

3. ANALYSIS OF SOCIAL AND ECONOMIC COSTS OF THE IDENTIFIED WATER-RELATED PRINCIPAL ENVIRONMENTAL ISSUES

3.1 WATER RESOURCES

Social costs relating to poor health and reduced fish production may eventually lead to the marginalization of the poor in Cambodia, particularly in the coastal area. Health costs from diseases, such as diarrhoea, caused by the ingestion of poor quality water affected by pollutants have not been fully studied.

In the meantime, the freshwater shortage is one of the impacts on the social costs and health of the people. While precise, comprehensive data on access to water supply are not available, it is estimated that only some 3.2 million people (32 per cent of the population) have access to clean drinking water, about 65 per cent of the urban population (mostly in Phnom Penh) and 26 per cent of the rural population. This bleak situation implies that a total of about 6.9 million people do not currently have access to clean water, some 6.4 million of them in the rural areas. Moreover, coverage by province varies widely, from 5-6 per cent in Koh Kong and Kompong Thom, for example, to 41-42 per cent in Pursat and Kandal. The expected population growth over the next five years implies that potable water facilities will need to be provided for an additional 1.5 million people before the 6.9 figure can be reduced.

Likewise, precise comprehensive data on the provision of environmental sanitation are not available. Access to it is even more limited than to clean water, with only an estimated 1.6 million people (16 per cent of the population) having such access: about 74 per cent of the urban population (again mostly in Phnom Penh) and 6 per cent of the rural population. In total, there are over 8.5 million people without access to environmental sanitation, roughly 8.2 million of them living in the rural areas.

(a) Phnom Penh water supply and sanitation

The Government's long-term objective for Phnom Penh City is that the Phnom Penh Water Supply Authority (PPWSA) should become a self-sustaining financial entity which will supply water meeting WHO (World Health Organization) drinking water standards to the population at an affordable rate, as shown in table 3.1. Plans and targets set by the PPWSA for water supplies to Phnom Penh City during the plan period 1996-2000 are to:

- Rehabilitate the existing water supply system, which should provide an adequate supply of potable water for about 640,000 people in the urban core of Phnom Penh as a first step;
- Increase the supply of potable water to some 220,000 m³/day (sufficient for a population of 916,000) in the urban core of Phnom Penh;
- Develop internal and external ongoing training with the goal of transferring technical and administrative and operational skills to the personnel of the PPWSA and the operators of the treatment and distribution systems to improve the efficiency of operation and maintenance;
- Coordinate with the external community in the development of plans, studies, projects and financing to avoid unnecessary duplication of efforts and wastage of time and resources;
- Work with the external community to obtain and develop the resources necessary to rehabilitate and extend the water supply systems until such time as the PPWSA is able to sustain future development and maintenance of the system.

Table 3.1 Phnom Penh water supply investment requirements, 1996-2000
(US\$000)

Item	1996	1997	1998	1999	2000	Total
Rehabilitation	-	-	-	-	-	-
Water treatment	12,200	13,900	-	-	-	26,100
Distribution	2,250	2,300	550	-	-	5,100
Extension	-	-	-	-	-	-
Water treatment	7,000	14,350	7,350	-	-	28,700
Distribution	1,000	9,000	4,000	4,000	2,000	20,000
Training	1,650	1,650	-	-	-	3,300
Total	24,100	41,200	11,900	4,000	2,000	83,200

Source: First socio-economic development plan, 1996-2000.

The Government's long-term objectives for Phnom Penh's sanitation is the creation of a sanitary city through the provision of sanitation and drainage systems which will:

- (a) Collect sewage from all areas of the city;
- (b) Provide primary and secondary treatment to all sewage prior to discharge into the environment;
- (c) Collect surface run-off from low-lying areas;
- (d) Provide primary treatment to surface run-off prior to discharge into the environment;
- (e) Be affordable to the city and based on a means of charging to be determined (possibly revolving around property tax or a surcharge on water bills).

The aim of the municipality of Phnom Penh for the sanitation and drainage subsector is to reduce flooding in the low-lying parts of the city and to increase the retention time in the drainage basins. The installation of 12 new pumping units is planned together with their associated civil engineering works. Included in the scheme is the dressing of Boeng Trabek retention basin and other rehabilitation work. This would cost an estimated US\$ 12.4 million over the plan period, as presented in table 3.2.

In addition, a study currently being implemented has a component to identify sewerage schemes that would benefit areas inhabited by the urban poor.

Table 3.2 Phnom Penh sanitation/drainage investment requirements, 1996-2000
(US\$000)

ITEM	1996	1997	1998	1999	2000	Total
Rehabilitation/extensions	-	-	-	-	-	-
Sewers / drains	2,829	2,833	1,897	-	-	7,559
Pumps / treatment	3,471	567	803	-	-	4,841
Total	6,300	3,400	2,700	-	-	12,400

Source: First socio-economic development plan, 1996-2000.

(b) Rural water supply

The Ministry of Rural Development (MRD) is responsible for rural water and sanitation, with the Ministry of Health (MoH) responsible for health education. Some 6.4 million rural people have no access to clean water and only 500,000 of them have access to environmental sanitation facilities. In order that human development can occur in Cambodia, a substantial improvement will be required in these basic services.

The Socio-economic Survey, 1993-94 indicates that nearly two thirds of rural households derive water from dug wells, while about one third obtain it from surface water. Moreover, as already noted, carrying water over long distances leads to considerable negative externalities for social and economic development, and the poor quality of available supplies has major health implications. An estimate of investment requirements for provincial water supply for the year 2000 is shown in table 3.3.

Table 3.3 Provincial water supply investment requirements, 1996-2000
(US\$000)

Town	1996	1997	1998	1999	2000	Total
Siem Reap	600	700	700	-	-	2,000
Sihanouk Ville	2,000	700	-	-	-	27,00
Takhmao	100	-	-	-	-	100
Svay Rieng	100	-	-	-	-	100
Prey Veng	100	-	-	-	-	100
Kompot	-	-	-	-	-	100
Kompong Cham	-	-	-	-	-	100
Kompong Speu	400	800	800	-	-	2,000
Kompong Thom	200	500	500	-	-	12,00
Takeo	-	1,000	1,500	1,500	-	4,000
Extend Kompong Cham	1,000	1,500	1,000	-	-	35,00
Kep	-	-	-	1,000	500	1,500
Sisophon	-	-	-	1,500	1,500	3,000
Kompong Chhang	-	-	-	2,500	2,500	5,000
Total	4,700	5,200	4,500	6,500	4,500	25,400

Source: First socio-economic development plan, 1996-2000.

The Government is committed to achieving universal coverage of access to environmental sanitation by the entire rural population in the foreseeable future.

Over 8.2 million people in rural areas would benefit from access to environmental sanitation between 1996 and 2000. Even with a combination of the most cost-effective technologies, universal coverage in environmental sanitation would cost an estimated US\$ 42.5 million in capital expenditure over the next five years. Resources of this magnitude are unlikely to be available, and the country's human and institutional capacity is insufficient to successfully implement an investment programme of this scale.

The broad magnitude of the costs of providing a safe water supply to 60 per cent of the rural population by the year 2000 is shown in table 3.4.

Table 3.4 Rural water supply investment requirements, 1996-2000
(US\$000)

Technology	1996	1997	1998	1999	2000	Total
Hand-dug well	900	900	1,050	1,050	1,050	4,950
Dug / drilled well	1,182	1,125	1,310	1,310	1,310	6,187
Hand pump shallow well	1,688	2,250	2,250	2,250	2,250	10,688
Hand pump deep well	1,330	1,425	2,090	2,090	2,090	9,025
Total	5,100	5,700	6,700	6,700	6,700	30,900

Source: First socio-economic development plan, 1996-2000.

3.2 FRESHWATER LIVING RESOURCES

Freshwater living resources are very important for Cambodia in terms of socio-economic and environmental development. However, the loss of freshwater living resources has caused great concern to people and serious socio-economic and environmental problems. The lack of a lowland policy has been instrumental in this decline.

3.3 MARINE LIVING AQUATIC RESOURCES

Marine living resources are the second most important issue after freshwater living resources. Because of a lack of law enforcement and policy together with the continuing over-exploitation of marine living resources, serious social and economic costs have to be faced.

The encroachment of foreign fishermen is another factor causing the decline of marine fish stock because of their destructive practices, such as the use of large-scale vessels equipped with modern fishing gear - push-nets, purse-seine and trawl nets. Dynamite fishing is one of the illegal fishing activities.

3.4 AQUATIC HABITATS

The aquatic habitats, both freshwater and marine, have been dramatically lost because of improper activities. The traditional cutting for firewood and charcoal by local people causes serious degradation and loss of aquatic habitats, mainly flooded forest and mangroves that are vital feeding and nursery grounds for many species of fishes, reptiles and waterbirds. Unfortunately, there has been no study project or research on this loss that could be used for the socio-economic valuation.

3.4.1 Economic loss owing the reduction in habitats

The loss of flooded forest area is caused by various illegal and destructive practices, especially in agricultural sectors such as conversion to rice fields (recession) and other croplands, and the expansion of fishing lots. Collection for firewood is another increasing cause for this loss.

There has also been continuous collection of some aquatic plants and weeds as vegetables that are traditionally preferred by most Cambodian people. These include various species, but especially the white and red lotus young roots (locally called *Kra-Ao Chhuk*), water hyacinne flowers (*Slab Changvar*, *Kandieng* and *Chrach*), and morning glory, (*Kanh Chhet*).

The mangroves in the coastal areas of Cambodia have been lost continuously and increasingly because of many practices, which are significant factors in habitat loss. These include the clearance for intensive shrimp farming, charcoal production, and settlement and urban area expansion. Coral reefs and seagrass beds are additional coastal habitats that have been dramatically lost, for almost the same reasons.

Unfortunately, an economic valuation of habitat loss has not been made.

3.4.2 Destructive exploitation of the aquatic resources of wetlands

The exploitation of the aquatic resources of wetlands has been increasingly practised by local communities. All activities, whether for income generation, alternative livelihood, or improved living standards, are becoming more destructive rather than useful or protective of wetland aquatic habitats.

Over-fishing, along with other practices such as dynamite fishing, the use of electric shocks, and the use of very small mesh-nets, cause, to a large extent, increased by-catches which are reportedly used for feeding cultured fishes (*Panganius* species and giant snake-head fishes).

All of these factors have caused a dramatic decline in fish stock, which has led to socio-economic losses. Apart from fishing, some other destructive practices have occurred to the reptiles, especially snakes (pythons for example), turtles and frogs. Sometimes flooded forest has been burned in order to catch turtles and frogs. Some practices in agricultural production (clearing flooded forest for receding rice and other crop harvesting, and expansion of fishing lots) could be additional factors, causing the loss of shelters, and feeding and nursery grounds for many species of fish, shellfish, invertebrates and reptiles.

The loss of these extremely valuable living resources has led to an insufficient nutritional regime for the Cambodian people. The current estimates suggest a decline in fish stock of over 50 per cent. Thus, the loss of habitats and aquatic living resources, particularly fishes, must be given high priority and effective measures for their wise use and sustainable management must be properly and urgently undertaken.

4. ANALYSIS OF THE ROOT CAUSES OF THE IDENTIFIED WATER-RELATED ISSUES

4.1 ROOT CAUSES OF POLLUTION

At present, the status of water pollution is at a moderate level in Cambodia if compared with other countries. However, the trend of this pollution has increased from year to year because of a lack of management policies, pollution source control, law and law enforcement, and finance.

The root causes of water pollution in Cambodia are as follows:

(a) Sewage: Sewage and wastewater management in Phnom Penh and other large municipalities is extremely poor. Almost all cities and towns are located close to surface water sources or the coastal area. Sewage and other wastewater has been discharged directly into public water without any treatment, except in Phnom Penh city where about 75 per cent of the total sewage and other wastewater is discharged through reservoirs as natural treatment and then into the Tonle Sap River.

There has only been one wastewater treatment facility in Battambang province (waste stabilization pond model), but now it out of use because of financial and technical problems. Moreover, the law and other regulations related to the wastewater control and effluent standards are still in the drafting stage.

(b) Solid waste: Most of the urban areas, such as Phnom Penh City, Battambang, Kompong Cham, Kandal, and the coastal provinces already have very significant waste disposal problems which can be expected to worsen as the population increases and the industrial sector grows. Management of solid waste is on the whole poorly managed and piles of rubbish in open spaces are common. These contribute to unsanitary conditions through the blockage of drains, water pollution, scavenging, and rodent and insect breeding.

In general, solid waste management is very poor in Cambodia. About 60 per cent of daily solid waste generated in most urban centres is collected and disposed in open burned dumpsites without sanitary or leaked-water protected facilities. Uncollected solid waste is burnt or directly dumped in public water areas.

The insufficient coverage of solid waste collection, inadequate management and uncontrolled disposal contribute to the problem of water pollution in Cambodia. The problem is compounded by inadequate financial support, lack of planning for management, and shortfalls in public awareness and education.

(c) Sedimentation: The intensive deforestation, poor agricultural practices, and gemstone mining are the major root causes of soil erosion which has led to heavy sedimentation in the central low-lying land, especially in Tonle Sap lake, rivers and coastal areas. Natural soil erosion and surface run-off are the second major sources of sedimentation in Cambodia.

The sedimentation of Tonle Sap Lake and some estuaries of the coastal delta has increased dramatically in the last two decades. However this conclusion is the result of a visual survey, not a scientific study.

Currently, the implementation of the government regulation banning illegal logging activities is still weak because of an inadequate and inefficient management. Other measures of preventing soil erosion have not yet been set up in Cambodia owing to lack of capacity and financial constraints.

(d) Agricultural waste:

- *Chemical fertilizer and pesticide residues:* The use of these substances for agricultural purposes has increased. The upward trend of indiscriminate use of these substances can cause water pollution problems as residues of these compounds are carried by surface run-off from cultivated areas to water bodies.

However, information on the area of use and the type and amount of these substances is not available because there has been no research or study of these issues in Cambodia.

- *Shrimp farm waste:* Toxic waste from shrimp farm aquaculture in Koh Kong province is discharged directly into the estuaries of the coastal area without treatment at all. It is believed that the shrimp farm waste has caused the water quality of coastal areas to decline, but there has been no project study of this problem.

4.2 ROOT CAUSES OF SURFACE WATER SHORTAGES AND QUALITY DEGRADATION

In Cambodia, surface water is a very important resource because it gives life support to the people, to all other living resources and to economic development. Multiple use has caused surface water shortages and quality degradation in some areas of the country.

- **Surface water shortages:** For several years the problem of surface water shortage has often happened in some locations situated far from the major water bodies or sources. These areas are southern Kompong Chhnang, Takeo, Kompong Speu, Prey Veng, Svay Rieng and eastern Kampot provinces.

The root causes of the shortage are:

- (a) Large population / populated areas;
- (b) Temporary scarce rainfall;
- (c) Financial constraints;
- (d) Fast growing economic development;
- (e) Lack of irrigation and water storage systems.

The intermediate causes are as follows:

- (a) Increasing need for water supply and agricultural irrigation;
- (b) Lack of appropriate water management policies;
- (c) Intensive deforestation.

- **Surface water quality degradation:** The degradation of surface water quality is primarily caused by the direct discharge of sewage and other wastewater from factories and hospitals into public water areas without treatment. The second cause of surface water contamination is the disposal of solid waste into water bodies and insufficient sanitary dumpsites for urban and municipal waste disposal.

According to the results of a surface water quality analysis made by the Mekong River Commission, the low quality of surface water (low dissolved oxygen, down to 1 mg/l) has taken place in some segments of the Tonle Sap River, upstream of the Bassac River, and in some parts of Stung Sanker, Stung Siem Reap and Tonle Sap Lake. Unfortunately, the information or data on surface water pollution caused by heavy metals, pesticides, PCBs and other chemical compounds are not available because the surface water analysis of these substances has not been measured yet because of lack of capacity.

The root causes of surface water quality decline are as follows:

- (a) Rapid population growth / populated areas: This causes the degradation and pollution of surface water by excessive and uncontrolled sewage discharge and solid waste disposal;
- (b) Lack of funds for the clean-up programme, treatment plants and other facilities;
- (c) Lack of expertise among responsible staff at all levels;
- (d) Lack of regulations regarding waste management and effluent standards for all kind of water pollution sources;
- (e) Lack of understanding and public awareness about the impacts of water pollution caused by careless waste disposal and sewage discharge into the water bodies.

4.3 ROOT CAUSE OF GROUNDWATER SHORTAGES AND QUALITY DEGRADATION

- **Groundwater shortages:** In Cambodia, the use of groundwater is still on a small scale for rural and urban domestic supplies and occurs mostly in the dry season. According to the report of a drilling programme made by UNICEF, groundwater shortage has taken place in a few areas of the country such as the central part of the country between Battambang and Pursat provinces, north-western Kompong Speu and northern Kompong Thom provinces. The root cause of the shortage is a natural feature of these areas where the groundwater aquifers are covered by hard stone and too deep for exploitation.

- **Groundwater quality degradation:** There is no data on the quality of groundwater in Cambodia. However, the UNICEF drilling programme showed that high iron concentration and increased salinity levels have been encountered in some provinces such as Takeo, Svay Rieng, Prey Veng, Kandal, Banteay Meanchey, Battambang, Kompong Speu, and the three coastal provinces. The root cause of the low groundwater quality results from the natural features of these areas. Groundwater quality monitoring for the whole country is needed in order to conduct a scientific analysis, which could then be used to formulate policy guidelines for groundwater management.

4.4 ROOT CAUSES OF FISH STOCK DECLINE

In recent years Cambodia has faced a serious problem of fish stock decline in all major fishing areas, both freshwater and marine and coastal waters.

The root causes of the fishing decline include:

- (a) Population growth;
- (b) Poverty;
- (c) Survival needs/ income generation;
- (d) Fund shortages;
- (e) Lack of capacity/ expertise;
- (f) Foreign investment and encroachment.

It is necessary to know much more about the detailed effects and influences of these factors.

- **Population growth** can result in growing threats to the natural resources (fish, in our case) in various aspects, such as: disturbance, over-fishing, pollution and degradation. A great number of fishermen, with different types fishing boats and fishing gear, have been competing through the use of illegal activities and destructive practices.

- **The poverty** of the local people could be another root cause of fish stock decline. All people strive to avoid poverty, trying to find a job to earn money. Fishing is a very important activity for Cambodian people, after crop harvesting. This can also lead to over-fishing and result in fish stock decline.

- **Survival needs or income generation** are important root causes of fish stock decline for the majority of rural people are generally poor. As their primary needs are for survival, efforts to generate income from different sources are of the first priority. Subsequently, the need for food security (fish food) is becoming excessive and leads to over-fishing.

- **Fund shortages** are another constraint on the wise use or sustainable management of fishery resources. Effective measures to control illegal and destructive fishing practices or inappropriate development are limited by lack of funds.

- **Lack of capacity or expertise:** There is an urgent need to improve human resources to enable effective and successful planning, surveys and research on fishing resources, solutions for the sustainable development and conservation of such vital resources. At present fish stock declines occur partly because of the low capacity of responsible staff.

- **Foreign investment and encroachment** are additional root causes for fish stock decline in Cambodia. Foreign investment has encouraged excessive catch and increased by-catch on the site (mainly in offshore areas), but almost all of the catch has been for export and not for in-country consumption. In addition, the fish food supply in the country has faced harmful activities from foreign fishermen.

The intensive shrimp culture in Koh Kong province has been practised by Thai businessmen. But the yields from farmed shrimps have reportedly declined from year to year, and the natural shrimp in the adjacent areas have become scarce. Pollution from shrimp farms is often discharged directly into coastal waters. This causes a scarcity of marine fish stock.

Some negative effects are expected to come from the fish culture in many localities on and around the freshwater wetland areas of Cambodia.

Both coastal and inland aquaculture contribute to unsustainable development and they have to be dealt with.

4.5 ROOT CAUSES OF HABITAT LOSS

A. Flooded forest losses

Flooded forest has been dramatically degraded and lost as the result of destructive practices and factors. The root causes of this habitat loss are as follows:

- (a) Population growth;
- (b) Poverty;
- (c) Financial constraints;
- (d) Lack of law enforcement;
- (e) Lack of capacity;
- (f) Low awareness of the local people.

Population growth is one of the problems which has various consequences. Because of higher population density on the central plain, including the Tonle Sap areas and the lower Mekong flood plains, the disturbance, encroachment and degradation of aquatic habitats has intensified over recent years.

Population growth can result in increases in many needs, particularly food security. Most people are farmers so they need more agricultural land to increase crop production, mainly rice. As a result, some 3,076 square kilometres of flooded forest have been lost between 1973 and 1993, while rice fields have increased from 25,210 square kilometres in 1973 to 26,097 square kilometres in 1993. The destruction of flooded forest has continued and even intensified. A large amount is cut and cleared every year for conversion to rice fields and other cropland.

The poverty of local people is seen as one of the important causes for flooded forest losses at Tonle Sap Lake and other localities. Poverty causes people to seek other means of income generation, to strive to improve their living standards, and to expand fishing areas. All of these factors cause the continuous loss of flooded forest habitat.

Financial constraints contribute to the loss of flooded forest habitat because the management, control and conservation of areas becomes impossible without funding. Plans and activities in such areas have often been delayed or even cancelled because of fund shortages.

Lack of law enforcement has been considered a root cause of habitat loss. It has allowed illegal and destructive activities to take place at an unprecedented speed. Since there is no respect for the laws and regulations, over-exploitation has become irresistible in the whole Tonle Sap area. As the result, some flooded forest area has been lost.

Lack of capacity, especially among responsible staff, is also a factor contributing to inefficiency and eventual failure in strategic planning and management of the freshwater wetlands.

Low awareness and inadequate understanding on the part of the local people in particular, and of the public in general, about the importance and benefits of sustainable development is another root cause of degradation. This has been reflected in the fact that people perform destructive activities without thinking of the negative consequences because they are unfamiliar with the new concepts of sustainability. Therefore, the destruction of flooded forest continues apace.

B. Mangrove losses

The following are considered the root causes of mangrove loss:

- (a) Population growth;
- (b) Poverty of the local people;
- (c) Financial constraints;
- (d) Lack of policy and law, no enforcement;
- (e) Lack of understanding and awareness;
- (f) Abuse and encroachment by foreigners;
- (g) Lack of capacity.

Population growth in the country from year to year creates complicated problems that are difficult to resolve. Increasing needs for food and other requirements, such as the generation of bigger incomes, and the improvement and expansion of settlement and croplands, become competing problems leading to the exploitation of mangroves. Step by step, coastal habitats have been lost because of these causes.

The poverty of the local people is among the root causes aggravating the state of mangrove management and conservation. This is reflected in some activities of the people as they look for a job and attempt to supplement the family income. Such activities seriously affect the natural resources. Because they are poor, they cannot buy modern materials or instruments for use (for example, electricity or gas for cooking). Their houses are constructed on water near the mangroves and partly from mangrove trees.

So this habitat is destroyed as mangrove firewood is used for cooking, for refining sugar, for protecting cattle from mosquitoes and for producing charcoal for export.

Financial constraints are always a problem for the achievement and implementation of all policies, even for family planning. It is impossible to control the destructive activities on site if there are no funds. The management, conservation and development of mangrove habitat cannot be successful when there are budget shortages.

Lack of policy and law specific for the sustainable management and conservation of mangroves, along with the lack of enforcement, have contributed to the failure to prevent illegal and destructive activities from happening throughout the country. The lack of strict control on mangroves has led to their destruction.

Lack of understanding and awareness must be mentioned as one of the root causes for mangrove habitat loss. Local people remain, at present, unaware of the importance of mangroves in supporting many lives, in providing them with many goods (for example, timber, firewood, fish, crabs, shellfish) and in providing other services for people living near and around the sites.

Abuse and encroachment by foreigners is often illegal and destructive for mangroves. In Cambodian coastal areas some thousands of hectares of mangroves have been cleared by investors or businessmen from Thailand over the last decade for intensive shrimp farming. Currently, national investors or shrimp farmers have followed suit. Almost all the total yield has been exported to Thailand and Viet Nam. In addition to shrimp farming, mangroves have been cleared for salt production and charcoal. All of these factors have extensively damaged the mangrove habitat in the coastal zone.

C. Coral reefs losses

As no systematic study has been carried out, information on this habitat is poor. However, the loss of coral reefs from coastal waters is expected to come from:

- (a) Population growth;
- (b) Poverty;
- (c) Lack of awareness of the local people;
- (d) Lack of policy and law;
- (e) No strict control or monitoring.

Population growth complicates the protection, management and conservation of natural resources. Coral reefs, one of the vital habitats for many marine species, have been exploited in a destructive way. As increasing numbers of people compete to earn money in any way they can, they discover that coral mining is able to generate extra income for their families. Consequently, corals are increasingly exported abroad, mainly to Thailand.

The poverty of people aggravates the situation of coral reefs in many ways. Poor people, for their survival needs, do not hesitate to exploit as much as possible the resource on hand. To avoid poverty they are forced to go fishing, to mine coral for sale, and to undertake other jobs to make money.

Lack of awareness by the local people is also an important factor in their lack of involvement and participation in the sustainable management and conservation of coral reefs. Because people do not know clearly the benefits that coral reefs can provide, they exploit and sell them to businessmen to earn money.

Lack of policy and law causes some negative results. There are no effective measures for the protection of coral reefs. Allowing illegal and destructive practices, such as coral mining and exportation, to happen freely has led to a massive loss of this vital habitat. Therefore, policy and law and enforcement must be specifically developed and promoted to avoid further damage to coral reefs.

No strict control and monitoring of illegal and destructive activities means that any activity can be practised, even if it decimates the coral reefs. No strict control on coral mining not only damages the habitat itself, but also causes a decline in marine fishes because of the loss of spawning, feeding and nursery grounds. Strict control is, therefore, very necessary.

D. Seagrass bed losses

The root causes of the loss of seagrass beds are the same as for mangroves and coral reefs. Therefore, we would like summarize the description of these as follows:

The growth and poverty of local people can accelerate the loss of seagrass beds because of many destructive and illegal practices in fishing such as push netting, trawling and trapping.

Lack of awareness by the local people on the impact of unsustainable fishing contributes to the continuing destruction of seagrass beds.

Lack of policy and law and monitoring, together with the lack of specific enforcement, have allowed harmful practices to seagrass beds to take place freely without limitation.

Lack of strict control and monitoring of seagrass beds has allowed this vital habitat to be destroyed for various purposes. This can result in the loss of feeding grounds for some endangered mammals, such as Green Turtle and dugongs, together with many other marine species. Strict control and monitoring might help protect and conserve seagrass beds for many marine species.

Annex I presents the causes of the identified water-related principal issues in Cambodia in tabular form.

5. CONSTRAINTS TO ACTION

Cambodia is a developing country that has mostly been isolated from the rest of the world for the last two decades. During this time, much has changed in the understanding of the environment, its biological and physical systems, and the interaction with those systems.

The Ministry of Environment was established in 1993 after the first election. Therefore, the Government faced many problems regarding environmental management and natural resource conservation, such as lack of communication and information in general, financial constraints, inadequate law and enforcement, and no clear mandates for agencies in management.

5.1 INFORMATION, SCIENTIFIC UNCERTAINTIES AND PUBLIC AWARENESS

(a) Information

- In general the information relating to water resource conservation and management is very sparse;
- Existing information is too old, not up-to-date, and not clear;
- There is no exchange information among government agencies;
- There is limited data and information on management.

(b) Scientific research and study

So far we have very few scientists, therefore, research and study on the status of pollution and water resource degradation was not conducted.

(c) Public awareness

- Environmental education is new for the Cambodian people;
- Low level of training in natural resource management in tertiary institutions;
- Lack of qualified teaching staff;
- Lack of technical language skills;
- Limited funds to support educational activities;
- Limited access to research facilities;
- Lack of public awareness;
- The mass media on environmental issues is low.

5.2 FINANCIAL AND ECONOMIC

Cambodia has demonstrated its commitment to environmental management through the establishment of a Ministry of Environment in 1993. The first national environmental action plan is being prepared and the recently published first five-year development plan refers especially to natural resources management and coastal zone management strategy, recognizing the importance of the coastal areas to the economic development of the country.

In comparison with most neighbouring countries, a large part of Cambodia's coastal resource base is still relatively intact. Although these resources can and should continue to be exploited for the economic benefit of the country, effective government planning, regulation and monitoring is necessary in order to ensure that the resources are not irreversibly depleted as has been the experience in several other South-East Asian countries.

Although there has been a downturn in economic growth in the last year, associated with the general malaise in all Asian economies and exacerbated by recent political events, Cambodia's economy will undoubtedly continue to grow, albeit at a slightly reduced pace, in the coming years. This growth will continue to exert pressures on the natural resources base, particularly in the coastal zone. Efforts are being made to adopt a more integrated approach to natural resource management. Most planning has and continues to operate along sectoral lines and priority efforts are aimed at national reconstruction and development. Accelerated development along the coast and in Tonle Sap's catchment areas without due consideration to the negative impacts and sustainability continues to be a serious problem.

• Gross Domestic Product (GDP)

Cambodia for the past twenty years has been ranked as one of the poorest countries in the world. In 1990, the GDP per capita was only US\$167. During the 1990s this has grown considerably. Table 5.1 lists some key economic indicators.

Table 5.1 Cambodian key economic indicators

ITEM	1990	1991	1992	1993	1994	1995	1996
GDP per capita (US\$)	167	216	222	241	252	-	-
Real GDP growth (%)	1.2	7.6	7.0	5.7	4.0	7.6	7.0
Agriculture (%)	1.2	6.7	1.9	-1.0	0.1	6.4	4.9
Industry (%)	-2.2	8.9	15.6	13.0	7.7	9.5	10.8
Services (%)	2.7	8.5	11.2	7.2	7.4	8.2	7.6

Source: 1990 - 1994 Asian Development Bank; 1995 - 1996 Public Investment Programme, Government of Cambodia.

Owing to financial constraints most government agencies and many projects have failed in management and implementation.

5.3 LEGAL, INSTITUTIONAL AND MANAGERIAL

A. Legal

(i) Legal development since 1993

The Constitution of Cambodia was adopted in September 1993. This established a judiciary separate and independent from the executive and legislative branches of government.

The new Government, elected in 1993, is rewriting Cambodia's legislative and regulatory infrastructure. The new laws and regulations are based on legal principles from common law, combined with aspects of the pre-1975 French civil code. Cambodia has recently been told it could be accepted into the Association of Southeast Asian Nations (ASEAN), and attempts will be made to ensure that its laws parallel those of other member countries.

Over two dozen laws have been adopted since 1993, including the Land Management, Urbanization and Construction Law, and the laws establishing the rights and responsibilities of various ministries. There are many other laws that are still awaiting execution by Parliament.

(ii) Legal structure and processes

Most major ministries prepare legislation. Prior to its reading in Parliament, it must be approved by the Council of Ministers. Both these requirements have caused delays in the adoption of legislation over the past few years as the Council of Ministers or the Parliament fail to sit and consider draft decrees.

(iii) Major issues to consider

Apart from the instability and the destruction of the legal system in the past two decades, two other factors have hampered the improvement of the legal framework. The first is the significant lack of resources in financial (for example, salaries), physical (for example, courtrooms, equipment, supplies) or human (for example, trained and qualified personnel) terms. Second, the present imperfections in the political system often adversely impact on the programme of legislative reform. The sharing of executive power by two opposing parties generates obstacles and a politicized senior bureaucracy, resulting in a lack of coordinated legislation programmes.

The legal environment of investment and land related activities is deficient. Only a few relevant laws have been passed, the majority having been under discussion in draft form for some years. These gaps serve to discourage potential entrepreneurs and investors. For existing laws, transparent implementation regulations are scarce and difficult to access. This results in most regulations being "negotiable".

(iv) Council of Jurists

In 1996, the Government created a Council of Jurists with a mandate to research, examine and advise the Council of Ministers on existing and draft laws and regulations. The Council assesses, drafts, coordinates and defines new laws and regulations. Importantly, it is tasked with monitoring implementation, establishing compliance procedures, and ensuring that these are followed.

(v) Environment Law

It is the stated policy of the Government in relation to the environment law:

- To promote economic development that conserves and rationally uses natural resources, and protects and enhances environmental quality in order that the nation achieves sustainable development - development that enables Cambodian society to satisfy its current needs without compromising the ability of future generations.
- To integrate development planning and decision-making processes with environmental information, concerns and considerations at the earliest possible stages, so that adverse environmental impacts are avoided and that this integration be achieved through implementation of an environmental impact assessment (EIA) process.

- That the people of Cambodia are a valuable source of environmental knowledge, and that their concerns should be considered in the decision-making process through public participation and information dissemination processes.

(vi) Existing legislation relating to environmental management

The development of environmental legislation is one of the national priorities and, at present, the law on environmental protection and natural resources management can be considered the framework for subsequent sectional laws, decrees, sub-decrees, and regulations for environmental protection and natural resources management.

The legislation is believed to cover most important sectors that have been addressed or that are being addressed to date. It is separated into pre-1993 (when the new Government was formed) and post-1993.

Pre-1993 Laws:

- Law for the management of fishery areas: This law (state council N° 33) passed circa 1987 defines fishing areas.

- Law for the management of the forest area: This law (State Council N° 35) passed in June 1988 defines the types of forests and states that forests are divided into classified and protected forests, the delimitation of forest boundaries and forest uses to be determined by sub-decree and regulations. The law further states that all sectors of society are obligated to protect forests; the exploitation of forest products without a permit is prohibited; logging operations are subject to government tax; the hunting of all species of animals is prohibited, with enforcement by the Department of Wildlife. Any person violating the law shall be fined or imprisoned according to the seriousness of the violation.

Post-1993 Laws:

- Law of Land Management of Urbanization and Construction: This law, passed by the National Assembly soon after its formation, elaborates the law's intent in matters directly impacting the natural environment.

- Law on Investment: This Law was passed by the National Assembly on 15 December 1993. Foreign investment in Cambodia is a simple, fairly open process. Cambodia does not differentiate between investment projects undertaken by foreigners or residents, as the investment law of 1993 governs both. Some sectors are restricted to nationals including import - export, and some transport, construction, accounting and law related activities.

The Cambodian Investment Board (CIB), operating within the Council for the Development of Cambodia is the government agency responsible for granting investment incentives and approving projects. Under the Investment Law, the Council for the Development of Cambodia is the sole and one-stop service organization responsible for investment activities.

The Investment Law guarantees equal treatment, with no nationalization adversely affecting property; no price controls; unlimited remittances of foreign currencies; and a 45-day decision limit on applications. The law also guarantees a maximum level of incentives, including 9 per cent corporate income tax; eight-year exemption from income tax; five-year loss/carry forward; 100 per cent exemption from import duties for selected projects; tax-free profit repatriation; tax-free profit and dividend distribution; and selected employment of non-Cambodian nationals. These incentives have to be applied for with each application.

Overall the law frees up the market for good, competitive, and transparent investment. The result is a strong emerging market place. However, with current political events, investor confidence may wane because of concerns as to whether the law is effective in the face of armed conflict.

- Law on Environmental Protection and Natural Resource Management. This law was passed by the National Assembly on 18 November 1996 and promulgated by the King on 24 December 1996. The law is divided into eleven chapters concerning distinct aspects of environmental protection and natural resource management.

Each chapter contains one or more articles that set out in broad terms the powers and responsibilities of the Ministry of Environment and other agencies of the Government in the areas of environmental protection and natural resource management. These provisions taken as a whole provide an overarching framework to guide the Ministry and the Government in developing a precise environmental management plan and thereby advance the mandated principles of environmental protection and natural resource conservation written into the Constitution.

- Sub-Decree on Construction Permission: This Sub-Decree was passed by the National Assembly in 1997 for the proper management of land use and natural resources.

- Royal Decree on the Creation and Designation of Protected Areas: This Decree was approved on 1 November 1993. It defines the Ministry of Environment as the responsible entity for supervising the planning and development of the national protected area system including the protection of terrestrial, wetland and coastal environments. The national protected area system includes national parks, wildlife sanctuaries, protected landscapes and multiple use management areas.

- National Protected Areas System Sub-Decree: This decree describes the authorities and mechanisms for planning and developing a national protected areas system. It has been submitted to the Council of Ministers and has been under review since November 1993.

Ratification of International Conventions

Cambodia is a party to the following international conventions:

- (a) International Convention for the Prevention of Pollution from Ships 1973 and Protocol 1978 (MARPOL) and its annexes I to V ;
- (b) International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969;
- (c) Ramsar Convention 1971;
- (d) World Heritage (Paris 1972);
- (e) Climate Change (Rio de Janeiro 1992);
- (f) Biodiversity Convention;
- (g) Agreement on the cooperation for the sustainable development of the Mekong Basin.

The Government of Cambodia should establish legal instruments and mandate responsible institutions to implement these international conventions and agreements, but there is a lack of appropriately qualified personnel to analyse these conventions.

Basel Convention : The Basel Convention is new to Cambodia. Cambodia will be a party to this convention but it needs more information on the scope of the convention and its relevance to Cambodia.

Legislation planned

The following pieces of legislation have been drafted or are being considered for drafting by the Government:

- ***Forestry Law***

This was adopted by the Government and reviewed by the specialized commission of the National Assembly before being sent to be voted upon by the plenary session of the Parliament.

- ***Mining Law, Petroleum Exploration Law and Factories Law***

These laws were submitted to the Council of Ministers for review and will be adopted by the Government in the coming year before being submitted to the National Assembly.

The draft mining law stipulates the responsibilities of the government agency issuing mining permits and controlling mining exploration activities. All of the mining activities covered under the draft law will be subject to environmental protection requirements including the preparation of an environment protection plan prior to mining activities and implementation of the plan during operations.

In addition to the Mining Law, the Ministry of Industry, Mines and Energy has produced the following draft laws: Law on petroleum exploration and Factories law. These laws are being reviewed by the Council of Ministers.

- ***Sub - Decree on Environmental Impact Assessment***

The draft Sub-Decree specifies an environmental review process which includes screening, initial environmental impact assessment, and full-scale environmental impact assessment, as specified in the Environmental Law. This review process applies to both proposed projects (for example, a proposal to build a road, erect a new factory or construct a large irrigation system) and existing ongoing activities (for example, a factory which is already in operation or existing palm-oil plantation).

- ***Sub - Decree on Water Pollution Control***

The Draft Sub-Decree on Water Pollution Control has been finalized and is being revised by the Ministry of Environment. The purpose of this Sub-Decree is the control of effluent discharge and the setting of water quality and effluent standards.

- ***Sub - Decree on Protected Area Management***

The purpose of this Sub-decree is to implement the Law on Environmental Protection and Natural Resource Management and especially to implement the Royal Decree of 1 November 1993. At present the Ministry of Environment faces problems in preventing violations in the protected areas and problems in the management process of protected areas.

- ***Sub-Decree on Agrochemical Use and Management***

This Sub-Decree was prepared by the Ministry of Agriculture in cooperation with the Ministry of Environment. It focuses on the provision of pesticide fertilizer and other agrochemical substances. Currently it is waiting for approval from the Council of Ministers.

- ***Sub-Decree on Solid Waste Management***

This Sub-Decree was prepared by the Ministry of Environment with technical legal support from the European Commission. It has focused mainly on transboundary waste movement, but it is also related to domestic solid waste management including collection transportation and disposal. It has been submitted to the Council of Ministers for approval within the current year.

B. Institutional agency

The government agencies responsible for water resource management are as follows:

1. Ministry Agriculture, Fishery and Forestry: Department of Hydrology, Department of Fishery, Department of Forestry and Wildlife.
2. Ministry of Industry, Mines and Energy: Department of Provincial Water Supply.
3. Ministry of Rural Development: Department of Clean Water Programme.
4. Ministry of Environment: Department of Natural Resources Conservation, Department of Environmental Pollution Control, Department of Environmental Data Management, Department of Environmental Impact Assessment Review.
5. Ministry of Public Works and Transportation: Department of Transport and Navigation, Department of Sanitation.
6. Ministry of Health: Department of Hygiene.
7. Ministry of Interior: Phnom Penh Water Supply Authority.
8. Council for Cambodia Development: Department of Investment.

There are also provincial and municipal departments of environment with district and local levels responsible for water resources management. However, we still have constraints on these matters, as follows:

- (a) Lack of definition of the roles and responsibilities of institutions and the relationships between them;
- (b) Lack of physical capacity and resources for enforcement;
- (c) Low appreciation of and understanding of the national need for management and conservation measures;
- (d) Weak capacity for policy formulation and strategic planning;
- (e) Flow and use of existing data and information, among both the administrative levels and among government departments.

6. ONGOING AND PLANNED ACTIVITIES RELEVANT TO THE IDENTIFIED ISSUES

In Cambodia, general environmental issues have been a priority for the new government elected in 1993. Therefore, some activities related to water pollution prevention and water resources management have just been started. Some activities have been planned to develop in the future.

Some programmes and projects activities concerning water resources management have been conducted by government agencies, and some in cooperation with donor agencies, non-governmental organizations and international agencies.

6.1 WATER POLLUTION PREVENTION

Ongoing activities

- *Capacity-building:* Long-term and short-term training courses for government staff responsible for water pollution control and water resources management have been conducted successively in the country as well as abroad. This activity is considered the first priority in measures to reduce water pollution. Most of the training programmes have been supported by international agencies such as: the United Nations Development Programme (UNDP), the World Health Organization (WHO), the European Union (EU), USAID, the International Maritime Organization (IMO), the United Nations Environmental Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO).

- *Law and legislation development:* There are some existing laws relating to water pollution prevention, such as the law on land management of urbanization and construction, the law on investment, the sub-degree on construction permission and the law on environmental protection and natural resources management.

The law on environmental protection was passed by the National Assembly in November 1996. But its implementation has faced some problems because it did not state clearly the monitoring process in any pollution sources or the legislative instruments for water quality protection, such as the polluter pays principle and duty reduction for pollution control equipment.

Therefore, in order to enforce the law some sub-decrees have recently been developed, such as: Water Pollution Control, Solid Waste Management, Protected Area and Environmental Impact Assessments. These have been sent to the Council of Ministers to wait for adoption. Meanwhile, effluent standards for all pollution sources have already been set up.

- *Environmental protection contract:* Although the sub-decree on environmental impact assessment has not yet been passed, in order to protect the environment from pollution the Ministry of Environment has required that all new development projects have an environmental protection contract stipulating the responsibility of project owners to contribute in reducing the pollution load in their waste before discharge into the environment. The contract form will be issued until the sub-decree comes into force.

- *Pollution source monitoring:* Monitoring pollution sources has been conducted by the Ministry of Environment in cooperation with the concerned ministries. However, the effectiveness of this monitoring is very limited because of the lack of capacity and control equipment.

- *Sewage rehabilitation:* This activity has developed only in Phnom Penh City under the municipality programme which is aimed at rehabilitating the damaged sewage pippins and sewage reservoirs in the City as the sewers become rapidly clogged in the rainy season.

Planned activities

- *Sewage management policy:* In order to prevent water pollution, the sewage management policy will be developed by the Ministry of Environment in cooperation with concerned agencies. In the policy, the following actions will be taken:

- (a) To rehabilitate and build sewerage systems in the densely polluted urban centres of Phnom Penh and Sihanouk Ville;
- (b) To conduct a feasibility study of the central sewage treatment of construction in the two high risk areas, Phnom Penh and Sihanouk Ville;

- (c) To enforce the implementation of laws, sub-decrees and effluent standards relating to water pollution prevention as they come into force;
 - (d) To improve public awareness on environmental protection in formal and informal education programmes;
 - (e) To set up the polluter pays principal as an important legislative instrument for water pollution prevention.
- *Implementation of the urban waste management action plan (1998-2002):*
 - (a) Upgrading open dumps in Phnom Penh to reduce the risk of adverse public health and environment impacts;
 - (b) Improving solid waste collection capability through privatization in urban centres, especially in Phnom Penh City and Sihanouk Ville;
 - (c) Constructing a sanitary landfill with at least a 10-year capacity, together with a pilot low-cost composting facility in Phnom Penh;
 - (d) Constructing a medical waste treatment facility in Phnom Penh;
 - (e) Training municipal staff in solid waste management and hospital staff in medical waste management;
 - (f) Launching a public information campaign on appropriate waste disposal in Phnom Penh, Siem Reap and Sihanouk Ville.

6.2 SURFACE WATER CONSERVATION

Ongoing activities

- Strengthening the capacity of government staff through long-term and short-term training courses, workshops and field visit studies in terms of water resources management.
- Cooperating closely with the Mekong River Commission and other involved organizations to solve the problems related to water resource use in the Mekong River basin.
- Monitoring the water quality along the Mekong River and Tonle Sap River with nine sampling points.
- Evaluating and reporting the status of river water quality as a base for scientific research and study.
- Rehabilitating and constructing reservoirs and irrigation systems in rural areas where there are problems of surface water shortage for water supply and irrigation purposes.
- Developing a watershed management programme in both central and coastal areas. The programme aims to prevent flooded forest and reduce sediment and pollution loads downstream and at the coastline. It also focuses on land use management, especially appropriate management of agricultural areas to reduce siltation and toxic chemical residues, which are carried by runoff into rivers and sea.

Planned activities

- Develop the draft water law and water quality standards by sectional use, such as: drinking purposes, agricultural use, recreation and navigation purposes, and water quality standards for public health protection and for living aquatic resource conservation.

- Increase a number of sampling point along the Mekong River and Tonle Sap Rivers, and set up many other new sampling points in the Tonle Sap Lake and other water bodies located close to the major urban centres in both central and coastal areas.
- Set up an appropriate policy guideline for surface water management.
- Control and monitor the water resource use for hydro-dams including environmental impact assessments, and the impact on navigation and living aquatic resources.
- Improve the existing laboratory capability for analysing parameters, which have not been measured yet such as BOD, heavy metals, PCBs, agrochemical substances and bacterial coliform.

6.3 GROUNDWATER CONSERVATION

Ongoing activities

In Cambodia, the use of groundwater for water supply and for irrigation is still small scale, mostly in the dry season. Meanwhile, there is insufficient information, knowledge or understanding of the groundwater resources of Cambodia for this valuable resource to be managed responsibly. In particular, much more information is needed on the size and safe yields of the aquifers and the recharge mechanisms.

To address this issue, the Department of Hydrology in cooperation with the National Mekong River Commission and non-governmental organizations started a data collection and interpretation capability project in 1996. The project was implemented consisting of five components:

- Development of a standard drilling log to be used by all agencies involved in drilling operations for rural water supply and for small irrigation, and to be forwarded to the Department of Hydrology at regular intervals;
- Training of drillers in the use of the log;
- Collection of data available in the provincial offices of external support agencies and the Department of Hydrology;
- The setting up of a national data collection "infrastructure", a proposal which will include the establishment of a nationwide well numbering system;
- Establishment of data storage and processing capacity at the Department of Hydrology. This entails evaluating available computer software, recommending standard systems to be adopted, expanding capacity and training staff.

Planned activities

In order to enable the wise use of groundwater, and to protect this resource from pollution and overuse, the Department of Hydrology has some planned activities as follows:

- Setting up the policy and guidelines for the allocation and sustainable use of groundwater resources;
- Establishing a groundwater quality monitoring network in the whole country as a base for evaluating the status of groundwater quality as well as quantity;

- Making a clear allocation of responsibilities among the governmental agencies such as Agriculture, Health, Rural Development, Environment, Industry and municipal authorities in the field of planning and management of groundwater resources.

6.4 AQUATIC LIVING RESOURCES MANAGEMENT AND CONSERVATION

Ongoing activities

- Inventory and management of Cambodian wetlands phase I (DANIDA / Mekong River Commission Project): completion time in February 1999;
- Classification of wetlands in Cambodia (Ministry of Environment, Department of Nature Conservation);
- Identification of important wetlands of Cambodia, selection of wetlands for inclusion into the Ramsar list of internationally important wetlands (Ministry of Environment);
- Surveys and researches on wetlands to identify the status of flora and fauna for sustainable management and conservation (Ministry of Environment);
- Capacity-building at the provincial level in coastal zone management (DANIDA Project with the Ministry of Environment);
- National wetland action plan, draft finalization (Ministry of Environment and some other involved agencies);
- Coastal resources studies (Ministry of Environment);
- Coastal zone management database for Cambodia (IDRC and Ministry of Environment);
- Environment impacts assessment (ADB-TA 2723-CAM).

Planned activities

- Inventory and management of Cambodian wetlands phase II (DANIDA /Mekong River Commission project) planned to be started in 1999;
- Technical assistance to Cambodia, Viet Nam and China for coastal and marine environmental management (Asian Development Bank Project for three years);
- Survey and research on marine and coastal resource management and conservation (Department of Nature Convention and Protection);
- Public awareness campaign for wetlands resources and biodiversity for wise use and sustainable management (Department of Nature Convention and Protection);
- Capacity-building for the department staff on wetland and water-related management and conservation (Ministry of Environment).

6.5 AQUATIC HABITATS CONSERVATION

Ongoing activities

- Flooded forest research on sustainable management and conservation (on Ramsar site, Boeng Chhmar, and some others around Tonle Sap lake);

- Research on the management of mangroves, seagrasses and coral reefs (Ministry of Environment).

Planned activities

- Campaign for public awareness on the benefits of wetland and resources and on biodiversity conservation needs;
- Scientific comprehensive research/studies on resources and biodiversity sustainable management and conservation on designated multiple use areas (by Royal Decree of 1 November 1993);
- Flooded forest replantation project (proposed by the Department of Nature Conservation and Protection);
- Mangrove replantation project (proposed by the Department of Nature Conservation and Protection);
- Conservation of coral reefs and seagrasses (proposed by the Department of Nature Conservation and Protection);
- Management and conservation of habitats in the national park at Sihanouk Ville;
- Creation of marine protected areas in Koh Kong province (by the Department of Nature Conservation and Protection);
- Research for economic valuation of wetland habitats (Flooded forest, mangrove, seagrasses and coral reefs), and biodiversity (waterbirds, fishes, shellfishes, reptiles and mammals);
- Development of management plans for Ramsar sites;
- Regional networking for information and data on living aquatic resources, particularly for aquatic habitats;
- Wetland restoration.

7. SPECIFIC ACTION PROPOSED FOR EACH IDENTIFIED ISSUE

7.1 POLLUTION

- (a) Strengthen governmental institutions on environmental capacity-building at all levels.
- (b) Improve legal institutional frameworks regarding environmental protection from pollution.
- (c) Make a master plan for development areas such as industrial zones.
- (d) Develop policy guidelines on waste management and pollution control.
- (e) Set up effluent standards for all kinds of disposal and waste discharge.
- (f) Improve sewerage systems and construct wastewater treatment plants in high risk and sensitive areas.

- (g) Set up the polluter pays principle.
- (h) Require environmental impact assessment reports for all development projects.
- (i) Take action on the enforcement of legislation and law regarding pollution protection.
- (j) Improve public awareness and public participation.

7.2 FRESHWATER SHORTAGE

7.2.1 Surface water

- (a) Improve the capacity-building of the government staff on surface water resource management.
- (b) Develop laws and regulations regarding water and water resources management.
- (c) Set up water quality standards for all kinds of use.
- (d) Require environmental impact assessments for all development projects that could have an impact on the quantity and quality of water resources.
- (e) Improve irrigation systems and stock reservoirs.
- (f) Make a national policy on surface water use and management.
- (g) Establish and implement a master plan on integrated management in various uses, such as irrigation, watershed control, domestic water supply, and flood control.
- (h) Increase a number of water quality monitoring stations.
- (i) Update information and data related to the hydrology of surface water.
- (j) Enhance laboratory services for water quality analysis.
- (k) Improve public awareness and participation.

7.2.2 Groundwater

- (a) Strengthen capacity-building in groundwater management.
- (b) Set up a policy and master plan for groundwater exploitation management and sustainable exploitation.
- (c) Develop laws and regulations relating to groundwater use and groundwater quality protection.
- (d) Require an environmental impact assessment for all projects using groundwater.
- (e) Establish a monitoring network for the survey and control of groundwater quality as well as quantity.
- (f) Improve public awareness on groundwater protection and management.

7.3 LIVING AQUATIC RESOURCES

- (a) Develop comprehensive conservation programmes for living aquatic resources.
- (b) Conduct systematic and scientific studies and research on living aquatic resources.
- (c) Campaign for public awareness enhancement.
- (d) Promote community involvement and active participation in LAR conservation.
- (e) Enforce strict controls and monitoring on illegal and destructive activities to LAR.
- (f) Formulate policy and law enforcement.
- (g) Develop a master plan for sustainable use.

7.4 HABITAT MANAGEMENT AND CONSERVATION

- (a) Conduct studies and research.
- (b) Enforce the law and develop policy.
- (c) Enhance public awareness.
- (d) Enforce strict control and monitoring.
- (e) Conduct inventories.
- (f) Develop master plans / management plans.
- (g) Cooperate with local people and involved agencies.
- (h) Network at regional and international levels.

8. IMPLICATIONS OF THE PROPOSED ACTION BY SECTOR

8.1 FINANCIAL ASPECT AND POLICY DEVELOPMENT

The operational and strategic policy for the proposed actions should be based on the nationwide implementation scheme in anticipation of the environmental conditions that might be changed within the next five-year socio-economic development plan (1996-2000). The most significant investment is expected in two areas, in sewerage services and freshwater supply. The projected investment needed to improve the water supply and sanitation/drainage comes to US\$ 160 million. This does not include the administering departments / authorities annual running costs or the recurrent costs related to production and maintenance. The level of achievement during the plan period will depend on the national capacities at all levels of government, the private sector and communities. Until such capacities are strengthened, a high degree of reliance on international agencies and non-governmental organizations will continue.

8.2 ECONOMIC DEVELOPMENT

The basic approach needed over the long term, in virtually every sector related to land and water resources, consists of institutional strengthening and inter-agency cooperation for concerted efforts in better resources management. Comprehensive coastal zone planning and local zoning and development plans should be prepared for the coastal region. The Government has encouraged foreign and private investment projects, but they are required to either prepare or be responsible for the preparation of an environmental impact assessment report. This will bring the projects into compliance with acceptable environmental standards.

8.3 AGRICULTURAL DEVELOPMENT

Cambodia's economy is based principally on agricultural production, such as:

- Crop harvesting: rice and other crops;
- Fisheries and aquaculture;
- Forestry and watershed management.

The effective and successful development of the agricultural sector could be met only on the condition that fundamental requirements are properly completed, such as the establishment of an innovative and available information and database system, the formulation and development of necessary policies and legal framework, together with preventive and protective measures and initiatives. In addition to these, stricter controls and monitoring must be regularly undertaken.

8.3.1 Crop harvesting

Crop harvesting, mainly rice production, has priority as the majority of Cambodians (about 85 per cent) are farmers. It is the primary source of food security and the predominant agricultural product in Cambodia.

Unfortunately, food security or self-sufficiency in rice production has not been reached since the last decade because of frequent natural disasters, such as drought, floods, diseases, decreased soil fertility, and increased pests/ rodents. The main causes for these seem to be the unsustainable use of natural resources, soil, forest, water and others, and the destruction of useful animals. The frequent use of pesticides could be an additional harmful factor, not only for humans but also for wildlife and soil and water.

Sustainability in crop harvesting, as well as for all other agricultural production, requires that the Government and the people work together. Action should be focused on:

- (a) Conducting comprehensive conservation and production programmes;
- (b) Developing appropriate land use policies;
- (c) Developing training programmes in sustainable crop harvesting/ sustainable agriculture; including the appropriate use of pesticides, insecticides, rodenticides and fungicides;
- (d) Developing public education programmes on the importance of forests for people and wildlife;
- (e) Banning the importation of pesticides and limiting their free sale;
- (f) Restoring wetland habitats, together with reforestation of degraded watershed and upland forests;
- (g) Improving intersectoral coordination and cooperation toward sustainable agriculture;
- (h) Encouraging the development and use of natural fertilizers/ compost fertilizers.

8.3.2 Fishery

Fishery is the second main source of income generation and national revenue/GDP contributor. It is also the second most important agricultural activity after rice production.

The current fishery management in Cambodia is failing and as a result there has been a dramatic decline of fish stock in recent years. Currently, most Cambodian people complain about the smaller fishery capture, and subsequently, the increase in fish prices. Fishermen complain about the small income from fishing. It could be that fishery will no longer be a significant national source of revenue.

The sustainable use and management of fishery resources will absolutely require:

- Political will on the part of the Government;
- Coordination and cooperation of all responsible and involved agencies in policy-making and the participation of the local people in planning and conservation of fish resources as these are vital sources of food/protein intake for the people, as well as for waterbirds and other animals;
- Capacity-building/expertise upgrading for the sustainable management and conservation of fishery resources;
- Strict controls on illegal and destructive fishing activities, such as:
 - Fishing in closed seasons;
 - Fishing by dynamite, electric shock; push-net fishing, tree-branch traps;
 - Very large-scale fishery industry by foreign fishermen;
 - Use of old tires;
- Limitation on the number and size of fishing lots and reorganization of fishing concessions;
- Comprehensive programme and master plan for sustainable fishery;
- Campaign for public awareness on the wise use and sustainable management of fishery resources.

8.3.3 Aquaculture

In Cambodia, aquaculture has been increasingly practised by people living on, near and around water bodies, in particular the Tonle Sap Great Lake, the Mekong River and other associated floodplain lakes, and at some localities in coastal areas.

The impacts of freshwater fish culture are as follows:

- (a) Increased by-catches for feeding cultured fishes (for example, Striped Catfish, Black-ear catfish, Giant Snake-head fish);
- (b) Degraded/lost natural wetlands, habitats and other resources;
- (c) Subsequent decline of natural/wild fishes;
- (d) Some pollution/water contamination from excessive feedings.

Further activities to be undertaken for preventing and reducing these impacts should include:

- The development of consistent legislation, regulations and guidelines for sustainable aquaculture;
- A limit to the expansion of aquaculture;
- Strict controls on destructive fishing causing the increased by-catches.

At the same time, some measures should be considered in order to eliminate and prevent the harmful effects of coastal aquaculture and intensive shrimp farming. These are as follows:

- Stopping the expansion of shrimp farms that are presently more destructive and aggressive to valuable coastal habitats;
- Constructing a treatment system for every shrimp farm so that polluted water will not be released into coastal waters;
- Applying appropriate technology for sustainable shrimp farming;
- Enhancing the awareness of the impacts of aquaculture.

8.3.4 Coral mining and conservation

The impacts from such activities might be prevented and reduced by undertaking the following measures:

- Banning and strict control on illegal coral mining and exportation;
- Education and awareness improvement on the importance and benefits of coral reefs;
- Prevention and removal of some pollutants (oil, nutrient and sediment) from the coral reefs/ better pollution management.

8.3.5 Seagrass beds

- Strict control on destructive fishing practices, such as push-netting, purse-seining, trawling;
- Promotion of public awareness on the significance of seagrasses and active participation of people in conserving them;
- Prevention and cleaning-up of water pollution in the areas that can negatively affect seagrasses.

8.3.6 Mangrove forest conservation

- Improving the understanding and awareness of local people on the benefits of mangroves;
- Banning the destruction of mangroves to make charcoal for export and the expansion of salt fields, intensive shrimp farming and other developments;
- Stopping the use of mangroves for fencing, housing and settlement expansion.

8.3.7 Forestry / Watershed management

- Definitive banning of illegal commercial logging and the stopping of intensive deforestation;
- Regular and strict controls on destructive activities;
- Improvement of public awareness on the importance and benefits of forests;
- Effective policies and law enforcement;
- Master plan and comprehensive inventory of forest resources;
- An updated information system and database establishment;
- Guidelines and regulations for the sustainable use of forests;
- Promotion of political will;
- Financial support mobilization and promotion of international cooperation;
- Reviews and limits on forest concessions and other inappropriate development in forests and watershed areas;

8.4 MANUFACTURING

Although at present industrial development in Cambodia is on a small scale, particularly in the coastal area, the Government plans to develop the industrial sector in the coastal area in the near future in order to improve the economy of the country.

The Government recognizes that industrial development will cause an adverse effect on both water quality and water resources. Consequently in order to achieve the plan while considering sustainable water resources, the Government has decided:

- To train government staff and support adequate equipment for monitoring industrial effluent discharge;
- To require an environmental impact assessment for any existing and new industrial projects;
- To establish industrial zones away from any public water areas, and to require new factories or existing factories to move if necessary;
- To develop regulations and laws relating to industrial wastewater control and to set up effluent standards and to make sure that waste meets the standards;
- To promote an education programme in both the formal and informal sector on water resources protection;
- To develop and effectively implement a polluter pays principle for all factories that discharge a large volume of wastewater.

8.5 MINING

Currently there are active mining operations for gemstones in certain border areas between Cambodia and Thailand, for construction materials (sand, gravel, crushed stone, granite) and certain industrial minerals (phosphate, limestone, marble, and ceramic clays). The current mining operations cause adverse effects on water resources as well as on water quality. In order to deal with this issue, the Government has taken the following measures:

- To request and, where possible, collect and analyse all existing contracts for mining operations; to renegotiate old contracts on a new standardized basis incorporating specific regulations on efficient / provincial government revenue sharing where necessary;
- To develop the mine and mineral law with strong environmental protection;
- To require an environmental impact assessment for any significant mining project;
- To establish a national inventory of all existing pits and quarries;
- To stop any illegal mining causing contaminated water quality and to stop the mining of living coral reef.

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ANNEX I
ANALYSIS OF CAUSES OF THE IDENTIFIED WATER-RELATED PRINCIPAL ENVIRONMENTAL ISSUES IN CAMBODIA

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
Sewage	- Phnom Penh	Sewage (3)	Uncontrolled discharges	Lack of sewage systems/ treatment facilities	Financial constraints	Affected human health	Build sewage systems Build treatment facility
	- Sihanouk Ville	Industry (2)		Lack of laws and effluent standards, and enforcement	Lack of capacity	Contaminated water	Capacity building
	- Battambang	Hospital (1)			Lack of public awareness about impact of water pollution	Reduce of fish production	Set up policy and regulations regarding sewage management
			Lack of control and monitoring		Migration of some species	Set up effluent standard	
						Extinction some biodiversity	Improve awareness
							Enforcement of law and standard
Solid waste	- Phnom Penh	Domestic (3)	Low knowledge on disposal	Lack of sanitary landfill	Financial constraints	Human health	Education program on waste disposal
	- Sihanouk Ville	Industry (2)		Lack of law and enforcement	Lack of capacity	Lack of inter-grated solid waste management policy	Water quality degradation
	- Battambang	Hospital (1)	Inadequate collection				Air pollution and bad odour
		Market (2)					

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
			Unsanitary dumpsite Uncontrolled disposals	Lack of recycling mechanism	Lack of understanding about waste disposal		Increase capacity collection to all areas Set up recycling system Improved disposal of hospital waste, hazardous waste
Sedimentation	a) Tonle Sap Lake -Estuaries in coastal line -Mekong and Tonle Sap River	Natural factors (2) Deforestation (3) Agricultural activities (2)	Soil erosion Unplanned land use Inappropriate watershed protection Intensive logging in the catchment area	Inappropriate land use development Inadequate law and regulation, and enforcement Absence enforcement and Control monitoring	Lack of capacity Lack of investment Inadequate water management policy	Degradation of Eco. System Loss of fish production Loss of lake function flooding High impact to GDP	Capacity building Public education Soil erosion control measure Set up land use planning Ban of logging
	b) Stung Sangker	Gemstone mining (3) (Foreign activity)	Tailings Discharge sediments	Lack of law and regulation Inappropriate technology	Lack of capacity	Shortage of surface water Degradation of aquatic habitats	Develop legislation and policies Capacity building

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
			Illegal business for export	Lack of EIA report on the mining activities		Loss of fish production Loss of tourism revenue Public health	Need EIA report and take into action
Shrimp farm waste	Koh Kong province	Shrimp farm aquaculture (Thai jointventure activities)	Uncontrolled discharge High demand for export	Lack of treatment facilities Lack of law and effluent standard Inappropriate technology use Lack of control and monitoring	Lack of capacity Lack of technology	Loss of mangrove Loss of aquaculture production High sedimentation Water quality degradation	Develop policy and guideline for shrimp farm practices Capacity building Need EIA report Enhance public participation
Surface water shortage	- Takeo province - Kompong Speu province	Rural domestic water supply (3) Agricultural irrigation (2)	Drough long period Little surface water sources	Lack of appropriate water management policies	Financial constraints Lack of capacity Global change	Human health Loss in agriculture production Increase poverty	Build water reservoirs Develop irrigation systems

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
				Intensive deforestation Increasing water consumption	Rapid population growth/populated areas Temporary scarce rainfall Inadequate reservoir Insufficient irrigation systems		Set up an appropriate water management policy Promote public participation Stop logging activity Capacity building Develop water law and regulation
Low DO	Down stream Tonle Sap River Up stream Bassac River Down part of Stung Sanker Down part of Stung Siem Reap	Sewage (3) Uncollected solid waster (2) Industrial (2) wastewater	Inappropriate sewer system Uncontrolled discharge and disposal Inappropriate and unsanitary dumpsite	Lack of treatment facilities and sewer system Inadequate solid waste collection facilities	Lack of capacity Financial constraints Rapid population growth Lack of law and effluent standard and enforcement Lack of public awareness about impact of water pollution	Human health Loss of fish production Increase treatment cost for tap water	Develop treatment facilities Improve solid waste collection facilities Develop law and effluent standard and enforcement Need polluter pay principle Need EIA report and take into action

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
							Improve water quality analysis capacity Set up new monitoring station Capacity building Promote public awareness
Ground-water shortage	Pursat province Kompong Speu province Kompong Thom province	Natural		Lack of data and information Lack of research	Financial constraints Lack of capacity	Human health Increase poverty	Develop research program Need investment
High iron and salinity concentration of the ground water	- Takeo - Svay Rieng - Prey Veng - Kandal - Banteay Meanchey - Battambang - Kompong Speu	Natural		Lack of data and information Lack of research	Lack of capacity Financial constraints	Human health	Develop research program Set up monitoring station

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
Fishstock decline	a) - Tonle Sap and Mekong - Floodplain - Lakes - Rivers	High demands partly for export Increase income	Lack of control Poor management Over-fishing Illegal and destructive fishing	Too many fishermen Inappropriate fishing methods Improper development e.g. aquaculture...	Financial constraints Lack of capacity Foreign investment Poverty Income generation	Lower income Increasing socio-economic problem and conflicts Decreased national revenue GDP	Enforcement of laws and policies Strict control and ban of illegal and destructive fishing practices
	b) In the coastal water		Lack of control Poor management Over-fishing Encroachment of foreign fishermen	Too many fishermen Inappropriate and illegal fishing Intensive shrimp farming Salt fields expansion	Financial constraints Lack of capacity in controlling and monitoring Increasing income Abuse for exportation	Loss of marine fish-stock Increasing conflicts Low nutritional regime High impact to GDP	Enforcement of laws and policies Strict control and ban of illegal and destructive activities

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
Habitat Losses							
a) Flooded Forest	Tonle Sap and Mekong flood plains	High consumption Conversion to agricultural lands	Increase income and agriculture production	Poor policy and management Lack of understanding and awareness	Finance constraints Lack of enforcement Population growth Poverty condition	Loss of fish nursery and spawning grounds Fish-stock loss	Enforcement of laws and policies Enhance awareness Strict control
b) Man-grove	Along the coastline	High income generation Alternative livelihood	Exportation Aquaculture conversion Salt production	High income Poor policy and management Low awareness	Lack of laws and policy Financial constraints Population growth Increasing several need Poverty	Loss of fish nursery and spawning grounds Low National revenue Decrease income Loss of buffer / filtering	Development and apply policy for sustainable mangrove use Researches Inventory

Major Issues	Location	Source	Causal Chain			Socio-Economic Impact	Action
			Immediate	Intermediate	Root cause		
c) Coral Reefs	In shallow coastal waters, around inshore inland	Illegal dynamite fishing Mining for exploration	Mining for exploration	Increasing income Poor management Alternative livelihood careless records	Lack of capacity in controlling and monitoring Financial constraints Rapid population growth Poverty/ Low living standard	Loss of fish nursery and spawning grounds Fish-stock loss Loss of buffer / filtering Decline in biodiversity	Development and apply policy for coral reefs conservation Researches Inventory Strong cooperation (region)
d) Sea-grasses	In shallow coastal waters,	Destructive fishing methods	Create income Alternative livelihood	Increasing income Poor management	Lack of capacity Financial constraints Poverty condition Growing needs for survivals and others	Loss of fish nursery and spawning grounds Fish-stock loss Loss of buffer / filtering	Development and apply policy for seagrasses conservation Researches Inventory Strong cooperation (region)

ANNEX II
Area statistics - 1973 /76 Cambodia land Cover (area in km²) (See Figure 2.15)

Province	U	Ar	Au	As	Ao	Av	Fe	Fc	Fd	Ff	Fm	S	G
BANTEAY MEANCHEY	14	2,164	32	26	0	0	1,816	0	944	134	0	2,270	79
Battambang	46	2,494	115	62	0	17	3,369	0	1,850	2,224	0	2,107	204
Kompong Speu	0	1,373	894	38	0	0	1,479	0	2,899	0	0	31	39
Kompot	0	1,393	153	30	0	18	1,745	0	1,277	0	38	15	326
Kompong Chhnang	0	772	550	12	0	21	429	0	1,854	908	0	61	295
Kandal	1	844	127	0	0	115	0	0	0	926	0	565	527
Koh kong	0	598	294	180	0	0	10,296	93	414	0	834	17	146
Kompong Cham	2	2,111	234	50	864	65	2,667	0	829	1,181	0	345	511
Kompong Thom	6	1,753	67	160	20	2	6,250	0	416	1,214	0	1,526	1,558
Kratie	0	534	3	53	39	192	4,537	0	5,978	203	0	151	27
Mondulkiri	0	2	0	10	14	0	4,443	0	8,372	0	0	475	369
Preah Vihear	0	222	2	47	0	0	4,050	0	8,992	0	0	262	8
Prey Veng	0	2,541	5	1	0	5	154	0	0	385	0	276	1,247
Pursat	2	1,696	0	160	0	71	6,214	0	1,411	871	0	861	88
Ratanakiri	0	66	0	292	0	0	7,878	0	4,022	0	0	187	2
Siem Reap	49	2,522	61	378	0	6	6,317	0	4,014	1,240	0	916	131
Sihanouk Ville	2	230	122	32	6	6	857	0	0	0	74	29	75
Stung Treng	0	45	0	27	0	0	5,934	0	4,501	0	0	294	14
Svay Rieng	0	1,668	0	15	0	0	287	0	0	0	0	88	792
Takeo	0	1,986	127	0	0	0	41	0	156	41	0	11	863
Phnom Penh	25	223	0	0	0	0	0	0	0	52	0	7	24
Tonle Sap lake	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	147	25,210	2,786	1,573	943	518	68,764	93	47,929	9,379	946	10,569	7,196

Area statistics - 1973/76 Cambodia land cover (area in km²)

Province	W	B	Total	
<i>Banteay Meanchey</i>	1	0	7,480	U - URBAN / CITIES
Battambang	14	0	12,501	Ar - Paddy / fields
Kompong Speu	3	0	6,756	Au - Upland crops
Kompot	0	24	5,020	As - Swidden agriculture
Kompong Chhnang	304	72	5,278	Ao - Orchards
Kandal	336	222	3,663	Av - Field crops
Koh kong	146	0	12,964	Fe - Evergreen forest
Kompong Cham	251	248	9,358	Fc - Coniferous forest
Kompong Thom	103	0	13,076	Fd - Deciduous forest
Kratie	322	22	12,061	Ff - Secondary forest
Mondulkiri	17	0	13,702	Fm - Mangrove forest
Preah Vihear	3	0	13,586	S - Shrub
Prey Veng	199	34	4,847	G - Grasslands
Pursat	82	0	11,457	w - Water surfaces
Ratanakiri	114	0	12,561	B - Barren lands
Siem Reap	92	0	15,726	
Sihanouk Ville	20	0	1,426	
Stung Treng	346	14	11,175	
Svay Rieng	0	0	2,850	
Takeo	186	19	3,430	
Phnom Penh	59	12	402	
Tonle Sap lake	2,216	0	2,216	
Total	4,814	667	181,535	

Source: Mekong Secretariat in cooperation with I.U.M.O for FAO and UNDP, 1994.

Area statistics - 1985 /87 Cambodia land cover area in km³ (See figure 2.16)

Province	U	Ar	Af	Au	As	Ao	Ap	Av	Fe	Fc	Fd	Fx	Fs
BANTEAY MEANCHEY	12	1,320	0	350	31	0	0	57	584	0	223	358	572
Battambang	0	1,957	20	275	33	0	0	56	1,601	0	1,729	1,416	136
Kompong Speu	0	868	0	667	0	0	0	38	1,287	0	2,551	95	404
Kompot	0	1,330	0	98	18	0	0	90	1,605	0	1,163	19	153
Kompong Chhnang	0	626	5	498	14	0	0	148	404	0	1,387	0	44
Kandal	8	321	0	248	0	0	0	957	0	0	0	0	3
Koh kong	0	209	0	252	21	0	0	21	10,218	82	307	78	376
Kompong Cham	0	1,781	0	760	72	16	729	948	1,431	0	389	32	449
Kompong Thom	0	1,786	31	135	188	0	7	37	4,813	0	383	323	945
Kratie	0	447	0	55	6	0	53	174	3,164	0	5,867	1,038	123
Mondulkiri	0	56	0	32	16	0	0	18	2,259	0	7,799	1,604	503
Preah Vihear	0	277	0	10	50	0	0	3	2,161	0	8,479	1,791	160
Prey Veng	0	3,068	0	17	4	0	0	458	14	0	0	0	41
Pursat	0	1,206	36	40	44	0	0	0	4,512	0	1,493	644	629
Ratanakiri	1	117	0	2	291	0	41	2	6,014	0	3,998	576	724
Siem Reap	0	2,332	83	177	557	0	0	116	2,942	0	3,898	2,098	610
Sihanouk Ville	0	216	0	16	36	0	0	85	781	0	0	4	75
Stung Treng	0	201	0	43	24	0	0	9	4,681	0	3,902	1,054	128
Svay Rieng	0	2,061	0	0	13	0	0	213	56	0	0	0	31
Takeo	0	1,740	0	219	0	0	0	191	0	0	114	0	78
Phnom Penh	42	124	0	36	0	0	0	46	0	0	0	0	1
Tonle Sap lake	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	63	22,043	175	3,930	1,358	16	830	3,668	48,527	82	43,679	11,130	6,185

Area statistics - 1985 /87 Cambodia land cover (area in km²)

Province	Ff	Ffs	Fm	St	Sn	Sa	Ss	G	Gs	Gf	Ga	Gm	W	B	Total
BANTEAY MEANCHEY	3	0	0	2,825	273	0	0	19	109	0	678	0	66	0	7,480
Battambang	1,917	25	0	2	1,652	809	0	0	0	60	774	0	40	0	12,501
Kompong Speu	0	0	0	33	350	439	0	0	0	16	0	0	8	0	6,756
Kompot	0	0	16	15	309	91	0	0	0	4	32	42	35	0	5,020
Kompong Chhnang	911	0	0	47	312	451	23	0	0	111	24	0	261	12	5,278
Kandal	789	129	0	2	350	65	9	0	0	102	0	196	441	43	3,663
Koh kong	0	0	600	25	293	184	0	0	5	11	0	0	271	10	12,963
Kompong Cham	871	4	0	5	929	362	63	0	0	87	91	0	315	24	9,358
Kompong Thom	1,093	0	0	515	1,114	689	1	0	43	151	660	0	162	0	13,076
Kratie	99	0	0	429	199	14	0	0	0	0	38	0	296	60	12,061
Mondulkiri	0	0	0	701	76	12	0	0	606	0	0	0	20	0	13,702
Preah Vihear	0	0	0	196	292	163	0	0	0	0	0	0	4	0	13,586
Prey Veng	302	48	0	2	315	71	12	0	0	32	8	21	434	0	4,847
Pursat	800	0	0	121	1,095	483	10	0	1	13	213	0	117	0	11,457
Ratanakiri	0	0	0	470	79	126	0	0	29	0	0	0	151	0	12,561
Siem Reap	871	8	0	52	896	769	0	0	20	9	194	0	94	0	15,726
Sihanouk Ville	0	0	69	0	30	38	0	0	0	0	0	48	26	0	1,426
Stung Treng	0	0	0	758	19	4	0	0	0	0	0	0	352	0	11,175
Svay Rieng	0	0	0	117	158	0	0	0	0	162	0	0	39	0	2,850
Takeo	284	63	0	2	311	22	4	0	0	11	65	25	301	0	3,430
Phnom Penh	14	5	0	0	71	2	0	0	0	39	0	0	22	0	402
Tonle Sap lake	0	0	0	0	0	0	0	0	0	0	0	0	2,216	0	2,216
Total	7,954	282	685	3,492	11,674	5,067	122	19	813	808	2,777	332	5,671	149	181,535

LEGEND for Map 1985 / 87

U	- Urban / Cities	Ff	- Flooded forest
Ar	- Paddy / fields	Ffs	- Flooded secondary forest
Af	- Receding rice fields	Fm	- Mangrove forest
Au	- Upland crops	St	- Woodlands
As	- Swidden agriculture	Sn	- Natural shrublands
Ao	- Orchards	Sa	- Abandoned shrublands
Ap	- Plantation	Ss	- Swamps
Av	- Field crops	G	- Grasslands
Fe	- Evergreen forest	Gs	- Grass savannah
Fc	- Coniferous forest	Gf	- Flooded grasslands
Fd	- Deciduous forest	Ga	- Abandoned grasslands
Fx	- Mixed forest	Gm	- Marshes
Fs	- Secondary forest	w	- Water surfaces
		B	- Barren lands

Source: Mekong Secretariat in cooperation with LUMO for FAO and UNDP, 1994.

Area statistics - 1992/93 Cambodia land cover (area in km²) (See figure 2.17)

Province	U	AR	Af	AU	AS	Ao	Ap	AV	FE	Fc	FD	FX	FS
BANTEAY MEANCHEY	0	1,967	2	171	3	0	0	177	562	0	924	93	255
Battambang	0	2,475	21	93	39	0	0	281	1,662	0	1,309	943	444
Kompong Speu	0	865	0	843	0	0	0	10	924	0	2,491	23	229
Kompot	0	1,525	0	195	0	0	0	5	1,546	0	976	2	145
Kompong Chhnang	0	532	22	727	1	0	0	197	167	0	902	87	195
Kandal	1	542	0	267	0	0	0	1,467	0	0	0	0	6
Koh kong	0	173	0	329	0	0	0	0	10,547	98	360	14	244
Kompong Cham	4	2,197	0	732	27	184	717	1,315	1,319	0	474	316	181
Kompong Thom	0	1,839	91	486	151	4	6	177	4,857	0	516	388	776
Kratie	0	730	0	89	10	0	22	245	3,122	0	5,190	1,195	4
Mondulkiri	0	64	0	0	105	0	0	0	2,164	0	7,792	1,032	234
Preah Vihear	13	392	0	45	27	0	0	0	2,216	0	8,346	1,874	155
Prey Veng	0	3,594	0	37	50	0	1	708	21	0	0	0	6
Pursat	0	1,459	32	74	41	0	0	115	4,624	0	1,064	374	1,103
Ratanakiri	0	99	0	9	768	0	0	0	5,636	0	4,858	691	301
Siem Reap	0	2,682	125	154	449	0	0	123	2,759	0	3,950	1,737	697
Sihanouk Ville	0	128	0	72	0	0	0	0	882	0	15	0	76
Stung Treng	0	188	0	18	11	0	0	20	4,578	0	3,841	1,004	102
Svay Rieng	0	2,286	0	0	102	0	0	201	47	0	0	0	0
Takeo	0	2,168	0	288	0	0	0	188	0	0	4	0	8
Phnom Penh	27	192	0	36	0	0	0	70	0	0	0	0	9
Tonle Sap lake	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	45	26,097	293	4,665	1,856	188	746	5,299	47,633	98	43,012	9,773	5,170

Area statistics - 1992/93 Cambodia land cover (area in km²)

Province	Ff	Ffs	m	St	Sn	Sa	Ss	G	Gs	Gf	Ga	Gm	W	B	Total
Banteay Meanchey	2	0	0	485	2,440	228	0	0	0	37	113	0	22	0	7,481
Battambang	779	1	0	132	2,109	754	0	0	0	142	215	2	11	30	12,510
Kompong Speu	0	0	0	780	472	104	0	0	0	6	4	0	5	0	6,756
Kompot	0	0	79	102	257	42	0	0	0	30	61	0	7	48	5,020
Kompong Chhnang	722	107	0	217	1,065	113	0	0	0	10	10	0	204	0	5,278
Kandal	706	22	0	14	160	27	0	0	0	68	10	0	282	91	3,663
Koh kong	0	0	637	56	401	69	0	0	0	0	0	1	0	7	12,963
Kompong Cham	453	0	0	50	973	123	0	0	0	1	5	0	202	39	9,358
Kompong Thom	172	726	0	330	1,419	286	0	0	45	196	450	0	161	0	13,076
Kratie	0	0	0	526	465	15	0	0	0	78	27	0	310	33	12,061
Mondulhiri	0	0	0	1,876	44	0	0	0	391	0	0	0	0	0	13,702
Preah Vihear	0	0	0	300	209	7	0	0	0	0	0	0	0	2	13,586
Prey Veng	79	14	0	34	167	0	0	0	10	32	8	0	74	12	4,847
Pursat	261	389	0	203	1,316	267	14	0	5	1	50	0	60	5	11,457
Ratanakiri	0	0	0	109	10	0	0	0	0	0	0	12	68	0	12,561
Siem Reap	337	234	0	103	1,615	481	0	0	4	64	98	0	114	0	15,726
Sihanouk Ville	0	0	135	4	41	6	0	0	13	0	0	0	0	54	1,426
Stung Treng	0	0	0	1,111	6	0	0	0	0	0	0	0	283	13	11,175
Svay Rieng	0	0	0	124	71	0	0	0	0	0	0	0	19	0	2,850
Takeo	185	45	0	7	250	6	0	24	0	172	37	0	46	2	3,430
Phnom Penh	11	0	0	0	11	0	0	0	0	12	7	0	27	0	402
Tonle Sap lake	0	0	0	0	0	0	0	0	0	0	0	0	2,216	0	2,216
Total	3,707	2,598	851	6,563	13,501	2,528	14	24	468	849	1,095	15	4,111	336	181,535

LEGEND for Map 1992 / 93

U	- Urban / Cities	Ff	- Flooded forest
Ar	- Paddy / fields	Ffs	- Flooded secondary forest
Af	- Receding rice fields	Fm	- Mangrove forest
Au	- Upland crops	St	- Woodlands
As	- Swidden agriculture	Sn	- Natural shrublands
Ao	- Orchards	Sa	- Abandoned shrublands
Ap	- Plantation	Ss	- Swamps
Av	- Field crops	G	- Grasslands
Fe	- Evergreen forest	Gs	- Grass savannah
Fc	- Coniferous forest	Gf	- Flooded grasslands
Fd	- Deciduous forest	Ga	- Abandoned grasslands
Fx	- Mixed forest	Gm	- Marshes
Fs	- Secondary forest	w	- Water surfaces
		B	- Barren lands

Source: Mekong Secretariat in cooperation with LUMO for FAO and UNDP, 1994.

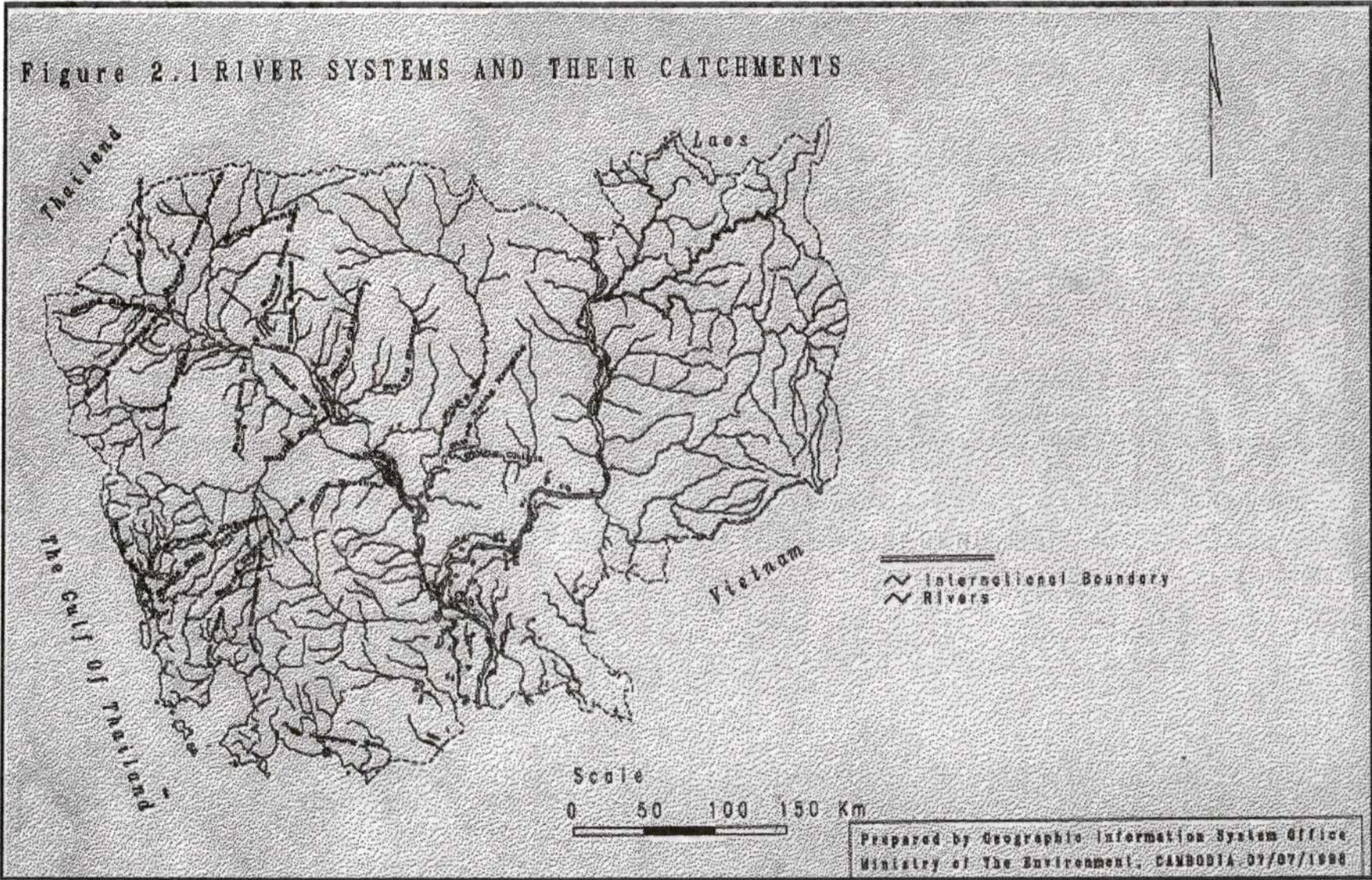
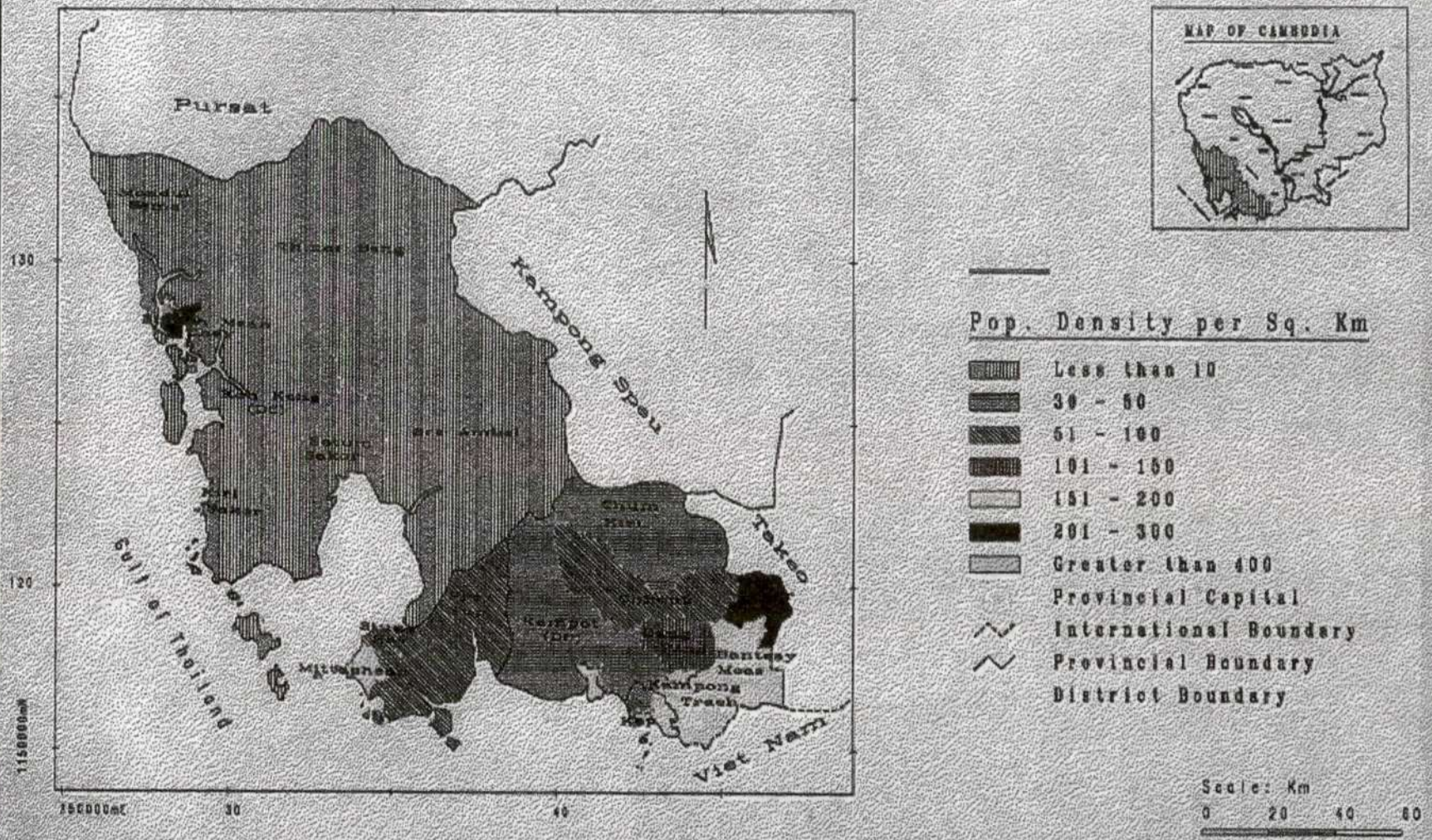


Figure 2.2 COASTAL CITY AND POPULATION DENSITY



Source: Cambodia Briefing Map 1984

Prepared by GIS Office, Min. of Environment, Cambodia. Date: 04/10/1997

Figure 2.4 OIL AND GAS EXPLORATION ZONE IN THE COASTAL AREA OF CAMBODIA

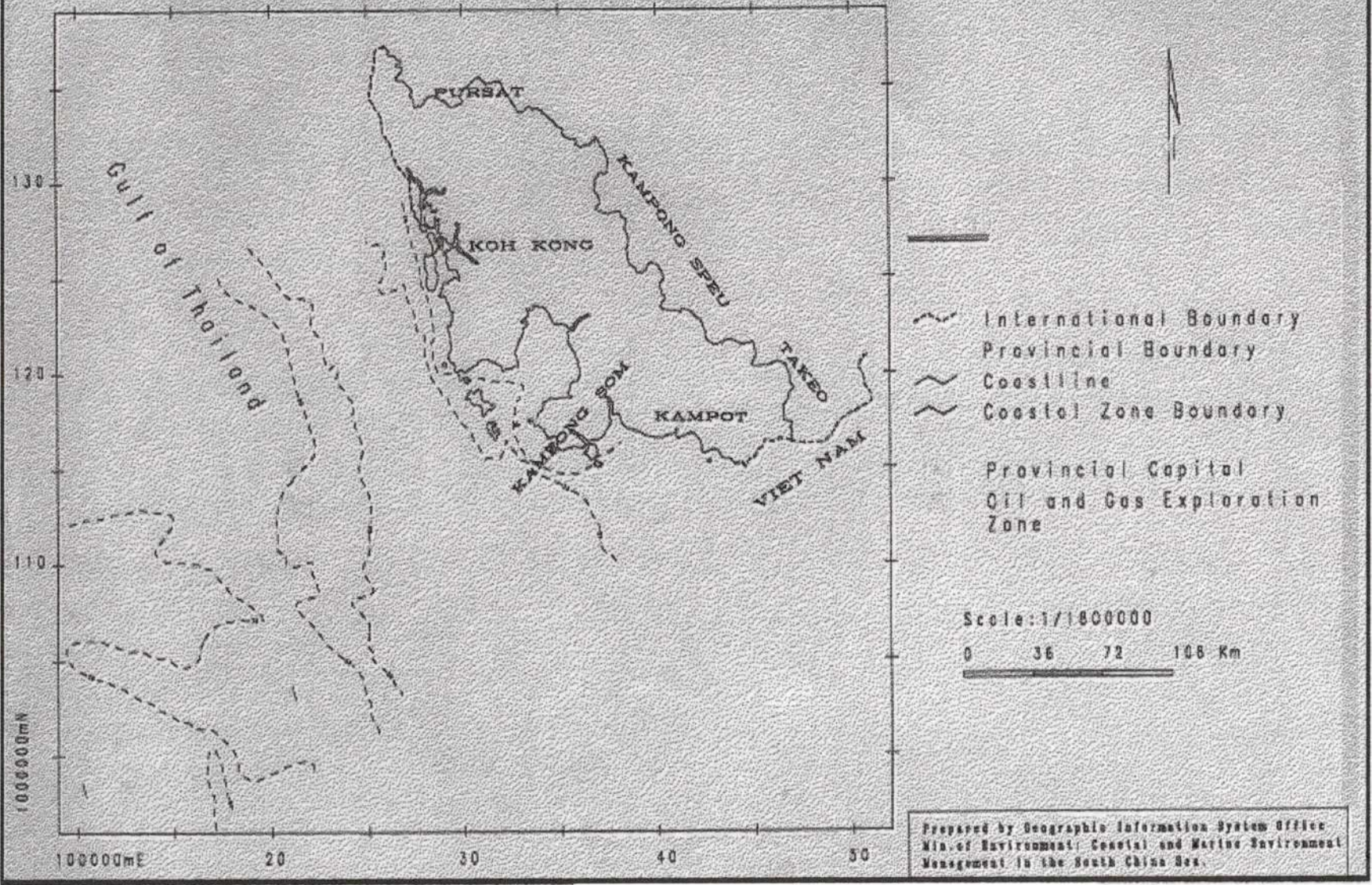


Figure 2.5 CITIES WITH POPULATION MORE THAN 100,000

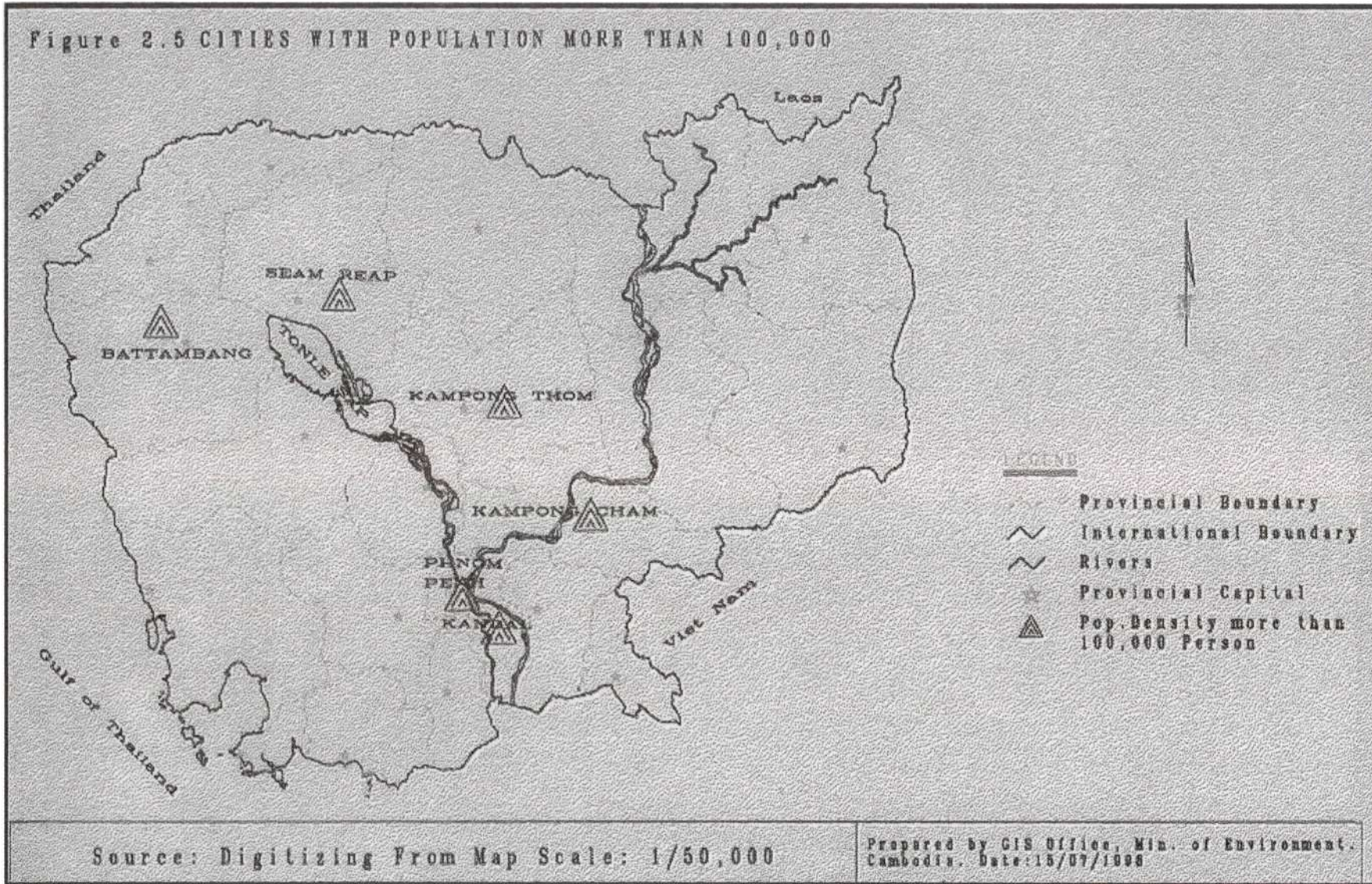


Figure 2.7 SHRIMP FARM IN THE KOH KONG PROVINCE

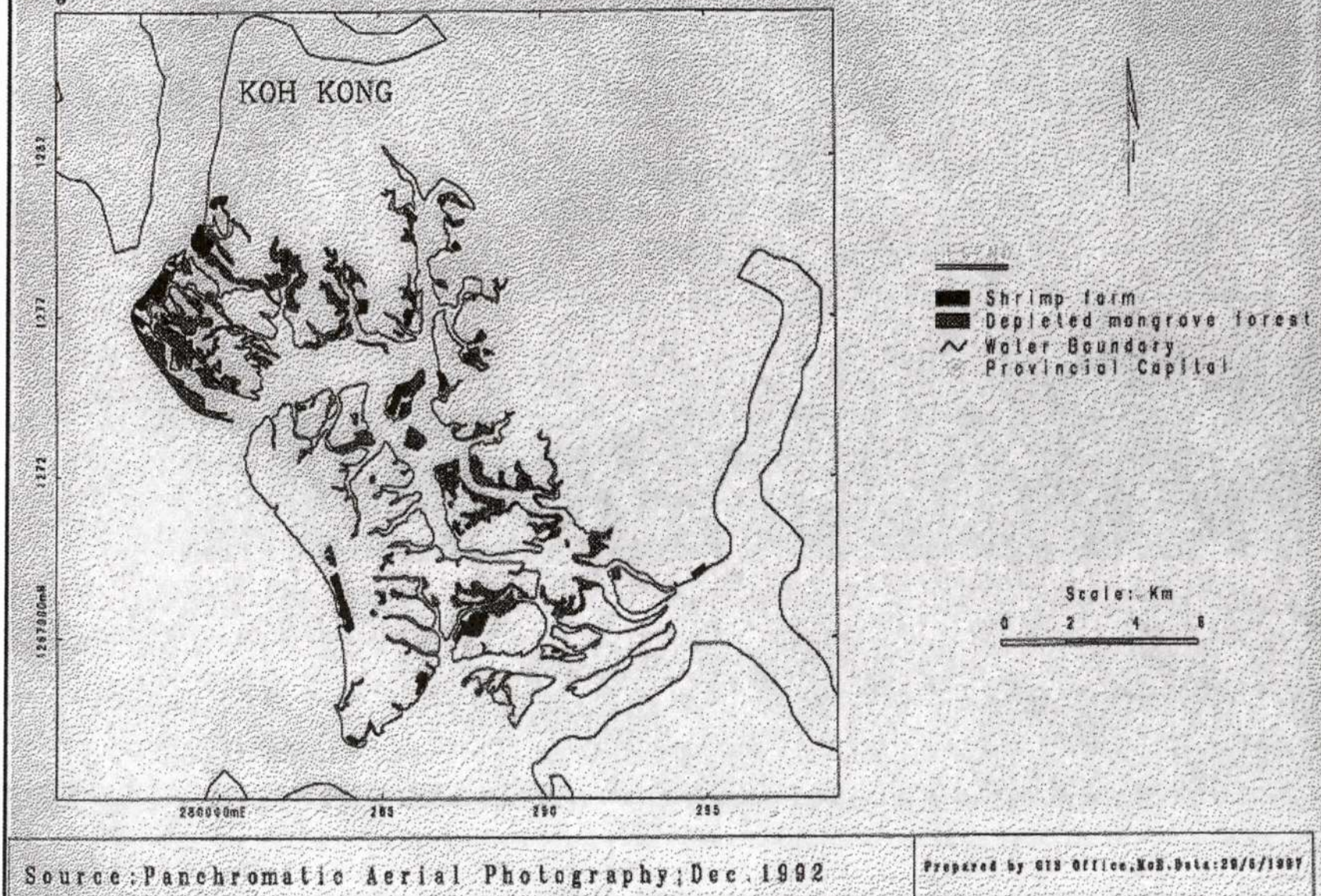


Figure 2.8 SENSITIVE AND HIGH RISK AREAS IN CAMBODIA

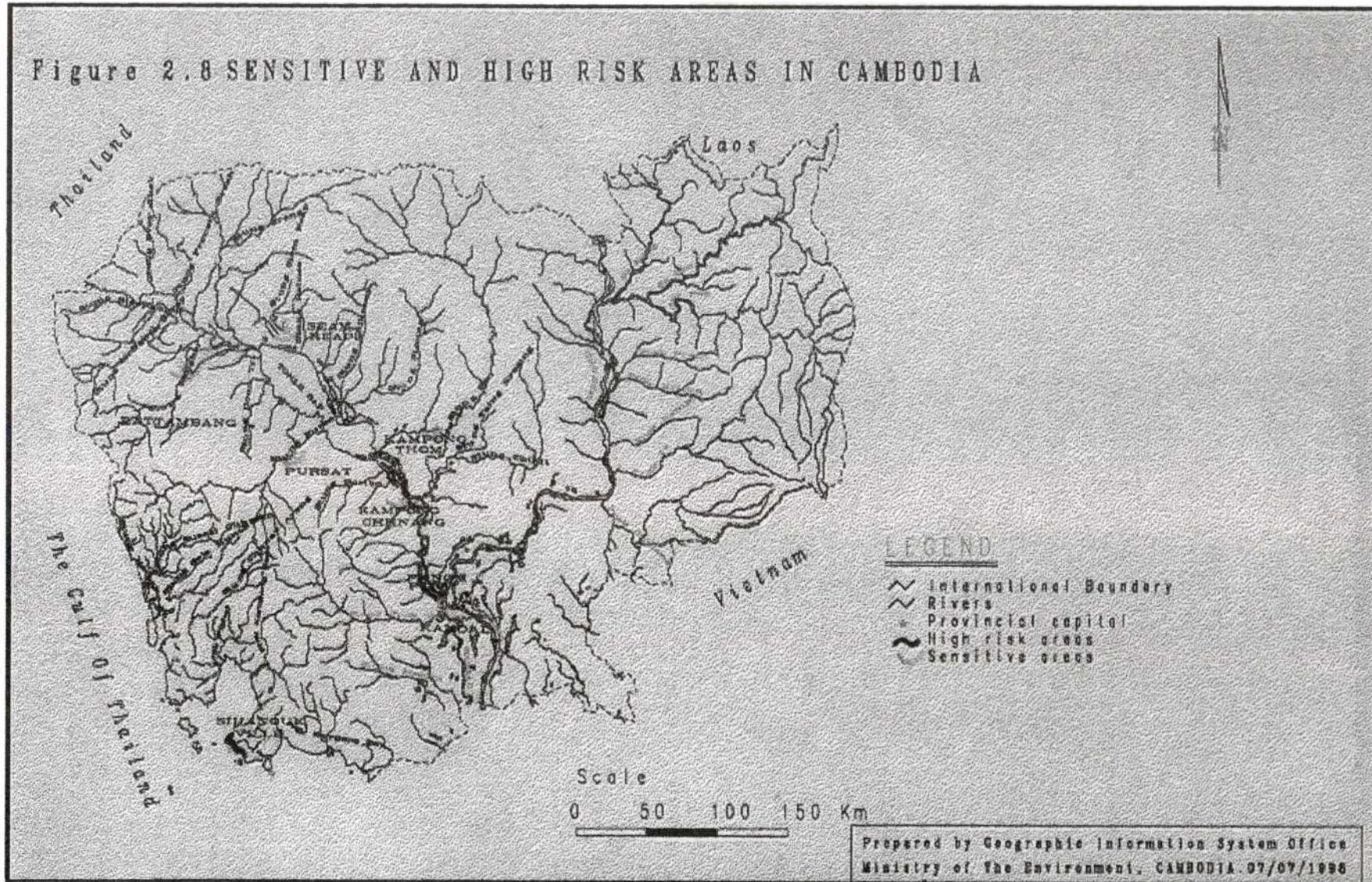


Figure 2.9 RAINFALL PATTERN IN CAMBODIA

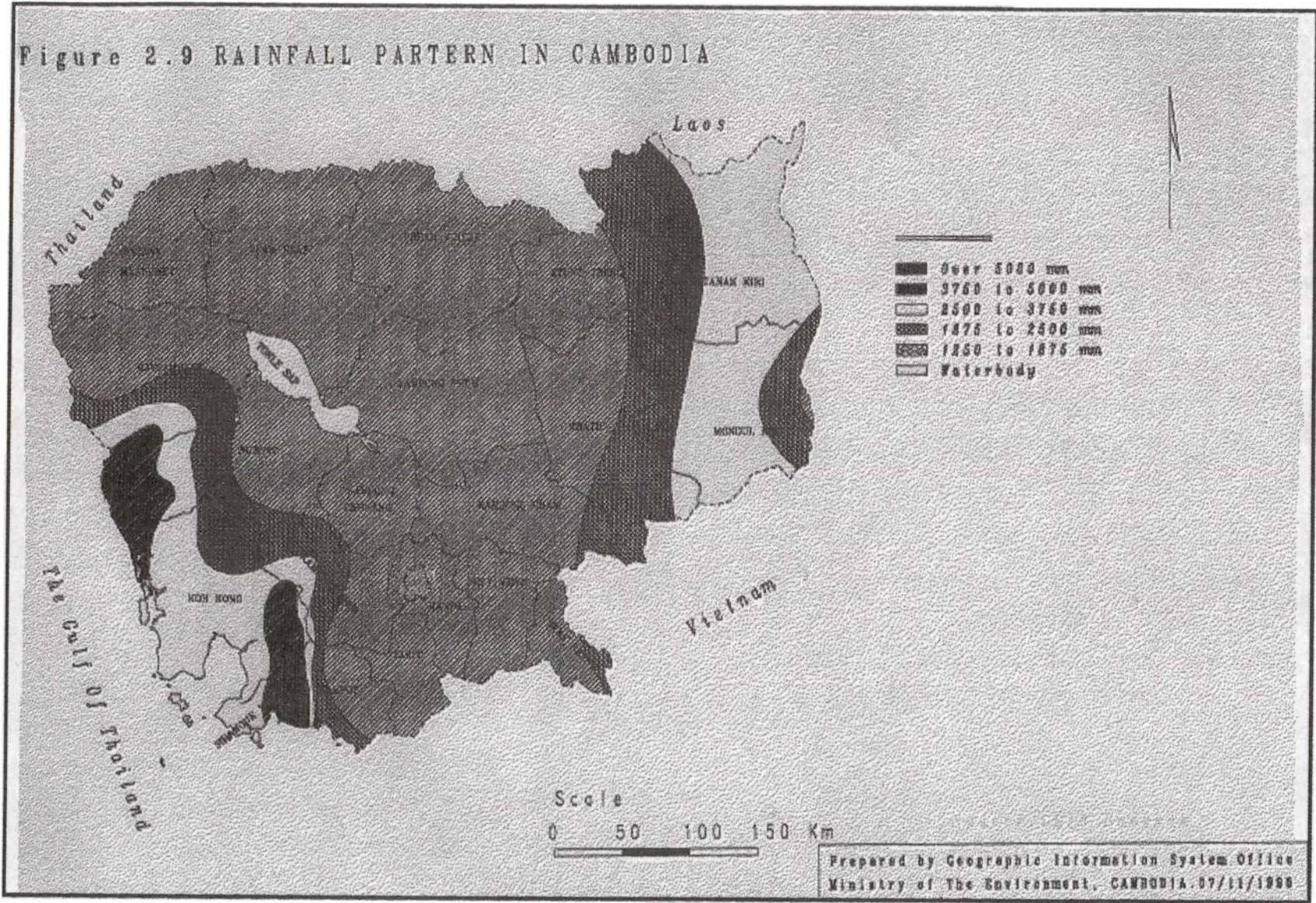


Figure 2.10 RIVER WATER QUALITY MONITORING NETWORK

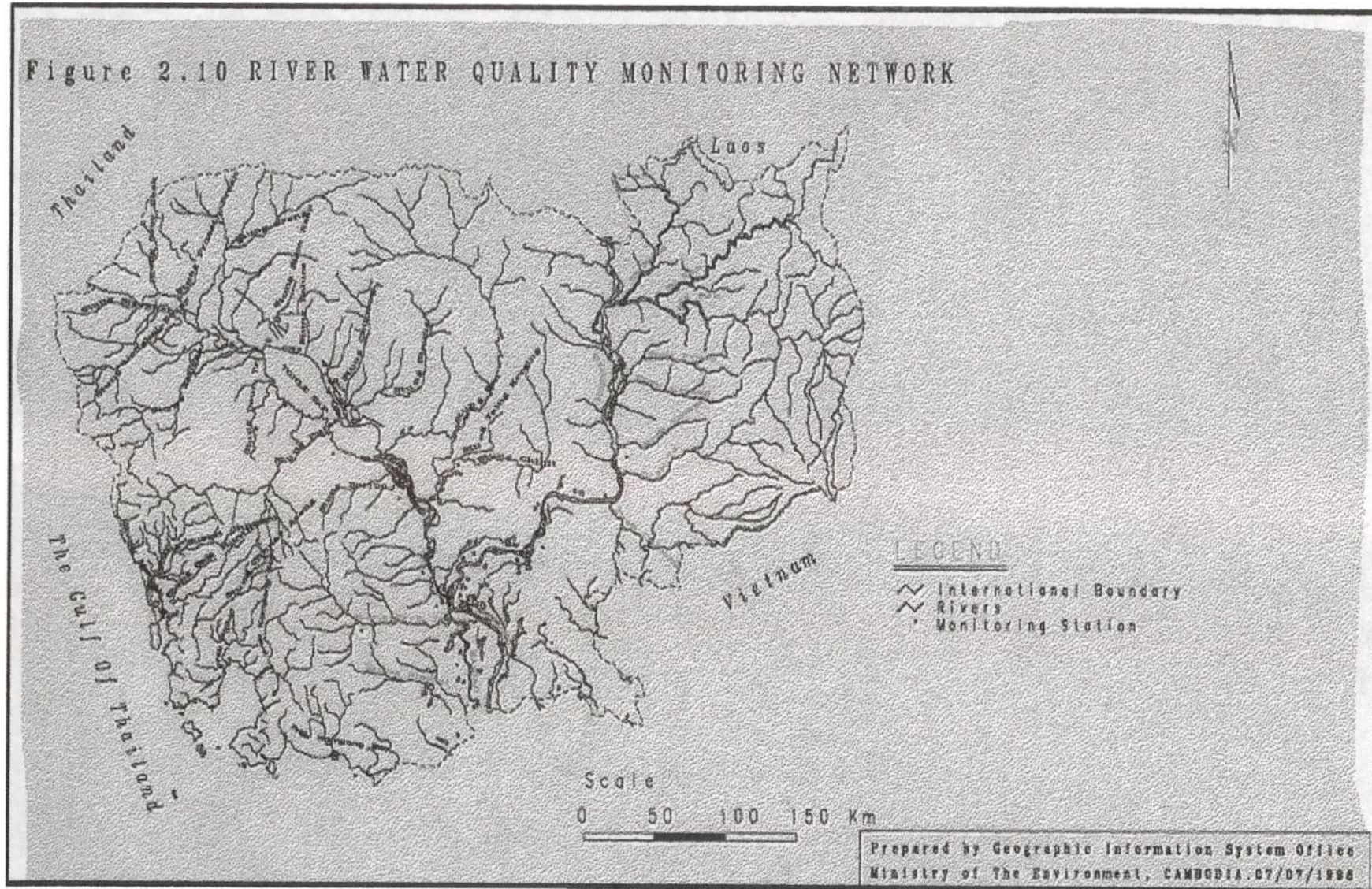
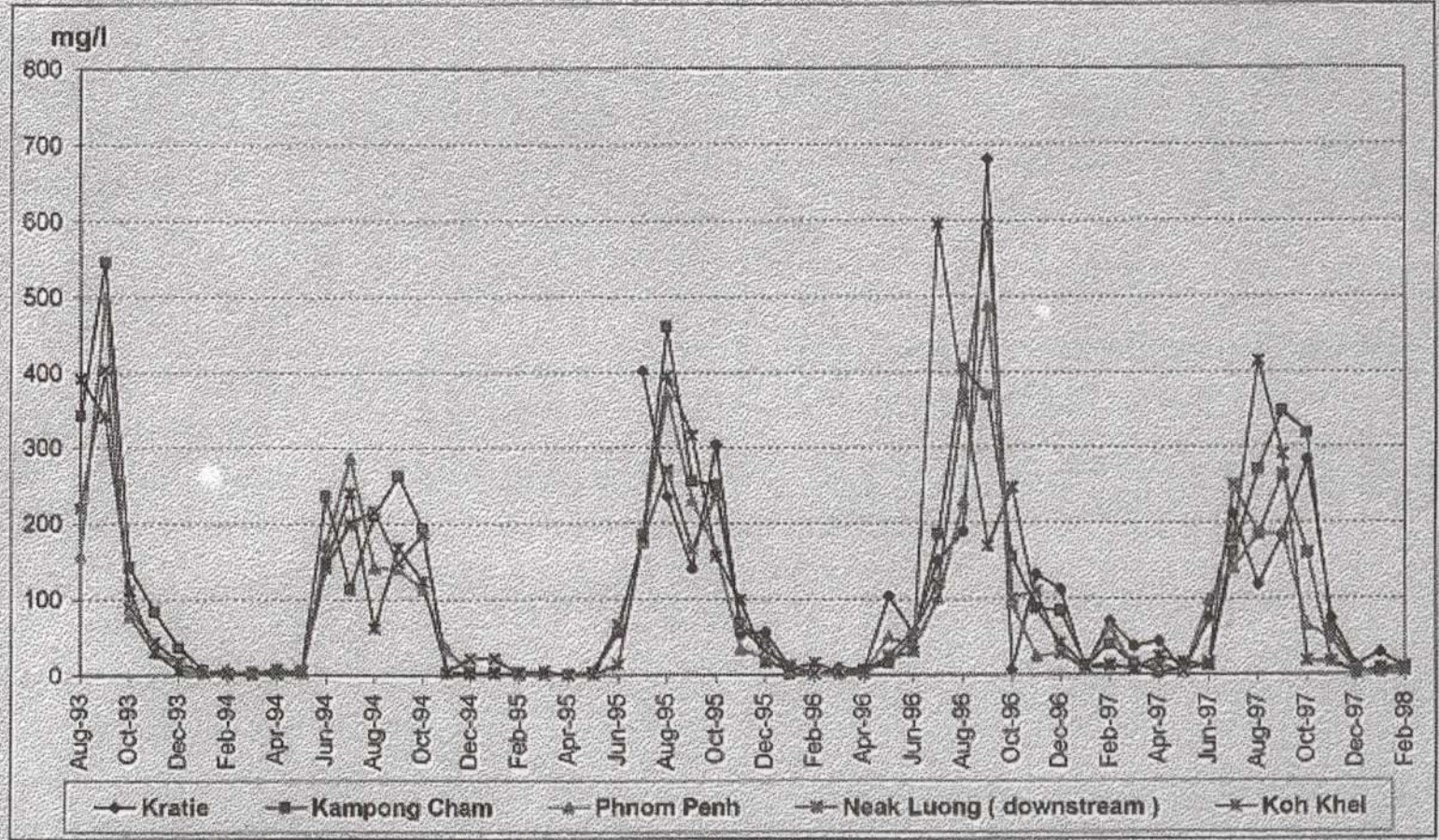
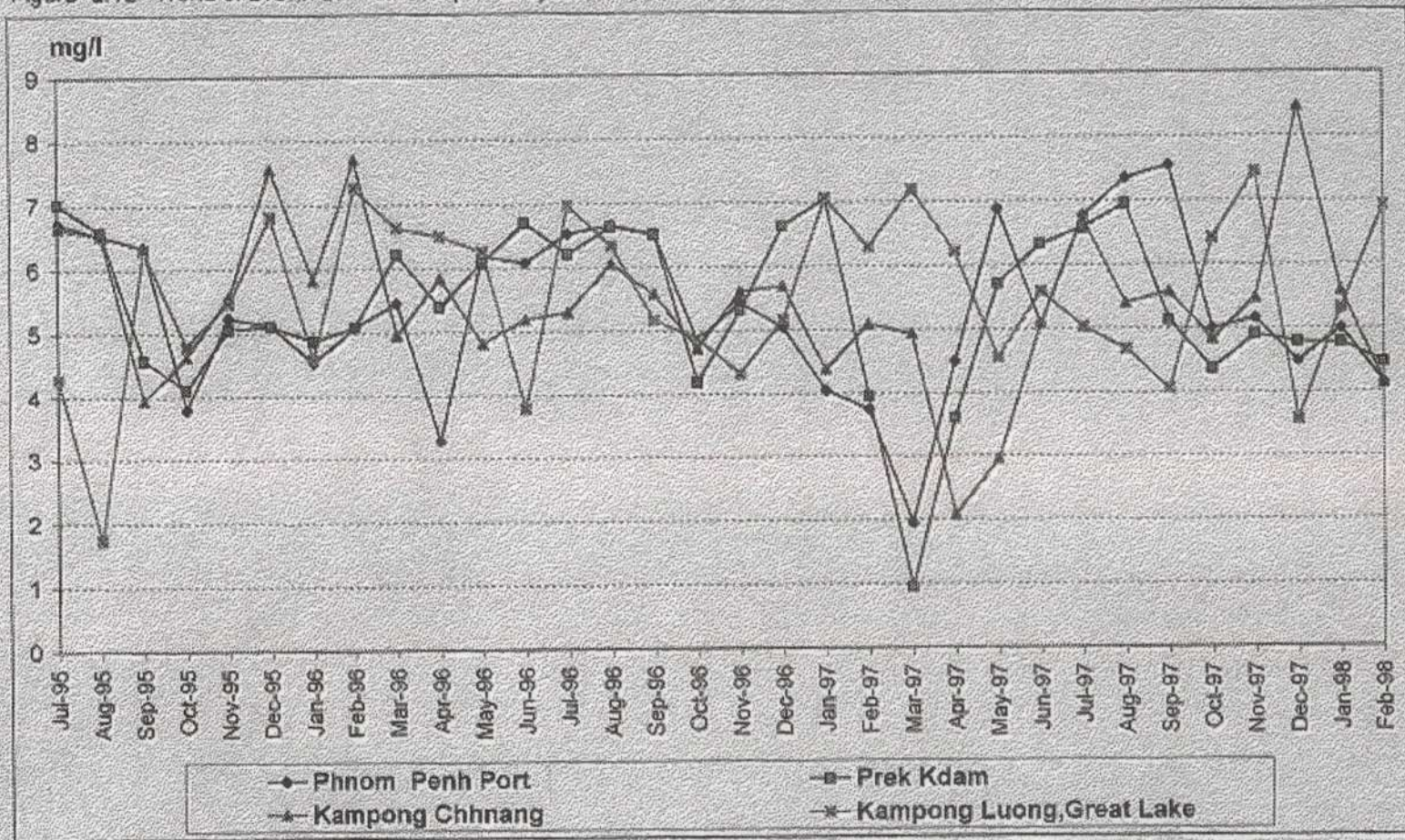


Figure 2.11 Trend of TSS in the Mekong river system



Source: General Directorate of Irrigation, Meteorology and Hydrology

Figure 2.12 Trend of D.O in the Tonle Sap river system



Source: General Directorate of Irrigation, Meteorology and Hydrology

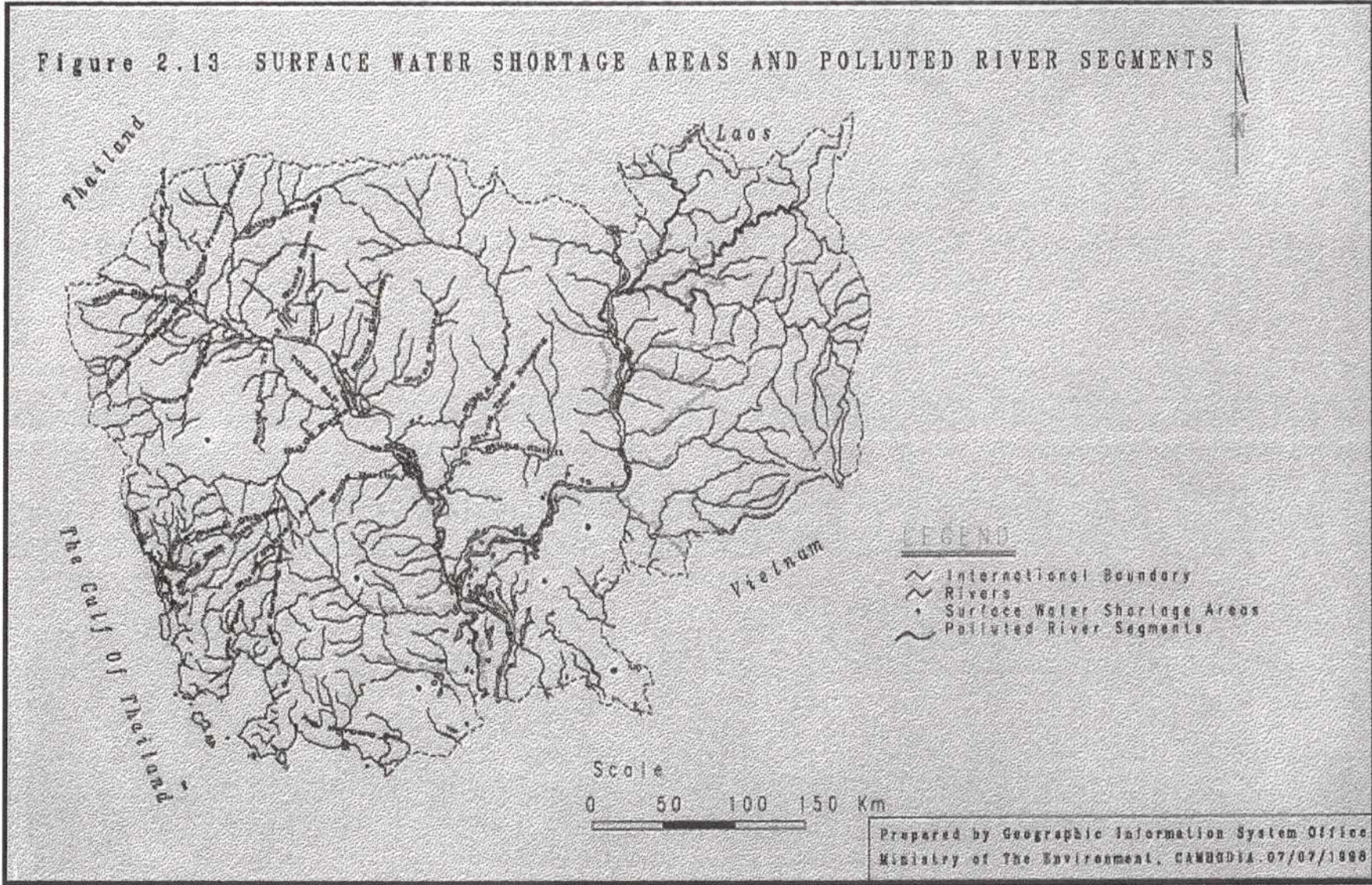
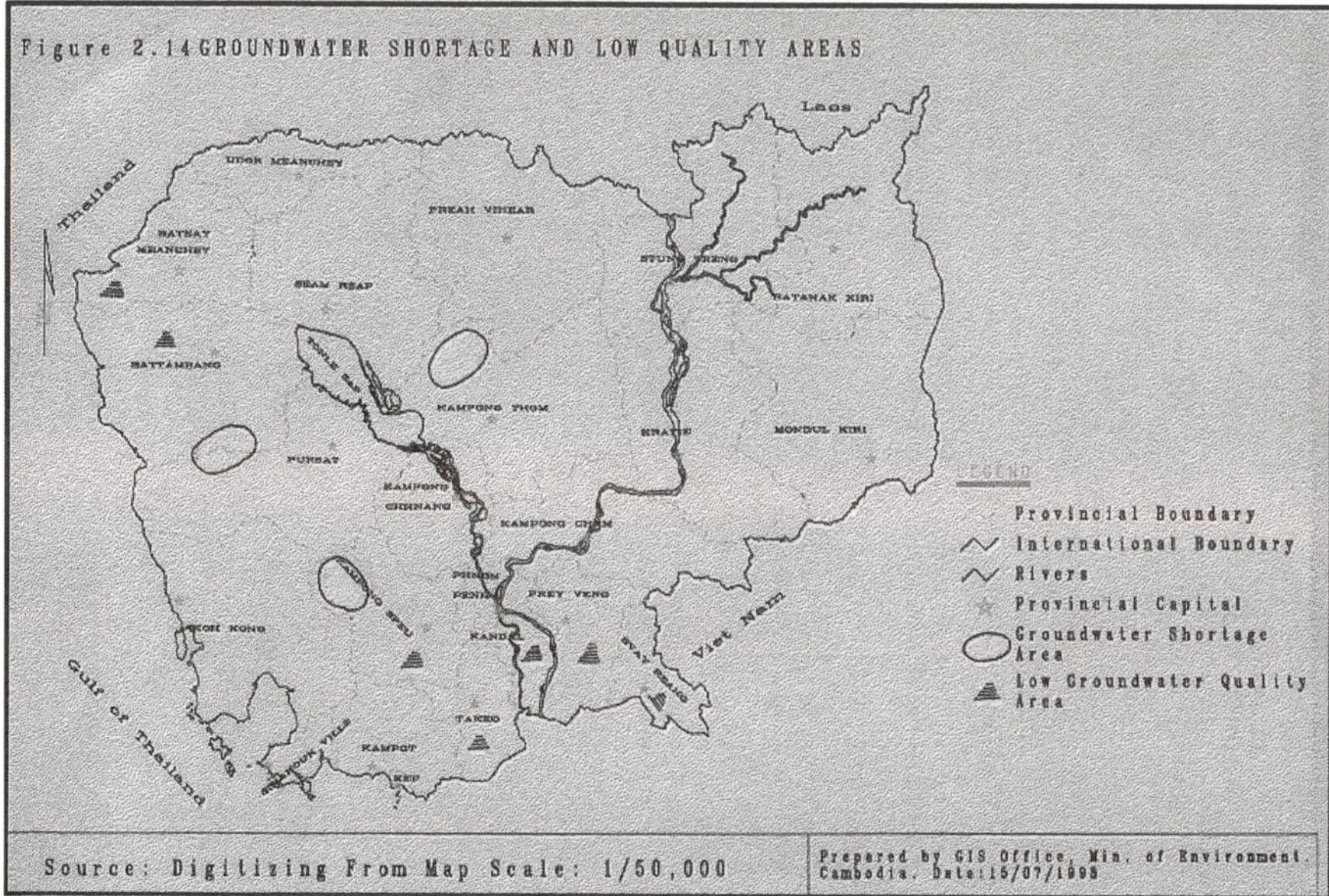


Figure 2.14 GROUNDWATER SHORTAGE AND LOW QUALITY AREAS



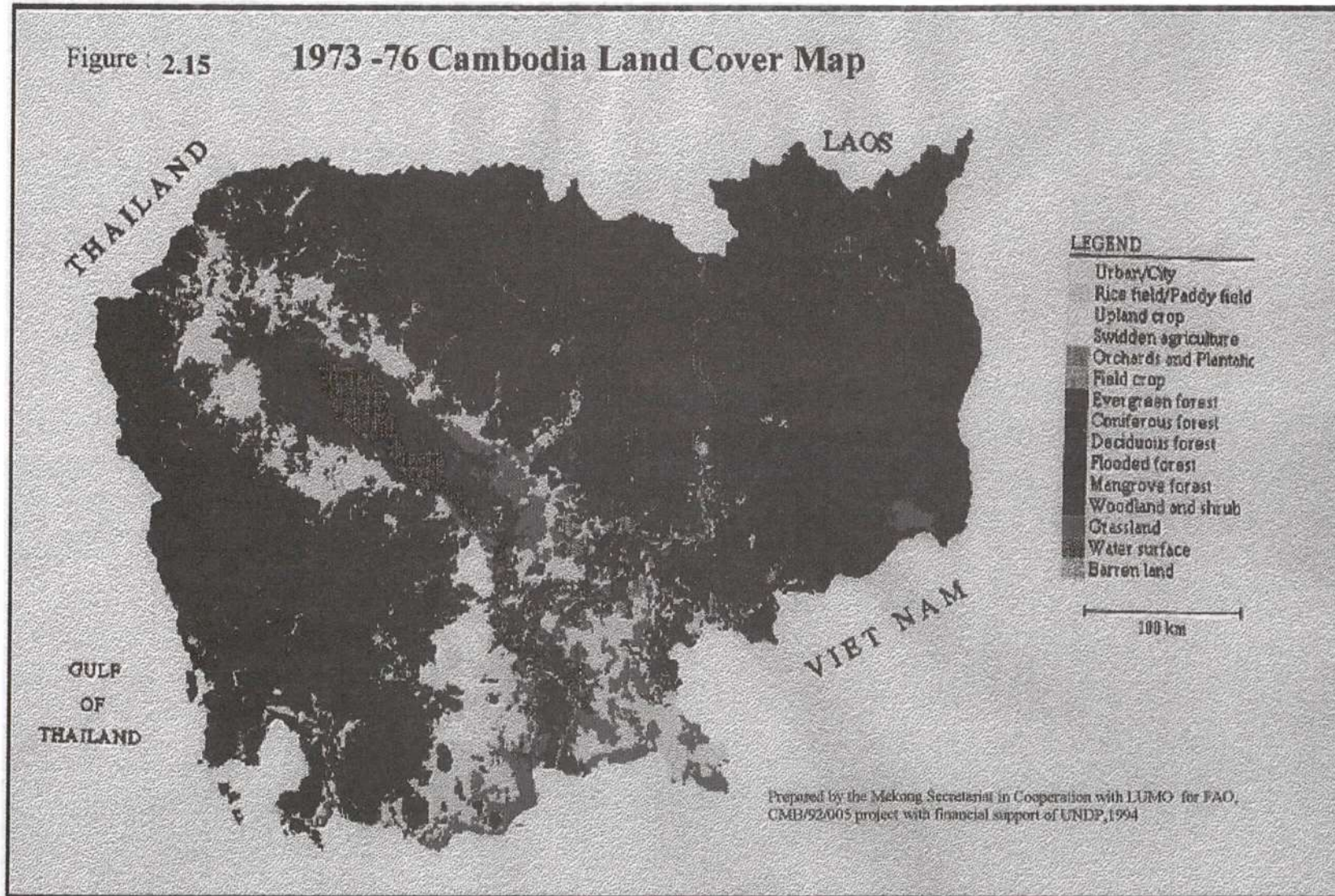
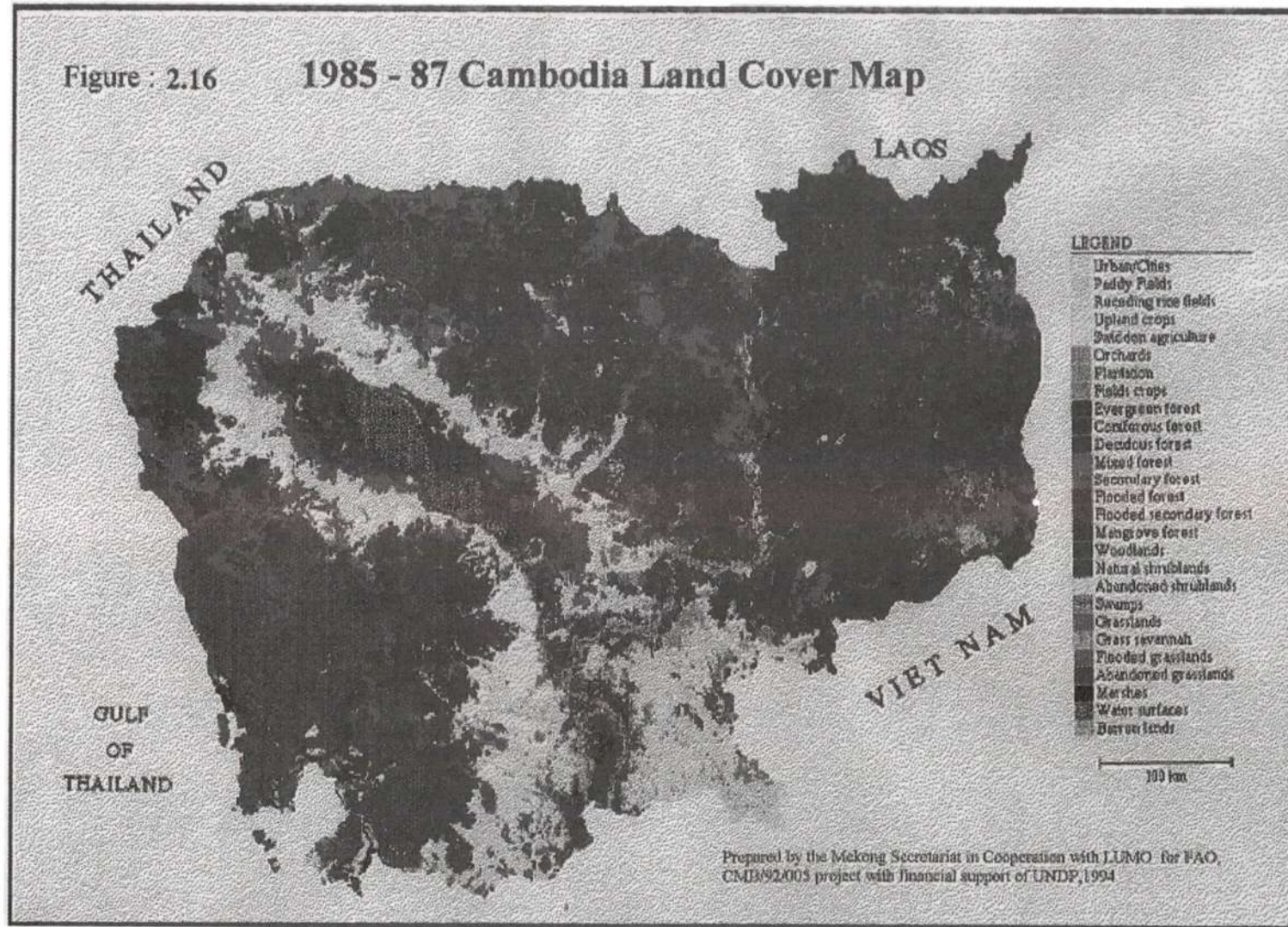
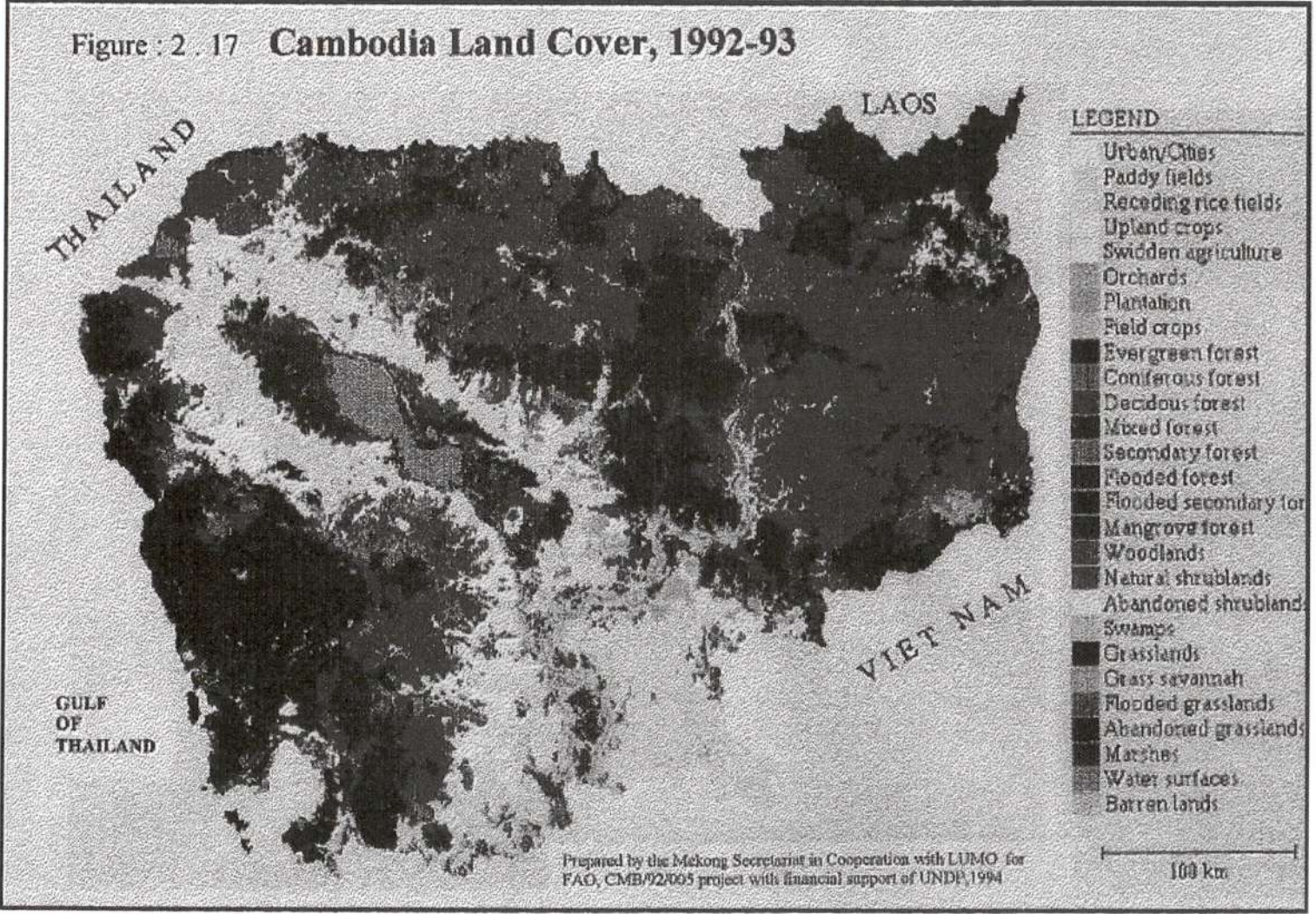
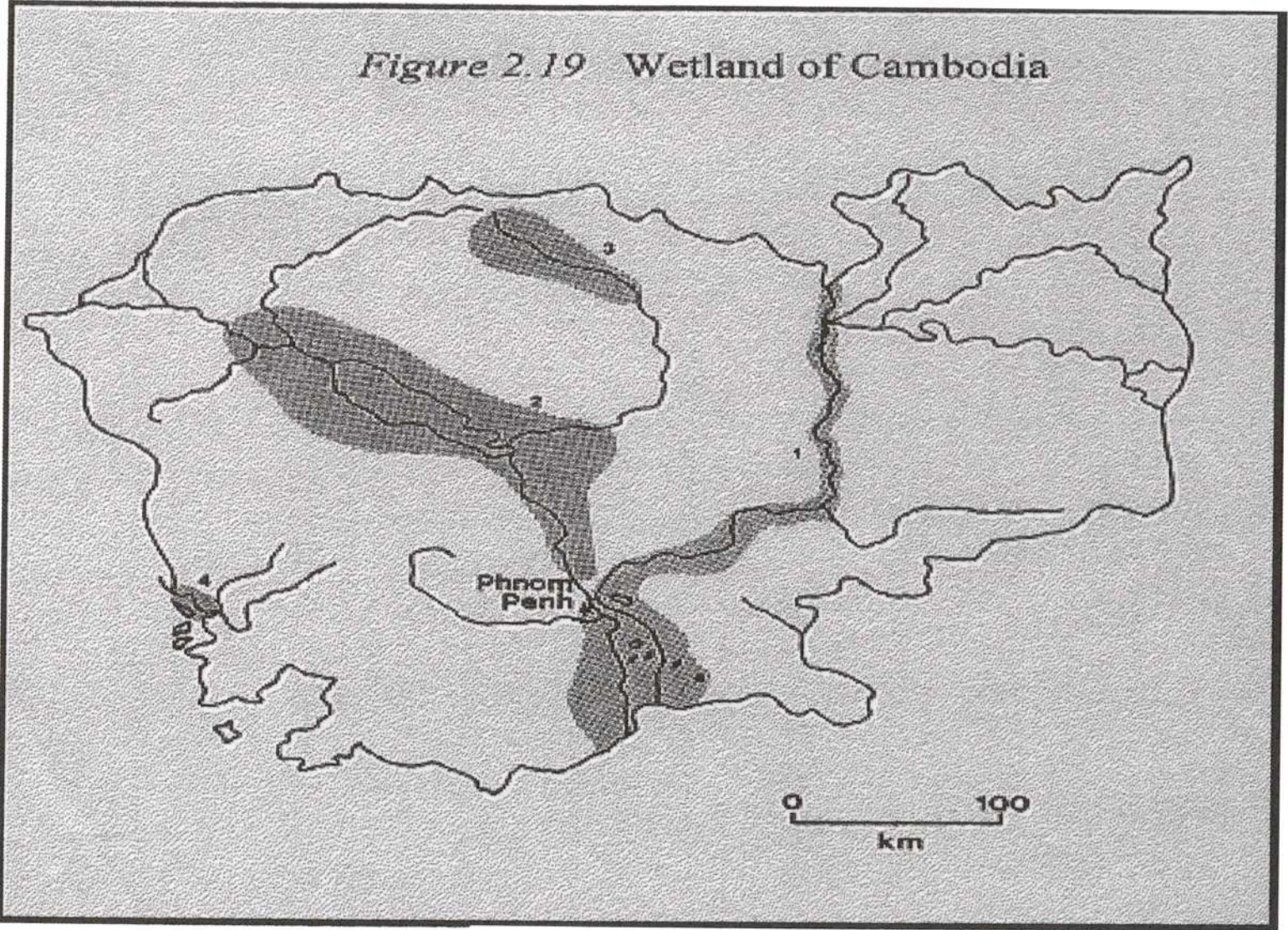


Figure : 2.16

1985 - 87 Cambodia Land Cover Map









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