples, Ta Prohm too is made of sandstone. The outer wall is made of laterite. Over the years, vagaries of the weather have caused the structure to deteriorate. Sandstone absorbs moisture and dries out in the hot season. Lichens growing on the exposed stonework appear to contribute to decay.

Apart from statues of The Buddha, there are also those of gods and kings. These and the general architecture are considered to be in the Bayon style. Both Buddhist and Hindu influences are evident. Damage to the complex is seen in the following areas:

a. front gate and eastern walls;
b. four galleries;
c. north and south gates;
d. libraries on the left and front;
e. store on the right; and,
f. lintels.

3.3.2 Recreation

The Tonle Bati Lake lying very close to the temple complex, is an important aspect of the hydrology of the project area. It also serves as a popular recreation area to people, mostly from Phnom Penh, who come here for a day of relaxation during holidays. Overnight accommodation is not available. The facilities offered are very basic and rather unsightly. These take the form of raised wooden platforms at the water's edge, having roofs of sugar palm leaves. These are rented out for the day. Limited amounts of food are available for sale at the lake site.

The recreation park which is on the southern bank of the lake,covers an area of about 3-4 ha. Between the motorable road and the water's edge, the land slopes at a gradient of about 20-30 %. The width of this bank varies with the season; being wide during the dry season when the lake area shrinks. This stretch of land is devoid of any vegetation because it is heavily used. Erosion is taking place unchecked. A part of this slope from the road has been eroded. The exposed tree roots indicate the magnitude of the problem. Little rills have given way to small gullies and before long, gullies of larger proportions that are difficult to rehabilitate, will be a common feature. The displaced soil moves down into the lake and can reduce lake storage capacity over time.

3.4 Of Relevance Outside Project Area

3.4.1 Borrow Pits

Three locations outside the project area have been identified as possible areas for purposes of obtaining earth for embankment work. The sites are slightly elevated and the soil is gravely. Earth has been removed earlier from these locations, perhaps for road, canal or embankment construction. Near these locations are paddy fields but no large scale settlements.

Removal of earth will entail the use of machinery at the site, vehicles for transportation of earth to work sites and men at work at the site during the day. Likely on-site impacts are noise, dust, runoff and soil movement during rain, exposure of sub-soil.

Off-site impacts relate to effects in the event of heavy rain and flash floods as the nearby paddy fields may be inundated and also suffer sedimentation. During transportation of earth on earthen roads, there would be the temporary nuisance of noise and dust caused by the vehicles, to which residents along the way would be subject to.

3.4.2 Phnum Thma Forest Reserve

To the southwest of the Tonle Bati lake is the Phnum Thma forest reserve. It is an area of about 2,000 ha under the control of the Department of Forestry and Wildlife. The present status of the vegetation is that of secondary scrub. The growth is often less than a metre high but provides a fairly good cover to the soil. It seems to check erosion effectively.

Almost total deforestation has taken place and remnants of the primary vegetation is only seen around three hillocks – Phnum Thma, Phnum Thma Doh and Phnum Phdau Pam. The first two are in close proximity to one another and all three are in the southern segment of the forest. Two of them rise to over 100 m above the surrounding gently rolling plain and exhibit many rock outcrops. On the top of Phnum Thma and Phnum Thma Doh, are two ancient temples, and the monks who reside have pledged to be guardians of a replanted forest.

Of the species of primary vegetation are the following trees:

beng (Pahudia cochinchinensis), roka (Ceiba malabaricum), chan (Diospyros decandra), ampil (Tamarindus indicus), rolousbay (Erythrina indica), chambak barang

(Terminalia catappa), mien (Nephelium longana), trhosek (Peltophorum dasyrachis), thnong (Pterocarpus pedatus), angkearbos (Milingtonia portensis), makakprey (Spondias spp), pongro (Schleichera trijuga), and krokoh (Sindora cochinchinensis).

The following animal species were reported to be present in the area:

poous tlann (Phython molurus), muntjac (Cervus muntjak), chroouk prey (Sus scrofa) and thunsay, rabbit. As to be expected, the area is presently not good habitat for many of the bird species as it is devoid of trees. Only two species were seen on the visit-black drongo (Dicrurus macrocercus) and Indian roller (Coracias benghalensis); species that prefer open areas. Butterfly life was numerous.

The Department of Forestry and Wildlife has plans to reforest the area. There is a nursery at the site with a capacity to produce a million seedlings. In 1993, the department had reforested 20 ha and hopes to cover 30 ha in 1994. Species planted include dipterocarps, cassias, peltophorum, acacia and eucalypts.

Progress in replanting is slow due to constraints of funds. Another disadvantage is the need to plough the land in order to eradicate a dwarf species of bamboo having a tenacious growth. The already reforested area is under continuos threat from firewood collectors who do not spare even the 2/3-foot high plants. The rabbit is the biggest pest of small seedlings. Over a section of the land, natural regeneration of dipterocarp is taking place. As this forest area is part of the southeastern catchment of the Tonle Bati river, it is important that it be reforested, protected and maintained as a protected watershed area.

3.4.3 Cheung Loung Lake

The Cheung Loung lake is outside the project boundary at the southeastern extremity; the boundary on the eastern side of Bati district being the lake. The eastern part of the Tonle Bati area drains into the lake through the existing canals, while the northern part also drains into the lake through the Tonle Bati river. A third, southern part, will drain into the Haknuman canal which does not enter the lake. It is important to asess the nutrient content in the return agricultural flows into the lake in order to determine chances of eutrophication. The lake is much larger than the Tonle Bati lake and receives a seasonal reverse flow from the Bassac river.

Typical hydrophytic vegetation around the lake margin has been replaced by paddy which is cultivated at different times during the year. The most productive paddy crop is what is grown as the water recedes after inundation, having left behind nutrient-rich sediment.

There are however, remnants of water-loving plants surviving in isolated patches. These include (Ipomea aquatica), kak (Cyperus spp), (Paspalum scobiculatum), (Jussiaea repens), (Echinochloa stagnina) and treng tuk (Saccharum spontaneum). Some of the hydrophytic plants that remain, such as the water lily, pralit khiew and the lotus, chhuk, provide items of food for the people. Deep water or floating paddy is also grown along the lake margins. The higher reaches of the usually inundated plain have vegetation forms that are typical of such situations, eg. reng phnom (Barringtonia acutangula) and romdenh kach (Elaeocarpus madopetalus). Floating masses of kaplok (Eichornia crassipes) abound nearer the shoreline.

Fishing is an important occupation to those living around the lake. On the eastern fringe of the lake, there are said to be about 150-200 fishermen. It was reported that some of them harvest about 3-4 kg fish per day. A number of species are found in the lake. Some of these include: kranh (Anabas testudineus), kray (Notopterus chitala), chhpin (Puntioplites proctozysron), lenh (Thynnichthys thynnoides), diep (Channa micropeltes), chkork (Cyclocheilichthys enoplos) and proloug (Leptobarbus hoeveni).

4. ENVIRONMENTAL IMPACT ASSESSMENT

4.1 Overview of Impacts

The proposed project aims to rehabilitate an area that has been in agricultural production over a long period of time. In the past irrigation water has been provided to limited villages with partial success.

As the land is already partially developed, the magnitude of impacts, if the project proposal is implemented, is considered low. These are assessed in table V111-6. All development actions are result-oriented leading towards general and specific environmental benefits.

During the construction phase, when work on canals, hydraulic control structures, roads and associated civil works such as culverts and, buildings, involve the use of machinery and movement of earth, a range of effects will be experienced. These however, will be of a temporary nature and good project management can mitigate these without too many problems.

For successful implementation of mitigation and enhancement measures, the active involvement of the people and institutions responsible for economic development, is required. For example, integrated nutrient supply has a number of components which the farmers can easily implement, while azolla culture has to be researched initially by the Department of Agronomy before a field application recommendation can be made. Likewise, control of pesticides require governmental policy and legislative changes. IPM methods have to be tested and recommended by the Department of Agronomy.

As institutions belonging to different ministries have implementation responsibility, a strong co-ordinating mechanism is required.

4.2 Impacts During the Construction Phase

SYNOPSIS: Often environmental ill-effects during construction of a project do not enter the mitigation process. These are taken for granted – perhaps due to the temporary nature – although mitigation should be addressed, if significant impacts are identified.

The construction phase of the project will be concerned mostly with rehabilitation and extension of the irrigation and road infrastructure. The impacts generated during this phase are considered to be of low to medium significance.

The main canals are to be cleaned, desilted, repaired and reshaped for slope. Embankments are to be repaired. The excavated spoil will be of a limited quantity and can be used in embankment repair; hence no disposal problems will be encountered. Additional earth will be obtained from outside the project area and transported to the work sites. Issues at borrow sites are discussed in section 4.14.

A major problem in field work can be erosion of exposed earth during rainy weather. This can be overcome by protecting with a temporary straw mulch or more permanently by sod-facing. However, dry seasons are best for earthwork so that erosion can be minimised; also having uninterrupted work days. As the main canals are being lined and embankments sod-faced, bank erosion, sedimentation and ponding will not be serious issues. Lateral, tertiary and quaternary canals are also to be rehabilitated but the earthwork involved will be much less than in the case of main canals. Embankments will be provided with laterite pavements. If dispersive soils are encountered, special precautions have to be taken.

Rehabilitation work will also be carried out at regulators, hydraulic control structures such as weirs and gates involving the use of iron, brick and cement. Dust and noise will be

generated during field operations but being localised, effects will be of a temporary nature. Noise can be minimised by keeping machinery in good working order. In servicing machinery pollution by oil and grease should not be caused. As houses are at a distance from the fields, impacts of noise and dust on the resident population will be minimal.

Construction work requires human resources and there will be an increased demand for labour, all of which may not be available in the locality. If labour is recruited from outside the project area, temporary housing may have to be provided.

In such instances sanitation has to be carefully examined so as not to allow pollution of water bodies and breeding of mosquitoes, as some species may be vectors of certain diseases. Provision of good drinking water is important. If work camps are to be set up, water-sealed pit latrines are suggested. Having basic first aid on-site is another requirement.

RECOMMENDATIONS:

a. Programming earthwork for the dry season.
b. Taking precautions to prevent sedimentation.
c. Providing good sanitation at work sites.
d. Having basic first aid.
e. Keeping machines in good working order.

4.3 Land Use

SYNOPSIS: While the lowland fields in the two districts will continue to be under paddy cultivation, with possibility of irrigated crop diversification in the dry season, the upland areas offer prospects for utilization in more productive ways than at present.

Can the under-utilized upland areas be put to more productive use? Soil classification and analyses carried out during this study indicate the suitability of the unirrigable land for a variety of other uses, eg. culture of multipurpose trees and shrubs, green manure, pasture and firewood trees. Therefore, with a certain degree of organisation, enhanced productivity can be achieved. The peoples' requirements seen to be in deficit at the present time are food (fruit and vegetable), firewood, animal feed (pasture and fodder), and farm needs such as fence posts, round poles and miscellaneous items. Village expansion will necessarily take place on this type of land as it is free of flooding.

If these lands can be systematically utilised, the following environmental benefits can be anticipated:

a. producing a larger volume of biomass which will absorb more carbon dioxide and help reduce global warming;
b. making available extra biomass for ex-situ green manuring;
c. preventing soil erosion and gradual land degradation;
d. improving organic matter status of surface layers;
e. acting as refuges for different forms of animal life that can be beneficial in agriculture as natural enemies of pests;
f. improving water retention and percolation;
g. improving the moisture regime of surrounding paddy land;
h. recycling nutrients from sub-surface to surface soil layers; and,

i. providing for miscellaneous food items such as mushrooms, bamboo shoots, leaves of different kinds and small animal forms.

Competing land uses for the unirrigable uplands will be to grow field food crops, fruit tree crops, pasture and fodder grasses, fodder shrubs and trees, firewood and timber trees and to practise systems of agroforestry. If these lands can grow high value crops suh as mushroom, asparagus and organically grown vegetables, there are assured markets, as demonstrated at the NGO fair held in March 1994 and reported by the Mennonite Central Committee. Such activities will enhance family income and also overcome land degradation.

It is suggested that regulations be considered to declare reservations along river and main canal banks, where natural vegetation will be a permanent feature. This is to check erosion of the banks. For guidance, the regulation in Sri Lanka is as follows: canals more than 3 m wide, a reservation of 15 m on each bank; rivers less than 4.5 m wide, a reservation of 20 m on each bank; rivers 4.5-15 m wide, 40 m on each bank and rivers more than 15 m wide, 60 m on each bank.

The question of land tenure and peoples' rights come into focus when discussing land use. The experience of the Mennonite Central Committee in the Tamkok Community Pilot Project in Takeo province is worth noting. A remarkable degree of success has been achieved and the government has shown interest in adopting similar approaches elsewhere.

RECOMMENDATIONS:

a. Utilising to optimum levels all unirrigable land by growing field crops, pasture, fodder grass, multipurpose trees (firewood, fruit, fodder, timber, medicine), regarding land tenure rights and based on joint forest management methods.

b. Leasing of state land for agroforestry and useful purposes, eg. growing industrial firewood so as to minimise and ultimately avoid using wood from the natural forest for firewood.

c. Converting old river courses into communal ponds for fish culture and small-time hydrologic uses such as water for vegetables. This will prevent growth of mosquitoes and water weeds.

4.4 Soil Management

SYNOPSIS: Generally, paddy soils in Cambodia are low in nitrogen and phosphorus. They are also low in organic matter. Fertilizer is imported and most farmers find the cost beyond their means. Hence fertilizer use is limited. However there are traditional skills of maintaining soil fertility and these methods should be intensified. It can be at least part of the answer to increasing productivity and maintaining soil fertility.

(1) Integrated Nutrient Supply

Under most tropical farming conditions there is a rapid depletion of soil fertility, often accompanied by an equally rapid breakdown of soil physical properties and a reduction in biological activity. Hence farm management is called upon to maintain soils in good condition for sustainable production, as farming becomes more demanding to meet the needs of growing populations, as is the case in third world countries.

To meet these challenges, different approaches to plant nutrient supply are called for. One such is to consider nutrient supply as an integral part of the farming system and not merely as a means of supplying nutrients to a particular crop. A FAO definition of integrated nutrient supply is as follows:

"The concept of integrated nutrient supply is a broad one embracing considerations of the nutrient cycle between the soil, the crop and the animal, the question of correct nutrient balance in fertilizer use including trace elements, combined use of organic manures and mineral fertilizers, the exploitation of biological sources of nutrient supply (nitrogen fixation) and the matching of nutrient supply to the cropping system as a whole and not to the needs of the specific crop."

It is not always that fertilizers of the required kind are available to farmers. This can be due to financial and logistic problems. On the other hand, if farmers are aware of the benefits of organic manures, soil fertility can be maintained to some acceptable standard. Adequate soil organic matter ensures better utilisation of mineral nutrients. Despite the presence of large numbers of livestock, manure is not utilized effectively. In the past,there had been widespread adoption of traditional organic soil management methods. However, over the years varying circumstances and influences, have brought about an erosion of these traditional skills. A revival of such seem opportune,both in economic and ecological terms. The following traditional practices are recommended:

a. recycling of nutrients: utilising all otherwise unutilised farm organic materials;

b. nutrient pumping: use of loppings of fallow vegetation, such as deep-rooted trees on fences and shrubs on bunds, as these pick up nutrients from the deep soil zone that includes nutrients leached down and nutrients released from mineralising rock;

c. biological nitrogen fixation: use of micro-organisms in combination with specific legumes, and azolla; and,

d. outside sources: use of organic materials from outside the farm.

i) Crop-Livestock Integration

If properly handled,livestock waste provides substantial quantities of plant nutrients. Urine contains as much as 50 % of the value of the waste, having as much as two-thirds of the nitrogen and four-fifths of the potassium. As the nutrients are in solution they are readily available and also activates materials that are being composted. When livestock are on free range, the excreta is lost. Improved housing is a prerquisite for maximising waste utilisation. This means having a cemented floor or a well ramped earthen floor with a thick layer of bedding material that will absorb the urine. The floor and the drain can slope to a composting pit where even the wash water will be collected. Bedding is turned into the pit every three or four days. Fresh poultry litter can contain over 3 % of nitrogen and phosphorus and over 2 % of potassium apart from a number of trace elements. When poultry are reared on the deep litter system, the resulting litter can be very beneficial in restoring soil fertility.

ii) Multipurpose Trees and Shrubs

There are many opportunities for growing trees and shrubs that will be of utility value in the farm and of economic use to the household. Tree crop culture fits in well in programmes designed to rehabilitate waste land. Many ecological benefits can be expected. When grown on paddy field bunds and on boundary fences, trees and shrubs will provide regular loppings for green manuring and mulching. A steady supply of round poles, sticks for trellising, fodder, firewood and timber at longer time intervals, are among other benefits that will be available.

Among species that can be grown are Gliricidia sepium, Gliricidia maculata, Sesbania sesban, Acacia auriculiformis, Leucaena leucocephala and Eucalyptus camaldulensis. Under Indian conditions it has been reported that Gliricidia sepium produced 18 kg ofleaves/plant/year, having a nitrogen content of 0.5 kg. On this basis 100 plants would produce 50 kg of nitrogen.

It is also interesting to note that under Philippine conditions,Napier grass (Pennisetum purpureum) has given 3 kg dry matter/10 linear metres,every 30 days. It has also been reported that 750 linear metres can meet all the fodder needs of a single draught animal. These conditions are similar to those in Cambodia and satisfactory results should be attainable.

iii) Crop Residues

Rice straw is the most widely available but has a competing use as a livestock feed. Work carried out at the International Rice Research Institute indicates that a tonne of paddy harvested, produces an equivalent 1.5 tonnes of straw having 9 kg nitrogen, 2 kg phosphorus, 25 kg potassium and substantial amounts of silica, calcium, magnesium and sulphur.

iv) Green Manures

On the basis of recent field trials carried out in Cambodia, in-situ green manuring has given encouraging results. Trials using Sesbania rostrata, grown before a paddy crop, has given nitrogen additions of upto 60 kg/ha under dry conditions.

v) Azolla

The use of Azolla as a source of nitrogen has been age-old practice in Southeast Asia. It is an aquatic fern, growing even on moist or saturated soils, in a symbiotic association with the blue-green alga, Anabaena azollae. It is capable of fixing atmospheric nitrogen. It has been reported that azolla is capable of fixing 3-7 kg nitrogen/ha. On decomposition, the nitrogen is released and can be used by the paddy. On a dry weight basis, azolla contains 4-5 % nitrogen, 1-1.5 % phosphorus and 2-3 % potassium. A good growth of azolla in a paddy field can suppress weeds. It is recommended that trials be carried out by the Department of Agronomy on the feasibility of azolla use as it offers possibilities of reducing the quantity of mineral fertiliser and therefore the cost of production and likely long-term environmental ill-effects.

RECOMMENDATIONS:

a. Encouraging maximum use of all available farm and non-farm organic materials, including livestock dung and urine for soil improvement.

b. Adopting systems of livestock housing that permit collection of dung and urine.

c. Ensuring optimum utilisation of farm land for the production of plant biomass, food, fodder, feed and firewood.

d. Adopting composting and green manuring where practicable.

e. Experimenting with azolla culture for use as paddy field manure and livestock fertiliser.

4.5 Irrigation and Drainage

SYNOPSIS: The current situation in the study area is that of an irrigation system poorly maintained. Rehabilitation will eliminate the ill-effects and improve the delivery of water into the fields and removal of excess out of the fields.

Irrigation systems are often blamed for many environmental ills. In fact many ill-effects can be triggered by faulty design and poor maintenance of irrigation systems. Proposals have been made to eliminate the ill-effects currently experienced in the study area through physical alterations to irrigation infrastructure.

RECOMMENDATIONS:

a. Having smooth gradients of bottom levels of canals to avoid ponding and subsequent mosquito breeding.

b. Controlling erosion of canal banks and embankments.

c. Flushing out canals periodically if necessary to remove mosquito larvae.

d. Co-ordinating activities of irrigation and public health departments to ensure vector control.

e. Ensuring effective field drainage to provide good soil medium for crop growth.

f. Considering the establishment of river and canal reservations for stability and erosion control.

4.6 Biodiversity

SYNOPSIS: Being a farming ecosystem with no natural systems remaining the presence of wild plants and animals in the study area is extremely rare. When natural areas are interspersed with farming areas, the ecological checks and balances are beneficial to agriculture, eg. control of certain pests.

The transformation from a natural to a farming ecosystem has been so extensive that space and circumstances do not permit the reintroduction of the ecology of that period. However,the project itself will provide better conditions for plant growth with the assurance of water most of the year.

The tree cover will be increased when the upland areas are grown to multiple-use trees. Likewise, the coverage on river and canal banks, roadsides, and more intensive use of home gardens will complement plant diversity. The availability of food,water and limited habitat will favour the re-appearence of certain small animals, birds and insects which can be favourable to agriculture, eg. the rat which is a major pest in paddy, can be kept in check by certain birds and snakes. Frogs too contribute to controlling pests in paddy. Butterflies, bees and other insects help pollinate fruit crops and increase productivity.

RECOMMENDATION:

a. Increasing tree cover over the area will provide a diversity of habitat and a variety of niches for certain species of fauna. It will add to aesthetics and improve livability.

4.7 Home Gardens

SYNOPSIS: The home garden must be a pleasant place to live in. It must be free of flooding, be sanitary, and be able to provide humans and livestock with certain basic needs of food and shelter. As it is also used to house poultry and animals, human health and sanitation must not be threatened in any way on account of poor livestock management.

Since land is limited, every effort should be made to obtain optimum productivity from each unit of land. A greater density of plants can be introduced on most holdings and in certain holdings forestry models can be simulated.

The natural evergreen forest exhibits a tiered canopy and effectively utilises vertical space, both below and above ground surface, horizontal space and, sunlight to maximum advantage. Where the farmer desires to grow seasonal vegetables, trees can be grown as in the

system of alley cropping which permits regular pruning and use for firewood and other farm needs. The space between the tree rows provide space for seasonal crops.

The top-most canopy in a tropical evergreen forest is occupied by dipterocarp species, and in the home garden too, dipterocarps such as Shorea robusta and Dipterocarpus obtusifolia or even jak, Artocarpus integrifolia, can be planted along fences and would provide valuable timber in the long-term and food in the short-term. The main canopy in a forest holds a variety of species and suitable domestic species include mango, breadfruit and jak.

The sub-canopy shelters shade-tolerant species such as anona. The shrub layer will accomodate crops like coffee. The ground layer will hold an assortment of shade loving plants such as ginger and turmeric. Yams such as dioscoreas, the orchid vanila, and pepper which are twiners and climbers can be trained onto the trees.

The soil likewise will be utilised at different depths depending on the rooting characteristics of each species. Thus nutients from different soil depths will be taken up by the roots and be eventually deposited on the surface as litter. This type of multi-species culture will attract a diversity of natural enemies of pests,including a variety of birds.

RECOMMENDATIONS:

a. Using the boundary fence to plant trees that are long-lived and tallest,as those that will provide timber,eg. dipterocarps. Other tree species that can be used are acacia, eucalyptus, ipil-ipil, and gliricidia.

b. Planting the level similar to the main canopy with species such as mango, rambuttan and jak.

c. Introducing shade loving species at the sub-canopy level and shrub level; suitable species are Anona and coffee.

d. Planting the ground layer with shade requiring ginger and turmeric.

e. Housing livestock separate from the living quarters for two main reasons – (a) health of humans and, (b) collection of dung and urine. To live together with animals is unhealthy.

4.8 Agrochemical Use

SYNOPSIS: The potential for pesticide problems of a serious nature is clearly seen, although current environmental problems due to agrochemical use are not widespread. The potential risks will increase, unless checks and balances are instituted early. This danger is identified both at levels of farm use and at import and marketing. The national IPM programme has had some interesting results which hold promise for wider application.

In third world countries paddy crop losses due to insect pests can be as high as 35 %. While the need to minimise insect damage in crop production is acknowledged, it is becoming increasingly important that pest control has to be carried out in the most cost-effective and environment-friendly manner. With the advent of modern technology and availability of high yielding varieties,more and more farmers are resorting to the use of chemicals for pest control. It is considered the easy way out. The chemical market has grown rapidly and aggressive selling has found its way to the farmers' doorstep. Even with the large amounts of chemicals in use, effective control of insect pests is not yet a reality, and may never will be.

Concern has been voiced on the ill-effects of indiscriminate pesticide use. WHO reports: "since the 1940s, over 1,600 insect species have developed significant resistence to major pesticides because of long-term and non-selective use. "The government of Cambodia is considering controlling the import and use of pesticides and is presently studying draft

legislation to this effect. The legislation is aimed at enabling society to "obtain the benefits from the use of pesticides with minimal adverse effects to man and the environment. "It is accepted that pest control prgrammes have a dual responsibility, ie. reducing crop losses while at the same time, minimising environmental damage.

A paddy monoculture is a simplified situation, very easily exploited by pests, particularly when successive crops occupy the same tract over many months. In this context, eradicating a pest is a difficult task. The more rational course of action will be pest management. Towards this end, government has taken some initiatives. Integrated pest management (IPM) has been introduced in the country and is continuing to benefit from donor assistance. IPM may be defined as: "any system that relies on a variety of aapproaches for controlling pests, including physical, biological, genetic and cultural methods, as well as pesticides. It relies on the concept of an economic threshold of pest population density or crop damage,below which the cost to control a pest is greater than the benefit of doing so. In agriculture, IPM components include efforts to breed crops resistant to pests and diseases, use of cover crops for weed control, timing of planting, crop rotation, and introduction of predators and parasites".

An IPM programme can reduce pesticide use, cost of production, health hazards to humans and animals and promote multiplication of natural predators and parasites. In view of the variety of hazardous chemicals being used, it is important to prevent a build up of pest resistance. This can occur from the repeated use of chemicals in high doses when species initially acquire tolerance levels. From this stage pests can rapidly proceed to the resistance level when they can survive very high doses of pesticide. Control using the particular pesticide or group of pesticides will then become impossible. The farmer then turns to still more toxic chemicals.

RECOMMENDATIONS:

a. Educating farmers on the hazards of indiscriminate pesticide use.
b. Implementing the findings of the national IPM programme through project extension activities.
c. Convincing government on the need for setting up without delay, pesticide control legislation and ensuring enforcement, to avoid human health and environmental damage.

4.9 Firewood

SYNOPSIS: Firewood is in short supply all over the study area. Unless early action is taken to establish firewood coops, people will be put to great inconvenience. They may have the rice but not the fuel to cook it with. The situation is so acute that people even uproot 3-foot plants from a government forest reserve. The Department of Forestry has no current programmes for firewood plantations. Opportunities for planting firewood species are many but the manner of management needs to be examined. Government-managed reforestation has met with little success upto now. This is the experience of many countries around the world. As there is a great demand for forest products, it is urgent that reforestation be accelerated. Work of the Mennonite Central Committee in Takeo province gives hope in alternative methods.

In the absence of data for the study area, firewood need is estimated at 4 m^3/household/year. The average family size is 4.9. The need here is on the basis of consumption in a similar Sri Lankan rural setting. Accordingly, the masterplan area, having 8,526 households will consume approximately 34,100 m^3 of firewood. Assuming that a hectare of mature eucalyptus will yield 200 m^3, an area of 170 ha will be required to provide the firewood needs of all the households.

Besides, the two brick and tile factories in Bati district consume about 700 m^3/year (1993 consumption being 680 m^3). Another 1000 m^3 may be requirement of miscellaneous light industries in the study area and eight to 10 hectares will be needed to provide this requirement.

All the commercial firewood comes from the national forest estate and class 1 hardwoods are also supplied. There is a great obligation on the part of government to see that alternative sources of firewood are made available, so as not to destroy national forests for purposes, where wood of lesser quality will be just as good.

Several opportunities exist in the masterplan study area to plant multipurpose tree species. These are:

a. unirrigable upland that are presently under-utilised;
b. river banks, canal banks and roadsides;
c. farm lots; and,
d. public places and other unused state land.

A combination of species may be planted depending on particular needs. Leguminous species will increase soil nitrogen, while all species will recycle nutrients from the sub-soil to surface layers apart from providing many other ecological benefits.

A number of methods are available for managing planted areas. Firstly, the long-tried government approach, tied down by numerous regulations, running through numerous after-care problems and achieving limited success in the end. Secondly, the community method, where the community manages but is not very popular with the people. Thirdly, individual planting on farm lots owned by the people. Fourthly, a combnation of the state and the people, with clearly defined user rights. The Takeo experience of the Mennonites seem to justify this means, for which there has also been a positive response from the Department of Forestry.

It is reported that the Takeo experience of joint forest management has shown that people "do understand very clearly the long-term environmental implications of deforestation" and that they "want to protect and replant" the remaining forest land. Participants in this project have been the Department of Forestry and Wildlfe, Takeo Provincial Forestry Office and Tramkok District Agricultural Service and Women's Association. This pilot exercise is carried out on a 500 ha degraded forest land provided by the Department of Forestry in Tramkok district.

Shortage of firewood may be interpreted as a symptom of a serious population /environment imbalance. Programmes where people participate are referred to by different terms such as "social forestry", "community forestry" and "village woodlot forestry". The common feature is that all involve local people and aim to meet local needs. Some of the benefits of village woodlots are as follows:

a. solving firewood and fodder shortage;
b. supplying building materials;
c. reducing erosion;
d. preventing downstream sedimentation;
e. promoting infiltration;
f. promoting nutrient cycling;
g. influencing micro-climate; and,

h. bringing about aesthetic enhancement.

RECOMMENDATIONS:

a. Establishing village firewood lots on unirrigable uplands through appropriate social forestry systems to ensure a continuous supply of firewood to all households.

b. Making available to the people seedlings of multipurpose tree species.

c. Allocating land to industrialists for growing individual firewood needs.

d. Growing multipurpose tree species on roadsides and canal banks.

e. Popularising energy efficient cooking stoves.

4.10 Fishery

SYNOPSIS: In view of its small-time nature, or family fishing that is mostly practised in the master plan study area, large scale fishery improvement is not considered feasible. The many ponds that dot the countryside are also not utilised in an effective manner.

The old river courses that are a feature of the Prek Thnot river valley seem particularly attractive to be converted into commercial aquaculture. The dislike shown by most people to rear fish in the ponds they own, is good reason for utilising these natural ponds which are presently under-utilised. Another is the diminishing catch from the natural fishery resource.

Fish farming by individual farmers can also be tied to paddy cultivation. During field inundation fish can be allowed in, if the pond is constructed adjacent to the field. There are mutual benefits for both paddy and fish.

Installation of fish ladders at Kompong Toul has been considered carefully. It does not appear to be practical for a number of reasons. Firstly, there is inadquate information on fish migration in the Prek Thnot river. Secondly, the Department of Fisheries does not consider the area as a major fishery. Thirdly, fish movement upstream in the Prek Thnot has already been interfered with at Kompong Toul and, at Roleng Chrey as far back as 1972, by the installation of gates. Even if ladders were to be installed at Kompong Toul, the gates at Roleng Chrey will act as barriers to futrther movement of the fish. Fish culture can be introduced in the waterbody created by the new gates at Kompong Toul and by conversion of the old river courses of the Prek Thnot river.

RECOMMENDATIONS:

a. Converting the old river courses into aquaculture ponds. This is a more rational form of land use.

b. Collaborating in fishery extension with specialist NGOs.

4.11 Water Quality

SYNOPSIS: As shown in results of water analyses carried out during the study, the quality of surface water bodies has been satisfactory. Ground water has also been satisfactory, except in a few isolated instances where a high iron content makes it unfit for human use.

A likely threat to water quality in the project area is from non-point sources of agricultural production. When fertiliser is used in excessive amounts, nitrates and phosphates can be leached or transported into surface and ground water. Accumulating in closed surface water bodies, these nutrients cause algal blooms, also called eutrophication. At present there is no fear of this happening and periodic monitoring will indicate changes taking place so that remedial measures can be taken if so warranted. Likewise, pesticide residues may accumulate at various points and analyses will be helpful as and when facilities become available in the country. If the project is extended at a later stage to cover the entire masterplan area, a fresh assessment of fertiliser use and likely residual effects will become necessary.

RECOMMENDATIONS:

a. Undertaking regular water testing at selected sites and for selected parameters to understand changes taking place.

b. Increasing the use of organic manures.

c. Using pesticides in combination with other methods of pest control which in effect is integrated pest management and is environment-friendly.

4.12 Health and Sanitation

SYNOPSIS: Many aspects of health and sanitation around the household and on the farm, such as pesticide application, need to be improved.

Separation of living quarters of humans and animals is an urgent sanitary requirement. Apart from contributing to good health, it will enable the collection of dung and urine for manuring fields. It will also reduce the fly and mosquito problems to a great extent.

Greater care needs to be exercised in the hosehold storage of agrochemicals. While educating farmers is a priority, government should introduce legislation and regulations which will also include imports. Sometime after project implementation an increase in living standards can be expected. This may result in the generation of more waste as people begin to spend more on food and consumer goods. Although individual family waste generation may be small, the community together will generate large amounts and disposal problems may arise. Such possibility is recognised for addressing at a later stage if the need arises.

While point sources of pollution as from industries, are not experienced, non-point sources such as agricultural runoff may subsequently prove to be a problem if excess phosphates and nitrates endanger aquatic life and nitrites in drinking water which can lead to the blue baby syndrome in infants.

Contamination of water bodies can give rise to a number of communicable diseases. These may be grouped as follows: water-borne (cholera and typhoid), water-washed (diarrhoea, skin and eye infections), water-based (helminthic diseases), water-related (malaria) and water-dispersed (some amoebic diseases).

Water-borne diseases by far form the largest category. Malaria can be a potential problem and epidemics are often linked to irrigation projects. Stagnant water provides breeding sites to the malaria mosquito, Anopheles which typically breeds in stagnant water.

Provision of safe water is discussed in the section on Rural Infrastructure. Public Health is addressed in the section on Socio-economy.

RECOMMENDATIONS:

a. Educating farm families on general sanitation.
b. Improving human housing.
c. Encouraging better housing for livestock.
d. Providing good drinking water.
e. Educating farmers on pesticide storage and use.
f. Flushing out canals periodically if ponding and mosquito breeding are evident.
g. Co-ordination of irrigation and public health institutions for vector-control.

4.13 Reforestation

SYNOPSIS: There are no large extents of land in the study area that can be forested. However, the Phnum Thma forest reserve – presently totally deforestedof about 2,000 ha, lying to the south of the Kandal Stung project area, merits special treatment because of its ecological importance to the Tonle Bati lake;being part of its southern catchment.

At the current rate of reforestation in the Phnum Thma reserve by the Department of Forestry, which is 20/30 ha/year, it will take many years before the entire land area is planted. The biggest constraint is the shortage of funds. The nursery on the same land is of adequate capacity to provide seedlings for the entire undertaking as planting will be on a staggered basis. Being a beautiful landscape, where there are also a couple of historical pagodas on hillocks, the land can lend itself to multiple uses. Tourism and recreation are suggested in a package of multiple uses.

Therefore, it is proposed that a separate management plan be drawn up for the area which includes land allocations for production of timber, firewood, fruit and also conservation areas of varying legal status. A satisfying feature in the Phnum Thma forest reserve is the natural regeneration of some of the dipterocarps, and a distressing feature is the uprooting of 2/3-foot replanted seedlings of timber species by the people of the area for use as firewood.

It is widely believed that governments world-wide have failed in their sole efforts to manage forest lands. Without the participation of the people, forest protection becomes a hopeless task. For good reason, the experience of the Mennonites referred to in section 4.7, is again focused upon. If a management plan comes to be drawn up for the Phnum Thma reserve, it is suggested that the Takeo experience be studied, more because the Department of Forestry and Wildlife considers it as a test case in "joint forest management". The purpose of laying down user rights at the very outset is to provide incentives and legal protection for local people to participate in protecting and replanting forests.

RECOMMENDATIONS:

a. Reforesting the Phnum Thma forest reserve which is actually outside the area of the masterplan study but can have valuable ecological advantages on the hydrology of the Tonle Bati lake.
b. Considering the preparation of a forest management plan with multiple use concepts.
c. Considering working through "joint forest management" concepts.

4.14 Borrow Area

SYNOPSIS: Generally, in major development schemes, borrow areas tend to get forgotten when the work is completed and are left unrestored. In such instances, these areas get degraded over time; become sources of sediment generation and when ponded, permit mosquito breeding.

When borrow areas are adjacent to paddy fields, it is necessary to take precautions to prevent flash flooding and sedimentation in the event of heavy rain. This should be done before borrowing begins and can take the form of a low embankment on the side of the fields.

When transporting earth from the borrow site to the work site in heavy vehicles, people living along the road can be bothered by dust and noise, and the road may be damaged by heavy vehicles. These are of course temporary problems over short periods of time. However, they can be minimised to a certain extent; by either covering loads of earth by tarpaulins or by wetting the surface layer of the load and by having a sufficient interval between two trucks so that the dust on the road is not too intense. Damage if any to the road and culverts should be repaired as soon as possible.

On completion of excavation, the surface should be levelled off to avoid the creation of small pits that may turn into small ponds during rains. This will avoid mosquito breeding to a great extent. With an average depth of two metres of excavation, sub-soil will be exposed. Exposed soil is a starting point for soil erosion.

One method of minimising erosion is to quickly establish a vegetative cover but it is difficult to get plants growing on sub-soil. The first colonisers of such places will be a variety of annual weeds. With incremental increases of organic matter and nutrients from successive weed populations, small shrubs will establish themselves. Tree growth will begin much later. A cover is possible by planting a quick growing creeper such as Pueraria from specially constructed "refuges of good soil" at intervals in the borrow area with a little added phosphate. Pueraria produces large quantities of biomass and covers the soil very effectively. Another alternative is to create a pond for aquaculture if other conditions are satisfying.

RECOMMENDATIONS:

a. Preventing likely flash floods while that can cause sedimentation of adjacent paddy fields.

b. Minimising inconvenience to people living along the road where earth will be transported to work sites.

c. Rehabilitating the borrow area to a reasonable degree in order to arrest continuing degradation.

4.15 Cultural Area

SYNOPSIS: The Ta Prohm temple complex of Tonle Bati lies to the south of the lake. Its origins date back to the 7th century. Its value is complemented by the adjacent recreation area.

Care has been exercised to prevent inundation of the cultural area by keeping the water level of the Tonle Bati lake at 7.8 m. An embankment will be constructed on the nothern side as a further insurance against inundation.

RECOMMENDATION:

a. Restoring the cultural complex buildings with expert archaeological advice.

4.16 Recreation Area

SYNOPSIS: The recreation area by the lakeside and the Ta Prohm temple has high visitor value. However, it is presently in a neglected state. Because of the slope there is serious erosion. The huts seem very unsightly.

Continuing erosion of the bank can also lead to sedimentation of the lake. The lake is vital to the supply of irrigation water to the Tonle Bati area. During the dry season the water level will be maintained at 5.5 m in order to maintain the recreation area. It is proposed that the bank be turfed and individual spots be allocated to each picnic party. These spots should be cemented or brick-paved and shelters in the form of garden umbrellas will be more attractive and have wider appeal than the unsightly thatch. Then it will be possible to increase the income from this spot. A well thought out management plan need to be prepared.

RECOMMENDATIONS:

a. Arresting soil erosion and returfing bank.

b. Removing (and prohibiting the use of) the elevated platforms on the water's edge.

c. Installing randomly placed paved circles or any fancied geometric design, equipped with garden umbrellas for the use of visitors.

d. Prohibiting littering. Installing litter bins or enforcing "carry your litter home."

e. Communicating rules to the public through prominently placed noticeboards.

4.17 Environmental Education

SYNOPSIS: If people have a better understanding of the environment than at present,including the different ways its component parts interact,then the goal of sustainable development will not be difficult to achieve.

Farming has had a long and historical tradition among Asian people. And so it has been in the Kingdom of Cambodia. Many are the age old practices that led to sustainable resource use and a wholesome lifestyle. However, these traditional practices and beliefs faded away with time, particularly with the advent of the green revolution.

Pressure on the resource base has been increasingly reflected through its inability to produce the expected yields to sustain a growing population. Environment has a bearing on all aspects of human life and activity. More and more evidence has come to light on the fragile nature of the earth's resources and the complex linkages that exist among different natural systems. For example, the ability of wetlands to filter agricultural runoff of nutrients such as nitrogen and phosphorus, which in turn prevents algal blooms in receiving waters. To understand the inter-play of natural linkages, farmers need to be provided with knowledge. This can be done through the proposed farmer groups. Improvement can be sought both to raise crop yield on a sustained basis and the living environment of the family.

Fortunately, in Cambodia the resource base is not pressurised by a large population, polluting industries and extreme exploitation. However, it is opportune to take stock and be guided by rational thinking. Environmental components as appropriate to the locality should be included in training programmes.

RECOMMENDATIONS:

a. Incorporting environmental components at appropriate training opportunties. Opportunities exist at water user associations, drinking water supply group, cultivation techniques study group, life improvement group and women's group.

b. Training of the trainers – staff of the Agricultural Development Centres.

c. Enlisting the support of specialised NGOs to assist in field activities.