LOCAL PERCEPTIONS OF ENVIRONMENTAL CHANGE IN A TROPICAL COASTAL WETLAND: THE CASE OF KOGGALA LAGOON, GALLE, SRI LANKA

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by

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Frontispiece: Aerial view of Koggala Lagoon, Galle, Sri Lanka - looking North.
(Source: February 1995, H. Molenaar)

ABSTRACT

Tropical coastal wetlands are under ecological stress, most notably due to accelerated development activities associated with these areas. Consequently, natural resource depletion and environmental problems in the coastal sector are increasingly serious issues, particularly in South and South East Asia, and have significant implications for their traditional resource-user groups.

This thesis is primarily based on a detailed investigation of the inter-relationships between environmental change and local perception of change at Koggala, Galle, southern Sri Lanka, where six sample Divisions bordering Koggala Lagoon were selected for in-depth study. Multi-disciplinary techniques from both the natural and the social sciences were employed, focusing on the environmental changes involved and on the perceptions of these changes by local fishing and farming communities. Particular attention was paid to changes in agriculture, to the reconfiguration of a coastal sand bar, and to the development of a Free Trade Zone. Participatory techniques involved the experimental use of group discussions. Visits were made to Malaysia and Thailand for comparative study purposes.

Results show that the fringing mangrove complex is currently threatened by a number of factors and that sand mining close to the lagoon outlet has severely disrupted water levels in the lagoon and ultimately rice-farming systems. The fishing community further perceives significant declines in their fish catch, attributing this to the loss of fishery nursery sites and to the seepage of agro-chemicals, some belonging to highly toxic groups, into the lagoon.

It is clear that local communities display a high degree of awareness of environmental change, as well as of the causes of this change. Such understanding can be used to develop local-level adaptive planning for wetland management. The use of discussion groups is seen as a novel approach to such wetland management programmes in the tropics.

Keywords:

Tropical wetlands, Mangroves, Coastal farming, Pesticides, Sri Lanka, South Asia, South East Asia, Group perceptions, Environmental change, Discussion groups.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGA	Assistant Government Agent
ASEAN	Association of South East Asian Nations
BOI	Board of Investment
CCD	Coast Conservation Department
CEA	Central Environment Authority
CRMP	Coastal Resources Management Project
CTB	Ceylon Tourist Board
CZMP	Coastal Zone Management Plan
DS	Divisional Secretary
DSD	Divisional Secretary's Division
DWLC	Department of Wildlife Conservation
EIA	Environment Impact Assessment
EPA	Environment Protection Agency
FTZ	Free Trade Zone
GA	Government Agent
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution
GN	Grama Niladhari
GND	Grama Niladhari Division
GOSL	Government of Sri Lanka
IADP	Integrated Agricultural Development Project
IRRI	International Rice Research Institute
KEPZ	Koggala Export Processing Zone
MCRST	Malaysian Coastal Resources Study Team
MFARD	Ministry of Fisheries and Aquatic Resources Development
MTSE	Ministry of Technology Science and Environment
NARA	National Aquatic Resources Agency
ONEB	Office of the National Environment Board
PS	Pradeshiya Sabha
SEJF	Sri Lanka Environmental Journalists Forum
TEAMS	Technology Evaluation and Management Services
USAID	United States Agency for International Development
USEPA	United States Environment Protection Agency

CHAPTER 1
TROPICAL COASTS: PROBLEMS AND PLANNING

1.1 Introduction

The destruction of the natural resources and ecosystems of the world's coastal areas is considered to be amongst the most pressing environmental management problems of this century (Goldberg, 1994; Hinrichsen, 1994). Coastal areas are the home of more than 60% of the world's population, and it is anticipated that migration to these areas will increase these numbers further (Tolba & El-Kholy, 1992). While there are many 'natural' causes for changes in coastal environments, human actions and poor development strategies are the most damaging. These have accelerated the pace of decline, most notably in coastal wetlands. Poor land-use practices, inadequate planning and focus on short-term economic gains are the chief impacts. Additionally, rising population pressure, in combination with some of the activities outlined above, has also increased the degradation of key coastal environments due to over-harvesting of the resources, pollution, and alteration of the environment (Platt, 1995). It is thus argued that unless serious and co-ordinated action is taken to change the negative trends observed today, extremely valuable coastal resources will be lost.

As a result of the significance of coastal problems, especially in the context of developing countries, examples evident in the literature (**Chapter 2**) all point to a polluted environment and one which is becoming built-up and prone to natural hazards (Chou, 1994a; Chua, 1991; Hinrichsen, 1990; Pinder & Witherick, 1990). More and more it is the case that coastal problems are seen in the context of a future accelerated sea-level rise, though differing opinions exist as to the scale and extent of the magnitude and rate of such changes. However, even given scaled-down predictions, local ecological and geomorphological responses to sea-level change will be most significant.

Undoubtedly such changes have serious implications for local communities who are dependent on coastal resources and who often have the least opportunity, in terms of food, jobs and development options. The study area of Koggala Lagoon, Galle, South Sri Lanka presents a prime example of the problems facing the majority of coastal wetland areas throughout South and Southeast Asia which have had serious repercussions on the local communities. This thesis is centred on an investigation of environmental change in Koggala Lagoon and its environs in the face of key disruptions which this area has experienced, most notably in the recent past. It includes an analysis of local perceptions to this change based on the use of discussion groups in six sample divisions bordering the lagoon. An important component of the research has been to initiate local-level adaptive planning for the lagoon and its environs using this novel approach.

Steps towards an integrated management scheme stemming from this work are presented in **Chapter 9**.

The major focus of the thesis is based in Sri Lanka but parallels have been seen by the author in Malaysia and Thailand where field visits were made during the research period (Section **1.3**).

1.2 The Fragility of Coastal Ecosystems

Coastal systems are subject to a range of disturbances, both human-induced and 'natural'. 'Sensitivity' and 'resilience' are two commonly employed concepts used to explain the response of environmental systems. 'Sensitivity' is the degree to which a system undergoes changes because of human or natural stresses, and 'resilience' relates to the speed at which the system recovers or adapts to such changes (Viles & Spencer, 1995). According to this system, mangroves are classified as having high sensitivity and low resilience to pollution. However there are many limitations in using these concepts. For example, it is often the case that there are a number of stresses acting on most coastal systems at the same time, which makes accurate assessments difficult. Furthermore, 'resilience' and 'sensitivity' depend to a large extent on time-scales.

Coastal wetlands are in a dynamic balance between acting as a source or a sink for sediment, organic matter and nutrients (Hollis *et al.* 1988; Maltby, 1991a). Natural events, such as cyclones, abrupt tectonic movements, and plant die-back may upset the balance in the short term. Similarly, human activities can have important impacts both in the short and longer term. Indonesia, for example, had lost 40% of its mangroves by the late 1980's because of logging, transformation to agriculture, and the creation of brackish water aquaculture (Giesen, 1993).

Coastal wetland ecosystems are dependent on water levels which are easily modified by water usage, excessive or impeded drainage and water regulatory works in upstream catchments. In the Dampier-Cossack region of north-western Australia, for example, out of $70km^2$ of mangroves surveyed, $12km^2$ were found to be dead. According to Gordon (1988) this was due to permanent ponding of seawater within a salt-evaporator near Dampier and the construction of a road which restricted tidal exchange. This led to an increase in soil salinity above the level tolerated by the seven species of mangrove found in this arid tropical setting. A similar situation has occurred in the study area where populations of the mangrove *Sonneratia* *caseolaris*[1] have shown a marked decline due to elevated salinity levels in the lagoon (see **Chapter 5**).

These ecosystems depend on specific qualities of water (salinity, nutrients, dissolved oxygen and suspended silt) and are easily affected by eutrophication, sedimentation, industrial effluent discharge, garbage dumping, inflow of sewage and other pollutants (Dugan, 1990; Mitsch & Gosselink, 1993; Williams, 1990). Similarly biotic communities in these wetlands are influenced by seasonal flooding regimes, water depth, nutrient inflow, and are inherently unstable (Orme, 1990; Adam, 1990). Many wetlands contain transient habitats representing a stage in ecological succession towards land formation or are deflected climax formations maintained by hydraulic agents such as tidal flooding and seasonal inundation. Aquatic communities in wetlands are thus differentiated by minor differences in hydrology and water quality. A small change in water levels caused by upstream hydrological engineering may have far-reaching consequences on the survival of plant and animal communities and on the productivity of the ecosystem (Davies & Claridge, 1993).

Human activities in and around coastal wetlands have direct and indirect impacts on erosion, accretion and water movements. Erosion may be encouraged by: removal of protective barriers, removal of wetland vegetation, direct removal of wetland sediment, reduction of sediment inputs and reclamation of land. In areas where erosion is naturally enhanced, such changes may be catastrophic. In the western Niger Delta, for example, deforestation of mangrove was found to contribute to erosion which was mainly caused by subsidence of the continental margin following oil and gas exploration (Ebisemiju, 1987; Moffat & Linden, 1995). Similarly wetland reclamation in the United Kingdom was dominantly for agriculture, but most recently land has been for industrial, urban and waste disposal uses (Adam, 1990; Doody, 1992).

Kamuladin (1993) illustrates the complex human impacts on wetland sedimentation in a study of the changes in mangrove shorelines in peninsular Malaysia. Surveys in this region reveal that net progradation occurred between 1914 and 1969, with accretion rates of 18-54m a^{-1} in some areas. A net increase of 26.7 km^2 of mangrove swamp resulted, which Kamuladin ascribes to extensive development of agriculture, especially sugar cane and tin mining. Agriculture and mining are assumed to increase sediments yields to rivers by increasing erosion. Similarly direct human interference with wetland sediments, as is the case with mariculture in mangrove swamps, has also been a common local source of disruption.

[1] See Table 5.2 for all nomenclatural authorities relating to mangrove plant taxa except for species which do not grow at Koggala where the authority is given in their first appearance in the text.

1.3 Environmental and Resource Management Problems of Coastal Areas

For the purposes of the present research, field visits were made to selected coastal wetland areas in Malaysia and Thailand, comparable with the main study site in Sri Lanka. The aim of this exercise was to assess the different impacts affecting coastal wetland areas in both these Southeast Asian countries, in an overall attempt to compare the problems of the study area with development problems broadly affecting Asian coasts. Drawing from this experience it was hoped that the study area could be observed from a wider international perspective.

1.3.1 Case Study 1: Malaysia

Peninsular Malaysia extends from latitude 1° 20' N to 6° 40' N and longitudinally from 99 $^{\circ}$ 35' E to 104 $^{\circ}$ 20'E and covers a total land area of 131,235 square kilometres. To the east, the country is bounded by the South China Sea; to the west by the Straits of Malacca and in the south by the Straits of Johor. The country as a whole has a coastline which extends to a total of 1,930 km.

Malaysian wetlands include freshwater and peat swamps, river and floodplain systems, lakes and open waters, rice fields, marshes, mangroves, *Melaleuca* forest and *Nipa* swamp forest. These have come under increasing pressure since the 1960's because of demands to convert them, as well as other lowland forested areas, into agricultural land (pers. comm. Louis, 1994) More recently, coastal areas have been developed for port expansion, urban and other settlements, as well as for tourist-related activities. The strategic location of wetlands in these relatively more accessible lowland sites has meant that even remnant wetland areas are being targeted for 'reclamation' prior to development (Dorrall, 1995). This general scenario also applies to the majority of wetlands in Sri Lanka and is common to the study area.

In 1966, there were some 1,076,670 hectares of wetlands in Peninsular Malaysia, but by 1974 these were reduced to 977,004 hectares (Said *et al.* 1992). In the past agriculture was the principal cause of wetland loss (Wong, 1979). Presently there are approximately 474,000 hectares of rice fields in Peninsular Malaysia (Department of Agriculture, 1989). Accelerated agricultural development was apparent in the 1970's onwards. Large agricultural schemes, including the IADP's (Integrated Agricultural Development Projects) have taken their toll on large areas of wetlands. By 1988, nearly 200,000 hectares of 474,000 hectares (approximately 40%) of rice fields in Peninsular Malaysia had been established under IADP's (Department of Agriculture, 1989). Apart from agricultural impacts, wetlands have been drained or filled in from time to time for the development of infrastructure, such as roads and highways, urban areas, and industry. Subsequently, more wetlands are degraded or lost through unsustainable timber logging, pollution, changes in hydrology and subsidence. Modern rice schemes, such as those in Sekinchan are extensive, and pose a serious environmental hazard in the form of agro-chemical pollution in adjacent wetland areas (Dinham, 1993; pers. comm. Abraham, 1994). In like manner agro-chemicals used in Koggala belong to some of the most toxic groups and present a potential threat (see **Chapter** 7).

Approximately 90% of the total extent of mangroves in Malaysia are distributed along the west coast where field visits were primarily conducted (see Figure 1.1). However since the 1960's, wetlands in this area have declined rapidly mainly as a result of reclamation for agricultural purposes (oil-palm, rice paddy, rubber) and industrial development. Now, of the original extent of mangrove, less than 50% remains (pers. comm. Salahudin, 1994). The 10117 ha Carey Island Oil Palm estate (Golden Hope Plantations) situated at the mouth of the *Sungai* Langat has replaced a large proportion of the mangrove in the Jugra reserve. In like manner, oil-palm mills in the district of Kuala Langat, pose a threat to mangroves from effluent discharge stemming from these mills. This has adversely affected riverine mangrove communities (pers. comm. Win, 1994).

It has been estimated that there are approximately 27,000 hectares of mangroves in the state of Selangor as a whole where field visits were conducted. The three major areas of importance are the Klang Islands, Kapar Forest Reserve and the Kuala Selangor Mangrove Forest. The Kuala Selangor Nature Park consists of approximately 320 hectares of mangrove forest situated directly in the outskirts of Kuala Selangor Town and is managed by the Malaysian Nature Society with funding from the Federal Government. The main impacts on the park include illegal logging and poaching (pers. comm. Rajan, 1994).

Probably the largest concentrations of mangrove in the state of Selangor are centred around the deltaic region of the *Sungai* Klang, the Klang islands (a group of seven mangrove-covered islands) and associated mudflats in the estuaries of the *Sungai* Klang and *Sungai* Langat. The entire mangrove ecosystem here maintains a rich fishery which supports a fishing village community, including several cage-culture communities (see Figure 1.2). However, largely as a result of a land shortage for industrial development in the state of Selangor as a whole, existing mangrove areas are rapidly being reclaimed and converted to other uses including tourist locations (pers. comm. Sasekumar, 1994). Land shortage for industrial development,

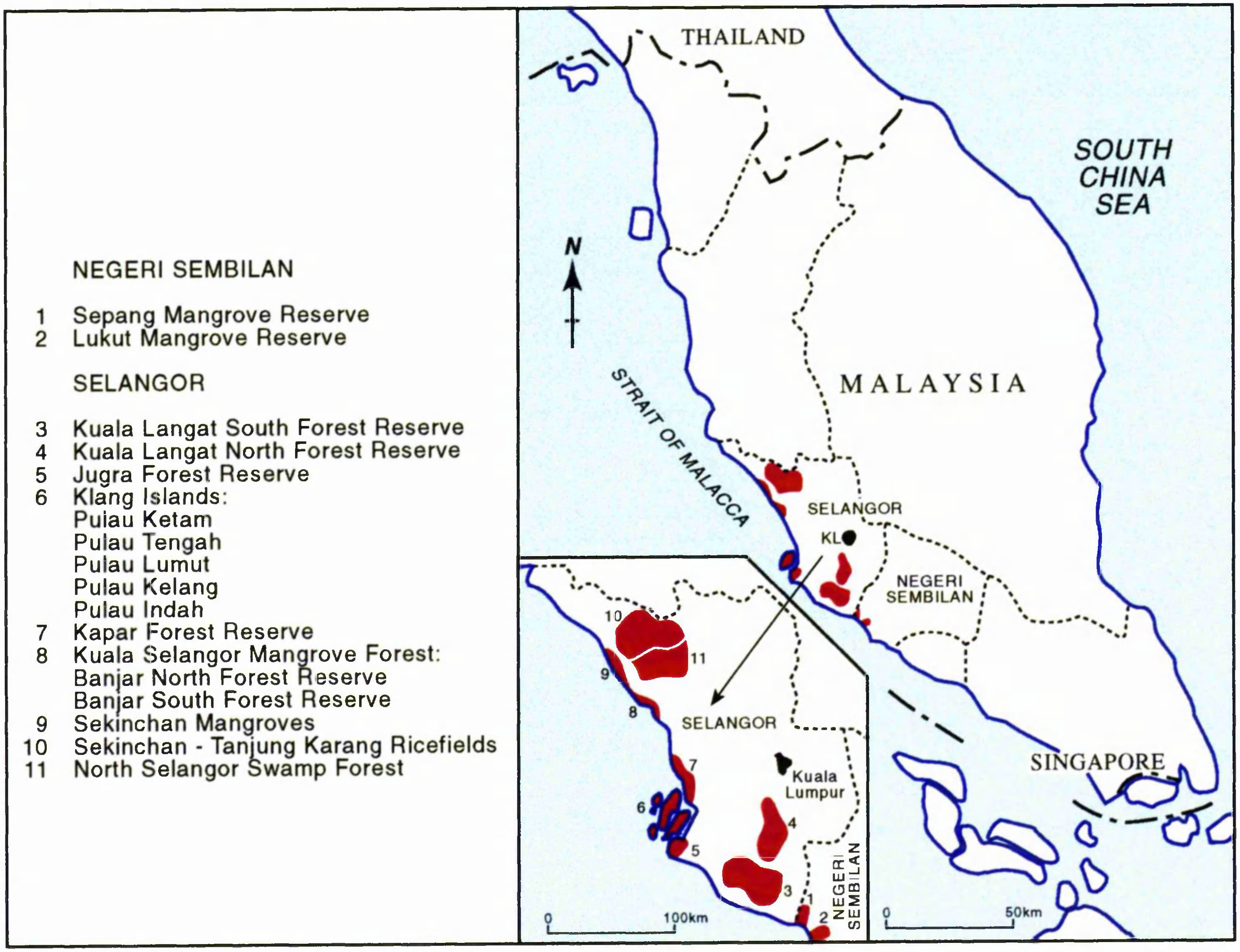


Figure 1.1 Map showing the location of Wetland Sites visited in Peninsular Malaysia

A:Cage culture in the Sungai Klang, Selangor - Malaysia.

B: Floating pens, Sungai Klang, Selangor - Malaysia.

Figure 1.2 Fishing community, Sungai Klang, Malaysia.
(Source: October 1995, V.N. Samarasekara)

particularly along the Southwest coast of Sri Lanka where the study area is situated is also an issue. This is a contributing factor for recent industrial developments which have resulted in the reclamation of significant areas of the fringing mangrove complex in Koggala to make way for a Free Trade Zone - the Koggala Export Processing Zone (KEPZ).

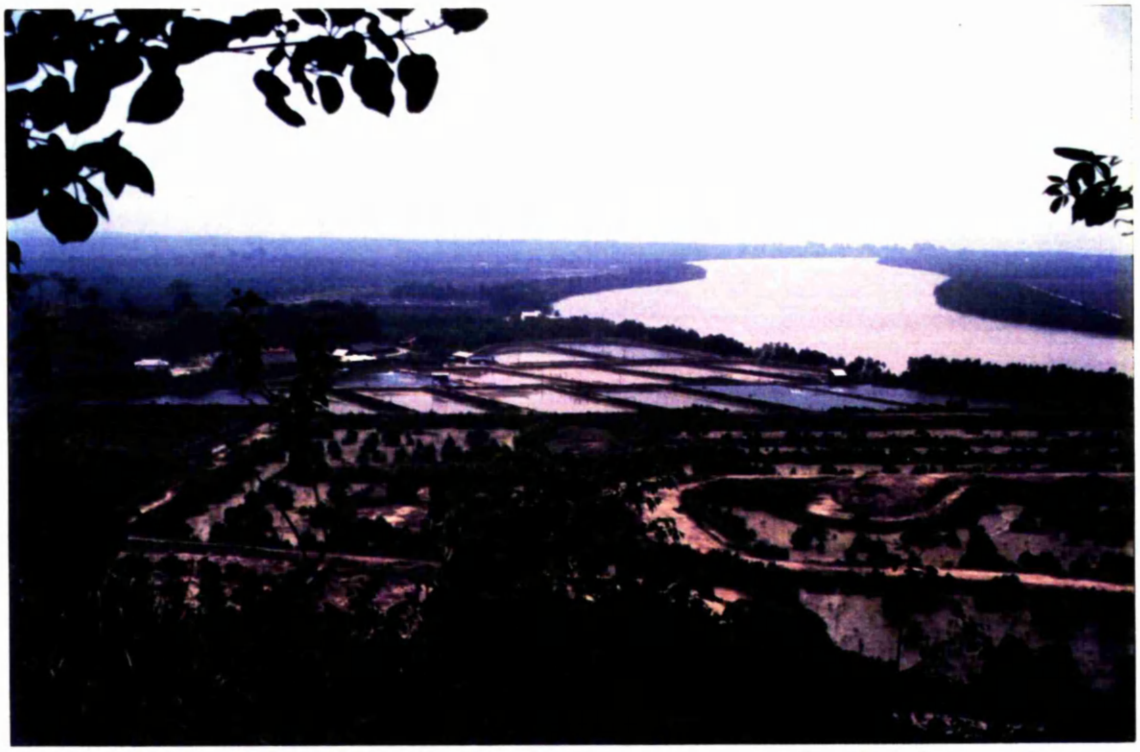
Port Klang presents a clear example of the impacts on wetland resources of increased industrialisation and urbanisation, which, as mentioned above, are very significant in the state of Selangor. Recently the Port Authority has expressed an interest in further developing the Port as a major tourist attraction (Selva, 1993). For this purpose Pulau Indah has been cleared for agriculture, housing development (Selva, 1994) and proposed extensions to Port Klang including a bridge connecting this island to Pulau Lumut. Developments are presently underway to re-locate all petroleum and chemical-based industries, including those handling dangerous goods, from Port Klang to Pulau Indah (*The New Straits Times*, 1992). Extensive plans to develop Pulau Ketam, including plans to build a golf course and tourist resort are presently underway and involve large-scale clearing and destruction of the mangrove community there (Miranda, 1992; *The Malay Mail*, 1992; Selva, 1992a;1992b; *The Star*, 1994). Accelerated development on the coastal areas of Selangor, adjacent to Port Klang, implies that more mangrove will be destroyed in the future (pers. comm. D'Cruz, 1994). Correspondingly the establishment of the KEPZ in the study area has resulted in accelerated development in adjacent areas with the result that further mangrove areas are being cleared.

Approximately 24,000 hectares of Selangor mangroves are under forest reserves, but the fate of some 3,000 hectares of state land mangroves is uncertain. In addition to this there are over 300 hectares of aquaculture ponds in Selangor, mostly located in previously productive mangrove areas. Although it has suffered considerable degradation and reduction in size, the Kapar Forest Reserve is the largest remaining mangrove forest in mainland Selangor. This whole area, together with the Klang islands, contribute significantly to Selangor's marine fish harvest by providing essential breeding and nursery areas for prawns, fish and cockles. Since about 60% of the total fishing force for Selangor is deployed in the Klang Strait-*Angsa* Bank waters, it is assumed that at least 50% of the total catch for Selangor is derived here (pers. comm. Khan, 1994). A proposal to establish an industrial park on this reserve somewhat similar to the KEPZ in the study area will ultimately mean the destruction of all that remains of the Kapar Forest Reserve (*Utusan Konsumer*, 1992a;1992b).

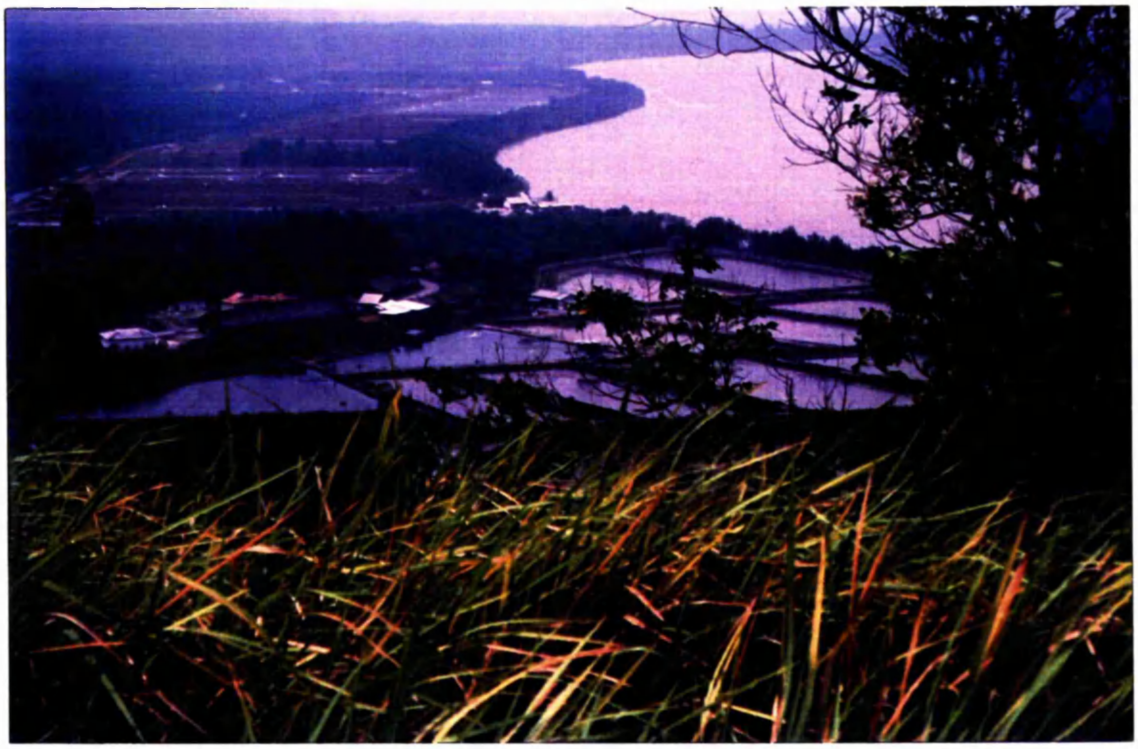
A: Clearing of mangrove prior to pond construction for shrimp culture in Telok Panglima Garang, Selangor - Malaysia.

B: Newly constructed pond for shrimp culture in Telok Panglima Garang, Selangor - Malaysia.

Figure 1.3 Shrimp aquaculture in Telok Panglima Garang, Selangor - Malaysia. (Source: August 1994, V.N. Samarasekara).



A: Mangrove areas cleared for agricultural purposes (foreground) and shrimp pond construction (background).



B: Rapid spread of aquaculture has resulted in extensive clearance of the Jugra mangrove reserve.

Figure 1.4 Impact of development on fringing mangrove of Sungai Klang, Telok Panglima Karang, Selangor - Malaysia. Viewed from the Jugra Lighthouse.
(Source: August 1994, V.N. Samarasekara)

In recent years, mainly as a result of the high market demand for prawns, both overseas and locally, aquaculture has grown in importance and is now a rapidly expanding industry. Consequently there is an ever-increasing demand for mangrove areas to establish ponds (see Figure 1.3). In 1990, there were over 4,000 hectares of aquaculture ponds in Peninsular Malaysia, most of which were established in previously productive mangrove areas (Said *et al.* 1992). Figure 1.4 shows the impact of such development along the Sungai Langat which has destroyed large areas of the Jugra mangrove reserve. The rapid growth of this industry is further demonstrated in the Lukut Mangrove Reserve where 541 ha of mangrove forest have been designated for brackish water aquaculture (pers. comm. Khan, 1994).

However, due to the acid-sulphate nature of mangrove soils, pond operations which are usually of the semi-intensive type are abandoned after a few years (Chua, 1993; Chua *et al.* 1989; Koon & Jin-Eong, 1988; Ruddle, 1993). Unfortunately, the abandoned areas are unsuitable for other agricultural uses, and the land is more often than not left idle (pers. comm. Sasekumar, 1994). Moreover, semi-intensive aquaculture requires the use of large quantities of chemicals to control the incidence of disease. After harvesting the shrimp, the water remaining in the ponds cannot be used again and is channelled out, untreated, into the surrounding mangrove forest, and replaced with a new supply. This causes pollution and, ultimately, destruction of the mangroves in the area adjacent to the ponds. In Telok the extent of aquaculture ponds is rapidly rising and as a result of effluent discharge the extent of the mangrove in this area is steadily decreasing.

Other noteworthy impacts on mangroves include garbage dumping directly in such areas or in sites adjacent to them. Examples are observed in the Jugra reserve and this problem is also common to Koggala. Recently effluents stemming from pig farms which are discharged into mangrove areas are a threat. The Bukit Pelandok Pig Farms (see Figure 1.5) which comprise the largest collection of pig farms in the state of Selangor are discharging untreated effluent into rivers and streams and adjacent mangrove areas. The ill effects of this are evident in the Sepang mangrove reserve. Pollution problems associated with effluents from pig farms have been recognised as a problem by the Department of the Environment and some steps have been undertaken in an attempt to curb these activities, such as providing abattoir services only to farmers having waste treatment facilities (*The Star*, 1994).

As is the case in Malaysia as a whole, agricultural conversion and logging have been the main causes of the rapid disappearance of the peat swamps in the state of Selangor where field visits

A: Bukit Pelandok pig farms, Selangor - Malaysia.

B: Effluents from pig farms pose a threat to adjacent mangrove areas in Sepang, Selangor - Malaysia.

Figure 1.5 Impact of pig farming on mangrove environments in Selangor, Malaysia. (Source: August 1994, V.N. Samarasekara)

were made. Visits to the districts of Sepang, Kuala Langat, Kuala Selangor and Sabak Bernam confirmed this. Apparently, at the beginning of this century, these districts had consisted of vast tracts of peat swamp forest (Abdul *et al.* 1989; Appanah *et al.* 1989). The largest block of peat swamp forest is in North Selangor where some 72,000 hectares have been recently gazetted (1990) as forest reserves, namely the Sungai Karang Forest Reserve (36,665 ha) and the Raja Mus Forest Reserve (36,161 ha). Most of these forests would have been cleared for development if not for active conservation efforts by concerned bodies.

The North Selangor Peat Swamp Forest plays a critical role in the hydrology of the area, reducing local flooding and acting as an important water supply to the nearby Sekinchan Rice Scheme. However the area is seriously threatened by over-exploitation and reclamation for agriculture. The extent of the rice fields within the Sekinchan rice scheme would have continued further into the peat swamp forest but for the fact that existing technology cannot drain the peat soil in these areas which extends to depths of approximately 45 metres (pers. comm. Rajasingham, 1994). Nevertheless much of this swamp forest has already been extensively logged. In the south-eastern corner, an area of about 3,600 ha is covered by extant mining leases. There has also been extensive clearance of the area north of the Sungai Besar-Tanjung Malim road for a pineapple plantation which had to be abandoned due to serious water-logged conditions.

Large peat swamp areas in the southern part of the state, lying mainly between Sungai Kelang and Sungai Sepang, have already been replaced with oil palm. The entire area was once a block of peat swamp forest within the Telok, Kuala Langat North and South forest reserves. At present, the Telok Forest reserve no longer exists. Agricultural conversion as part of Malaysia's 'Green Revolution' (*Projeck Revolusi Hijau*) has resulted in extensive tracts of this reserve being cleared and replanted mainly with oil palm and rubber. In other areas significant portions of the reserve have been cleared for the establishment of a Free Trade Zone (*Telok Panglima Garang*) in the 1970's and, more recently, low-cost housing, which have both reduced the extent of the riverine mangrove. Similarly the Kuala Langat North forest reserve has been reduced from 5,865 hectares to 1,572 hectares, and Kuala Langat South Forest Reserve from 12,414 hectares to a mere 1,766 ha over the last decade (Said *et al.* 1992). Plans to develop an international airport within the Sepang district will more than likely mean that the remaining peat swamp forest will be unable to withstand this development.

Field visits conducted in Malaysia thus reveal that Sri Lanka as a whole, and the study area in particular, share a number of common impacts on wetland areas. The most notable include conversion of mangrove areas for industrialisation, urbanisation and agriculture.

1.3.2 Case Study 2: Thailand

Field visits in Thailand were primarily to two main sites: the coastal province of Samut Songkhram located on the Mae Klong river, approximately 64 km Southwest of Bangkok, and Pak Phanang Bay in Nakhon Si Thammarat Province located on the eastern side of Thailand's southern isthmus.

Southern Thailand has a coastline of approximately 2600 km. Throughout this region there has been a rapid increase in the loss and decline of coastal resources. This is largely a consequence of the growth in tourism, fisheries, port development and shrimp farming, which is more evident here than in other parts of Thailand (pers. comm. Hussain, 1994). In addition, economic growth experienced in the country as a whole, together with increasing population pressure, have resulted in large-scale destruction of the mangrove environment, loss of fishery resources and pollution problems (Srichai *et al.* 1994).

In the early 1900's Pak Phanang was one of the most prosperous regions in the south of Thailand. Traditionally rice, which covered much of the lowland areas, had been the staple crop. However, modernisation brought changing land use and increased demand for the natural resources in the region. Deforestation, rapid industrialisation and conversion to high intensity farming and double-cropping as a part of the 'Green Revolution' (Coastal Resources Institute, 1991) generated a series of environmental problems in Pak Phanang.

Following a series of typhoons in the 1960's, which destroyed farming lands, local residents turned to shrimp farms most of which were developed as a means of income in mangrove forests and rice fields. However, this rapidly expanding industry bought with it many environmental and social problems. With present intensive techniques, each pond is effective for an average of five years before its productivity is cut by infection or other difficulties, after which period a pond is abandoned (see Figure 1.6) (pers. comm. Pantanahiran, 1994). In addition sludge from the shrimp farms is released into canals, polluting existing rice paddies and is diverted into surrounding mangrove areas (see Figure 1.7) which, according to Forestry officials, has caused significant die-back. Saltwater supply to the shrimp ponds is facilitated through the use of inland canals and this has caused problems with saltwater intrusion into the

A: Abandoned shrimp pond due to infection.

B: Shrimp pond cleaned prior to re-stocking.

Figure 1.6 Shrimp aquaculture in Pak Phanang, Thailand.
(Source: September 1994, V.N. Samarasekara)

A: Effluent from shrimp ponds is directed into adjacent mangrove areas.

B: Shrimp pond effluent consisting of thick sludge, adheres to mangrove roots causing eventual death.

Figure 1.7 Impact of shrimp aquaculture effluent discharged into mangrove, Pak Phanang, Thailand (Source: September, 1994, V.N. Samarasekara).

freshwater systems affecting local supplies of drinking water and also supply to the rice fields. The use of agro-chemicals as part of the intensive farming techniques employed have similarly contributed to the loss of freshwater supplies in this area (Boromthanarat *et al.* 1994).

Presently, the central issues in Pak Phanang revolve around conflicts between differing economic activities, pollution and degradation of the mangrove and surrounding wetland areas. These issues are also common to the study area. Freshwater, productive land and the assimilative capacity of the environment were initially perceived as unlimited. However the limitations of land and water resources have become evident since farmers and shrimp producers started to compete for finite water and land resources. Pollution of surface water by effluent from shrimp ponds and the consequent increasing salinisation have created a range of adverse effects: rice fields are poisoned, birds and freshwater fish are killed and drinking water has deteriorated (Boromthanarat, 1995). Resource-user conflicts are an issue in Pak Phanang between shrimp farmers and traditional rice farmers. Such conflicts are also being experienced in Koggala between the fishing and the farming communities.

Environmental conditions continue to decline as a result of shrimp-farming activities. Marine life and water conditions are affected by shrimp-farm effluents, and by domestic and industrial water contamination. Mangrove forests are being deforested for timber and shrimp-farm development. Saltwater is intruding inland by river or channel systems, floodplains or groundwater. This further degrades the aquaculture and fisheries resources. At present a clean domestic water supply is becoming difficult to obtain. The whole scenario cannot be blamed on shrimp farming alone; rather the entire approach to comprehensive resource management and land-use planning has been at fault (pers. comm. Boromthanarat, 1994).

Correspondingly in Samut Songkhram, the main impacts on wetland areas including mangrove forests are extensive shrimp farming and large-scale conversion to salt pans (pers. comm. Dilokwanich, 1994). Samut Songkhram, Phetchburi and Samut Sakhorn are the biggest salt producers in Thailand as a whole. Shrimp farming is steadily declining in Samut Songkhram and is no longer as extensive as in parts of the south of Thailand, largely as a result of problems associated with disease and water quality.

1.3.3 Summary of Key Themes

Field visits conducted in Thailand and Malaysia further illustrate the importance of coastal resources and more significantly the rapid rate at which they are being destroyed primarily for short-term economic gains. Coastal wetland areas in these two countries are being subjected to increasing population and economic pressures manifested by a variety of coastal activities, notably coastal aquaculture, waste disposal, salt-making and industrialisation. The accelerated rate of development in Malaysia and rapid economic growth of the country as a whole has resulted in increasing pressure to exploit coastal resources beyond sustainable limits. As a result key coastal resources are being destroyed in the face of new development. Indiscriminate logging and cutting of mangrove for aquaculture and other activities has brought temporary gains in terms of fish production, but losses in nursery areas of commercially important fish and shrimp, coastal erosion and land accretion. The same is true for Thailand where most notably the expansion of intensive shrimp farming, particularly in parts of the south, has meant that key mangrove resources and rice paddies are increasingly being converted to shrimp ponds which has also had the effect of causing conflicts between different resource user groups.

The situation in Sri Lanka is not very different from these two examples, and the study area shares a number of common features with the current situation in Malaysia and Thailand, where the pressures of accelerated development have adversely affected wetland areas. Though admittedly not as developed as in Thailand and other countries in South east Asia, the shrimp farming industry is rapidly gaining increasing importance, and together with industrial developments concentrated particularly in the southern coastal parts of the island where the study area is located, there has been a growing tendency to exploit coastal resources beyond sustainable limits.

1.4 Coastal Resources Management in South and Southeast Asia

Prevailing management approaches in this region have been criticised for failing to consider the interrelated nature of upland, coastal and marine ecosystems (Chua, 1991; Chua & Garces, 1994) and the dependence of local communities on wetlands for immediate resource needs (Maltby, 1989; Tobin & White, 1993). More significantly there has been a general lack of understanding of the underlying causes of environmental stress by policy makers and resource managers. As a result, uni-sectoral management strategies still prevail in the management of coastal resources. According to Chua (1991:162) this may be due to a number of reasons, "including the lack of implementable management strategies to resolve current and immediate environmental problems, inadequate databases for multi-sectoral plan formulation, and mounting economic pressures as well as the irresistible political force for the economic development of the rural coastal areas."

In the last decade some progress has been made. The six countries in the ASEAN region are attempting to minimise resource-use conflicts through developing reconciliatory management options that can be accepted by most users of the resources (Valencia, 1991; White, 1985). The development of site-specific integrated coastal resources management plans have shown some success. Examples of such initiatives in Indonesia are described by Sloan and Sughandhy (1994) and Sloan (1995). Specific plans to maintain the ecological functions of the Segara Anakan Lagoon in Central Java, Indonesia, are described in White *et al.* 1989; ASEAN/US Coastal Resources Management Project 1992.

Other coastal resources management efforts are currently being attempted for Jakarta Bay and the Straits Of Malacca (Burbridge *et al.* 1988). More recently, broad-based coastal management training programmes have been initiated in the Philippines to address the problems of lack of expertise in planning and implementation in the country (McManus, 1995). Integrated management plans for Ban Don Bay and Phangnga Bay in Thailand (ONEB-MTSE, 1992), Brunei Darussalam (Chua *et al.* 1987; Department of Fisheries *et al.* 1992); Singapore's urban coastal area (Chia, 1992); the Lingayen Gulf (National Economic Development Authority, 1992) and South Johor, Malaysia (MCRST *et al.* 1992) are currently in action.

Similarly in South Asia, recent initiatives in the development of coastal management plans have been undertaken in the Maldives (Shepherd, 1995). In India, initiatives have been undertaken on the Tuticorin coast to prevent and manage coastal pollution (Santhanam & Venkataramanujam, 1995). The current status of conservation and environmental management actions for the South Asian Seas region are summarised in a series of IUCN reports. Relevant issues for Pakistan are described in Pernetta, 1993d; Sri Lanka, Pernetta, 1993e; India, Pernetta, 1993b; Maldives, Pernetta, 1993c and Bangladesh, Pernetta, 1993a. Recent initiatives in Sri Lanka are described in Section **9.4.1.**

The associated problems of coastal resources use in developing nations are complex (see **Chapter 2**). However to achieve the fundamental aims of coastal resources management the reconciliation of resource user conflicts should be guided by the principle of sustainable development. To achieve this the co-operation and participation of local communities in such programmes are essential to their success. However this aspect appears not to have received the emphasis warranted in existing wetland management plans which should be integrated into rural area development strategies in which traditional resource-use rights can co-exist with government-sponsored economic and socio-economic plans.

Effective management cannot proceed through science, socio-economics or politics alone. Solutions to problems and issues are seldom straightforward and they normally require an integrated approach. Examples from the South and Southeast Asian region demonstrate this point clearly. Since a fundamental objective of resource planners and managers is sustainable development, this implies forms of development aimed at enhancing the contribution to human welfare. It involves participation, not just from government agencies and NGO's, but from all sectors of society. In recognising the complexities inherent in natural systems clearly a more interdisciplinary and integrative approach is required (Price *et al.* 1992). The case for an integrated approach in wetland management using local communities will be discussed using the experience of Koggala Lagoon as an example in **Chapter 9**.

1.5 Aims of Thesis

The aim of this thesis is to assess the interrelationships between environmental change and local perceptions of this change in communities living in six sample divisions located on the borders of Koggala Lagoon, a coastal wetland in south Sri Lanka. The relevant background for this study is the context of environmental and resource management problems associated with development activities affecting Asian coasts which have just been described.

A key objective of the research was to identify the most significant environmental changes affecting the study area in the recent past, and the effects such changes have had on the fishing and farming communities living on the borders of the lagoon. An attempt was made to analyse the past and current role of these two communities in relation to environmental changes in the area. By comparing their present position with times past an attempt was made to discover the degree to which changes in the natural environment have in turn affected them and the various adaptations they have had to make in the light of some of these changes. The decision to assess the nature of environmental change and its interrelationships with economic and social change amongst the two communities necessitated an interdisciplinary approach drawing from both the physical and social sciences. A strong emphasis throughout the research was placed on participatory approaches involving local communities. This was an intrinsic part of the research.

Using the group discussion as a research tool, the interrelationships between environmental change and local perceptions were used as a basis on which local-level adaptive planning by local communities could be initiated. The use of the discussion group in this instance is seen as a novel approach in the developing world and its relevance for wetland management programmes, particularly in Asia, is developed. It should be noted that the use of group discussions has been extensive in the field of social sciences (Banks, 1957; Burgess *et al.* 1988; Harrison & Burgess, 1994; Morgan, 1988) and especially in rural development projects (Bhadhuri & Rahman, 1982; Burkey, 1993; Cernea, 1985; Chambers, 1983; Chambers, 1992; Farrington & Adrienne, 1988; Hall, 1986; Midgley, 1986; Mukherjee, 1992; Pausewang, 1987; Scoones & McCracken, 1989; Tilakaratna, 1991; United Nations, 1990; Wickremarachchi, 1991; Wignaraja, 1991; Whyte, 1991; Verhagen, 1986). By contrast, in wetland management projects, particularly in the Asian region, it has been largely neglected. This is in spite of the significant headway being made in participatory approaches to wetland management in Asia (see **Chapter 9**).

The thesis is divided into three sections. In **Chapters 1-3** the relevant research context and general background are surveyed. Using examples derived from field visits conducted in Thailand and Malaysia, **Chapter 1** has provided an international perspective on the study area.

Chapter 2 deals specifically with environmental and development problems associated with coastal resources in South and Southeast Asia, illustrating the universality of coastal problems experienced in the study area and those in South and Southeast Asia more generally. **Chapter 3** examines the geographical setting of the research site and presents reasons for its selection. This chapter also provides the reader with a summary of the key themes of the research and in so doing contextualises the study.

By contrast, **Chapter 4** focuses on the choice and explanation of the main research techniques employed during the study.

Chapters 5-8 illustrate the major research findings. Evidence for the nature and extent of environmental change in the study area is given in **Chapter 5** and individual case studies of the farming and fishing communities are presented in **Chapters 6** and **7** respectively. **Chapter 8** is concerned with an analysis of group perceptions to environmental change.

Finally **Chapter 9** presents a brief summary of the findings and the major conclusions drawn. Based on these findings and on discussion groups conducted in the sample six divisions, preliminary recommendations for the sustainable management of the lagoon are presented.

CHAPTER 2
COASTAL RESOURCES IN SOUTH AND SOUTH EAST ASIA - A REVIEW OF CURRENT ISSUES

2.1 Introduction

It is the aim of this chapter to outline the current state and development of wetland ecosystems in South and South East Asia. It will address the causes and manifestations of environmental problems associated with development activities on Asian coasts which have important ecological, economic and social consequences. For this purpose attention will be primarily focused on wetlands situated in coastal areas comparable to the study site. Current patterns of utilisation and activities will be highlighted, with an emphasis on those which are proving unsustainable. Special reference will be made to the situation in Sri Lanka, the country of the present study. Individual case studies from Malaysia and Thailand, where field visits were made during the research period (for comparative study purposes), have already been presented in **Chapter 1**.

Section **2.2** of this chapter will summarise key environmental issues relating to coastal environments, setting the scene for further discussion. Section **2.3** will provide a general introduction to wetlands, illustrating the wide diversity of wetland types, and the extent and distribution of this ecosystem in Asia. Following this, Section **2.4** will highlight the values of wetlands, and, using the mangrove ecosystem and its associated resources as an example, will demonstrate the importance of this wetland type for local communities. An overview of the present status of wetlands in Asia will be made in Section **2.5** and particular reference will be made to key coastal resources using case studies of coral reefs (Section **2.6**) and mangroves (Section **2.7**). Finally, Sections **2.8** and **2.9** will provide an introduction to wetland ecosystems in Sri Lanka and their associated values, in an attempt to contextualise the study area in relation to similar environments in Sri Lanka and problems affecting them.

This review will illustrate that more people than ever before are now dependent upon coastal areas for their livelihoods, and, as a result, pressures on South and Southeast Asian coastal resources are severe. Using key examples derived from both field surveys and existing literature obtained throughout the research period in Sri Lanka, Thailand and Malaysia, this review will illustrate that the problems of natural resources depletion and environmental degradation in the coastal sector, factors which are reflected in the study area, are becoming serious issues in most South and Southeast Asian countries. Moreover it will demonstrate that the combined affects of these changes to the environment are reducing the quality of life and health of local communities, especially the rural poor.

2.2 Coastal Environmental Issues of South and Southeast Asia

The coastal zones of South and Southeast Asia are endowed with a tropical climate, productive ecosystems, and rich renewable resources. Approximately half the world's coral reefs lie in these regions with an estimated 182,000 km^2 in Southeast Asia alone and a further 146,000 km^2 in the Indian Ocean (Smith, 1978; Wells, 1993). In addition to this, 12 per cent of the world's mangroves (White, 1985) are found in South east Asia. According to Chua (1991) the Southeast Asian region produces about 8.4 million tonnes of fish, or ten percent of world production; provides employment for not less than 2.5 million fishermen; supplies fish protein to almost all coastal inhabitants; and generates an export trade of close to US$ 1 billion per year. Oil and natural gas, which have become the mainstay of the economies of Brunei Darussalam, Indonesia and Malaysia, will continue to be an important focus of economic activities in these nations.

The problems faced by most South and Southeast Asian nations with respect to the use of coastal resources are somewhat similar to those confronting the developed nations in terms of dwindling renewable resources and environmental degradation, but differ immensely in severity. The Second World War left behind shattered economies, and the abundant natural resources in the region became the main-stay of most economies. Post-war reconstruction and economic expansion encouraged large-scale and indiscriminate exploitation of natural resources which were considered a steady source of raw materials for the industrial development of colonial powers. Hence between the 1940's -1960's, national policies in most Southeast Asian nations were based on large-scale exploitation of natural resources (Chua & Garces, 1994).This pattern is especially relevant to Sri Lanka, where since Independence in 1948, coastal settlements have grown in size and economic importance, particularly in the south, southwest (where the study area is located) and west of the island. Fishing, tourism, industry and agriculture, sustain the growing economy in this region (Olsen *et al.* 1992; Burns, 1994).

The human population in Southeast Asia, of which a large percentage is concentrated along the coast, has increased two-fold over the last half century (Chua, 1991). Most of the region's main cities and towns are located within the coastal zone, and over 70% of it's population is estimated to be presently concentrated in coastal settlements (Chou, 1994a,b). Towards the 1980's rapid industrialisation in some countries in the region was towards marine transportation, oil exploration, manufacturing and service. These caused pollution in the form of industrial, agricultural and domestic waste discharges which enter river systems and coastal waters, thus impairing the life support systems in the marine environment (Chua *et al.* 1989).

Similarly in South Asia, population density is high, averaging almost 200 people km^{-2} with population densities along the coastline approaching 400-500 km^{-2}. The state of Kerala, for example, in the south-west tip of India, has one of the highest population densities in the country. However, the density of the fishing population along the coast is twice that of the rest of Kerala, at around 1,000 people km^{-2}. (Hinrichsen, 1990). Correspondingly demographic pressure on the coastal region in Sri Lanka is probably the most crucial factor when considering the main impacts in this area. At present, the southern coastal area has a population density of 450 persons km^{-2}, compared to 260 persons in the country as a whole (see Figure 2.1). By the year 2001, the population density on the south coast is expected to rise to about 1,000 persons km^{-2} (Korale, 1992).

Furthermore, the coastal region of Sri Lanka, defined as the 67 divisions of the Assistant Government Agents (AGA) with a coastal boundary (Olsen *et al.*1992) (see Figure 2.1), contains 24% of the total land area and 32% of the population of the country, and contributes about 40% of the nation's gross domestic product (Sauvundranayagam *et al.* 1993). It covers approximately 65% of the urbanised land area and units producing two thirds of the total output of organised (factory) industry. The nation's principal transportation infrastructure and approximately 80% of the tourism-related infrastructure and sites are located here (Olsen *et al.* 1992). Development activities in Sri Lanka that have major implications for coastal areas and resources include the expanding tourist industry, rapid housing development, expansion of infrastructural facilities, industrialisation, expansion of urban centres and more recently aquaculture projects. In the case of tourism it should be noted that about 85% of tourist revenues come from facilities in coastal areas. Today over 75% of graded hotels and over 80% of the hotel rooms are located along the coast (Seneviratne, 1991; Burns, 1994).

The growth in coastal populations in the South and Southeast Asian region is exceeding the rate of growth of the total world population mainly as a consequence of migration to coastal areas (Meiyue & Mulley, 1994; Pernetta & Elder, 1993). Such coastal migration is particularly high in some developing countries, such as the Maldives, where the drift to coastal urban areas is associated with the search for employment, education, health care and other services. The capacity of the coastal environment to support such dense aggregations of people is severely

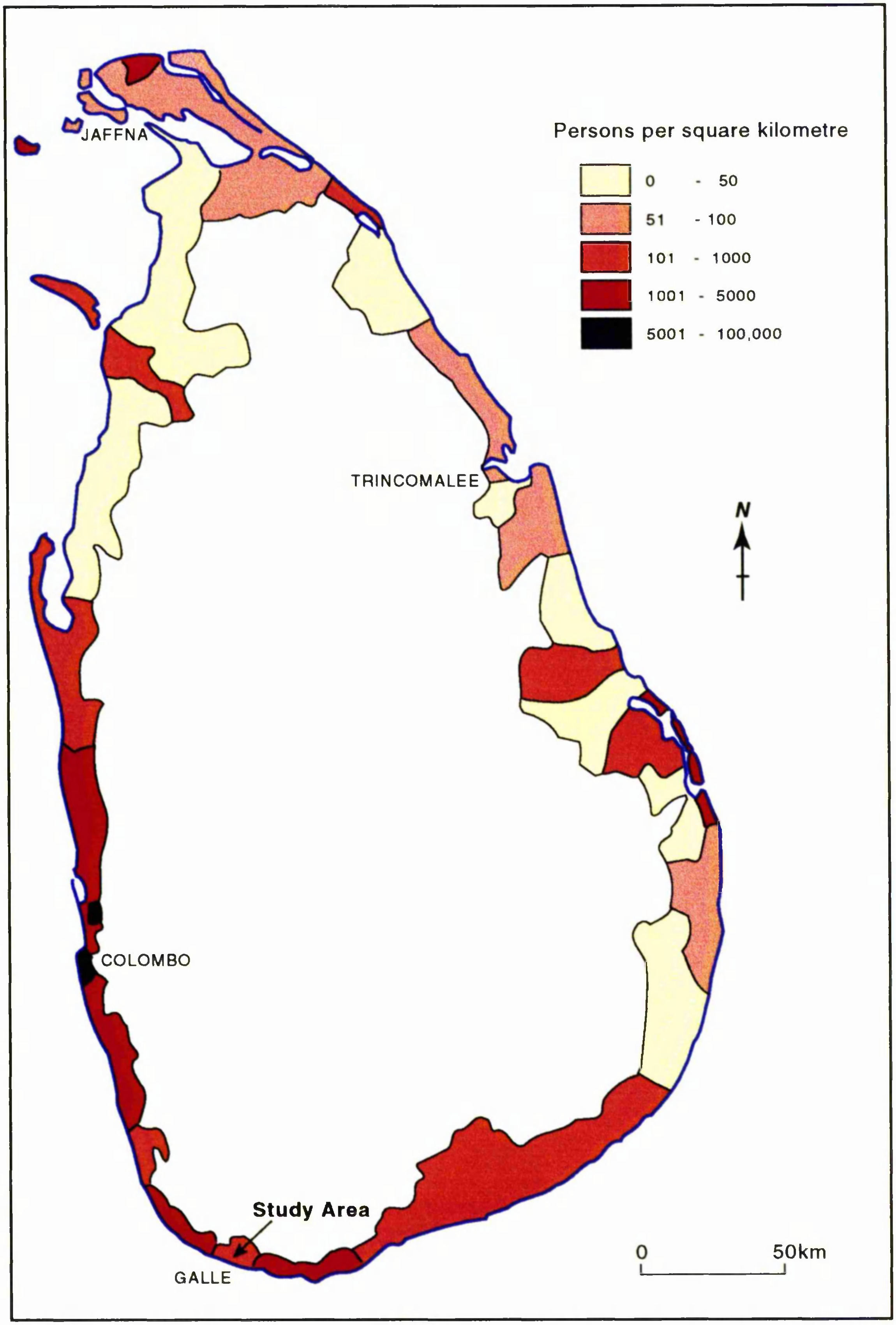


Figure 2.1 Population Density in the Coastal AGA Divisions, 1981
(Survey Dept. of Sri Lanka, 1988)

strained and in many instances grossly exceeded, resulting in severe environmental degradation (Linden, 1990; Pernetta, 1993c; UNEP, 1986b).

The threat of rising sea-levels also has major implications for coastal areas (Broadus, 1993; Flather & Khandker, 1993; Leatherman, 1989 and Woodroffe, 1990; Reed, 1990). The consequences of sea-level rise in this region include increased frequency and extent of flooding; rearrangement of unconsolidated coastal sediments and soils; increased soil salinity; changed wave climates; accelerated dune and beach erosion; changes to bank and wetland vegetation and changes in coastal water clarity. Such changes have severe repercussions. For example, changes in nutrient levels in coastal waters will alter marine-based primary productivity and may alter the frequency of harmful algal blooms impacting fish and shellfish resources. In some cases environmentally un-sound development will also increase susceptibility to predicted global climatic changes in this area. The widespread conversion of mangrove ecosystems to other uses, such as mariculture for example, seriously reduces coastal protection against storm and wave erosion. In spite of this, in many coastal areas, in this region, potential impacts of climatic change and sea-level rise are overshadowed by existing environmental problems (Pernetta & Elder, 1992; Pernetta & Elder, 1993).

Throughout South Asia urban areas are expanding. The region's largest cities are all located on or near the coasts: Karachi, Bombay, Mangalore; Madras; Vishakapatnam; Calcutta; Dhaka; Chittagong and Colombo. In a like manner the majority of South East Asia's cities and villages are coastal and it is here and in South Asia where sheer numbers are overwhelming coastal resources (Hinrichsen, 1990; Hardoy *et al.* 1992). In Sri Lanka, as urbanisation has followed the main road and rail lines that skirt the coast, competition for coastal land has pushed the poorest of the fisher families virtually on to the beach edge where they live in fragile huts made of plaited coconut leaves (*cadjan*). Competition for land is so severe that some have even erected their huts on the revetments built for coast conservation purposes (Tampoe, 1988).

The following review will illustrate that the reliance on coastal areas throughout South and Southeast Asia has reached an unprecedented scale as people are increasingly dependent on such areas for their livelihoods: for fishing, mariculture, forestry, building materials, agriculture and tourism (Bunpapong, 1989; De Alwis, 1993; Domroes, 1993; Smith, 1994; Tolba & El-Kholy, 1992; UNDP/WTO, 1993; Wong, 1993). As a result, pressures on coastal resources are large. Mangrove forests are being exploited on a large scale for firewood, tannins and timber, and are also being converted into brackish-water fish and shrimp ponds. Coral reefs are being adversely affected by sedimentation due to coastal construction, soil erosion and dredging of harbours. In the study area, a significant human population is directly dependent upon the fishery stocks in the lagoon and associated sea for employment and income. During the recent past, however, the multiple services of this wetland system have expanded with increasing urbanisation and industrialisation of the area which are undermining the ability of the ecosystem to support its multiple uses. With the added pressure of increasing population pressure, competition over limited resources is more keen and signs of depletion are becoming more evident.

Environmental quality has also been greatly affected by activities in the coastal zone. Water pollution is widespread. In addition most of the urban centres in the region are not fully equipped with sewage treatment facilities and as a result many canals, rivers and streams have become open sewers and drain directly into the nearby bays, lagoons and coastal waters. Pesticides are widely misused and freely enter water systems, thus threatening rural and urban consumers (Chua, 1991; Hay *et al.* 1994).

Although coastlines everywhere are suffering from an influx of people accompanied by resource degradation, the extent of this is qualitatively and quantitatively different between North and South. Coastal zones in the developed, northern countries suffer more from untreated industrial and municipal wastes than from indirect effects of runaway population growth. Furthermore, the rich countries may have the capital and technology to control pollution of coastal waters (Hinrichsen, 1990).

Another aspect of coastal degradation and pollution is related to the fact that coastlines pay the ultimate price for mismanagement of the land. Watersheds denuded of forest quickly erode. Sediment is washed out of the hills and transported to the coasts via rivers and streams, where it smothers estuaries and coral reefs depleting fisheries. The River Ganges, for example, drains an area of just over one million km^2 of intensively worked farmland and heavily harvested forestland and delivers 1.46 billion t yr^{-1} of sediment to the Bay of Bengal (Hinrichsen, 1990). Similarly annual deforestation of about 40,000 ha in Sri Lanka as a result of clearing for agriculture has resulted in soil erosion which is causing accelerated sedimentation of inshore marine and lagoonal habitats (Baldwin *et al.* 1991).

In summary, the problems of natural resources depletion in the coastal zone along with environmental degradation, factors which are reflected in the study area, are serious issues in most South and Southeast Asian countries. Although the pace of resource loss varies from region to region, along most coastlines water quality is declining. Stocks of commercially important fish and shellfish are being depleted. Prime agricultural land is being lost due to erosion. Critically important habitats, such as coral reefs, mangrove wetlands and seagrass beds, are being destroyed or degraded. The combined affects of these changes to the environment are reducing the quality of life and health of the coastal population (Olsen & Hale, 1994).

2.3 Introduction to Wetlands

The term 'wetlands' groups together a wide range of inland, coastal and marine habitats which share a number of common features (Dugan, 1990). The difficulty in defining wetlands, especially in areas where they are transient and continually changing without marked seasonal pattern, and where human and natural interference has led to alteration of prevailing environmental conditions, has given rise to over fifty definitions of the term currently in use (Said *et al.* 1992). For the purpose of the present discussion the definition provided by the Ramsar Convention (1971) will be used. This defines wetlands as:

> *"Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed six metres."*

It should be noted here that it has been argued that though this definition takes into account limnological, topographical and physico-chemical criteria and the origin of the wetlands, the examples quoted are not representative of the tropics. This is particularly obvious in relation to coastal wetlands (Windevoxhel, 1995).

Asia is estimated to have about 280 million hectares of wetlands, including permanent rice fields and river channels. This is about 13% of the total area of the continent-equivalent of the size of Western Europe excluding Finland. Of this, 120 million hectares are supposed to be 'natural' wetlands. The Directory of Asian Wetlands lists 947 sites with an area of 73 million hectares, the combined area of France and the U.K (Scott, 1989a). In June 1995 a total of 58 wetland sites from 13 countries in Asia were mentioned in the Ramsar list, with an area of 3.2 million hectares or 4% of the area included in the directory (Davis, 1994).

The range of wetland habitats which come under the mandate of the Ramsar convention is wide and encompasses reef flats and seagrass beds in coastal areas, through mudflats, mangroves, estuaries, rivers, freshwater marshes, swamp forests and lakes, saline marshes and lakes (Davies & Claridge, 1993) (Table 2.1). As with definitions, there is a wide range of

Table 2.1 Wetland Classification

1.Salt Water		
1.1 Marine	*1. Subtidal*	a) Permanent unvegetated shallow waters less than 6m depth at low tide, including sea bays, straits. b) Subtidal aquatic vegetation, including kelp beds, seagrasses, tropical marine meadows. c) Coral reefs.
	2. Intertidal	a) Rocky marine shores, including cliffs and rocky shores. b) Shores of mobile stones and shingle. c) Intertidal mobile unvegetated mud, sand or salt flats d) Intertidal vegetated sediments, including salt marshes and mangroves on sheltered coasts
1.2 Estuarine	*1. Subtidal*	a) Estuarine waters:permanent waters of estuaries, and estuarine systems of deltas
	2. Intertidal	a) Intertidal mud, sand or saltflats, with limited vegetation b) Intertidal marshes, including salt marshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes c) Intertidal forested wetlands, including mangrove swamp, nipa swamp, tidal freshwater swamp forest.
1.3 Lagoonar		a) Brackish to saline lagoons relatively narrow connections with the sea
1.4 Salt Lake		a) Permanent and seasonal, brackish, saline or alkaline lakes and marshes
2. Freshwater		
2.1 Riverine	*Perennial*	a) Permanent rivers and streams, including water falls b) Inland deltas.
	Temporary	a) Seasonal and irregular rivers and streams b) Riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland.
2.2 Lacustrine	*Permanent*	a) Permanent freshwater lakes (> 8ha), including shores subject to seasonal or irregular innundation b) Permanent freshwater ponds (< 8ha)
	Seasonal	a) Seasonal Freshwater Lakes (> 8ha), including floodplain lakes
2.3 Plaustrine	*Emergent*	a) Permanent freshwater marshes and swamps on inorganic soils, with emergent vegetation whose bases lie below the water table for at least most of the growing season b) Permanent peat-forming freshwater swamps, including tropical upland valley swamps dominated by *Papyrus* or *Typha* c) Seasonal freshwater marshes on inorganic soil, including sloughs, potholes, seasonally flooded meadows sedge marshes, and dambos d) Peatlands, including acidophilous ombrogenous or soligenous mires covered by moss, herbs or dwarf shrub vegetation and fens of all types e) Alpine and polar wetlands, including seasonally flooded meadows moistened by temporary waters from snow melt f) Freshwater springs and oases with surrounding vegetation g) Volcanic fumaroles continually moistened by emerging and condensing water vapour
	Forested	a) Shrub swamps, including shrub dominated freshwater marsh, shrub carr and thickets on inorganic soils b) Freshwater swamp forest including seasonally flooded forest, wooded swamps on inorganic soils c) Forested peatlands, including peat swamp forest.
3. Human-created wetlands		
3.1 Aquaculture		a) Aquaculture ponds, including fish ponds and shrimp ponds
3.2 Agriculture		a) Ponds, including farm ponds, stock ponds and small tanks b) Irrigated land and irrigation channels, rice fields. canals and ditches. c) Seasonally flooded arable land
3.3 Salt exploitation		a) Salt pans and salines
3.4 Urban/Industrial		a) Excavations including gravel pits, borrow pits and mining pools b) Wastewater treatment areas including sewage farms, settling ponds and oxidation basins
3.5 Water storage areas		a) Reservoirs holding water for irrigation and/or human consumption with a pattern of gradual, seasonal, draw down of water level b) Hydro-dams with regular fluctuations in water level on a weekly or monthly basis

(Source: modified after Scott, 1989a in Dugan, 1990)

classifications for wetlands; e.g. Cowardin *et al.* (1979); Dugan (1990); Larson *et al.* (1989); Scott (1989a). The number of wetland classification systems illustrate the difficulty in satisfying specific regional and national situations.

In the case of Sri Lanka, examples exist for almost all categories that are given in Table 2.1. Section **2.9** will concentrate on reviewing those wetland areas in Sri Lanka which have been impacted by development and other key activities that have resulted in an overall loss of some of the key functions that wetland areas serve.

2.4 Wetland Values and Local Communities

Natural wetlands are among the most productive areas in the world, in particular those situated along the coasts in the tropics (Birkeland, 1985; Davies & Claridge, 1993; Mitsch & Gosselink, 1993; Soegiarto, 1985; Twilley *et al.* 1992; Verdugo, 1990; Williams *et al.* 1990). Their shallowness, high temperatures, high nutrient content and profusion of light, guarantee a large biomass turnover and rich and diverse plant and animal communities. They provide nesting, spawning, nursery and feeding grounds for birds, fish, shrimp and other animal species, many of which are of great economic and commercial importance (Barbier, 1990; Birkeland, 1985; Chong, 1990; Cintron & Schaeffer-Novelli, 1984; Hatcher *et al.* 1989; Jansson *et al.* 1988; Macnae, 1974; Martsubroto & Naamin, 1977; Naamin, 1991;Robertson & Duke, 1987; Sasekumar *et al.* 1992; Sasekumar & Chong, 1987; Thurairaja, 1994; Turner, 1977). In particular mangroves are known to play an important role world-wide as nursery areas for Penaeid prawns (Frusher, 1983; Gwyther, 1983; Le Reste, 1973; MacNae, 1974; Mohamed & Rao, 1971; Robertson & Duke, 1987; Staples, 1980; Tabb *et al.* 1962; Walker, 1974).

Sasekumar & Chong (1987), in state by state summaries for Peninsular Malaysia, show that where the mangroves are most extensive the yields of shrimp are highest. This general association of mangrove areas and shrimp yields is also discussed on a trans-tropical basis by Turner (1977) and by Martosubroto and Naamin (1977) who report on 14 provinces in Indonesia and Subramaniam & Krishnamurthy (1990) who report on the maritime states of India. Similarly, from his study of the fisheries in the Matang and Merbok mangrove ecosystem in Malaysia, Huat (1989) concludes that over two-thirds of the coastal fisheries are either dependent or associated with mangroves. In comparable terms, both the fringing mangrove complex and a connection with the sea is vital in Koggala Lagoon, to sustain populations of commercially important shrimp and crustacean species.

The importance of wetlands has much to do with their many positive ecological and environmental functions and uses. There is, however, much imprecision about the use of these two terms. For the purposes of the present discussion, wetland benefits will be used to include wetland functions, uses, values, attributes, features, goods and services which may have a value to people, wildlife, natural systems or natural processes (Adamus *et al.* 1991; Claridge, 1991). In this context wetland benefits include water supply for domestic, industrial and agricultural use; flood control and regulation; shoreline protection; erosion control by the binding and stabilisation of the substrate by plant roots and deposited vegetative matter; carbon cycling; dissipation of wave and current energy and trapping of sediment and water purification. Noteworthy reviews of these benefits are provided by: Burbridge, 1984; Davies & Claridge 1993; Dugan, 1990; Hamilton & Snedaker, 1984; Hollis *et al.* 1988; Maltby, 1986,1991a; Mitsch & Gosselink,1993; Othman, 1994; Richardson, 1985; Sather, 1992; Sather & Smith, 1984; Williams, 1990.

Wetland ecosystems provide a number of important products that have sustained local communities (Chabwela, 1988; Fun, 1995; Giesen, 1995; Karim, 1993; Khan & Khan, 1995; Said *et al.* 1992). Such products include food staples (Krishnamurthy, 1992; Maltby, 1991b; Soerjani, 1988;) and non-food plants including reeds for thatching (Ghosh & Santra, 1995). They also provide major grazing areas for domesticated animals and habitats and food for waterfowl and other wild animals. In Koggala the local communities have relied heavily on the products of the wetland mainly at a subsistence level. Such uses include fuelwood, reeds for thatching and mat making and honey production.

Numerous examples exist in the literature of the central role wetlands play in the lives of local communities, particularly in parts of the developing world where rural communities are dependent on wetlands for immediate resource needs. Section **2.4.1** illustrates this drawing examples from the mangrove ecosystem. The importance of Koggala Lagoon for local communities in the study area is dealt with in later Chapters.

2.4.1 Traditional Uses of Mangrove Resources

The utilisation of mangrove ecosystems in terms of direct products as well as benefits deriving from the manipulation of the ecosystem has been well known and widely discussed (e.g. Baines, 1975; Chan & Nor, 1987; Christensen, 1983; Christensen, 1978; Davies & Claridge, 1993; Dugan, 1990; FAO, 1982; Hamilton & Snedaker, 1984; Hutchings & Saenger, 1987; Knox & Miyabara, 1984; Maltby, 1986; Rollet, 1987; Saenger *et al.* 1983). Although relatively low in biological diversity they are extremely important to coastal societies for both subsistence and commercial purposes. Local uses of mangrove forest products are well documented in Kunstadter *et al.* (1985) with case studies from South and South east Asia. Burbridge (1990) lists 50 direct products of mangrove forests, ranging from firewood and charcoal, through chipboard and glues to cigarette wrappers and hairdressing oils. In addition to this they provide supplies of natural renewable resources such as fuelwood (including charcoal), tannin (Chew *et al.* 1990; Pearman, 1955), dyes, poisons, alcohol (from *Nypa* sap), construction materials (timber and thatching), and food (both plant and animal).

In Thailand mangrove charcoal has traditionally been used by coastal villagers for daily cooking purposes. Compared with other charcoal, mangrove charcoal has many special qualities. The fire burns strongly over a long time even when small quantities are used, the heat is steady and the charcoal produces less dust, making it convenient for users to handle (Aksornkoae, 1995; FAO, 1992). In recent years, however, it has been exploited as a commercial product and is exported. *Rhizophora apiculata* and *Rhizophora mucronata* are the predominant mangroves employed, being favoured for their high calorific value and low soot production (Aksornkoae, 1993). According to Aksornkoae *et al.* (1985) the average charcoal production from mangroves in Thailand is approximately 479,192 t yr^{-1} (see Figure 2.2).

Charcoal produced from mangrove wood is also popular in other Southeast Asian countries. According to a 1987 UNDP/UNESCO report, the charcoal produced from mangrove forests amounted to 15,000 tonnes per year in the Phillipines; 43,000 t yr^{-1} in Malaysia and 21,760 t yr^{-1} in India. In Vietnam, *Rhizophora apiculata* and *Bruguiera parviflora* Wight and Arnold ex Griffith are converted into charcoal, which constitutes the main mangrove product in the south coastal delta (Hong & Hoang, 1993). In India, Bangladesh, the Philippines, Thailand, Malaysia, Indonesia and Vietnam mangrove wood continues to be an important source of cooking fuel for coastal communities. Other uses include mangrove poles which are used for foundation piling, scaffolding and fish traps. In Matang, Malaysia, some 2000ha of mangroves are thinned for production of 3-4 million poles every year (Chan, 1987; Kuan, 1994a). Similarly in Indonesia, mangrove forests produce approximately 170,000 poles per year (Wiroatmodio, 1995).

Tannin extraction from mangroves is used in the production of ink, plastic and glue and is used for dyeing fishing nets and leather. In Koggala, fishermen use the tannins derived from *Rhizophora* bark to strengthen their fishing nets (see **Chapter 6**). In the Sunderbans *Ceriops decandra* (Griff.) Ding hou is the main source of tannin (Chaudhuri & Choudhury, 1994). Similarly the use of mangrove forests for the production of wood chips exported to Japan for the production of rayon is noted mainly in Indonesia and Malaysia.

A: *Rhizophora apiculata* harvested for charcoal production.

B: Dome-shaped brick kiln for making charcoal.

**Figure 2.2 Mangrove uses in Samut Songkram, Thailand.
(Source: September, 1994, V.N. Samarasekara)**

Figure 2.3 Nipa palm, Samut Songkhram, Thailand.
(Source: September 1994, V.N. Samarasekara)

According to FAO (1985)Indonesia produces approximately 306,000m^3 of *Rhizophora* woodchips per year. The nipa palm (*Nypa fruticans* - (Thunb.) Wurmb.) is one of the most common, widely distributed and useful palms in the mangrove forest (see Figure 2.3) (Fong, 1980; Saenger *et al.* 1983; Wongkaew & Techapinyawat, 1995). It is a very popular plant in the coastal areas of southern Vietnam where it is planted to protect the land from erosion by the coastal dwellers near their tidal stilts houses in the rural communes of the Mekong delta (Hong, 1995). It is also utilised for thatching and as a source of sugar (Hong & Hoang, 1993).

The arid nature of Pakistan and the absence of well-developed forest in the interior means that mangroves are considered a major forest resource (Rizvi & Banquer, 1995). Mangroves are traditionally used for construction timber, fuelwood, and for fodder, mainly for camels. It has been estimated that 5,000 camels graze in the mangroves, principally on *Avicennia marina* during the dry season from June to October (Pernetta, 1993d). As a result, overgrazing of mangrove areas by camels poses a significant threat.

The mangrove reserve of the Sunderbans is of great economic importance to Bangladesh, providing a livelihood for some 300,000 people during certain seasons of the year. Here mangroves are exploited for a wide range of forest products, in particular timber, pulp wood and firewood, and wood for making matches, hardboard and pallets (Chaudhuri & Chakrabati, 1989; Chowdhury, 1995; Mukherjee & Krishnan, 1980;). A detailed account of timber production and other resource utilisation in the Sunderbans is given by Chaudhuri & Choudhury (1994).

In India mangroves have a broad range of traditional uses in construction, as fuel, food, fodder and as medicinal plants. Timber and charcoal are exploited commercially under well regulated plans in some areas. In West Bengal large numbers of people are employed in mangrove exploitation where *Bruguiera gymnorhiza* is a particularly valuable timber. In the Gulf of Kutch an average of 300 tonnes of fuel and 130 tonnes of fodder are gathered annually (Blasco, 1974; Davie, 1991).

Although firewood, timber and charcoal have been the major products of mangrove forests in Southeast Asia, of equal value is the forest's role as a breeding ground for local fisheries. In the Matang Forest Reserve, for example, Government revenue from charcoal in 1976 was the equivalent of US $424,000, and the wholesale value of forest products was estimated at US $9 million. At the same time the government revenue from fish landings was equivalent to US $12 million with an estimated wholesale value of US $32.7 million (Lal, 1990; Tang *et al.* 1981).

The aquaculture of fish and shrimps in ponds (*tambak*) constructed on mudflats or dug from the mangrove forest has been a traditional practice in Southeast Asia for centuries. These systems of aquaculture require little capital; do not displace other forms of food production; do not require external inputs; and are integrated into the agricultural cycle (Wilks, 1995).

2.5 An Overview of the State of Wetlands in Asia

Although wetland areas in Asia comprise only about 14% of the world's land surface area, the region currently supports about 56% of the world's human population and thus has an average population density about eight times that of the rest of the world (Scott, 1989a). Current threats to wetlands in Asia have been reviewed by a number of authors. Examples in the literature which also highlight various conservation efforts being made include: Markham, (1989); Tydeman, (1993); and Russell, (1994). Most of the threats described are as a direct consequence of increasing population pressure.

In parts of the developing world, the rural economy and human well being are even more closely dependent upon wetland resources. The consequences of wetland loss are therefore fundamentally more severe in developing countries. Here loss of wetland resources leads to flood damage, contaminated water, suffering and death (Dugan, 1993). Wetlands in South and Southeast Asia are considerably worse off than those in East Asia. According to Scott (1989b) 82% of wetlands are under particularly severe pressure in Bangladesh; Malaysia (86%); the Philippines (69%) and Sri Lanka (68%), while in Burma, Indonesia, Kampuchea, Laos (inland wetlands only), Pakistan and Singapore at least 50% of all sites are moderately to severely threatened. However the actual threats to the wetlands are many and vary from region to region (Sebastian & Davies, 1994).

Coastal wetlands are under extreme pressure from drainage for agriculture and disease control. Lake Tempe in South Sulawesi for example, one of the most productive wetlands in Indonesia, is currently under threat from agricultural extension programmes aimed at reclaiming a total of 20,000 hectares of the wetland area (Giesen, 1991). Though draining wetlands may increase local yields over the short term, this may also cause large reductions in yields elsewhere in the ecosystem, or reduce the entire ecosystem's ability to sustain harvests over the longer term. One cause of the 50% cut in the fish catch in the Grand Lac of the Mekong could be the clearance of trees for farming around the lake, in turn causing increased erosion, siltation and water cloudiness (Maltby, 1986; Trinh, 1994).

Mangrove forest, which stabilises shorelines and deflects storms, is being exploited on a large scale for firewood, tannins and timber, and more significantly is being converted into brackish water fish and shrimp ponds. Coral reefs face assaults from sedimentation due to coastal construction, soil erosion and dredging of harbours. Coastal forests have been replaced with agricultural land and towns. Over-fishing is a chronic problem along the entire coast from Pakistan to Bangladesh. More than 80% of all wastes are flushed into coastal waters untreated. Many beaches are used as garbage dumps, while solid wastes are often disposed of in shallow coastal waters (Hinrichsen, 1994). Bangladesh's wetland resources have suffered considerably from the impacts of a burgeoning human population including direct extraction and habitat loss (Gupta *et al.* 1990; Pernetta, 1993a; UNEP, 1982;1985a;1987;). In the Ganges-Brahmaputra floodplain alone, an estimated 2.1 million ha of wetland have been lost to flood control, draining and irrigation development. Amongst these are nationally important wetland areas such as Anal Beel and Chalan Beel (Nishat, 1993).

Marine pollution levels are higher in coastal waters than in the open seas. This issue is of great environmental concern, particularly with the continuing trend of increasing coastal populations. The factors contributing to the degradation of the marine environment have been identified to be mostly human activities (GESAMP, 1990; Gomez *et al. 1*990). Industrial pollution is now becoming a major problem as nations become more developed. In Pakistan, for instance, the main pollution problem is domestic sewage in the Karachi area which is discussed in some detail in UNEP (1982;1986c;1987) and Gupta *et al.* (1990). Also of concern is disturbance from agro-chemical factories, a steel mill and the construction of a new port at Karachi which all pose a serious threat to the estuaries of the Indus Delta (Maltby, 1986; Pernetta, 1993d). Similarly garbage dumping along Bombay's 35km long west coast is a serious problem, causing coastal pollution which directly affects the livelihoods of Bombay's 40,000 fishermen and the 60,000 women and children who dry and sell fish (Datta, 1994).

The Tuticorin coast, in the Gulf of Mannar in South India, is presently undergoing rapid industrialisation with various shore-based industries resulting in a range of pollution. Impacts include the reduction of large beds of seagrasses and associated eutrophication mainly due to the disposal of untreated sewage water into the coastal waters. Effluents stemming from shrimp farms located along the coast drain directly into the sea and affect drinking and irrigation water (Santhanam & Venkataramanujam, 1995). Similarly, wetlands in the Coramandal Coast of Tamil Nadu are under increasing threats from industrial pollution and restricted freshwater access (Thiyagesan & Nagarajan, 1995). This situation is also common to the study area.

The Samarinda and Kutai coastal area region in East Kalimantan, Indonesia, has undergone rapid development since the early 1970's, particularly for oil and gas extraction, which has brought economic benefits not only to the region but also to the country as a whole. However the impacts of these developments such as coastal water pollution by oil, ammonia and thermal wastes, as well as physical removal or degradation of mangroves and coral reefs, have threatened the sustainable capacity of coastal ecosystems to support further economic development. The current development pattern has also displaced some traditional livelihoods of many people including fisheries and coastal aquaculture (Dahuri, 1994).

In Bais Bay in the Philippines, it has been estimated that approximately three quarters of the region's mangrove habitats have been lost due to conversion to mariculture and over-harvesting for fuelwood. Coral reef degradation as a result of dynamite fishing, sedimentation from agricultural run-off from deforested uplands, and water pollution as a result of discharges of sugar mills and domestic wastes, pose a serious threat (Calumpong, 1994; Hinrichsen, 1994).

Phangnga Bay located in the Upper south region of Thailand is rich in coastal resources which support a broad range of economic activities. Tin mining contributes to high water turbidity in the bay due to the discharge of mine tailings. Large areas of mangroves are denuded due to conversion for agricultural, industrial, aquaculture and urban developments (Aksornkoae *et al.* 1988). Increasing population and tourism in the area contribute to poor water quality due to the discharge of untreated sewage into the bay. Agricultural and industrial discharges also compound the water quality management problems (Limpsaichol & Bussarawit, 1991; ONEB-MTSE, 1992).

The inland coastal waters of south Johor in Malaysia are subject to various types of pollution from human activities. Aside from domestic sewage, other materials discharged into the receiving waters include organic and industrial waste. If left unchecked pollution would result in the degradation of water quality and ultimately limit the beneficial uses of inland and coastal waters (Koh *et al.* 1991; Lim & Leong, 1991; MCRST, 1992). Similarly in Malaysia traditional fishermen in Port Klang have been adversely affected by timber wastes which have been dumped into the Sungai Pendamar which have damaged their fishing nets (Azman & Lim, 1993).

Pollution of near-shore waters from chemical pesticides and fertilisers is a serious problem in parts of India, Bangladesh and Sri Lanka. Agricultural communities along India's coast spread 5 million tonnes of fertilisers a year on their fields and use 55,000 tonnes of pesticides

(Hinrichsen,1990; Pernetta, 1993b; UNEP, 1982;1985b). Residues from these chemicals end up in coastal ecosystems, poisoning marine life and adding to the problems of eutrophication initiated by millions of tonnes of untreated sewage (GESAMP, 1990).

A summary of the main threats which occur most frequently in South and Southeast Asia are shown in Table 2.2.

Table 2.2 Summary of the main threats affecting wetlands in South and Southeast Asia

1. Conversion of wetlands to salt pans
2. Mining activities and oil exploration
3. Diversion of water supplies for domestic and industrial irrigation
4. Conversion to aquaculture ponds
5. Pollution from domestic sewage, pesticides and fertilisers
6. Over-exploitation of fisheries resources
7. Drainage and reclamation for agricultural purposes
8. General disturbance from human activities including settlement encroachment
9. Tourism
10.*Commercial logging of forestry operations

(Source: Present study)

*The final category is particularly worth noting in Southeast Asia where most of the major wetlands are mangrove forests.

2.6 The Status of Key Coastal Resources - Case study 1: Coral Reefs

Reef deterioration is taking place in many areas, including the Philippines, Indonesia, Malaysia and Sri Lanka (Ginsburg *et al.*1994; Wells & Price, 1992). Principal causes of damage include dynamite fishing, inland agricultural activities such as deforestation, and marine dredging which creates sedimentation (Salm, 1994). The environmental effects of dredging on the marine environment have been documented in numerous studies and most recently reviewed by Engler *et al.* (1991). Southeast Asian reefs are probably among the most seriously threatened in the world, because most are fringing reefs. Moreover the coastal populations in this region rely heavily on marine resources.

About half of the world's coral reefs lie in South and Southeast Asia (Wells, 1993). Coral reefs have the highest primary productivity of any coastal ecosystem, contributing about 10-15% of the total fisheries catch annually in the ASEAN region (Chua, 1991; McManus, 1988; White *et al.* 1994). The most extensive reefs occur in Indonesia and the Philippines (Gomez *et al.* 1994). Diversity of reef fishes and reef-associated organisms is also high. Coral reefs in this region support both resident and visiting fish species and are valuable for artisanal and commercial fisheries. In Sabah, East Malaysia, reef fishes make up 25% of total fish catch (Mathias & Langham, 1978). An estimate of 25% has also been reported for the Philippines (Carpenter, 1977). In Trengannu, West Malaysia, the figure reaches 30% during certain months (De Silva & Rahman, 1982). Numerous other products are found on reefs, including aquarium fish, mother of pearl, marine curios, and even pharmaceutical compounds (Wells & Price, 1992; Wells *et al.* 1994). Other major biological groups of the reef which provide a source of food include molluscs, crustaceans, echinoderms and seaweed. The reefs also play an important role in protecting the mangroves and seagrass beds from storm and wave damage (Wells & Price, 1992; White, 1987).

Coral reefs in Southeast Asia are being impacted by growing and diverse human activity. Excessive harvesting of edible fish, shellfish and other reef-related organisms for food has led to rapid depletion of stocks. The marine curio and aquarium trade has had devastating impacts on the ecosystem (Alcala *et al.* 1988; Hingco *et al.* 1991; Wood, 1986; Wood & Wells, 1988). Destructive fishing methods such as the *muro-ami*, blasting and poisoning are equally detrimental. The demand for live reef food fish in Indonesia is depleting stocks, degrading reef communities and in the process killing divers (Johannes, 1995; Milan, 1993). To many fishermen, who use dynamite or cyanide to capture fish, it is the question of survival or starvation although they are fully aware of the consequences of destroying the resources and the dangers this poses to their lives (Chua, 1991; Pratt, 1996). Similarly a large portion of reef in the Western Linggayen Gulf has been destroyed as a result of destructive fishing methods including the use of dynamite and sodium cyanide combined with poor land management and pollution (Menez *et al.* 1991).

Coral mining weakens the framework of reefs and the activity also destroys live corals and other organisms overlying the limestone foundation. Activities on land such as deforestation, mining and reclamation, increase the sediment level in the sea which in turn affects coral growth by direct smothering. Sedimentation resulting from coastal and marine tin mining in Phuket has affected the reefs there (Chansong, 1988). Extensive land reclamation in Singapore since 1963 has affected the deeper zones of reef slopes (Chou, 1988; Hilton, 1996).

In the South Asian region the largest and richest reef areas occur in Chagos, the Maldives and the Laccadive Islands. Chagos is reported to have the most pristine coral reefs remaining in the Indian Ocean while the Maldives and Laccadives are a close second (White & Rajasuriya, 1995). Essentially all the reefs in this region associated with mainland coasts are degraded or in varying states of disturbance. A summary of the known threats is given in Table 2.3. Many of these are common to all reef areas in the region but occur at different levels of intensity. Coral mining is a regional problem that occurs in India, Sri Lanka and Maldives. Sea level rise is a particular concern in the low lying islands, especially if coral and sand mining continues unabated in these areas (Quraishee, 1988). Sedimentation is a common problem on all mainland reefs of India and Sri Lanka. Overfishing is more common in heavily populated coasts of India and Sri Lanka and is less of a problem in the Maldives (White & Rajasuriya, 1995).

The reefs of Sri Lanka are divided into three categories: true coral reefs; sandstone reefs and boulder reefs of crystalline rock. The later two reef types are, in varying degrees, covered by coral (Rajasuriya, 1991). Most fringing coral reefs, under which category the coral reef in Koggala falls (Lanka Hydraulics, 1992), are found on the south-western, southern and eastern coasts. It should be noted that the study area has been highlighted as "a region where large scale destruction of the reef as a result of human activities has occurred." (Rajasuriya *et al.* 1995:431).

Sri Lanka has nearshore coral reefs of varying quality along about 2% (up to 32km) of the linear coast (Baldwin *et al.* 1991; Samarakoon & Pinto, 1986; Swan, 1983). Reefs are mostly of a fringing type in nearshore waters or patch reefs on rocky substratum varying distances from the shore on the continental shelf. Most of these coral reefs have been severely degraded by human-induced damage which includes sedimentation from poor land-use practices and construction; coral mining in beach and marine waters (UNEP, 1986a); destructive fishing methods; tourism-related activities (Smith, 1994); pollution; seasoning of coconut fibre; collection of ornamental fish and reef organisms and over-fishing (White & Rajasuriya, 1995). In Koggala a large number of hotels have been constructed along the coast and this area has undergone rapid development of the available tourist facilities since the establishment of the KEPZ. Such rapid unplanned tourism development has potential negative environmental impacts on the reef (see Table 2.4).

Table 2.3 Major causes of reef degradation in Sri Lanka

Human Disturbance
Coral Mining
Coral mining from the sea for lime production
Fishing
Blast fishing
Over-harvesting
Bottom-sea nets to catch spiny lobsters and reef fish
Using non-selective fish gear
Indiscriminate netting in reef areas
Ornamental Fish Collection
Uncontrolled collection of live marine organisms for the aquarium trade
Using 'moxy nets' for ornamental fish collection
Excessive collection of shells and other invertebrates
Pollution
Pollution from land based sources
Sewage disposal
Pollution from shipping
Sedimentation
Sedimentation due to unplanned land clearance practices and coastal erosion
Sedimentation due to construction of ports and harbours
Boats
Damage caused by boats and anchors
Glass-bottom boats and fishing crafts colliding against reefs
Discharging waste oil and bilge water from boats
Natural Impacts
Starfish
Crowns of Thorn Starfish (*Acanthaster planchi*)
Storms
High wave action and storm surges during the monsoons

(Source:Rajasuriya *et al.* 1995)

Table 2.4 Major causes of reef damage in Koggala

Human Disturbance
Tourist Activities
Boat anchoring on live coral (glass-bottom boats)
Reef walking
Coral and shell collection
Fishery
Boat anchoring on live coral and damage caused by anchor chains
Discharge of oil and bilge water from fishing boats
Ornamental Fish collection
Reef fish, invertebrate and live coral collecting
Pollution
Effluents discharged from hotels
Discharge from lagoon of water polluted due to coconut husk retting
Sedimentation
Sedimentation due to coastal erosion

(Source: Present study)

2.7 The Status of Key Coastal Resources - Case study 2: Mangroves

Mangroves represent the dominant soft bottom plant communities of the marine-terrestrial transition in tropical and subtropical regions. As a consequence of the range of spatial and temporary variation in physical factors found in such environments, the biological communities display remarkable adaptations which permit them to survive under harsh environmental conditions. The plant species are members of terrestrial families which have adaptations to survive under conditions of high salinity, low oxygen and nutrient availability in the soil, wind and wave action, and substrate instability (Carter, 1991; Pernetta, 1993).

The majority of the world's mangrove forests are distributed along the tropical and sub-tropical shorelines of developing countries. Only 90 species of mangroves are known to exist in the world, of which 55 are, in general, restricted to mangrove swamps (Aksornkoae, 1995; Christensen, 1983;). Their centre of distribution and their greatest floristic diversity is achieved in the tropics, notably in the Indo-Pacific, with 63 species widely distributed (Chapman, 1976; Macnae, 1968). An account of the status of the mangroves of India is described by Blasco (1977) and more recently in Desmukh (1991). Southeast Asian mangroves represent more than 30% of the world's mangroves and are the most diverse in species composition (see Figure 2.4). Almost half of the 40 tree species have commercial importance (Hundloe & Boto, 1990;

A: *Avicennia* spp.

B: Aerial stilt roots of *Avicennia* spp.

Figure 2.4 Mangrove diversity and adaptations, Sepang, Malaysia.
(Source: August 1994, V.N. Samarasekara)

Aksornkoae, 1995). The largest remaining contiguous area is the Sunderbans forest, covering nearly a million hectares of the Ganges delta (Maltby, 1986; Tomlinson, 1994).

Mangrove forests are among the most productive forest ecosystems in the world in terms of gross primary productivity (Rodin, 1975). Estimates of production rates of around 25 kg ha^{-1} day^{-1} are not uncommon (Morell *et al.* 1993). Shedding of plant parts, i.e. leaves, floral parts, fruits twigs, branches and bark, known as litterfall, is an important source of organic detritus, which supports economically important detrital marine food webs (Odum & Heald, 1975; Twilley, 1988).

The patterns of deforestation and degradation in mangrove areas situated in developing countries are similar and have been generally attributed to a rise in coastal populations accompanied with rapid economic expansion. Sections 2.7.1 - 2.7.3 will illustrate this point with examples drawn from the South and Southeast Asian region. A description of the mangrove ecosystem in Sri Lanka and particularly the study area are dealt with separately in **Chapter 5**.

2.7.1 Mangrove Degradation

Mangrove-dominated coastlines are under increasing pressure from urbanisation, coastal agriculture (particularly rice production and mariculture for penaeid prawns, salt ponds and other forms of intensive development) (Pernetta & Elder, 1992). Even where large scale conversion of mangroves is not occurring, increasing levels of unsustainable resource extraction, including, felling for fuelwood and charcoal are severely depleting these ecosystems. In combination with other sources of stress, such as increasing levels of pollution from both domestic and industrial sources, mangroves even when they are not being physically destroyed are becoming rapidly degraded. The consequences of this loss are important when considering that, with the exception of Australia, the world's remaining large mangrove areas are all found in developing countries (Hutchings & Saenger, 1987).

To summarise, the main causes of mangrove destruction can be classified broadly under two main categories:

- over-exploitation by traditional users;
- destructive action resulting from activities generally unrelated to the sustained uses of mangroves.

Where mangroves provide a buffer between land and shallow seaward communities, such as coral reefs and seagrass beds, the removal of mangroves from an area may bring about the degradation of adjacent marine communities. This results from the of loss of food and of shelter for the juveniles of offshore species of fish and shellfish and also because of accelerated offshore sedimentation - the major cause of pollution in coral reef communities.

In situations where freshwater inflows into mangroves are altered by various upstream activities in the catchment area, changes in agricultural and forest land use (e.g. logging) may alter the amount, timing and quality of water entering the system. Of major destructive effect are large scale reductions of freshwater inputs caused by human water uses such as irrigation (Chowdhury, 1995). Mangrove dependent fisheries are affected by less favourable habitat conditions imposed by higher water salinity and by the reduced production and export of leaf detritus. Specific examples of the problems described above are evident in the Sunderbans in Bangladesh which has been deteriorating in recent years (Ismail, 1990; Mahtab, 1992; Siddiqui, 1994). Similarly increasing salinity in the Indus, as a consequence of dam construction, has adversely affected the mangrove communities there (Rizvi & Baquer, 1995).

Since the 1970's the construction of fish ponds has increased at a phenomenal rate, particularly in Southeast Asia, driven by the high prices for the products and the low investments required for pond construction (Chua, 1989;1993). Intensive prawn farms have been set up since the 1980's across the coasts of Asia, in some cases displacing local fisheries in the process (Boonsong & Eiumoh, 1995; Phillips *et al.* 1990; Ruddle, 1993) (see Figure 2.5). In Indonesia, for example, ponds where milkfish were traditionally raised have now been converted to cultivating prawns solely for the export market (Yosuke, 1987).

In Thailand the conversion of mangrove areas for aquaculture, mainly of tiger prawn (*Penaeus monodon*), is common along the eastern and south eastern coasts of the Gulf of Thailand, especially in the provinces of Samut Songkhram, Samut Sakorn, Rayong, Chantaburi, Chumporn, Surat Thani and Nakhon Si Thammarat (pers. comm. Havanond, 1993). In Chantaburi province for example, practically the entire mangrove area has been converted into shrimp farms (Aksornkoae, 1993; Boonsong & Eiumnoh, 1995; Csavas, 1994). Equally in the Eastern coastal region of the Mekong Delta only scattered secondary growth remains in the existing mangrove formations which have been degraded as a result of over-exploitation mainly due to clearing for shrimp farms (Trinh, 1994). In Malaysia brackishwater pond culture has caused the destruction of large tracts of coastal mangroves (**Chapter 1**).

A: 'Intensive' shrimp aquaculture pond.

B: Grading Tiger Prawn (*Penaeus monodon*) at sorting station.

Figure 2.5 Shrimp aquaculture, Pak Phanang, Thailand.
(Source: September 1994, V.N. Samarasekara)

Studies in the State of Perak show that in the period between 1984-1992 there has been a 100% annual increase in the pond production of cultured prawns which have resulted in the widespread clearance of mangrove areas (Kuan, 1994b).

According to recent reports based on 1987 data, some 100,000 hectares of mangrove forest, which is approximately 64.3% of the total converted mangrove area in Thailand, have been turned into prawn farms (Bangkok Post, 1993; Kongsangchai, 1995). Recent research suggests that between 1985 and 1990, Thailand has lost a potential fish harvest of 800,000 tonnes while gaining only 120,000 tonnes of prawns (Bangkok Post, 1991). The expansion of shrimp farming to the western coast provinces of Trang, Phang-Nga and Phuket has increased the overall damage to mangroves in Thailand (pers. comm. Aksornkoae, 1994).

Khao Sam Roi Yot National Park in Thailand has suffered greatly from the direct impact of encroachment and from secondary impacts by unrestricted aquaculture growth (Enright, 1995; Parr & Hughes, 1991). Similarly in Indonesia alone, over 10,000 square km of mangroves have been converted into brackish water ponds (*tambaks*) for the cultivation of shrimps, prawns and fish (Hinrichsen, 1994). Proposals have evolved in relation to Lake Chilika, in Orissa, India, to build several 50 hectare prawn ponds. Essentially this would mean that private companies would move in on traditional fishing grounds to cultivate and to harvest vast amounts of prawn for commercial export (D'Monte, 1995; Mitra, 1992; Platt, 1995). While intensive aquaculture techniques have increased yields, these often prove to be short-lived as pollution and diseases cause yields to crash. Chemicals used in prawn ponds also cause significant environmental problems. For instance in South Thailand's 'rice-bowl', between the provinces of Nakhon Sri Thammarat and Songkla, rice yields crashed as chemical effluents from 15,000 acres of prawn farms polluted irrigation canals used to irrigate paddy (The Nation, 1991).

In parts of Southeast Asia, the overuse of anti-biotics has resulted in the development of resistant strains of viruses, making certain infections almost untreatable. Many prawn farms have been abandoned after about five years because of disease or pollution (pers. comm. Sasekumar, 1994). In some areas, farmers are experimenting with water filtration and settling tanks for water outflows; but in others, where land is cheap and investors do not have a stake in it, they move elsewhere as soon as yields decline, taking their profit but leaving a wasteland (Wilks, 1995). In the Philippines, over-extraction of ground water for prawn farms in Negros Occidental has been sighted as causing lands to subside and saltwater to intrude from the sea (Primavera, 1991).

Since the early 1980's, shrimp farming for export has been encouraged by the Vietnamese Government and has become a widespread activity which has in recent years encouraged people from outside mangrove areas to resettle in the forest land with the intent to engage in shrimp farming. Available information indicates that the shrimp culture area, which was more than 50,000 ha in 1981, went up to 120,000 ha in 1987. The area currently under shrimp farming is considered to be much more extensive with about 80,000 ha under shrimp farming in Minh Hai province alone (Hong, 1995).The damage done by conversion of mangroves for aquaculture is however far deeper than the simple loss of forest area (Khoon, 1988). An assessment of the ecological and economic impact of mangrove conversion in Southeast Asia is provided by Paw & Chua (1991).

The standard practice in some areas for stocking shrimp ponds is to collect wild larvae (seed) in fine meshed nylon nets, and then sort the non-shrimp 'waste' and discard it along the shore. In the Sunderbans there are presently saline fisheries in approximately 33,200 ha that produce annually 11,600 tonnes of shrimp and fish. However about 40,000 shrimp seed collectors annually harvest about 540 million seed of *P. monodon,* and in the process kill an estimated 10.26 billion seeds of other fish and shrimp, which has serious implications for the future yields of these species. (Chaudhuri & Choudhury, 1994; Chakrabati, 1986). This direct pressure on the fry in and around mangrove areas combines with the loss of mangrove habitat to threaten coastal and estuarine fisheries. Baruadi (1990) illustrates that in Bone Bay in Sulawesi, prawn fry have disappeared in areas where mangroves have been cut. Similarly Ong (1982) calculated that Malaysian mangroves were more productive under forms of forest exploitation than as fishponds. This is the case in South Sulawesi where the conversion of mangroves to *tambak* may represent a substantial loss to the local economy (Giesen *et al.* 1991).

In Indonesia a linear relationship has been demonstrated between the extent of mangroves remaining along the coastline and the abundance of shrimp in the adjacent sea (Martosubroto & Naamin, 1977). The correlation does not hold for all tropical areas, but it emphasises the central role of mangrove forests as a breeding ground for marine species, and the economic implications of their careless destruction. Despite the very high revenues to be gained from aquaculture, even where it is extensive it may represent only 10% of the total fisheries catch (Saenger *et al.* 1983) and it has been suggested that consequent deterioration in the offshore catch will lead to an overall loss in revenue and foreign exchange earnings.

The destruction of mangrove forests in the development of brackish water aquaculture is concentrated in Southeast Asia. The following examples show the extent of the problem. In the

Philippines the area of fish ponds expanded from 88,000 ha in the early 1950's to 174,000 ha by 1972 and 210,000 ha by 1987 when an estimated 3,500ha were being converted each year. In some areas extensive mangrove forests were almost completely cleared for the construction of fish ponds (Baconguis *et al.* 1990). In Indonesia in 1980 there were 185,000ha of fish and shrimp ponds, which had increased by 30,000ha by 1985 (Choong *et al.* 1990). In Thailand the rate of conversion was increased by the practice of leasing land in mangrove forests to squatters only after it had been cleared for pond construction (pers. comm. Choowaew, 1994). The production of shrimp in former mangrove ponds doubled between 1977, when the market was worth US $78 million (Christensen, 1978). In the Indo-Pacific as a whole an estimated 8000,000ha of mangrove forest were converted to brackish water pond aquaculture between 1973 and 1977 (FAO, 1982; Saenger *et al.* 1983).

Over-exploitation of mangrove areas is a major problem in the Sunderbans (Bhattacharaya, 1990). It is thought that *Excoecaria agallocha* may have declined by 45% since 1959 (Scott, 1989b). In the Chakria Sunderbans, large areas of mangrove are being cleared for the construction of shrimp ponds and 8,500 ha are no longer productive (Chaudhuri & Chakrabati, 1989). In Bangladesh as a whole the area under shrimp farming has increased from 40,000ha in 1983 to 68,000 ha in 1984 and to 115,000ha in 1988, which has contributed to the destruction of mangroves, the increased siltation of rivers, competition for agricultural land and pressures on shrimp seed sources (Holmgren, 1994; Mahmood, 1988; Mollah, 1993). According to Katebi & Ghulam-Habib, (1988), in the Chakaria Sunderbans, pressure from powerful individuals and the fisheries Department led to the dereservation and subsequent destruction of 30% of the reserved and protected forest.

The pressures of over-exploitation for forestry and fishery products have been discussed. Mangroves are vulnerable to a variety of additional threats. These are perhaps less widespread globally, but in particular countries and in particular areas are highly significant. Perhaps the most extensive is that of reclamation of land for agriculture. Although this is always costly even in direct terms, and very often results in acidic soils with low yields due to the rapid oxidation of sulphuric compounds in the mud when they become aerated, it has still been extensively practised in Vietnam (Christensen, 1983; Hong & Hoang, 1993; Saenger, 1983).

Where mangroves have been close to urban developments, as they often have been since ports and mangroves are both associated with estuaries, clearing for urban expansion has led to mangrove destruction. The most common forms of conversion are to housing and residential development, coastal tourist facilities and industry, including small port development. Specific cases of these problems are evident in Singapore where a large proportion of the country's mangrove forests that have been reclaimed have been utilised to provide sites for housing, industry, parks, solid waste disposal, agriculture, water impoundment's, and fish and prawn ponds (Pratt, 1996).

In Thailand human settlements in mangrove areas are widespread and cover many provinces such as Chonburi, Rayong, Surat Thani, Krabi, Nakhorn Sri Thammarat and Phuket (pers comm. Pintuanok, 1994). Villages in these provinces vary in size from a few houses, built on platforms raised on stilts, to highly urbanised settlements and industrialised cities. This urbanisation accounts for a large proportion of reclaimed mangrove land and the trend continues to increase (pers. comm. Havanond, 1994) (Kongsangchai, 1995). A similar situation exists in Vietnam where increased development in and around cities and towns has adversely affected the mangrove communities there (Hong, 1995).

Conversion of mangrove areas for salt pond construction is widespread over the tropical coasts of Asia. In the north western coastal zone of Gujarat, a huge chemical-salt industrial complex has been constructed and has adversely affected a considerable area of mangroves (Gupta *et al.* 1990). In Thailand the total area of mangroves converted to salt ponds is estimated to be about 10,560 ha (Aksornkoae, 1995). In Vietnam, forests of *Sonneratia caseolaris* have been destroyed to form salt pans in the dry season (Hong & Hoang, 1993).

Solid waste disposal into mangrove forests has risen with the ever-increasing human populations in urban areas. Though the total area affected by this activity is very small in global terms, these areas are important because of their proximity to urban population centres. Liquid waste disposal of organic materials stemming from agricultural, agro-industrial, chemical-industrial and domestic processes are discharged in to nearby rivers and coastal waters. Excessive concentrations of livestock waste, food processing wastes and domestic sewage can cause deterioration of riverine environments to conditions unfavourable for aquatic life. Though many individual mangrove species are resistant in various degrees to these impacts, the general equilibrium of the system may be upset, and may result in a shift to another ecosystem structure (Hutchings & Saenger, 1987).

An additional threat to mangrove ecosystems is that of rising sea-levels. Research on past sea-level rise suggests that low island mangroves are the most vulnerable. Autochthonous mangroves will be unable to accumulate sediment fast enough to keep pace with rising sea water. The principal threats come from sea level rise and associated changes in sediment dynamics and salinity (Pernetta, 1994; WWF, 1993). Other threats of varying importance in different areas include reductions in freshwater inflow due to upstream irrigation projects, increased sudden sedimentation due to upstream erosion, run-off of agricultural fertilisers and pesticides, pollution from oil spillages, pollution by urban or industrial effluent and mining activities (Aksornkoae, 1985).

Thus to summarise: the threats to mangroves can be broadly categorised into direct pressure on the resource from local populations; direct pressure on the resource due to intensive, commercial use; and indirect pressures as externalities of other processes.

2.7.2 Summary and Comparative Rates of Loss

There is some difficulty in finding comparable data to document the change in mangrove extent over time. Existing figures for loss of mangrove area to agricultural development may in some cases be partly offset by the extension of mangroves by accretion in estuaries, and by planting programmes, as for example in the Sunderbans of Bangladesh. In spite of this, figures that are available are not encouraging. The general picture is one of steady levels of clearing, particularly for urban development, and extensive exploitation for products such as firewood, tannin and charcoal, up until the 1960's. In the 1960's there is a dramatic expansion in the rates of mangrove loss due to land reclamation and aquaculture, accelerated by industrial logging for wood chips in the 1970's and 1980's. The major reported areas of loss have been in South East Asia where conversion to rice paddies and aquaculture is occurring at an unprecedented rate and oil spillages have added to these large losses.

As a direct result of some of the activities outlined above there have been a number of studies on comparative rates of loss of mangrove areas. Hellier (1988) for example reports a loss of mangrove areas in India from 682,000 ha in 1963 to 365,500 ha in 1977. Similarly in Thailand aerial photography and satellite imagery indicate that in 1961, mangrove forests covered approximately 367,900ha of the coastal area (Klankarmsorn & Charuppat, 1982 cited in Aksornkoae, 1993). The area gradually decreased to 312,732 ha in 1975; 287,308 ha in 1979 and to 196,428 ha in 1986 (Klankamsorn & Charuppat, 1987 cited in Aksornkoae, 1993). A Thai survey in 1989 showed that the existing mangrove area is approximately 180,559 ha (Royal Forestry Department, 1991).

Correspondingly in the Philippines in 1918, there were estimated to be 400,000-500,000ha of mangroves and of these it is estimated that only 140,000ha remain today. Sixty per cent of this decrease is due to conversion into culture ponds for milkfish and shrimps (Primavera, 1991;

Baconguis *et al.* 1990). According to Kunstadter (1985), 200,000 ha of mangroves were reclaimed for agriculture in Indonesia between 1969 and 1974.

In Vietnam the use of napalm and herbicides during the Vietnam war (1962-1971) resulted in the degradation of nearly 40% of the mangrove forests in south Vietnam (Odum *et al.* 1974; Viles & Spencer, 1995). In other areas, mangroves were exploited for their resources or replaced by agricultural and shrimp farms. Since 1983, the quantity of shrimp captured in the sea has decreased in many localities due to over fishing and consequently mangrove forests have been increasingly destroyed for shrimp farming. While various estimates regarding the distribution of mangrove forests in Vietnam have been made, these are difficult to verify due to the extent of damage and continuous changes being made to these areas. According to the Forestry Inventory and Planning Institute in Vietnam there are 252,500 ha of remaining mangrove forest (Hong & Hoang, 1993).

In peninsular Malaysia approximately 20% of the mangrove forest was lost through agricultural reclamation between 1960 and 1980 (Ong *et al.* 1980). In Sabah mangrove forests covering approximately 0.32 million ha of the coastline are disappearing at a rate of about 5000 ha per year (Ghaffer, 1995).

2.8 An Introduction to Wetland Ecosystems in Sri Lanka

As an island nation, much of Sri Lanka's development has been associated with maritime activities (Cook, 1951). The political and commercial interest shown in Sri Lanka by the leading maritime nations of the West since the beginning of the sixteenth century resulted in the mapping of its coastal areas in greater detail and with greater accuracy than for many other tropical islands. Old topographic maps produced by Ptolemy, the veteran map maker of the 2nd century AD, are among the earliest to show the coastal areas of Sri Lanka in detail. Several centuries later, when Robert Knox visited the country in the 17th century, more information on the coastline was made available to navigators, his map reflecting the remarkable knowledge of the coastline possessed by the Dutch during their period of rule (Bandara, 1989).

In pre-colonial times, coastal areas in Sri Lanka were under minimal stress since the indigenous centres of civilisation were inland and were so organised that they made practically no demands on coastal resources. Although the drift southward from the inland centres commenced a century or two earlier, the concentration of communities particularly in the south west coastal areas was in response to opportunities created by the Portuguese, Dutch and British colonial powers commencing in the sixteenth century. The building of forts at strategic points along the coast to safeguard against attack by other colonial European powers, and the collection for export of hinterland produce, such as cinnamon, arecanut and arrack, led to the development of a string of small coastal towns along the south-west coast (Tampoe, 1988).

The Post Independence era brought an intensification of development activities and, being the most densely populated region, the coastal areas throughout the island, already liable to the erosive impact of the Indian Ocean (Eaton, 1961; Swan, 1974; Zeaper, 1960) and also subject to pressure from human activities since the colonial era, came under still further stress due to the increased pace of development. As a result of the combined effects of increased population pressure in coastal areas and the growing exploitation of building materials, derived from coastal areas for both housing and urban development, these areas have begun to show increasing signs of ecological stress (pers. comm. Samarakoon, 1994).

The wetlands of Sri Lanka can be broadly considered under three groups:(a) offshore and marine systems which include sea bays and straits, small offshore islands and inlets; (b) coastal systems including estuaries; brackish to saline lagoons and mangroves swamps; rocky sea coasts; sandy beaches; salterns; salt pans and aquaculture ponds; and (c) inland systems which include rivers and streams and human-created lakes including tanks and reservoirs (Kotagama *et al.* 1989). It has been recorded that Sri Lanka possesses three hectares of inland lentic (static) water for every km^2 of land (Amarasinghe, 1992). In addition the country has one of the highest densities of inland tanks, lakes, ponds, marshes and other still waters available for any country in the world (pers. comm. Senaratne, 1994). More than 10,000 irrigation reservoirs which exceed 170,000 ha in total are the basis of the hydraulic civilisation that existed in Sri Lanka in the sixth and fifth centuries B.C (Amarasinghe, 1994).

A considerable amount of research has been conducted on the wetlands of Sri Lanka. The level of expertise is high and there are many Government agencies, institutions and universities involved in wetland related studies. In the past emphasis was largely on obtaining basic biological information for commercial reasons e.g. fisheries research (Bruin, 1971; Fernando, 1983; Jayasekara, 1986; Samarakoon, 1986). In the last five years, however, since Sri Lanka ratified the International Convention of Wetlands of International Importance there has been considerable interest in wetland related studies (pers. comm. Dissanayake, 1994). Currently an effort has been made to document all major wetland sites in the country in an attempt to design conservation and management plans as part of a elaborate Wetland Conservation Project conducted by the Central Environment Authority (Sri Lanka) with financial and technical assistance from the Netherlands.

The Asian Wetland Directory (Scott, 1989a) lists a total of 41 wetland sites for Sri Lanka. An additional list drafted by a national group of wetland investigators adds a further 35 wetland sites. Most of these sites have been studied and documented to a degree and though wetland reserves in some cases have been established, protection and management systems have yet to be formulated (pers. comm. Bentham, 1993). Most of these sites are coastal lagoons and mangrove swamps (see Figure 2.6), many of which are threatened by conversion into housing sites, agricultural lands, salt pans, or are affected by drainage, siltation and pollution (see Table 2.5).

For the purposes of the current research an overview of the main coastal wetland habitats in Sri Lanka including estuaries, lagoons, seagrass beds, mangroves and salt marshes has been presented. This information is based on field visits, reviews of existing literature during the research period, and the author's experience. Attention has also been made to relevant factors which have contributed to the general decline of these wetland types (see Table 2.7). Closer attention will be paid to coastal wetlands, including estuarine and lagoonal ecosystems, the latter being the category under which the study site falls.

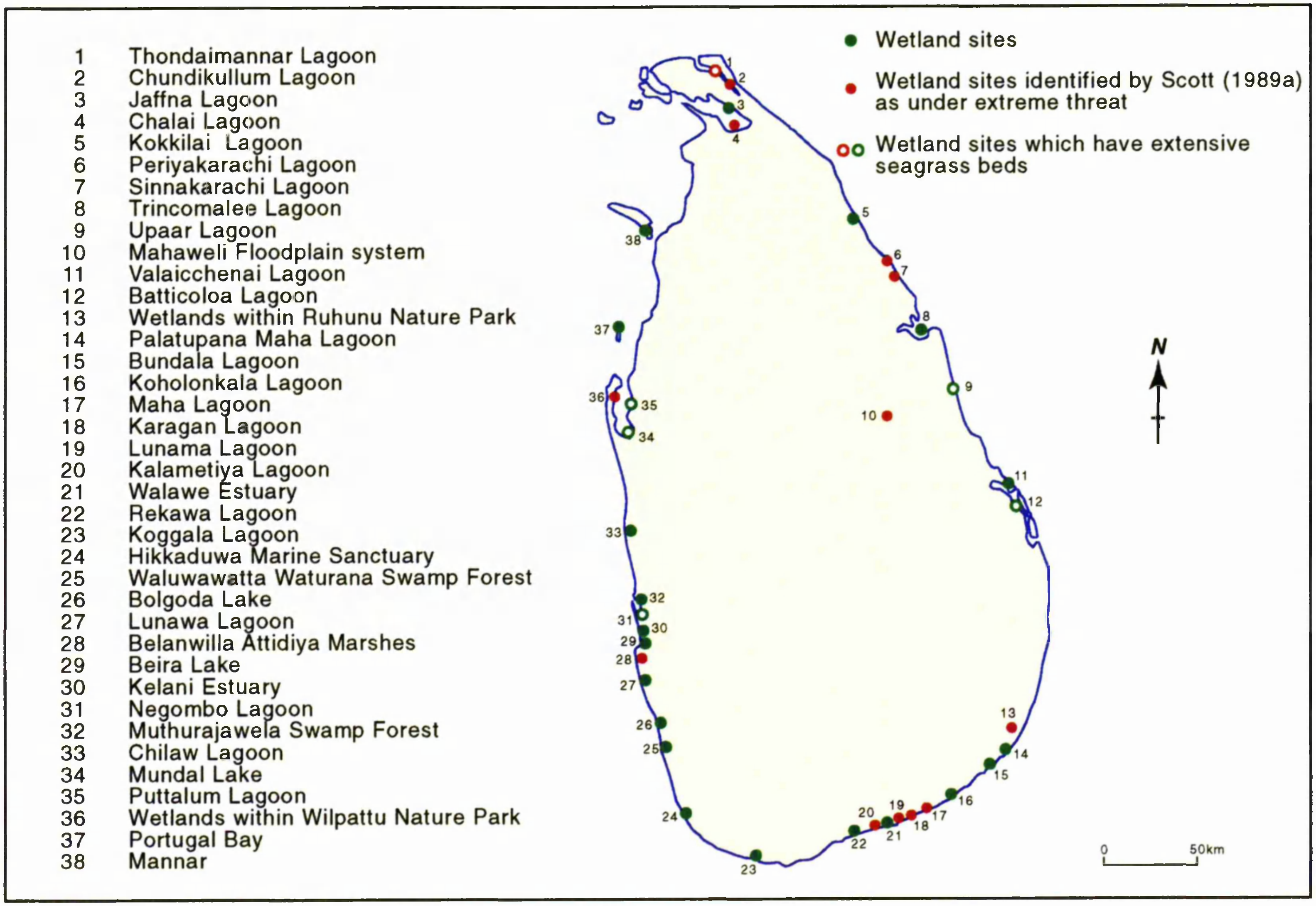


Figure 2.6 Distribution of Wetland Sites (including Basin Estuaries and Lagoons) in Sri Lanka

Table 2.5 Impacts on Coastal Habitats of particular concern to the Coast Conservation Department (CCD)

Coastal Habitat	**Impacts of particular concern to the CCD**
1. **Coral Reefs**	Physical damage to coral reefs and collection of reef organisms beyond sustainable limits; Increases in freshwater runoff and sediments; Introduction of waterborne pollutants.
2. **Estuaries /Lagoons**	Encroachment; Changes in sedimentation patterns; Changes to the salinity regime; Destruction of submerged and fringing vegetation; Inlets modifications; Loss of fishery habitat.
3. **Mangroves**	Changes in freshwater run-off, salinity regime and tidal flow patterns; Excessive siltation; Introduction of pollutants; Conversion of mangrove habitat and over-harvesting of resources.
4. **Seagrass beds**	Physical alterations; Excessive sedimentation or siltation; Introduction of excessive nutrients or pesticides.
5. **Salt marshes (tidal flats)**	Degradation of bird habitat or seed fish collection sites; Obstruction of storm water.
6. **Barrier Beaches, Sand Dunes and Spits**	Sand mining; Erosion; Dune Migration.

(Source: Coast Conservation Department, 1990)

2.8.1 Wetland Values

In Sri Lanka a substantial proportion of the natural economy and social welfare of the people depends on the productivity of wetland ecosystems. This is especially the case in the southern, south-western and western coastal areas of the country (pers. comm. Wijesinghe, 1993). However, despite the importance of the range of goods and the services wetlands provide, they have largely been taken for granted and the case of Koggala Lagoon is no exception. As a result, maintenance of natural wetlands has received low priority. The situation in Sri Lanka is not much different from the general Asian example. Here many wetland ecosystems have been, and to a large extent are still, indiscriminately exploited for commercial, agricultural, residential and industrial development, and, at an increasing pace, as dumping grounds for domestic, agricultural and industrial waste (Kotagama, 1993; Jayawardena, 1987).

Wetland sites in Sri Lanka identified by Scott (1989a) as being under extreme threat are shown in Figure 2.6. It should be noted that this list is by no means exhaustive and fails to include significant wetland areas which are under extreme pressure from some of the activities listed above. The study area, for example, shares a number of common pressures and threats with these sites and yet is not included in this category.

2.9 Coastal Wetlands in Sri Lanka

2.9.1.Salt Marshes

Salt marshes consisting of herbaceous salt-tolerant plants growing in sandy or muddy coastal flats in arid areas, occur mainly as sparse, short growth, interspersed with scrub mangroves (Pemadasa *et al.* 1979; Wijesinghe *et al.* 1993).They are prevalent in the drier regions of the country in the north and west from Pullikulum to Manthai; the total area is estimated at 23,819 ha (GOSL, 1987; Samarakoon & Pinto, 1986). In Mannar District where tidal flats are more extensive, the marsh vegetation contains up to 56 species.

This ecosystem is important in Mannar and Puttalum as sites for the collection of milkfish fry (*Chanos chanos*) for brackish water aquaculture. In addition they are important for waterfowl and as grazing areas for cattle. The main threats to marshes are overgrazing and conversion to salt pans and aquaculture ponds which have significantly reduced the extent of this vegetation type (CEA/Euroconsult, 1994a; GOSL, 1987; Lowry & Wickramaratne, 1989). Also significant is the excessive collection of fish seed and the construction of embankments and bunds which impede natural drainage patterns. In Koggala the marshlands surrounding the lagoon provide an important habitat for both resident and migratory waterfowl (Samarasekara, 1992).

The Belanwilla-Attidiya Marshes are situated on the south-eastern outskirts of Colombo and comprise a mosaic of shallow freshwater ponds, marshes and seasonally flooded grasslands, with scattered pockets of shrubs and small trees. The marsh proper is state owned and has sanctuary status. However it is still used for fishing purposes amongst local residents and also for livestock grazing and cutting of trees and shrubs for fuelwood and utility timber purposes. The Bolgoda canal runs through the marsh serving irrigation to adjacent paddy fields. Identified by Scott during the International survey of Asian wetlands in 1989, this marsh system is under pressure from dumping of domestic and industrial waste directly into the Bolgoda Canal. This has caused fish kills and eutrophication, unauthorised reclamation of marshland and settlement and pollution of surface and ground water by nearby factories in the Ratmalana Industrial Estate. Also significant is the clogging of canals with water weeds and silt and pollution caused by agricultural seepage (CEA/Euroconsult, 1991). Disruption has also been caused to the natural hydrology of the marsh by canal construction, sluice and embankments.

2.9.2 Estuaries and Lagoons

The total area of estuaries and lagoons has been estimated at 158,017 ha by GOSL (1987). There are approximately 45 estuaries belonging to two types: basin estuaries where rivers discharge into relatively shallow basins, which open into the sea as in the case of the Puttalum, Chilaw, Negombo and Jaffna Lagoons (Arudpragasam, 1974;1975) and riverine estuaries, where rivers discharge into the sea by way of relatively shallow channels as in the Kalu ganga (estuary), Kelani ganga and Nilwala ganga estuaries (Arudpragasam, 1984; Samarakoon & Pinto, 1986). The total extent of basin estuaries is estimated at 40,000 ha. Relevant summaries relating to the estuaries and lagoons in the island include (Abeywickrama, 1960; De Silva, 1984; Fernando, 1983; Marga Institute, 1985; Norris, 1957; Pernetta, 1993e). Samarakoon & Pinto (1986) list 40 true coastal lagoons most commonly situated along the southern, south-eastern and eastern coasts, where littoral drift causes accumulations of sand as barriers and spits at river mouths, restricting freshwater discharge. The total area of the lagoons is estimated at about 20,000 ha.

Estuaries and lagoons are amongst the most economically valuable habitats in Sri Lanka. They support fishing and employment of thousands of coastal residents (pers. comm. Fernando, 1993). In 1977 for example, 1684 fishermen depended on the fishery of the Negombo Lagoon; in 1983 this number increased to more than 2,000 and in 1991 the number has been estimated at 3000 (Samarakoon & Zon, 1991). The Puttalum estuary and the lagoons within the Bundala National Park also harbour an important fishery. Similarly fishing is a major traditional income-generating activity in the study area (see **Chapter 6**).

The use of unsustainable fishing methods is a major threat in estuaries and lagoons often resulting in overfishing. Destructive fishing methods employed in Rekawa Lagoon, such as placing wooded barriers in the water to guide fish into traps (Sinhala: *Ja-Kotu*) and the use of fine mesh nets, restrict the movement of fish and shrimp through the lagoon and result in the capture of large numbers of juveniles as well as adults (Ganewatte *et al.* 1995). In like manner Koggala Lagoon is affected by destructive fishing methods which include the use of brush-piles, resulting in the capture of juveniles, a possible reason for the declining fish populations in the lagoon. Other impediments to fishing in estuaries and lagoons include obstructed connections with the sea which affect salinity levels and prevent restocking and recruitment patterns with the sea.

This problem is evident in the Karagan Lagoon (CEA/Euroconsult, 1994b) and in the Kalametiya Lagoon (CEA/Euroconsult, 1995a) and most recently the study area has been similarly affected. In Hikkaduwa (25km north of Koggala) depleted coral fish populations have been attributed to dynamite fishing and the overfishing of ornamental fish for the aquarium trade (Nakatani *et al.* 1994).

Estuaries and lagoons are important for ornamental fisheries which provide employment in Negombo Lagoon, Bolgoda Lake, Trincomalee Bay and the study area. In addition they also provide seed fish and shrimp for the aquaculture industry. In this connection poorly planned and inadequately regulated aquaculture projects have been responsible for the decline of lagoonal systems. A summary of impacts associated with aquaculture projects is show in Table 2.6.

Table 2.6 A summary of impacts associated with aquaculture projects in Sri Lanka

• Clearing of vegetation by diversion of freshwater into ponds;
• Destruction of lagoons through channelization;
• Saltwater intrusion into agricultural lands and domestic wells;
• Increasing eutrophication in the water sources caused by leaching of acidic substance during pond construction and by the effluents released during aquaculture operations.

(Source: Present study)

According to Jayasinghe (1991), 30% of the total coastal land that has been allocated for shrimp farms as at 1992 has been mangrove and saltmarsh. Though not as developed as in parts of Southeast Asia, aquaculture is beginning to gain importance in Sri Lanka as a potential major export. With the introduction of Government backed schemes organised for local prawn farmers to attend training programmes on shrimp culture in Thailand (Jayatileke, 1994; De Alwis, 1994), the growth of this industry seems set to expand rapidly.

In the Puttalum Lagoon, aside from the secondary problems of waste and pollution discharge, the primary environmental impact associated with the construction of aquaculture ponds is their siting. In 1994, a total of 450 shrimp farms had been approved by the authorities. However, the total number of farms in the area was over 900 (Dayaratne *et al.* 1995). This has disrupted and destroyed some of the best wetland habitat in the estuary, including the mud and sand flats used by a number of important migratory and resident birds (Scott, 1989a). In addition to this most if not all aquaculture farms are currently releasing untreated effluents into adjacent water bodies. A primary survey of water quality in the Dutch canal area where the majority of these farms are located reveals relatively high nutrient levels and suspended solids (Corea, 1992;1993; Corea *et al.* 1995). Also of concern is the use of toxic chemicals such as Rotenone and Malachite Green - organic compounds which are applied to the ponds to control bacterial and fungal infections. Both these substances are banned in the USA and present a significant hazard to all forms of aquatic life (IPCS/WHO, 1992).

Probably the most significant impacts on estuaries and lagoons are those associated with pollution (Baldwin *et al.*1991; IUCN/UNEP, 1985). The most noteworthy environmental problem connected with factories is waste effluent, which is increasingly polluting the inland waterways of Colombo, coastal lagoons, estuaries and some nearshore ocean sites (Gupta *et al.*1990; UNEP, 1982;1986a;1987). Industrial wastes in Sri Lanka are not generally treated before being discharged into rivers, lagoons and the oceans. As a result periodic fish kills are common and have been noted throughout the island, in recent times particularly in the Kelani river (pers. comm. De Alwis, 1993). Textile dyeing and printing industries are causing widespread pollution in Ratmalana and Moratuwa. In Colombo, the total waste from industry discharged into the city's canal network is estimated at 70,000 persons equivalents, or 3,900 kg Biological Oxygen Demand$_5$ per day (Baldwin *et al.*1991). In Koggala dumping of untreated solid waste materials from the KEPZ onto a marshy area of land bordering the lagoon is a major cause of concern.

UNEP (1986a) describes pollution in the Colombo Canal System, northern Bolgoda Lake System, and at Kelani River where 60 industrial operations discharge effluent. Deteriorating coastal water quality due to direct and distributed discharges of wastes from hotels, oil dumped by glass boats and fishing boats, and pollutants discharged by two fresh water outlets is a problem in Hikkaduwa (Nakatani, *et al.* 1994). A Tannery situated on the borders of the Kelani estuary is responsible for discharging effluent containing high levels of chromium which has had disastrous effects on aquatic communities. (Rathnasooriya *et al.* 1993).

The Beira Lake which is also described in UNEP, (1986a) has a catchment of approximately 81 ha which encompasses most of the commercial area of Colombo. There are over 1000 outfalls, including 28 major storm water outlets, illegal sewage outlets and industrial waste outlets. In addition to this there are 5 squatter settlements comprising over 6000 families living on the banks of the lake. Having encroached dangerously close to the lake, these settlers are part of the pollution problem (NARA, 1985; Dissanaike & Malaweera, 1993). Similarly the pollution of Lunawa Lagoon is a result of industrial effluents which are discharged into the lagoon from industries situated in the Lady Catherine Estate. It has been estimated that 95% of the pollution in the lagoon is due to the release of toxic chemicals from textile industries. Once a flourishing fishing lagoon, now it is a mosquito-ridden stagnant body of water (Senaratne, 1993; Noja, 1995).

Control over domestic and industrial wastes is fragmented and weak and large areas of the coast receive untreated sewage. Even in population centres where sewage systems exist, the sewage is frequently untreated prior to discharge (pers. comm. White, 1993) Most problems are in the Colombo region (Lowry & Wickramaratne, 1989; Abeynayake, 1992). Sludge from a paper factory at Valaichchenai and Embilipitiya has caused some damage in the Valaichchenai Lagoon and the Walawe estuary respectively (Baldwin *et al.* 1991). Negombo Lagoon is the sink for untreated industrial effluents from 45 industries situated in the Ekala area, the State Distilleries company and partially treated effluents from the Katunayake Export Promotion Zone (pers. comm Fernando, 1993). Apart from this input of toxic waste from larger industrial establishments, numerous small-scale industrial operations discharge their untreated effluents directly into the lagoon. Pollution has become chronic, as indicated by the persistence of skin ulceration among sensitive fish such as the chromides and periodic fish kills are reported, mainly attributable to these episodic discharges of toxic effluents (Samarakoon & Zon, 1991; CEA/Euroconsult, 1994f).

Primary productivity levels in Puttalum Lagoon are already low when compared with other estuaries (Samarakoon & Pinto, 1986). This factor alone is a good measure of the impact that pollution imputs have already had. Pollution problems in the lagoon are exacerbated by the drainage of domestic waste water from the Puttalum town. Detergents together with domestic effluents, and in some cases sewage, are brought in via drains into the water body (CEA/Euroconsult, 1994a;1994e).

Estuaries seriously affected by pollution include the Kelani and Walawe estuary (Baldwin *et al.* 1991). In the Walawe estuary, major contamination comes from the two main state-owned sugar factories. Other areas receive industrial effluent, domestic/municipal waste and sewage, and as in Negombo Lagoon, oil from fishing craft, boat repair yards, and fuel supply stations along the banks. Certain southern lagoons are experiencing increased nutrient contents due to the retting of coir, which leads to the release of nutrients such as nitrogen and phosphorous, causing low levels of dissolved oxygen (Bandara, 1989). This is a problem also common to the study area.

Desalinisation has adversely affected several lagoons and estuaries. The salinity of the Kalametiya-Lunama Lagoons dropped considerably when excess freshwater from the Uda Walawe reservoir was diverted into them in 1950, a factor which has significantly affected the prawn fishery (CEA/Euroconsult, 1991;1995a). Reduced fishery potential in Karagan Lagoon has resulted from changes in the salinity regime and inadequate recruitment from the coastal waters (CEA/Euroconsult, 1994b).

Irrigation schemes that started out as drainage or saltwater exclusion schemes have altered the salinity levels in several southern lagoons so that fisheries have been adversely affected or totally destroyed. Such impediments to natural drainage patterns have had a major impact on the Puttalum Lagoon, Dutch Bay and Portugal Bay where poorly sited bund construction, associated with aquaculture ponds and salt pans, has caused major flooding problems. Added to this, the bund construction has partially blocked tributaries within the delta causing back-water flooding which has affected both rice fields and villages. A parallel situation is seen in the study area. Correspondingly Rekawa Lagoon, situated 200km south of Colombo in the Hambantota district, is threatened by the diversion of freshwater which in the past drained into the lagoon from upland and lowland agriculture. Salinisation of rice fields as a result of badly designed irrigation interventions has meant that about 300ha of paddy land has had to be abandoned (Ganewatte *et al.* 1995). In several cases, deterioration of groynes and flood gates has allowed salt water to enter once again and adversely affect the expanded cropland. This is a major problem in the study area (Samarasekara, 1994).

Sedimentation of coastal lagoons resulting in shrinkage has affected a number of lagoons in the country. A survey of the Rekawa Lagoon in the early 1980's indicated that the surface area of the lagoon was 350 hectares (Samaranayake, 1983), whereas a study by Jayakody (1994) measured the surface area at 250 hectares in 1993. This apparent shrinkage of the lagoon is attributed to sedimentation and the resulting expansion of mangroves into the main body of the lagoon. The problem of sedimentation is also an area of concern in Hikkaduwa due to sediments discharged from two freshwater outlets, beach erosion and sediments brought by the Hikkaduwa River which are also affecting the quality of the coral reef in the area (Nakatani *et al.* 1994). In Kalametiya Lagoon the area of open water in the lagoon has decreased by more than 50% during the past 30 years largely due to siltation which has resulted in the expansion of the mangrove community here which is further accelerating the process of siltation (CEA/Euroconsult, 1991). In Negombo Lagoon increased sedimentation is presenting a threat to the lagoon fishery (Samarakoon & Zon, 1991).

Intensification of agriculture has led to the degradation of a significant number of lagoons due to the run-off of agro-chemicals into the system (pers. comm. Mubarak, 1993) This has resulted in the excessive enrichment of coastal waters containing high levels of organic pollutants which have resulted in eutrophication and periodic fish kills. Complaints of reduced catch amongst fishermen in the Walauwawatta Waturana Swamp Forest located in the Kalu Ganga basin have been largely attributed to this factor (CEA/Euroconsult, 1994c). They have in particular noticed a decline of the Giant Snakehead (*Channa marulus*). Similarly in Rekawa Lagoon there is concern that water draining into the lagoon is polluted with agro-chemicals (Ganewatte *et al.*1995). This is also a problem in the Palatupana Maha Lagoon where proposed irrigation schemes aim to divert drainage waters contaminated with high levels of agro-chemicals into the lagoon (CEA/Euroconsult, 1994d). Similarly complaints of the fishermen in the study area can be attributed to the same reasons outlined above.

Pressures from agricultural intensification also come in the form of unbridled government expansion programmes. Wetlands within the Ruhunu National Park have been affected in this way. Here efforts to clear and irrigate land and resettle large numbers of people closer to Bundala Lagoon are likely to result in wetland degradation and the proposed upland drainage schemes would significantly alter the salinity of the lagoons in the park (Laird, 1991). The Puttalum Lagoon, which is a semi-enclosed system, receives water from catchment areas where aquaculture and agricultural activities take place. Thus it is possible that excess nutrient loads could enter the lagoon which would lead to eutrophication and algal blooms (CEA/Euroconsult, 1994a,f). Similarly Karagan Lagoon, which is a semi-enclosed basin, receives sewerage seepage from poultry farms situated adjacent to it (CEA/Euroconsult, 1994b).

Livestock production is the second largest traditional economic activity around Bundala National Park (Laird, 1991). This has led to problems of overgrazing and destruction of wildlife habitat. At present the carrying capacity of cattle for most areas has been exceeded and a serious overgrazing problem exists. This has led to the formation of thorn-bush dominated by introduced invasive species such as *Opuntia dillenii* (Ker-Gawl.) Haw (CEA/Euroconsult, 1993). Elsewhere overgrazing has led to soil denudation, increased erosion, increased run-off and reduced soil permeability. In Karagan Lagoon, Palatupana Maha Lagoon and Kalametiya Lagoon, grazing pressure by roaming buffalo has led to reduced plant diversity around the lagoons. This has also led to problems of eutrophication through excessive inputs of dung and urine.

Table 2.7 A Summary of the key threats affecting estuaries and lagoons in Sri Lanka with examples

HUMAN ACTIONS	EXAMPLES
Direct	
• Drainage for agriculture, forestry and mosquito control	e.g Thondaimannar Lagoon; Bundala Lagoon
• Conversion for aquaculture/mariculture	e.g Thondaimannar Lagoon; Chalai Lagoon; Kokkilai Lagoon, Periyakarachi Lagoon; Maha Lagoon; Mundal Lake; Puttalum Lagoon
• Landfilling for residential and industrial development and solid waste disposal	e.g. Muthurajawela swamp; Jaffna Lagoon; Lunama Lagoon
• Mining of coral and sand	e.g. Karagan Lagoon; Rekawa Lagoon; Hikkaduwa marine sanctuary;
• Pollution from run-off from agro-chemicals, nutrients from domestic and industrial sewage and sediments	e.g. Jaffna Lagoon; Batticaloa Lagoon; Palatupana Maha Lagoon; Negombo Lagoon
• Pollution from the discharge of industrial effluents	e.g. Valaichchenai Lagoon; Walawe estuary; Lunama Lagoon; Kelani estuary
• Conversion into salt pans	e.g. Chalai Lagoon; Sinnakarachichi Lagoon; Koholankala Lagoon; Maha Lagoon; Puttalum Lagoon;
• Unsustainable felling of fringing mangrove communities for fodder, fuel and traditional fishing methods	e.g. West end of Jaffna Peninsula; Trincomalee Bay; Chundikkulum Lagoon; Batticaloa Lagoon; Kalametiya Lagoon; Puttalum Lagoon
• Eutrophication	e.g. Beira Lake; Lunawa Lagoon
• Illegal/Over-fishing	e.g. Negombo Lagoon; Rekawa Lagoon; Bolgoda Lake
• Illegal hunting and trapping	e.g. Bundala Lagoon; Belanwilla Attidiya marshes; Wetlands in the Wilpattu National Park
• Conversion for salt water exclusion scheme	e.g. Thondaimannar Lagoon; Chundikkulum Lagoon
• Disturbance caused by wrongly sited tourism facilities	e.g. Bundala Lagoon; Hikkaduwa
• Overgrazing by livestock	e.g. wetlands within the Ruhuna National Park
Indirect	
• Hydrological alterations by canals, dams, roads and other structures	e.g. Mahaweli Ganga Floodplain System; Puttalum Lagoon; Dutch Bay; Portugal Bay
• Sediment diversion by dams, deep channels and other structures	e.g. Kalametiya Lagoon
Natural Causes	
• Biotic effects i.e. siltation	e.g. Upaar Lagoon; Batticaloa Lagoon; wetlands in the Yala and Ruhuna National Park, Kalametiya Lagoon

(Source: Present study)

Mining of mineral resources around lagoons situated in the southern part of the island is common. Coral mining in particular is worth noting, in areas such as Hikkaduwa (Banda, 1990; Nakatani, 1994). The coral is mined extensively for lime production used in the construction industry and results in significant coastal erosion. In Rekawa, coral mining which provides direct and indirect income to nearly 500 people, has continued unabated for nearly two decades. Consequently this has accelerated beach erosion, even depriving fishermen of a place to berth their fishing boats (Ganewatte *et al.* 1995). In Karagan Lagoon gem and shell mining takes place in close proximity of the lagoon. This has resulted in unofficial tracts being cleared leading to soil erosion. A similar situation occurs in Bundala where fossil shells are extracted from beds close to the lagoon, which disturbs soil structure and destroys vegetation cover also leading to soil erosion.

2.9.3 Seagrass Beds

Seagrass beds, composed of rooted seed bearing marine plants (halophytes), occur in shallow, sheltered nearshore and coastal waters and as underwater meadows in estuaries and lagoons. They are the only flowering plants that have returned to the sea and their entire life cycle, including pollination, occurs underwater. Seagrasses, and their associated epiphytes and abundant detritus, provide an important link in the complicated food chain which ties coastal wetlands, such as estuaries and mangroves, to offshore coral reefs (Abeywickrama & Arulgnanam, 1991).

The major economic importance of seagrass beds stems from their provision of critical nursery grounds for many commercial species of fishes and shrimps (IUCN/UNEP, 1985). Most marine fish are caught from nearshore coastal waters along the north-western and north-eastern coasts where seagrass beds abound. Other functions and values include: binding sediment and stabilising the bottom against erosion and the provision of food to several marine organisms. Some species such as parrot fish feed directly on the seagrass leaves, while penaeid shrimp feed on the grass detritus. Certain juvenile fish feed upon epiphytes. One commercially important species in the estuaries and lagoon fisheries - *Etroplus suratensis* is found mainly among seagrass beds. Fortes (1990) provides a review of economic valuations of seagrass-associated fisheries. These values, though theoretical, provide an indication of the importance of the resource.

Seagrass beds are most important on the north-west and north-east coasts and they may support more than 50% of the country's near-shore fishery production (GOSL, 1987). The most extensive beds are shown in Figure 2.6. Seagrasses are sometimes dried and used as fodder

(UNEP, 1986a). The distribution and composition of seagrass beds in Puttalum and Negombo lagoon are described by Jayasuriya (1989;1990).

Seagrasses are particularly susceptible to disturbances. The greatest threats facing them include erosion sediment from coastal deforestation and poor agricultural practices, destructive fishing gear, including bottom trawls and drag nets (e.g. Dutch and Portugal Bays and Negombo Lagoon); digging for polychaetes (e.g. Negombo lagoon); siltation and eutrophication (Lowry & Wickramaratne, 1989) ; pollution from industrial and municipal wastes.

2.10 Summary of Key Themes

- From the review given above, it is evident that the coastal areas and waters of tropical Asian countries house some of the world's richest ecosystems. Productive fisheries supported by coral reefs, mangrove, estuarine and lagoon habitats are of considerable economic importance to people living in these areas for both subsistence and commercial purposes.

- However the examples given in this chapter point to an increasingly polluted coastal environment and one which is becoming ever more densely populated and built-up. As a result of the growing pressures on these coastal resources and environments, the potential economic revenues available from them are diminishing.

- Throughout much of South and Southeast Asia, the expanding population in the region has placed a growing demand on living and non-living resources, with marine resources playing a major role. Consequently nearshore fisheries in most Asian countries are over-fished and habitat quality is significantly lower than thirty years ago. For most countries in this region the reality is similar. The trade-off between environmental quality and opportunities for employment and poverty alleviation are not easy to decide.

- The situation in Sri Lanka is not much different from the Asian norm. The coastal habitats in this region are small and vulnerable to degradation. The extent of biologically productive mangrove systems, estuaries, coral reefs and seagrasses is decreasing (CCD, 1988) at the same time as important estuarine and lagoon systems are becoming increasingly polluted. Mangroves are being cut for timber and fuelwood, and the habitat converted into aquaculture sites or human settlements. According to current rates of depletion, the existing mangrove habitat will have been reduced by up to 50% by 2001 (Olsen *et al.* 1992).

- The coastal zones in the southern part of Sri Lanka, the area under which the study area falls, are among the most densely populated parts of the island and as a result most of the coastal resources in this region are heavily utilised. Fishing, coconut-based industries, coral and sand collection, and tourism are the main activities, all of which have contributed to the general decline in this zone. This area has also suffered major pollution problems created by a largely urban environment. For a long time the beach and the lagoons situated here have been considered to be dumping grounds for solid wastes and outlets for sewage outfalls. A recent survey revealed that there are as many as 22 major sewage outfall structures in the area between Galle and Colombo (Bandara, 1989).

- From this review it is clear that the example of Koggala Lagoon is consistent with the current position of most Asian coastal environments. Due to a combination of some of the problems outlined in this chapter the traditional resource base is increasingly showing signs of not being able to support the number of people already utilising these resources for agriculture, fisheries and, more recently, tourism and industry.

CHAPTER 3
AN ENVIRONMENTAL AND GEOGRAPHICAL PROFILE OF KOGGALA LAGOON AND ITS ENVIRONS

3.1 Introduction

The purpose of this chapter is to provide an introduction to the study area and to the key themes of the research. It should be stressed that the material relating to this chapter is primarily based on the research findings of the author because very little published material is currently available.

Chapter 3 has been structured as follows. Section **3.2** describes the geography and history of Koggala. For a deeper understanding of the central theme of environmental change, knowledge of related historical aspects is important as a baseline. The key theme of disruption is evident throughout the history of Koggala and knowledge of the history of the area is vital to interpret recent events. Section **3.3** provides an introduction to the physical geography of the study area, including details relating to climatic patterns; geology and soils; and a general introduction to recent changes relating to the hydrology of the lagoon. Similarly Section **3.4** provides a brief overview of the main vegetation types in the lagoon and its environs, with an emphasis on the fringing mangrove complex.

A summary outline of pertinent aspects relating to the political, institutional and legal frameworks that operate in the area is presented in Section **3.5**. In the context of the research, an understanding of this framework is meaningful for two reasons. First it provides an introduction to the relevant administrative structure, which has a bearing on the way in which activities are carried out at the divisional level. Therefore it applies directly to the sample six divisions which are featured in this study. Secondly, it describes the various authorities that have a jurisdiction over the study area, an important matter when considering management plans.

A socio-economic profile of the local communities in the sample six divisions, compiled from surveys conducted by the author (see **Chapter 4**) is presented in Section **3.6**. This section also presents an introduction to the social structure of the study area and highlights the close connection between the local communities and their 'natural' resources.

This chapter concludes with sections on the past and present role of agricultural (Section **3.7**) and industrial (Section **3.8**) developments and gives an evaluation of how such changes have affected resource-use. The objective here is to present the contextual background for the central theme of environmental change in Koggala. Emphasis is given to key historical and social impacts which have influenced the environment and the natural resources in the area and ultimately the degree to which the local communities have had access to these resources.

3.2 The Geography and History of Koggala

3.2.1 Geography

Koggala Lagoon is situated in the south of Sri Lanka (lat. 6°N, 80°E), about 16 km to the east of Galle, the capital of the Southern Province. The total extent of this coastal lagoon is 727 ha (Arumugam, 1969), being approximately 6km long and 5km wide, with an average depth of two metres. Together with its 'environmental impact area' it encompasses a total of approximately 1,500 ha (see Frontispiece).

This wetland represents a brackish marshy area, merging into a tidal coastal lagoon, which opens to the sea at its southern end, where it is interconnected with the near coastal waters and coral reef system. Koggala Lagoon and its surrounding areas support many of the coastal resources and ecosystems typical of Sri Lanka's southern coasts. On the borders of the lagoon are a number of villages whose inhabitants are mainly associated with farming and fishing activities centred on it (see Figure 3.1).

The lagoon is surrounded by undulating terrain rising between 30-100 metres above sea level, covered mainly by plantation cultivation and homesteads. The narrow coastal zone is bounded by the main Galle Matara road and on one side by the Koggala Export Processing Zone and is well served by railway and road networks. Towards the north western limit of this zone there is a small air-strip and associated buildings of the Sri Lankan Air Force. The air force base is mainly used for security operations and for internal flights.

3.2.2 History

'Koggala' literally means 'the rock where the herons nested'. The area around the lagoon has a rich folklore and a history dating back to early Buddhist times (500 B.C). Rocks within the lagoon bearing stone inscriptions referring to the victorious battles of King Samatha's army and the defeat of the Kafirs further illustrate its historical significance (pers. comm. Ahubudhu, 1994). The early inhabitants of Koggala are believed to have been sun-worshippers and in several literary works of the past Koggala is frequently mentioned. The references are mainly to people who lived from fishing in the lagoon and the nearby sea, in addition to agricultural pursuits centred around rice cultivation (Ahubudhu, 1994).

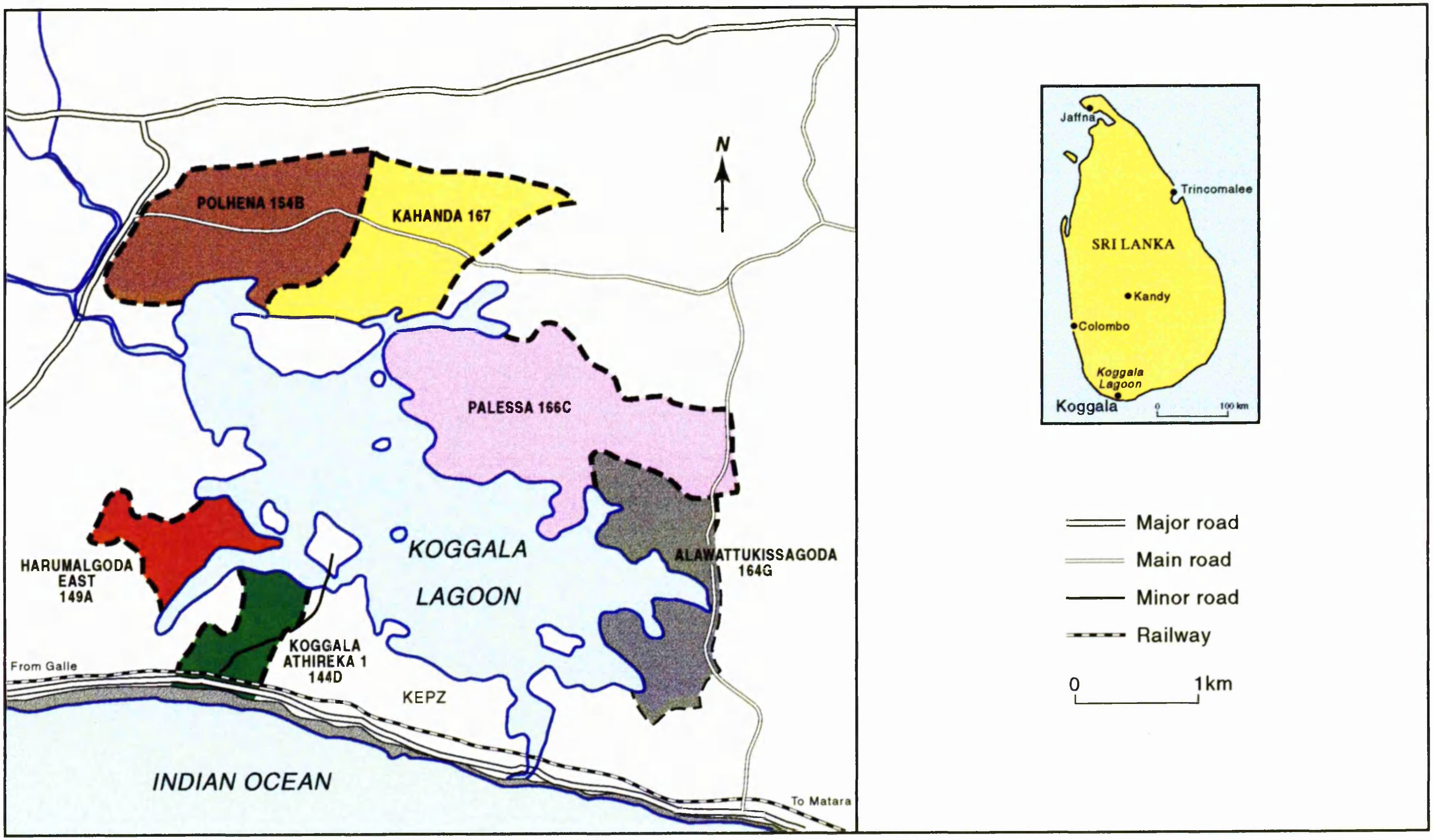


Figure 3.1 Research area showing the six sample divisions

Koggala also features prominently from historical times in the works of many writers, poets, and scholars who contributed to the intellectual climate of the country. In recent times greater prominence have been given through the cultural and literary works of Martin Wickramasinghe, a well known author, whose many works relate to the time he lived there. His home has been converted into a Folk Arts Museum and is a prominent land mark today. In addition there are a number of ancient Buddhist temples of noteworthy historical and cultural significance (TEAMS, 1994). Examples include the Talatuduwa Hermitage established on the Talatuduwa islet which has about 20 resident monks. The Hirigal Devala and temple are over 300 years old and are mentioned in the famous book *Gamperiliya,* 'Revolution in the village', by Martin Wickramasinghe. This temple has sculptures and paintings dating back to the Kandyan era (1469-1815). The Ranwella temple houses the printing press used to produce the first Sri Lankan newspaper (1896), '*Nawaloka*'(New World).

Evidence of human settlements in the area dates back to the 3rd century B.C (see Figure 3.2). The Ruhunu Provincial Kingdom was established around this time. These communities were largely dependent on inland, not coastal, resources. By the 14th century, cinnamon and citronella growing were major economic activities (Prematileke, 1989). Galle became an important harbour for the cinnamon trade (Cook, 1951; Bansil, 1971). After the Portuguese arrival in 1505, and the Dutch in 1638, most of the arable land was converted to cinnamon plantations (De Silva, 1982; Abeyasinghe, 1966; Arasaratnam, 1988). Landlessness among the traditional farming community resulted from this conversion to cinnamon growing, because they were increasingly compelled to work as labourers on the plantations. The Dutch provided special privileges to certain labourers to ensure the continuation of this industry enabling some of them to rise in social status and to become land owners and community leaders (Kotelawale, 1967). Fishing, however, was not an important activity during this period and was taken up mainly by landless groups.

With the replacement of the Dutch by the British in 1797, coconut replaced cinnamon cultivation as the most important economic activity. As coconut cultivation was much less labour intensive than cinnamon, a large number of people became unemployed in the process and turned to fishing as an alternative. The coir industry started at the turn of the century and has supplied fibre for handicrafts, rope and household products and exports. Graphite mining also became a new industry during the early colonial period. The nearby Galle harbour provided an outlet for this produce primarily to the West (Samaraweera, 1987).

The Second World War brought substantial changes in the lifestyle of the community living around Koggala Lagoon. A massive population evacuation (until 1949) took place to make room for an air base and military camp. This camp was largely inhabited by African and Australian Allied troops. The lagoon itself played a vital role in the war as it was used as a landing site for Catalina and Sunderland Planes engaged in reconnaissance activities (see Figure 3.3) (Tomlinson, 1976). To facilitate the landing of these planes the level of the water in the lagoon was raised by the partial bunding of the outlet to the sea.

The disruption caused by the evacuation, the bunding, and the military activities in the area, again seriously affected the lifestyles of the people who were only allowed to return to whatever remained of their homesteads in the mid 1950's. On their return they faced problems of increased landlessness. Several excerpts from letters written to the Prime Minister during this period describe the many hardships experienced by the inhabitants:

> *" Since we left our villages on the 24th of March in obedience to the twenty four-hour notice to quit, we have been living a most lamentable life. The state of life since then has been scarcely better than pauperism to most of us."* (Plea from the Original Hereditary Land Owners of Koggala, 30th May 1955, cited in Ahubudhu, 1994).

> *"Obeying the twenty four hour quit notice of the 24th March 1942 we had to seek shelter in whatever corridor or pavement that we came across, irrespective of to whom it belonged, with only our pots and pans and whatever light furniture that could be carried about in our possession. From that day onwards all these eight long years, we have been wanderers here and there, with our children and ones connected, having neither a fixed abode nor a decent means of living. The problems that face us for immediate solution is that of unemployment. It is too well known that nearly all the inhabitants of Koggala depended for their daily bread on the Koggala lagoon (Oya) and the sea. It was due to the coir industry that flourishes in Ceylon, and sea and river fishing that we managed to keep our bodies and souls together. From where else could we hope to get that same aid to make a living that we used to get readily from the Koggala lagoon and the sea?"* (Plea from the Original Hereditary Land Owners of Koggala, 12th March,1950, cited in Ahubudhu, 1994).

In 1950, about 100 lagoon fishermen that were displaced from Koggala during World War II were settled in the area around Rekawa Lagoon, situated about 200km south of Colombo in Hambantota district. This caused a number of social problems as the fishermen from Koggala were considered to be intruders by the well established fishing community in Rekawa. There was very little social interaction and occasionally violent conflicts ensued over the different methods of fishing practised by the 'outsiders.' This animosity reportedly still exists today (Ganewatte *et al.* 1995).

Figure 3.2 Time-line analysis illustrating key events in Koggala Lagoon and its environs

DATE	HISTORICAL EVENT
200 B.C	Initial civilisation present in Koggala.
AD 1505-1650	Portuguese colonial occupation of the coastal districts.
1650 -1797	Dutch colonial occupation of the coastal districts.
1797	British colonial power established in the country.
1942	Inhabitants of Koggala evacuated to make way for a Military camp.
1942	Bund built to facilitate landing of sea planes in lagoon.
1945	End of Second World War.
1948	Sri Lanka gains independence from Britain.
1950's	A section of the original hereditary inhabitants of Koggala allowed to return to their former homestead. Approximately 100 fishing families re-located in Rekawa Lagoon.
1952	Bund built to facilitate landing of planes in lagoon removed by farming community to lower water levels to enable rice cultivation to commence again.
1970's	Intensification of agricultural activities as new technologies of the 'Green Revolution' are introduced to the study area.
1983	Irrigation rehabilitation projects initiated with the Warrabokke Salt Water Exclusion Scheme. Increased problems relating to lagoon water intruding into rice land.
1990	Initial land clearance and filling of site of proposed Free Trade Zone. Residents (fishing community) re-housed in GN division of Eddunkele.
1991	Koggala Export Processing Zone established- building work within zone continues.
1991	Fish found dead in localised spots within the lagoon.
1992	Sand mining initiated from sand bar at mouth of lagoon.
1993	Ongoing physical problems associated with the sand bar removal e.g. flooding of homesteads to highest recorded levels. Diseased fish found in lagoon.
1994	Rising number of abandoned rice fields due to salt water inundation.

(Source: Present study)

3.2.3 Summary of Key Issues

- From a historical perspective key events in Koggala Lagoon and its environs have had a significant impact on both local communities and on the ecological conditions. This is clearly demonstrated by the influence of the colonial powers which spanned the period 1505-1948 and this to a large extent controlled the crop types that were cultivated during that time. This in turn dictated the rise and fall of different social groups.

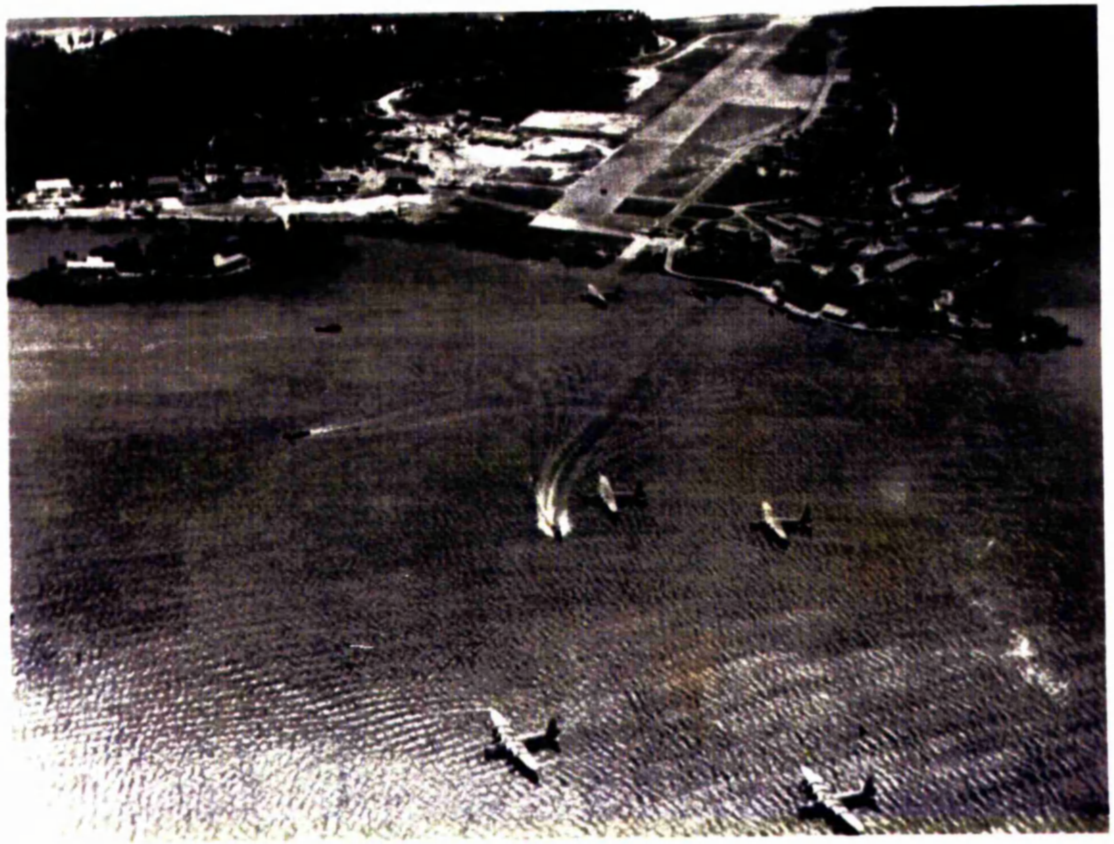


Fig 3.3 Aerial view of Sunderland and Catalina planes in Koggala Lagoon during World War II.
(Source: RAF Museum - Hendon, 1944)

- Similarly, the upheaval caused by the population evacuation in the area during World War II played a crucial role with both social and physical repercussions. As well as being a very traumatic time for the residents, the duration of the evacuation represents a period of almost ten years when there would have been a minimal amount of physical stress on the lagoon and its surrounding areas. The bund that was built in order to raise the water levels in the lagoon in 1942 was probably the only physical disturbance to take place during this time. It was later removed by the farming community when they returned to their homesteads as it prevented them from cultivating their rice lands due to high water levels.

- During the post war period a major area of concern was the issue of landlessness amongst the displaced groups. This problem has not been adequately resolved and is still a source of resentment among many residents (see **Chapter 8**).

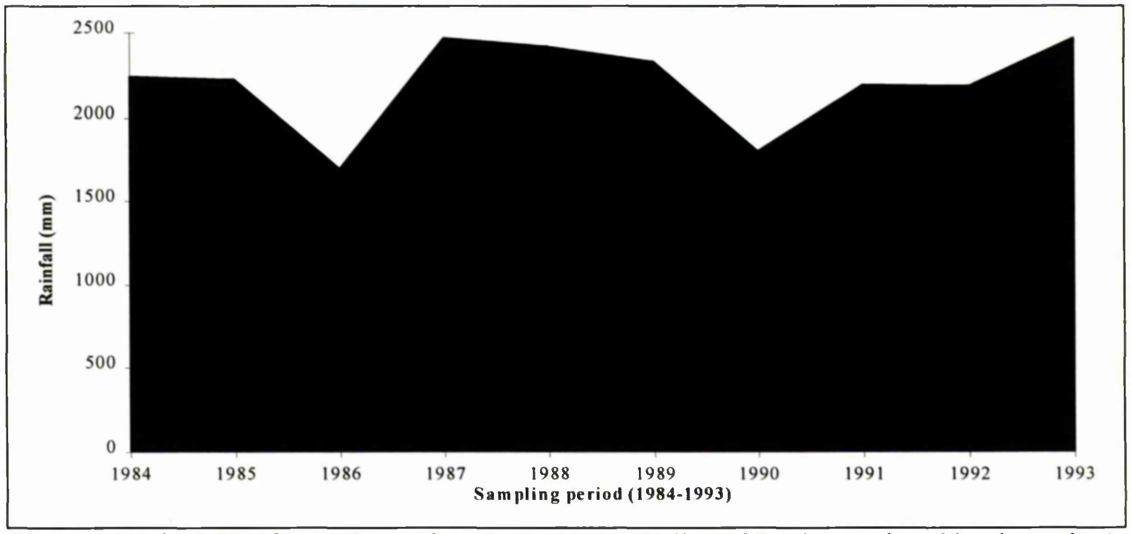
In the context of the present research, an understanding of these key historical events in Koggala is fundamental in helping to interpret recent developments in the area in both a social and physical context.

3.3 The Physical Geography of Koggala

3.3.1 Climate

The study site falls within the low and mid country wet zone which covers the southwest part of the island and extends from the coast to the western and southern slopes of the central massif. It is also located in the agro-ecological region WL4 which is defined as an area of a 75% expectancy of an annual rainfall exceeding 1,525mm (Survey Department, Sri Lanka, 1988; Thambyapillay, 1960; Domros, 1974).There are two heavy rainfall periods during the year and rainfall also occurs in the intervening months. The mean annual temperature is 27°C at the coast and, with increasing altitude, it progressively falls to 20°C at mid elevations.

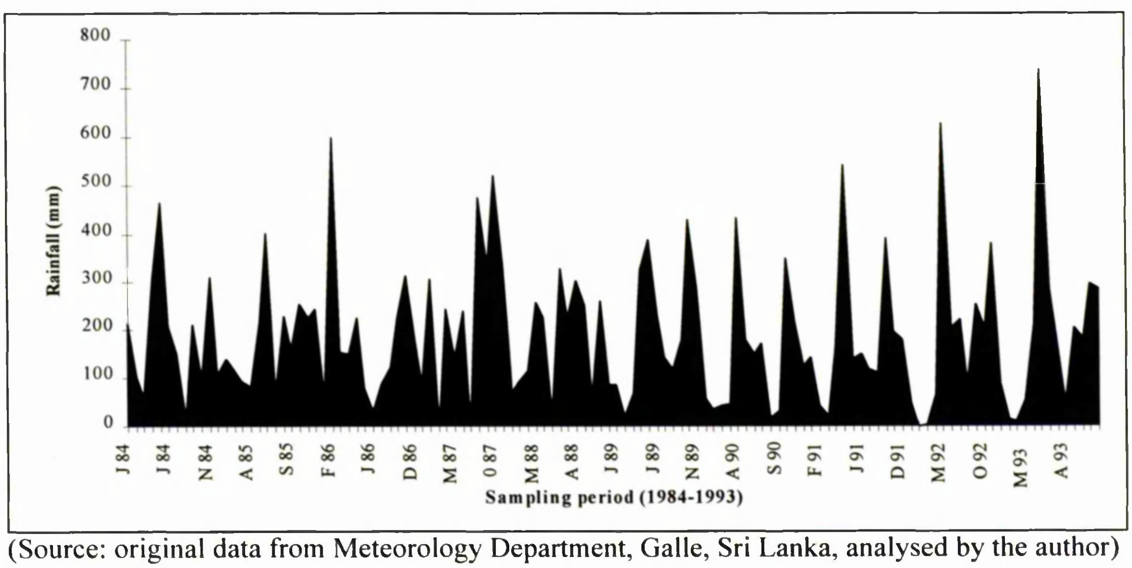
Figure 3.4 Total yearly rainfall in the study area 1984-1993



(Source: original data from Meteorology Department, Galle, Sri Lanka, analysed by the author)

The mean annual rainfall in the study area over the last ten years has been 2,201mm (see Figure 3.4). There are two distinct rainy seasons, the Southwest monsoon from mid-April to mid-June, averaging about 273mm month^{-1}, and the Northeast monsoon from mid-September through November, averaging about 246mm month^{-1}. The driest time of the year is January through March, averaging 73mm month^{-1} (see Figure 3.5). It may be noted as a matter of interest that the Maha cultivation season for paddy, which is reckoned to be from September to March, begins at the tail end of the South West monsoon, and covers the intermonsoonal months of October, November, the full NE monsoon period and a month of the second intermonsoonal period. The Yala cultivation season is from April to August and thus the season begins during an intermonsoonal month and covers the major period of the SW monsoon.

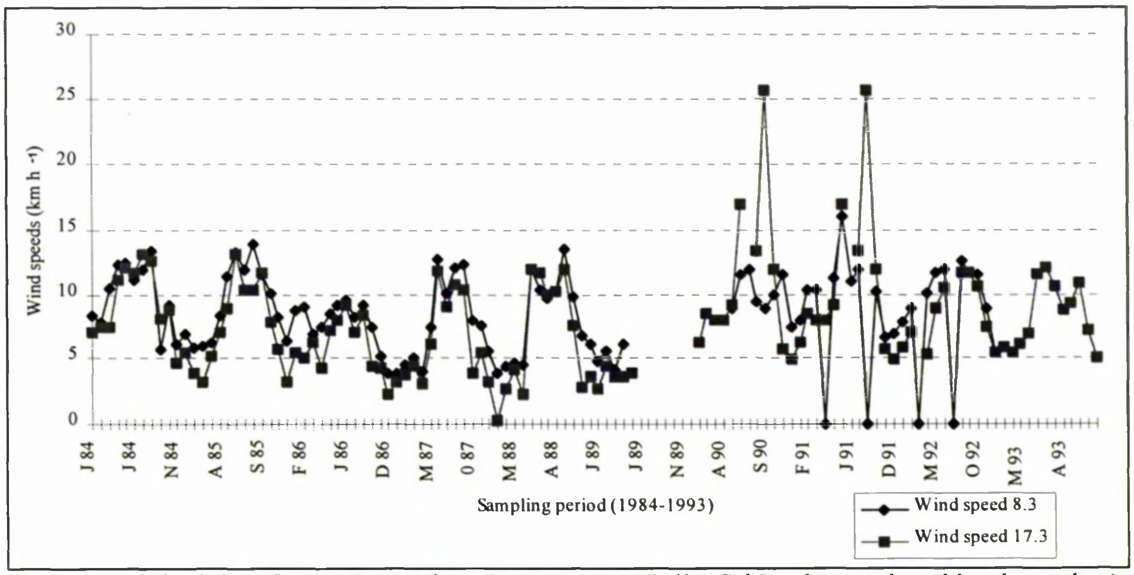
Figure 3.5 Mean monthly rainfall in the study area 1984-1993



(Source: original data from Meteorology Department, Galle, Sri Lanka, analysed by the author)

Figure 3.6 presents an analysis of wind data recorded at the Galle observatory over the last ten years. The maximum wind speed recorded at 8.30hrs was 25.6km h^{-1} in September and the minimum was 2.2 km h^{-1} in January. Corresponding figures for 17.30hrs are a maximum wind speed of 13.9 km h^{-1} in August and 3.8 km h^{-1} in January. The windiest time of the year generally coincides with the South west monsoon. Data collected for the last ten years shows that from May to October (8.30hrs) the average wind speed is 9.0km h^{-1} whereas for November to April it averages 0.2km h^{-1}. The main wind directions are at 8.30hrs N to NW from November through February and mainly SW for the rest of the year. At 17.30hrs, the wind blows NE from November through February, E in April and March, and mainly SW for the rest of the year.

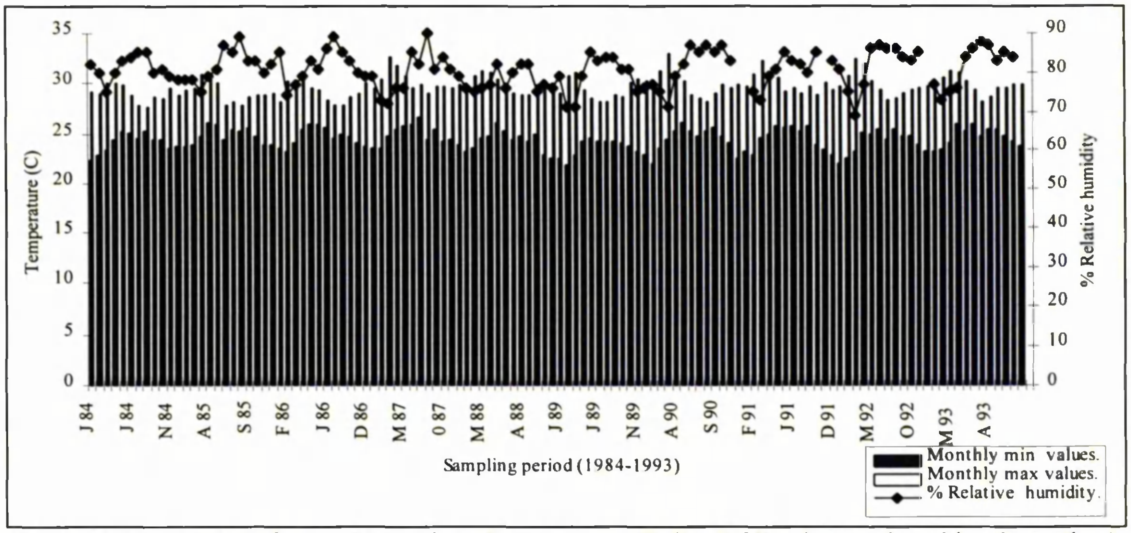
Figure 3.6 Mean monthly wind speeds (km h^{-1}) in the study area 1984-1993



(Source: original data from Meteorology Department, Galle, Sri Lanka, analysed by the author)

Mean monthly maximum and minimum temperature figures together with (%) relative humidity values recorded over the period 1984-93 are presented in Figure 3.7 (Meteorology department, Galle Observatory). The highest mean monthly maximum of 32.9 °C occurs in March and the lowest mean monthly minimum of 27.7 °C in August. The highest day temperatures generally occur between 12.00hrs and 15.00hrs, and the lowest between 05.00hrs and 06.00hrs. There is little variation in the mean monthly temperature, the average range being from a low of 26.2 °C in January to a high of 28.1°C in April.

Figure 3.7 Mean monthly maximum, minimum temperature values and (%) relative humidity in the study area 1984-1993



(Source: original data from Meteorology Department, Galle, Sri Lanka, analysed by the author)

3.3.2 Geology and Soils

The geological history of the area has been studied by Cooray (1984). Other important sources of information are Weerakody (1990) and Swan (1983). The following description of the geological processes are based on these studies, supplemented by field observations conducted during the research period. The South-western Group, one of the upper Palaeozoic rock formations as described by Cooray (1984), dominates the geology of the entire south-west region of Sri Lanka where the study area is located. The major rock types are metasediments, charnockites and granites or pegmatites. The charnockites and undifferentiated metasediments occur in the coastal plain concurrently with bands of diopside-scapolite, calc-granulites or gneiss (Survey Department, 1988).The coastal area is covered predominantly with Quaternary deposits. The river alluvium and the lagoonal deposits (clay, silt and sand), marine deposits (beach sand, beach rock, coral debris) and aeolian deposits (dune and wind blown sand) were formed in the Holocene, while the partly ferruginous gravels are of Pleistocene origin. According to Weerakody (1990) deposits of clay, silt, mud and sand from Koggala Lagoon correspond to the Holocene period.

Landforms off the coastal plain mostly exhibit a marine influence, since the high sea levels during the Quaternary submerged the area. In addition, ancient marine landforms as well as landforms altered by marine action in the immediate hinterland are the result of the rise of the sea level since the mid Holocene time (Weerakody, 1992). The mid-Holocene high sea level caused the expansion of the Koggala Lagoon by submerging the surrounding lowlands and adjacent dendritic valleys while, further upstream, these valleys were filled by alluvium. Thus, an irregular embayment was formed by the submergence. The western part of the embayment had developed into a coastal ridge (sand bar) (see **Chapter 5**). The threat of rising sea-levels, which has major implications for coastal areas has already been discussed in Chapter 2. The possible effects of rising sea-levels on coastal areas in Sri Lanka, which is tectonically stable, and particularly on the study area, include increased frequency and extent of flooding leading to even greater saltwater intrusions into the lagoon, water logging of the soil and coastal erosion taking place on a much larger scale than at present.

The underlying geology in the study area which has been outlined above provide the foundation for two dominant soil groups. These are the Red-Yellow Podzolic soils and Wet Mountain Regosols with soft and hard laterite (Survey Department, 1988; Alwis *et al.* 1973). The west of the lagoon is bordered by a shoreline of sand and alluvial soils mixed with shell fragments and remnants of decaying corals. Waterlogged muddy soils are characteristic on the marshy lands adjoining the lagoon. The environs of the lagoon are undulating intermingled with small valleys. The steeply elevating high ground is covered by red earths which are characteristic for the south-west of Sri Lanka. The lagoon is known to have supported an extensive mangrove vegetation which accelerated the deposition and sedimentation of alluvial and marine deposits in the lagoon.

3.3.3 Hydrology

Hydrological data relating to Koggala Lagoon are limited. Specific details relating to the changing hydrology of Koggala Lagoon are given separately in **Chapter 5**. This section will present an overview of key issues relevant to the research.

Water levels in the lagoon have most recently been impacted by sand mining of a coastal sand bar located close to the mouth of the lagoon. This 'naturally' formed sand bar had an important role in controlling water levels in the lagoon and had been traditionally breached with minimal effort by farmers during periods of heavy rainfall to avoid water from the lagoon flooding the surrounding rice fields. As a result of this sand mining, which was initiated early in 1992, irreparable damage was done to the stability of this sand bar which has been completely washed away. Now the water levels in the lagoon can no longer be controlled using traditional means. Naturally this has caused concern amongst local resource users and environmentalists since the lagoon's hydrology, salinity, and thus ecology, have changed dramatically.

As a result, of these actions, flooding of village homesteads and roads is now common (see Figure 3.8). Moreover the prolonged flooding of rice fields now experienced not only hampers land labour but it also stops drainage flushing. Paddy cultivation on the alluvial plains in the northern and north western corner of the lagoon has virtually ceased, and the abandoned fields have been rapidly transformed into marshes.

3.3.4 Summary of Key Issues

- The changing hydrology and ecology of the lagoon since the destruction of the sandbar has been the most serious disruption in recent times. The ecological and social repercussions of which have been most heartfelt by the two main communities (fishing and farming) dependent on the lagoon. Inundation of the surrounding rice fields with saline water has always been a problem in Koggala but not on the same scale as it is now. A mean rise in the lagoon's waters has had the effect of raising the water levels in about 500 ha of rice paddy land, forcing many farmers to abandon rice cultivation (see **Chapter 7**). In addition to this people living in those villages situated close to the lagoon have experienced flooding of village roads and homesteads, making them inaccessible for days on end. This problem is heightened during the monsoonal months because the study area experiences heavy rains (see **Section 3.3.1**). Sea-level rise will increase the tendency of this saltwater to intrude.

- A viable connection with the sea is essential to maintain the productivity of the lagoon fishery. However the destruction of the sand bar has resulted in elevated salinity levels in the lagoon. The fishing community now complain of traditional freshwater fish species being wiped out and the difficulties associated with fishing near the mouth of the lagoon as strong tidal currents damage their nets.

A: Flooding of village homesteads in Duwamalalagama (Harumalgoda East 149A). (Source: May 1995, D. Samarasekara)

B: Flooded rice fields, Polhena 154B. (Source: May 1994, V.N. Samarasekara)

Figure 3.8 Flooding in Koggala.

3.4 The Vegetation of Koggala Lagoon and its Environs

As illustrated in Chapter 2, wetland areas are among the biologically richest and most productive ecosystems known, in particular those situated in the tropics. Koggala Lagoon and its environs consists of marsh lands, a network of freshwater canals, and a fringing mangrove community. Due to centuries of human impact the vegetation in most of the area has been subject to many changes.

This section provides a brief description of the phytoplanktonic communities, littoral and surface aquatic vegetation, water fringing vegetation and terrestrial upland vegetation in the lagoon and its environs (Samarasekara, 1992). The present status of the fringing mangrove complex based on field surveys is presented separately in Chapter 5.

3.4.1 Marsh and Aquatic Vegetation

Koggala Lagoon is rich in phytoplankton (Samarasekara, 1992). These organisms are the basic link in the food web of higher animals and determine in large measure the importance of wetlands of this type. The dominant species of phytoplankton and algae correspond to areas of the lagoon with high concentrations of nitrates, dissolved salts (high conductivity), low pH, and reduced oxygen content (Samarasekara, 1992). This could indicate a certain degree of pollution. The presence of blue-green algae in the southern parts of the lagoon supports these findings but further studies would be required to verify the reliability of these organisms as pollution indicators.

The surrounding marshland in Koggala consists mainly of previously cultivated paddy fields and a network of freshwater inlets. The extent of this marshy area is steadily increasing with the rising number of rice fields being abandoned due to saline inundation (see Chapter 7). Consequently the vegetation in most of the study area has been subject to changes. Extensive areas of the marshlands are covered with a combination of sedges and grasses and patches of *Acrosticum aureum* have also established here. Extensive reed beds (*Phragmites karka* (Retz.) Trin. *ex* Steud) previously existed along the northern borders of the lagoon where salinity had been generally low (Alwis & Dassanayake, 1993). These populations have now dwindled possibly as a result of increasing salinity levels now experienced in these areas (De Alwis & Dassanayake, 1993; De Silva *et al.* 1994).

A variety of aquatic plants are found in former paddy fields, ponds, canals and channels, their occurrence being related to the level of enrichment of the water by organic and inorganic materials, by the degree of salinity and by water depth (Samarasekara, 1992). Dominant plant species include grasses and reeds belonging to the family Poaceae, sedges belonging to the family Cyperaceae and cattails belonging to the family Typhaceae. In addition members belonging to the family Nymphaceae are distributed mainly in areas of reduced salinity. Field surveys conclude that the current distribution of this vegetation type has been dramatically reduced as a result of elevated salinity in the lagoon.

The transition between the surrounding marshlands and the lagoon is characterised by a brackish water flora and mangrove forest. This area is important in both an ecological and economic sense. It is a area of high productivity, acting as a silt trap and providing spawning, nursing and feeding grounds for a variety of economically important fish and crustacean species. In addition to this it supplies coastal waters with nutrients.

Seagrasses which are located in this zone constitute an important habitat in Koggala Lagoon, providing sediment stability and a nursery ground for aquatic fauna which in turn serve as stock for lagoon and ocean fisheries. Four major seagrass genera and five sea grass species have been recorded (Samarasekara, 1992). *Halophila ovalis* (R. Br.) Hook. f, *Potamogeton pectinatus* L., Trimen Fl. Ceyl. and *Ruppia maritima* L. appear to be present most commonly near places where fresh water enters the lagoon. The occurrence of *Potamogeton pectinatus,* which has been mostly reported from elevations above 1000m, indicates that it has now spread to lowland waterways (pers. comm. De Alwis, 1994).

It is a common belief among the fishing community (see **Chapter 6**) that shrimps in the lagoon breed exclusively in the dense mats formed by these seagrasses. As a result of this they are a commonly utilised site for brush-pile fishing. Interviews conducted with the Fishing community indicate a considerable decline in the extent of these beds. This could be as a result of the inflow of increasing levels of agro-chemical inputs used in the surrounding rice fields which have direct access to the lagoon. Declining populations may also be due to the present nature of the lagoon which is exposed to a greater tidal input, a characteristic which is not generally tolerated by these communities (Abeywickrama & Arulgnanam *et al.* 1991), increased sedimentation from coastal deforestation, pollution from industrial wastes and destructive fishing methods which are described in Chapter 6. Although herbicides and fertilisers are used in the surrounding catchment areas and adjacent rice fields, to what extent the inflow of agro-chemicals has impacted the aquatic flora remains to be investigated.

3.4.2 Fringing Vegetation and Mangroves

Koggala Lagoon harbours a diverse mangrove vegetation. The major species are listed in Table 5.2. The most common species is *Rhizophora mucronata.* Evaporation during the dry season can raise the saline soil conditions in the lagoonal fringes providing conditions under which only mangrove and mangrove associates can thrive. A map showing the present status of the mangrove community compiled by the author is given in **Chapter 5**.

According to residents of the area, the mangrove formations in Koggala once existed as thick belts fringing the total periphery and the many islets within the lagoon. The alluvial plains in the northern and north eastern section were in former days covered with a swamp vegetation. Dominant species would probably have been, *Rhizophora mucronata, Sonneratia caseolaris*, intermingled with reeds and floating vegetation. These formations have now dwindled, both in terms of species and coverage. Fuelwood collection, the use of twigs for traditional brushpile fishing (Sinhala: *Mas-athu*), clearing of mangrove for homestead cultivation and reclamation for agricultural purposes are the main reasons for the dramatic decline and disappearance of the mangrove complex.

3.4.3 Summary of Key Issues

- The distribution and abundance of the important vegetation types occurring in the wetland and their relative ecological significance have been indicated based upon available information (Samarasekara, 1992). The most important issue here is the role these formations play in supporting and maintaining the productivity of the lagoon and the adjacent coastal zone, on which the local communities in the area depend upon for their livelihood.

- Koggala's coastal resource system is diverse and rich in both ecological and economic terms. A mangrove and lagoon system support both lagoon, nearshore and offshore fisheries for shrimp and a variety of fish. However this ecosystem and all its resources are threatened by the removal of the sand bar, and the use of agro-chemicals in the surrounding rice fields and plantations, which have collectively had an impact on water quality and water movement through the lagoon.

Human induced impacts such as felling of the mangrove complex bordering the lagoon for fuelwood, and unsustainable fishing practices are also beginning to show signs of exploitation. The social factors behind such actions are an important issue and one that is dealt with in **Chapters 6** and 7.

3.5 The Political and Institutional Framework

The institutional framework operating within the study area is summarised in Box 3A below and is represented diagrammatically in Figure 3.9.

Box 3A Administrative setting and Local Government Structure relating to study area

Administrative setting and Local Government Structure

- Sri Lanka consists of 25 administrative districts and nine provinces. The hierarchy of regional administrative divisions that supports the central government now consists of Provinces, Districts, Divisions and Gramaseva Niladhari units, in descending administrative order and area.

- The Thirteenth Amendment to the Constitution in 1987 provided for devolution of power to the provinces, and this process is still underway. Provinces are now the fundamental administrative units of regional governance, and they have concurrent jurisdiction with the central government over the protection of the environment, soils, coastal fisheries, and wildlife, among other resources. Districts still form the basic units in the parliamentary election process, but they have lost much of their traditional local authority. A unified village-level administrative service has been introduced by bringing together the former Grama Seva Niladhari, Vaga Niladhari (Cultivation Officer) and Visesa Seva Niladhari (Specialist Services Officer) into one rank, renamed as Gramaseva Niladhari (Village headmen).

Pradeshiya Sabha

- Pradeshiya Sabhas (PS) are bodies of elected members which form the divisional level link in the chain of decentralisation of power. They were set up through the Pradeshiya Sabha Act of 1987 with the objective to provide greater opportunities for people to participate effectively in the decision making process relating to development activities at the village level.

Divisional Secretariat

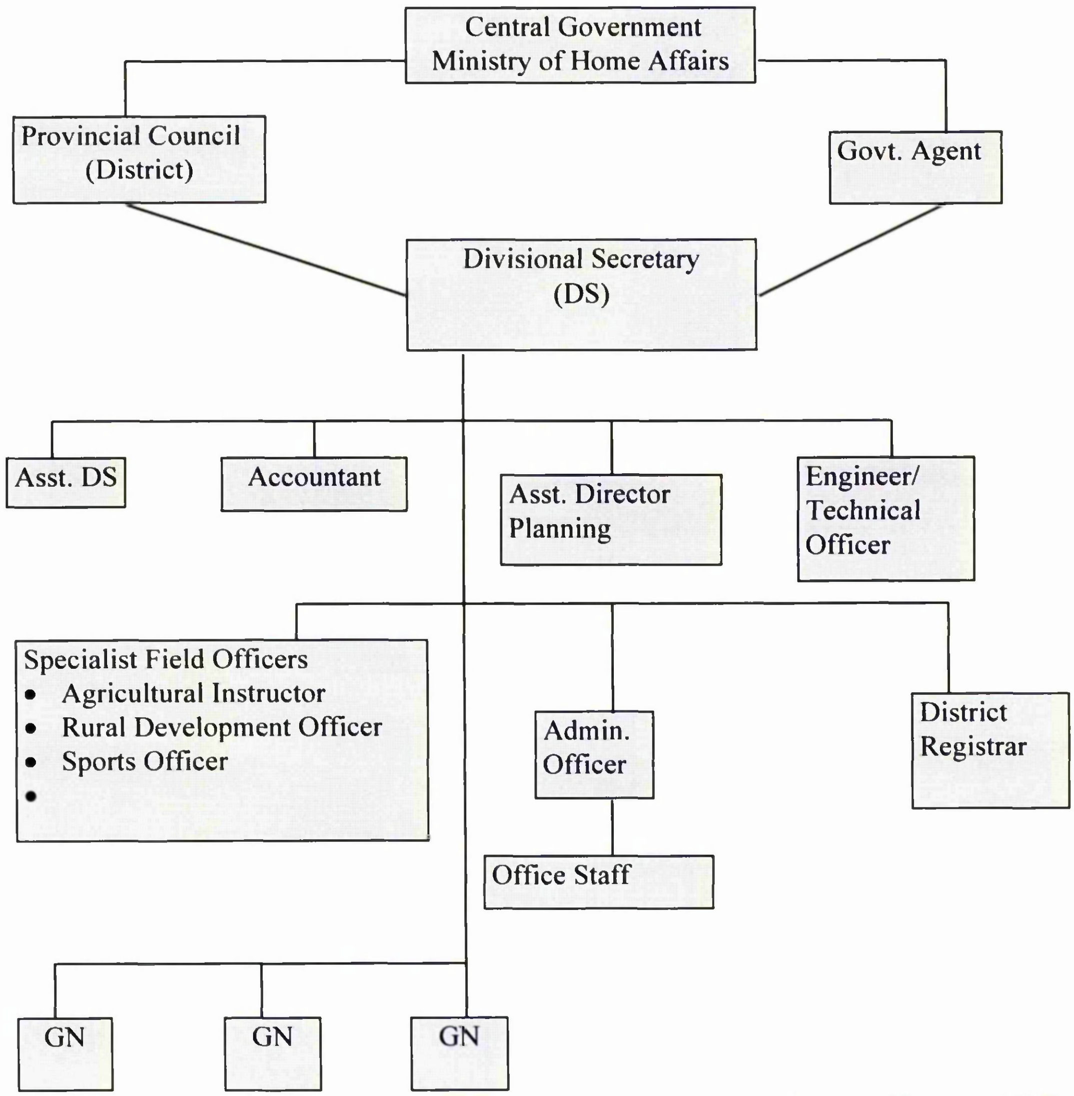
- The Divisional Secretariat is headed by the Additional GA who is an appointed middle - grade officer of the Sri Lankan Administrative Service and handles central government functions. The Additional GA is assisted by an Assistant GA, and administration, accounting and planning support staff, and serves the central government through funds allocated by the Provincial Council.

Grama Niladhari Division

- Assists the Provincial council, the Pradeshiya Sabha and the Divisional secretariat in all matters at grass roots level.

(Adapted from Baldwin *et al*, 1991)

Figure 3.9 Government administrative structure at the divisional level



(Source: Hewage, 1993)

A general government policy is to devolve responsibility to local authorities. In the present administrative framework, the Divisional Secretariat (DS) is the unit of government best suited for this role in activities of the study area. The DS implements the development projects of the Division and provides basic services to the inhabitants.

3.6 The Demography of the Study Area

3.6.1 Population Dynamics

Population density in the Galle District is the seventh highest in Sri Lanka with some 498 persons km^{-2} .The total population of Galle District was 946,000 in 1991, with the highest concentrations of people found along the coast (Dept. of Census & Statistics, 1992; Olsen *et al.* 1992; Wanigaratne, 1992). The town and harbour of Galle are the main population centres of the District with an urban zone extending well beyond the town borders. The Habaraduwa Division which covers the study area has a total population of 83,258 with a density of 307 persons km^{-2} (TEAMS, 1994).

The Galle district has shown a remarkable fall in population growth rate, from 1.8% in 1981 to 1.1% in 1989. Habaraduwa Division, however, still experiences a higher population growth, with an annual rate of increase up to 2.1%, which indicates its partly rural character (Urban Development Authority, 1992). In general, it is acknowledged that the District population numbers and densities have reached a saturation point well beyond the economic carrying capacity and employment supply (Ratnayake, 1990; TEAMS, 1994).

Females outnumber males in Galle District, giving a sex ratio of 100 females per 94 males, as compared with 100 females per 104 males for Sri Lanka. This highly unequal ratio is said to indicate that Galle District experiences a great out-migration of men in search of labour and better job opportunities elsewhere (Ratnayake, 1990). Data for the Habaraduwa division indicates that in rural areas, specifically the GN divisions, this surplus of women still exists. This is illustrated in the study area by the fact that females outnumber males in 11 of the 15 GN divisions that border the lagoon. In the case of the study area, females outnumber males in five of the six sample divisions (see Figure 3.10). This feature can be explained in terms of the lack of employment prospects for a significant proportion of the population many of whom have primary and secondary level education. The fact that less qualified persons with appropriate skills have better employment opportunities is probably the main reason for the out-migration of males in search of work elsewhere.

The study area is situated in the Habaraduwa Divisional Secretary's Division (DSD) of the Galle District in the Southern Province. This DSD, which has an administrative boundary of 103.2 km^{-2}, is bordered in the east by the Weligama DSD of the Matara District, in the south by the Indian Ocean, in the west by the Galle DSD, and in the north by the Akmemana DSD. For administrative purposes Galle district is divided into a total of 102 Grama Niladhari Divisions

(GND). Fifteen of these divisions, comprising a total of fifty four villages border Koggala Lagoon (see Table 3.2). For purposes of the present study six GN divisions, comprising a total of twenty three villages were chosen for in-depth study (see Table 3.1). The reasons for this choice are discussed separately in **Chapter 4**.

Data pertaining to this section was obtained mainly from a questionnaire compiled by officials at the Local Regional Council completed by the Grama Seva Niladharis (Village headmen), based on their personal knowledge of the residents in their respective divisions constituting the study area. This information was verified subsequently by the author using random checking techniques including unstructured interviews conducted with the residents and interviews with former Village headmen. In addition, relevant literature and records available at the Local regional council (Habaraduwa Pradeshiya Sabha) were also consulted (see **Chapter 4**).

Table 3.1 General particulars relating to the fifteen G.N Divisions bordering Koggala Lagoon

G.N DIVISION NAME	POLLING AREA	CONSTITUENT VILLAGES
1. Polhena - 154B	**Habaraduwa**	**Polhena; Thoragoda; Bataketiya**
2. Palessa - 166C	**Ahangama**	**Palessa; Kerena; Jambrissa**
3. Koggala Athireka 1 - 144D	**Habaraduwa**	**Koggala Janapadaye; Magalthota; Gudumulla; Riladukanda**
4. Kahanda - 167	**Ahangama**	**Pedurugoda; Ranagahagoda; Kahadagama; Ganegoda; Boraluketiya; Dawaniyawatta; Welituduwa; Etambagahagoda; Koralegoda**
5. Harumalgoda East - 149A	**Habaraduwa**	**Duwamalalagama; Harumalgoda east**
6. Alawattukissagoda - 164G	**Ahangama**	**Alawattukissagoda; Gurukanda**
Koggala - 144A	Habaraduwa	Sinha Dheewaragama; Koggala
Katukurunda - 144C	Habaraduwa	Liyanagoda; Katukurunda
Koggala Athireka 2 - 144E	Habaraduwa	Koggala Janapadaye; Magalthota; Mudaliyakanda; Thalatuduwa
Godawatta - 149C	Habaraduwa	Godawatta
Welikonda - 153C	Habaraduwa	Puwakwatta; Mahagoda; Welikonda
Kataluwa West - 162	Ahangama	Alabadagoda; Giniwellagoda; Welladdaragoda
Atadahewathugoda - 162A	Ahangama	Medagoda; Atadagewatugoda; Hunugoda
Tittagalla East. - 166	Ahangama	Acharigoda; Barangoda; Badaturugoda
Kahanda Athireka - 167A	Ahangama	Pansala; Rilawella; Ihalagoda; Paduwallugoda; Managewaththa; Mungoda; Galawangoda; Weligoda; Wawulugoda; Johayikumbura

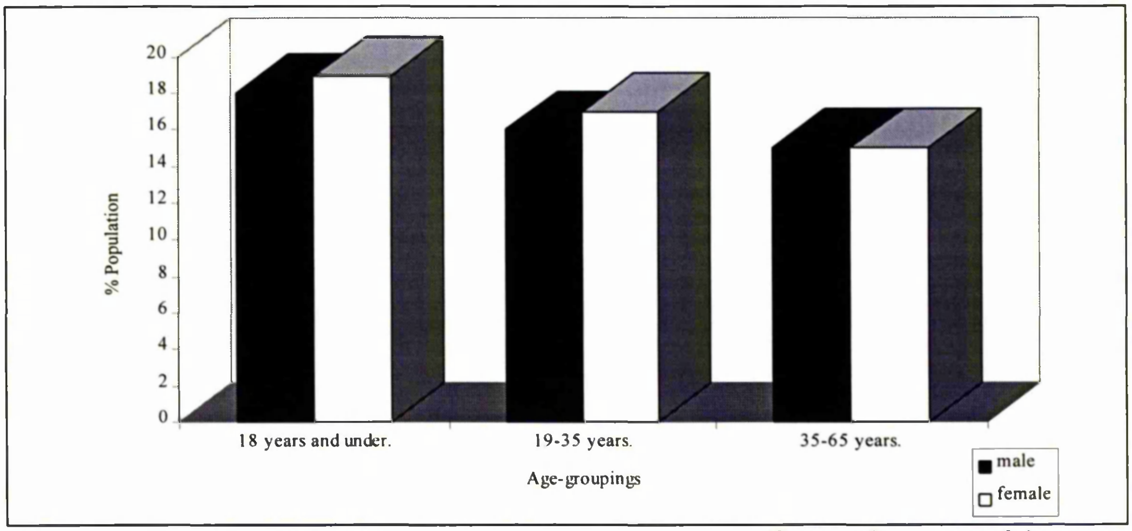
(Source: Present study)

(Numbers 1-6 represent sample six divisions)

There are a total of 1449 families living within the study area comprising a total of 6676 people. The average household size is 5.5 persons (Ratnayake, 1990). Females comprise 51%

of the total population (see Figure 3.10). The female population in the childbearing age group of 19-35 represents 17% of this total population. This segment of the population is important as it reflects the potential for population growth. Correspondingly males comprise 49% of the total population and 33% of the population are in the 19-35 age group.

Figure 3.10 % Distribution of the male and female population in the sample six divisions



(Source: Present study)

3.6.2 Ethnic and Religious Composition

Despite the colonial influence of the Portuguese and Dutch from the early 1500s to the late 1700s[1] in the Habaraduwa AGA Division, 98% of the population is Sinhala Buddhist. In the GN divisions of Kahanda and Palessa there are a total of 3 families who are recent converts to Christianity, though this conversion is generally held to be due to economic reasons[2] (pers. comm. Lokuhettie, 1993).

Although they share some common features, the Sinhala caste system is quite distinct from the Indian model, possibly due to the impact of Buddhism (Leach, 1960; Gombrich, 1988). The very essence of this caste system is its flexibility; there is no rigid stratification and individual castes are more of the 'functional type', associated with landholding (Samaraweera, 1987; Ryan, 1993). Although society was based on a caste oriented structure in pre-colonial and colonial times (Ryan, 1958), especially with regards to the determination of occupation, caste is no longer a factor in one's type of employment (Ross & Savada, 1990). In social interaction

[1] During this period there was a mass forced conversion to Christianity of the local people under the Colonial powers.

[2] In Kahanda and Polhena a few families have converted to Christianity. In return they receive a small amount of money in community programmes developed by Colombo based Christian organisations.

and politics, however, caste consciousness is still an important issue (pers. comm. Ratnapala, 1993).

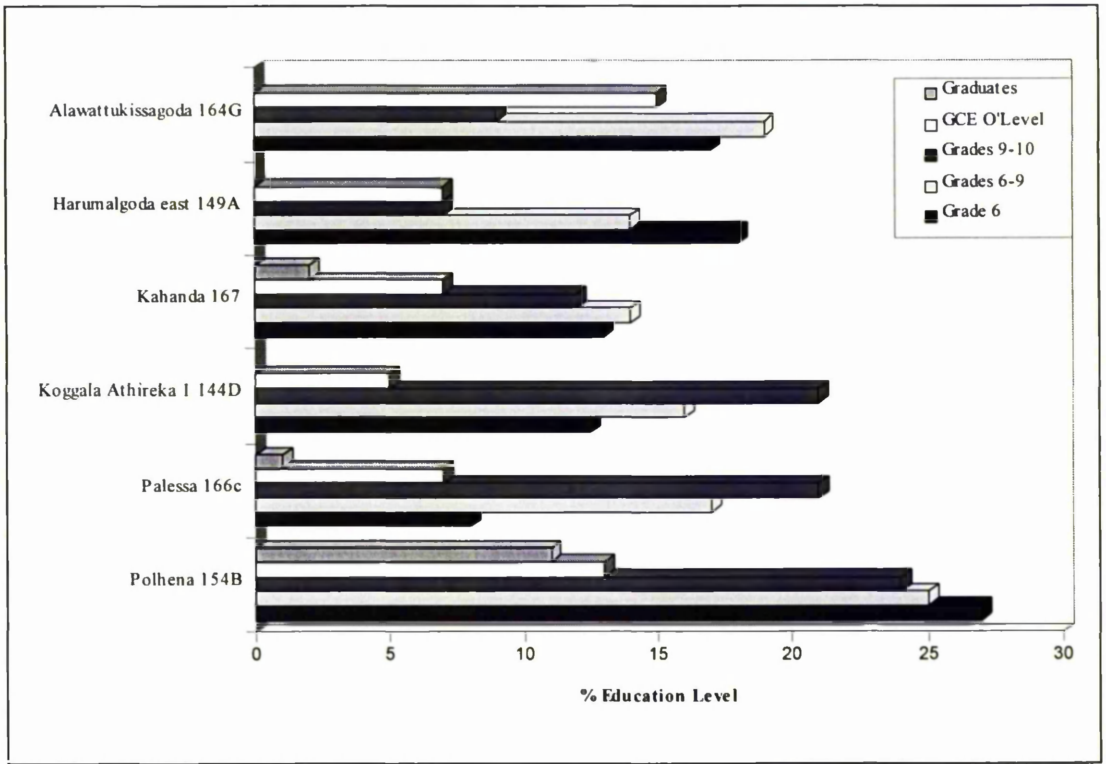
European rule introduced important changes in Sinhala castes. The new economic opportunities which opened up under the rule of the first two European powers enabled some castes to shift from their traditionally ascribed occupations. A classic example of this is illustrated by the Karava, the fisher caste, which increasingly began to engage in trade and in activities requiring artisan skills. Such involvement outside traditional occupations gave this caste a head start over others when economic opportunities greatly expanded under the British. The period of British rule brought about an end to the formal indices of caste through the introduction of a new economic framework. However this did not lead to a obliteration of caste identity in society. The most striking change was the replacement of caste interdependence by caste competition (Roberts, 1982).

The study area is represented by a total of five major castes; Goigama (farmers); Karava (fisherfolk); Halagama (cinnamon peelers); Durawa (sub-caste of the fishercaste); and Wahumpura (toddy tappers). The Goigama and Karawa groups are in the majority followed by the Durawa , Halagama and Wahumpura, the latter two comprising as little as 15% of the total population of Koggala (pers. comm. Lokuhettie, 1993). The majority of people in the study area belong to the Goigama and Karava castes and the divisions chosen for in-depth study reflect the overall caste composition in the area.

3.6.3 Education

There are both primary and junior schools in almost every GN Division and the standard of education is comparable to other parts of Sri Lanka. Poverty is the main reason for children of school-going age not attending, even though schools are within easy distance. Group discussions and surveys conducted by the author during the research period revealed that the parents of such children could not afford to spend on the basic necessities required for attending school. According to the officials of the Department of Education, the lack of qualified teachers and facilities, such as desks, chairs, books and water, are problems which are reflected in the Habaraduwa division as a whole.

Figure 3.11 % Education levels in the sample six divisions



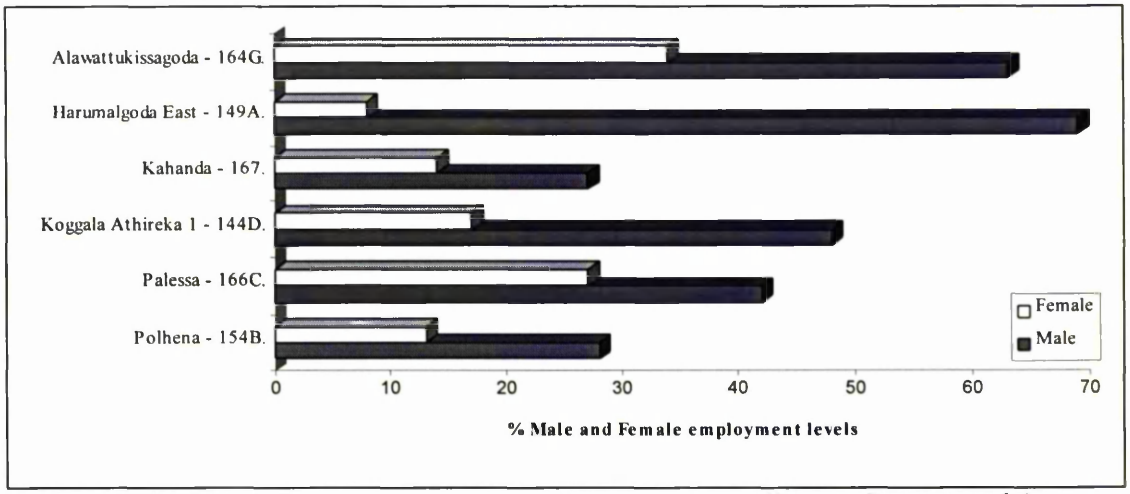
(Source: Present study)

The standard of education in the divisions as a whole is generally quite high in terms of national standards. However in some of the fishing villages education levels were admittedly lower, with significantly higher number of schooleavers and lower school attendance rates. Group discussions conducted in the area reveal the reasons for this to be mainly economic (see **Chapter 8**). Standards of education level reached by male and female residents are generally the same and show no significant differences. Figure 3.11 illustrates the education standards reached by residents within the study area.

3.6.4 Labour Force and Employment

According to field surveys a total of 46% of males in the divisions comprising the study area are in employment and a further 25% are unemployed (see Figure 3.12). In contrast according to this data 22% of females in the sample six divisions are employed and 44% are unemployed. Admittedly there are problems with both sets of data which are discussed below and based mainly on differences in definition of what age-group constitutes the labour force, and the role of women as part of the labour force. However the general consensus is that unemployment levels are rising and this is considered to be a significant problem in the area.

Figure 3.12 % Employment levels in the sample six divisions



(Source: Present study)

The main types of occupation that provide employment for the working population are sea and lagoon fishing and farming. Other forms of employment include carpentry, masonry, labour and local government service. As forms of self-employment there are those who are engaged in black-smithery, copra production and jewellery making, but in relatively small numbers. Trading and the coir industry are the most prominent. The coir fibre industry is concentrated in the GN divisions of Koggala Athireka 1 and Harumalgoda East, however in recent years it has been in decline. There are a number of reasons for this and according to those engaged in this industry the most significant are the high prices of raw materials, lack of proper facilities for sale of the produce and the lowering of profits compared to earlier times. These factors have collectively reduced the number seeking employment in this industry. A relatively small proportion of females in employment have secured jobs at the KEPZ and in contrast few males have been successful in securing employment there.

According to official estimates (Local Regional Council), approximately 658 residents from the area are engaged in casual labour, which is almost 9% of the total number of residents in the study area. Surveys conducted by the author reveal this figure to be much higher, particularly with regard to the growing number of farmers who as a result of uncontrolled flooding and subsequent salinisation of their rice lands are increasingly compelled to engage in casual labour to supplement their income. All the farmers and fishermen interviewed stated that as a direct result of the recent physical changes in the lagoon and its environs they were forced to work as casual labourers for which they received a daily wage of approximately Rs.75.00[3]. Such work was limited to nearby coconut and tea estates or in the nearby urban centres. In this context it should be noted that official estimates fail to pay attention to the number of women who engage in casual labour in tea estates.

Given the unpredictable nature of daily wage labour, the proportion of casual labourers constituting the labour force differs in each division at different times. In addition the unpredictable nature of fishing and farming as sole forms of income means that most residents in these divisions are engaged in more than one form of employment which make it difficult to get accurate figures for each individual occupation. For example fishermen engage in casual labour on an *ad hoc* basis during off-season periods.

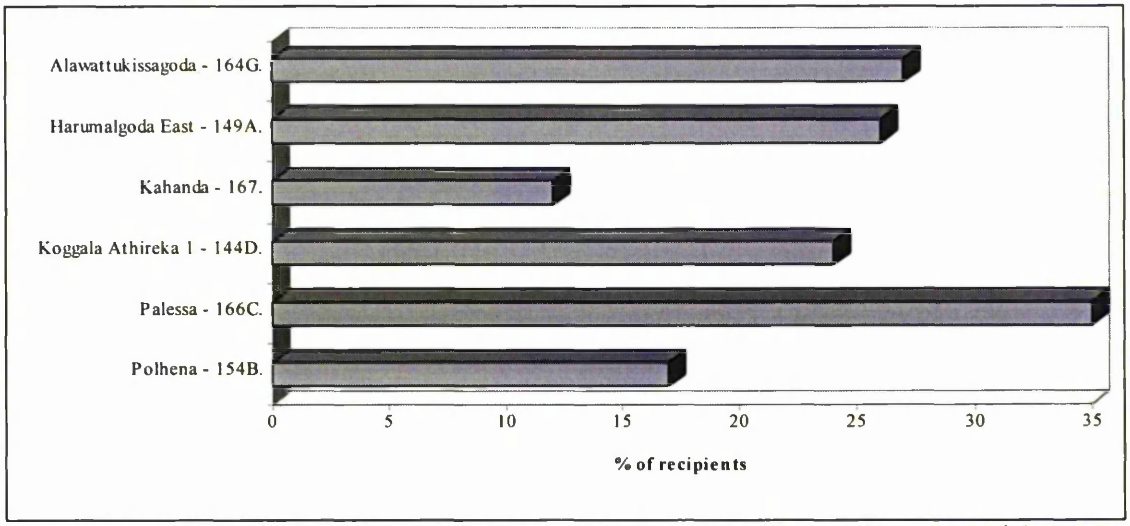
A striking feature of unemployment levels in the area is that the majority of the unemployed have primary and secondary level education. Female unemployment is relatively high mainly due to the fact that females are engaged in household work and their participation in wage employment, which takes them away from home, is low. However it should be noted that official figures relating to female employment, and unemployment levels, should be looked at with caution as in many cases the female population is engaged in many of the activities their husbands are engaged in but do not see themselves as being wage earners in their own right. That they are involved in harvesting rice, mending fishing nets, and making rope from coir fibre etc. is not regarded as being distinct from general household duties.

3.6.5 Income and Expenditure

Since income data from questionnaires are generally unreliable given the sensitive nature of the topic, entitlement for food stamps was used as a more objective indicator of income level in the sample divisions. Families with a total income less than Rs. 750/- per month are regarded as being below poverty level and become entitled to food stamps. The proportion of foodstamp-receiving families in each division is given in Figure 3.13.

[3] Conversion rate (June 1996): Rs. 82 = £1.00

Figure 3.13 Janasaviya recipients in the study area



(Source: Present study)

Twenty four per cent of the families in the study area are Janasaviya recipients. The Janasaviya (Community Strengthening Scheme) was established in 1991 by the United National Party (former Government) in the hope of alleviating poverty . It is essentially a development scheme aimed at those segments of the population receiving a monthly wage less than Rs.1,458. Recipients are entitled to a capital certificate with a face value of Rs. 25,000 on the date of issue. This certificate can be used as collateral to obtain a bank loan for self-employment projects. In addition, certificate recipients are also ensured a monthly interest of Rs. 250 from the National Savings Bank.

3.6.6 Housing and Amenities

Houses in the study area are mainly of a permanent structure. Sixty-six per cent of houses are constructed from bricks and tiles while approximately 23% are constructed from mud. Most houses are surrounded by a garden or located in the middle of homesteads and are mainly situated along the inland tarmac road corridors and along the coast road. Seventy eight per cent of families own their own homes compared to 24% who rent accommodation and 9% who are without permanent abode. Approximately 24% of households are connected to electricity.

The prevailing housing situation is attributable to the affordability of these houses for low-income families, combined with the general problem of landlessness which poses a restriction on families constructing permanent structures. The cost of an average house is in the region of Rs.10,000-20,000. In addition to these problems all households featured in the study are affected by severe flooding from the lagoon and during the rainy season it is common for homesteads to remain submerged for 2-3 weeks at a time. This problem has been accentuated in recent times by the removal of the sand-bar (see **Chapter 5**).

The Department of Health provides medical services through district and rural hospitals and dispensaries for people in the area. People seek medical treatment mainly from Karapitiya Teaching hospital and also from Ayurvedic treatment dispensaries located in all but one of the Divisions. In addition public health services are available through Public Health Inspectors and Public Health Midwives. Health problems include malnutrition and helminthic infestations (pers. comm. Fonseka, 1994). These problems are aggravated by a lack of sufficient sanitation facilities medical care and adequate nutrition.

More than 60% of the households in the area utilise water from wells for drinking and cooking. Almost all houses use fuelwood for cooking which is collected from the surrounding area and more significantly from the fringing mangrove community which as a result has been adversely affected over the years (see **Chapter 5**). The lack of adequate sanitation is a major area of concern. Though Pit latrines situated away from the house, and with a raised squatting platform, constitute the general type (65% of residents own this type), 29% of households also use unsanitary temporary latrines composed of coconut planks. These provide breeding grounds for flies and mosquitoes. Household waste disposal is also very haphazard; residents generally dig pits and the waste is buried or else burned.

3.6.7 Summary of Key Issues

- The people of Koggala and their social infrastructure comprise a rural community closely connected with the natural resources and processes analysed in earlier sections. Their quality of life is not high, but the natural resources and environment provide them with an income. Since the economy of Koggala is not strong or diversified and incomes are low, this reliance on the land and the sea make any changes in the natural resources immediately apparent in family incomes.

- Economically, agriculture and fisheries are the main industries. Smaller industries such as brick making and coir manufacturing have become less significant in recent years but nonetheless supplement incomes and provide some diversity to the economy. Occupations depend on natural resources, but unemployment is significant. Most local families are supported to some extent with supplemented income by government social welfare.

- The people of Koggala face a multitude of economic, social and health problems. Unemployment is very high with low occupational diversity and income. Females outnumber males in eleven of the fifteen divisions that border the lagoon. This is due to the fact that a significant proportion of the male population has moved out from the area in search of employment. Many people manage to get by on welfare but ultimately, the community cannot hope to depend on such outside assistance. Poor sanitation and health problems add to the general low standard of living

3.7 Land and Resource Use

Agricultural land-use maps of the sample six divisions are presented in **Chapter 7**. The maps were compiled from intensive field surveys conducted during the research period using aerial photographic cover and blueprints of the area as references to illustrate the present status of the key resources in the area.

3.7.1 Agricultural Economy and Historical Trends

Presently the main economic activity in Sri Lanka is agriculture. Although, there is a paucity of reliable information relating to land use practices in ancient Sri Lanka, it is believed that agriculture in the early period was restricted primarily to rice cultivation (Bansil, 1971; Wimaladharma, 1977; Richards & Stoutjesdik, 1975). As a whole agriculture contributes more than 27% to Gross Domestic Product, nearly 70% of all foreign exchange earnings, and employs more than 53% of the total labour force (Ratnayake, 1992; Zerby, 1991). The agricultural sector has been described as classically dualistic in the separation of an export-oriented plantation enclave from a large peasant sector (Herring, 1989). In the Sri Lankan agricultural economy, the peasant sector employs more than 80% of the rural population. Rice is the preferred crop (857,000 ha) and farmers cultivate it mostly in small-holdings (Agricultural statistics of Sri Lanka, 1992; Dent *et al.* 1993; Dayaratne, 1991) (see Figure 3.14). About 60% of these holdings are less than 2ha in size which provide the major staple food, rice (see **Chapter** 7). In Sri Lanka where the human:land ratio is high (245 persons km^{-2}) and more than 80% of the people live in rural areas and practice subsistence agriculture (Abesinghe, 1991; Simmonds, 1985; Gooneratne & Gunawardena, 1984; Brow & Weeramunda, 1992), many incomes are below the poverty line and as in other parts of the country this also applies to Koggala.

The plantation sector produces mainly tea, rubber and coconut. These plantation crops are cultivated in large holdings and are produced primarily for exports (see Figure 3.15) (Berugoda, 1991). A large proportion of export earnings are used to import basic consumer goods including rice and wheat (Ratnayake, 1992; Ministry of Plantation Industries, 1992). The extent of land under tea, rubber and coconut as at 1989 was 222,000 ha, 199,000 ha and 1,028,562 ha respectively (Central Bank of Ceylon, 1990) (see Figure 3.15). Although the total production and exports have not decreased significantly in recent years, the share of export earnings from plantation crops in the total export earnings has been falling. The percentage share of tea, rubber and coconut in the Gross National Product in 1990 at constant 1982 prices was 2.4%, 0.6% and 2.6% respectively. Out of the total export value, the share of agriculture was about 37% and that of tea contributed about one quarter and rubber and coconut 23.9% and 3.5% respectively. (Central Bank of Ceylon, 1990).

The coastal region has over 420,000 agricultural holdings with an average size of 0.65ha. About one-third of these holdings contain both crops and livestock and about 6% have only livestock. The majority (61%) grow only crops (Olsen *et al.* 1992). In this region, which also covers the study area, agriculture is less dominant than in the country as a whole. While the coastal region contains about 25% of the country's total croplands, it produces only about 17% of the national gross domestic agricultural product (Subasinghe, 1991).

With the introduction of new high yielding varieties (HYV) of rice, it has become essential to use agro-chemical imputs (Farmer, 1977), and farmers in the study area depend on them heavily for profitable yields. In addition the modernisation of traditional practices of farming have required costly inputs. For example, from 1977 to 1986 the cost of fertiliser and pesticides in Sri Lanka have increased by 72% and 150% respectively. Imported inputs according to data from the Hambantota district, amounted to approximately 50% of the total input cost in 1985 (Abeysekara, 1988). Recent studies show that costs of fertilisers and pesticides in Koggala, as in many areas of the world, are rising in comparison to yields (Arumugam, 1992). This has led to a number of growing problems for the farmers in the study area which are discussed in **Chapter 7**.

The environmental impacts of agricultural practices in coastal areas, including the excessive use of agro-chemicals, soil erosion and reductions in sediment loads which contribute to the enrichment of critical coastal habitats such as estuaries and lagoons, have been illustrated in **Chapter 2**. In this context scientists have become increasingly concerned about long-term productivity constraints associated with soils that have been farmed for many years with ever-increasing applications of chemical fertilisers (Abeysekara, 1988). Though it is clear that Sri Lanka clearly cannot return to the level of productivity of the ancient sustainable systems, estimated at only 1.5 tonnes ha^{-1} (30 bushels $acre^{-1}$) at Independence (Bansil, 1971). Input costs must be contained, and environmental externalities minimised with improved data and analyses of long term fertiliser and pesticide impacts on soils and sustainable productivity. Changes in these inputs may be seen as economically necessary in the context of the study area.

Figure 3.14 Land Ownership in Sri Lanka

	000's Ha	% of total
1. Total land area	6570	
2. Private land	1,166	17.7
• **freehold**	1,065	16.2
• **land grants**	101	1.5
3. State land	5,404	82.3
• **Alienated under various schemes** [1]	818-1000	12.5-15.2
• **vested in Land reform Commissioner** [2]	4.6	6.2

1. Village expansion, colonisation, middle class allotments, highland colonisation, youth settlement, encroachment regularisation, special leases.
2. Land nationalised 1972-75, mostly plantations, perhaps 20000ha paddy.
(Source: Wijetunga, 1991)

Figure 3.15 Crop Statistics in Sri Lanka

Crop type	Area under cultivation (hectares)	Production.	Total earnings (Rs. Mil)	Export share of GNP	Percentage of exports
Tea	222,000	233 million kilograms	19, 823	2.4	24.9
Rubber	199,000	140 million kilograms.	3,080	0.6	3.9
Coconut	1,028,562	2,523mn nuts.	2,783	2.6	3.5
Paddy	857,000	2,538 metric tonnes.	N/A	5.1	N/A
Sugar	10,501	57 metric tonnes.	N/A	N/A	N/A
Minor export crops	N/A	N/A	3,165	N/A	4.0

(Source: Central Bank of Sri Lanka, Annual Report 1990)

3.7.2 Agricultural Patterns in the Study Area

The Lagoon, the lands occupied by the KEPZ (Koggala Export Processing Zone) and the Air Force Base are all state owned. The BOI (Board of Investment) purchased a total of 90 ha for the KEPZ, land that was formerly a highly productive coconut estate and homestead area. All other land in the area is privately owned.

Agriculture, notably rice farming has traditionally been a major source of income for residents of the GN divisions that constitute the study area, though the extent of this crop has declined in recent years (see **Chapter** 7). Tea, rubber, coconut and cinnamon are the principal plantation crops cultivated which reflects the main crop types cultivated in Galle district as a whole (TEAMS, 1994). In the study area the land close to the sea are mostly cultivated with coconut with some patches of mixed cultivation. Towards the interior, cinnamon, tea, rice, rubber and mixed cultivation are more evident. In some areas shrub lands mixed with abandoned rice paddy lands are found. In addition cattle, water buffalo, goats and poultry are raised and graze freely within the site. Field surveys conclude that land fragmentation, lack of ownership of land and landlessness which are significant problems affecting Sri Lanka as a whole (Block, 1988; Obeysekara, 1966) are also major problems encountered in the study area. Homesteads in the villages around Koggala Lagoon are planted with edible fruit tree species like Jak fruit and spices such as black pepper, cloves and cinnamon are cultivated on a small scale. Recently it has become a new practice to plant lowland tea in and around homesteads.

Coconut grows well on the relatively saline soils where it is generally cultivated in small holdings as a home garden crop. Nearly 60% of the homegardens that have coconut are less than 0.5 ha in extent. Large coconut estates are rare and most plantations are under 10 ha. It should be noted that 90ha of prime coconut land was cleared to make way for the KEPZ. The major tea growing areas are Kahanda and Polhena. According to official statistics tea occupies a total of 78.1 ha in the study area. Field surveys conclude that this figure is likely to be much higher as most tea lands are confined to small-holdings of less than 5 hectares which are not included in official statistics. In the study area as a whole only three estates have an extent of 8-32 ha. Cinnamon occupies a total of 129.5 ha (Local regional council, 1993). It is grown on a large scale in Palessa where it has been planted in highly eroded areas. This crop is the least labour intensive and for this reason exists in almost all the divisions. Rubber estates in the area are scattered and except for one large estate of 15ha, all other estates are under 5ha. The total area under rubber is 35.6 ha (Local regional council, 1993).

Rice has traditionally been the main agricultural crop in the study area and accounts for a total of 122.6 ha (Local Regional Council, 1993). However saline intrusion and inundation in recent times is drastically reducing the total extent of this crop and rice lands immediately bordering the lagoon are rapidly being transformed into marshlands (see **Chapter** 7). As a result prospects of further expansion of paddy production are limited. Paddy is cultivated during the Yala and Maha seasons and new high yielding varieties which require a high input of agro-chemicals dominate (BG 350,351). In those areas where rice paddy is grown, growing vegetables on raised plots of land within the rice fields and also in contour bunds (Sinhala: *weli*) is common.

3.7.3 Fisheries

Fishing is the most important economic activity connected with the coastal region in Sri Lanka, and many local communities, particularly along the South west coast where the research area is located are dependent on it for their livelihood (Samarapala, 1986; Amarasinghe, 1993; MFAR, 1990) Coastal artisanal fishery production is largely for internal consumption, but foreign exchange is earned through exports of shrimp, tuna and ornamental aquarium fish (Olsen *et al.*1992). Fishing is concentrated in coastal waters, classified as the first 40km from the shore (Baldwin *et al.*1991) and prior to the last two decades fishing was primarily carried out from non-motorised craft such as dug-out canoes, catamarans and log crafts using non-destructive fishing techniques such as angling, gill-netting and beach seining (Rajasuriya *et al.* 1995).

Precisely because of its traditional and small scale nature, the fishery of Koggala Lagoon provides employment and income to a substantial segment of the population. An estimated 500 families in the fifteen GN divisions with a border on the lagoon obtain their sole or major source of income from fishing in the wetland and associated sea. It is difficult to obtain accurate figures since registration of gear and boats involves a fee which many fishermen try to avoid. As a result the number of fishermen tends to be underestimated. In Koggala the business of catching and trading in fish and crustaceans is a small scale, partially modernised activity which supplements agriculture in the area. Of the gear some are operated on foot while others are operated from traditional craft - outrigger canoes (Sinhala: *oru*) without motors. By convention motorised craft are not used for fishing in the wetland, whereas such craft are used for fishing at sea. The fishing techniques commonly adopted are brushpile fishery (Sinhala: *mas-athu*), laying of mini-cages with baits, cast net fishing, surrounding fish through gill-nets, kraal fishing and pole and line fishing. Specific details relating to the fishing community including fish species found in the lagoon derived from field surveys are described in **Chapter 6**.

In addition to traditional fishing activities centred around the lagoon the collection of reef fish and invertebrates for the ornamental fish-export industry is of considerable importance. In fishery export products, ornamental fish exports are the third highest after prawns and lobsters (Baldwin *et al.* 1991).The current value of the ornamental species exported from Sri Lanka as a whole is estimated to be about US$ 2 million (Rajasuriya *et al.*1995; Beets, 1994). The main portion of this value can be attributed to marine fish (Chaetotonidae, Pomacetridae, Acanthuriidae, Gobiidae, Balistidae, Labridae, Pomacentridae, Blennidae). Approximately 150 fishermen in Koggala are engaged in the collection of ornamental fish which are sold to private companies engaged in the export trade. A list of the species commonly encountered with sale prices is given in **Chapter 6**. The destructive fishing methods employed in the collection of reef fish include fishing with explosives and the use of moxy nets. This has caused habitat destruction and depletion of high value species in the area (Rajasuriya *et al.* 1995; Lanka Hydraulics, 1992; White & Rajasuriya, 1995). These activities have also contributed to the degradation of the fringing coral reef in Koggala (Lanka Hydraulics, 1992) (see **Chapter 2**).

3.7.4 Summary of Key Issues

- Agriculture, lagoon and sea fisheries are the main economic activities in Koggala. In addition to this a number of small scale industries help to supplement incomes. Agriculture and fisheries are very dependent on the environmental quality of the area and are directly affected by changes in the pattern of water level fluctuations in the lagoon.

- The ecological stability of the lagoon is threatened at the moment by several activities which include the lack of proper sewage handling facilities by residents, the discharge of agro-chemicals used in the surrounding rice fields and plantation land into the lagoon and the dumping of industrial waste products from the KEPZ onto the borders of the lagoon. The combined effects of these pollutants in the lagoon may be responsible for the decline in catch experienced by the fishing community. Pollution may well have been responsible for the occasional fish kills that have occurred in the past. Further increases of such inputs might well endanger human health through bio-accumulation in the food chain. Also of importance are the changes associated with rapidly fluctuating water levels.

- The current value of fish and shrimp caught in the lagoon is significant locally and the number of people depending on the lagoon directly or indirectly for their livelihood as fishermen is important for the area. For this reason the polluting of the lagoon and other processes currently threatening fish production also have potential adverse economic impacts.

3.8 Industrialisation

3.8.1 Achieving NIC (Newly Industrialised Country) Status in the Twentieth Century

Sri Lanka is a small island economy heavily dependent on a few exports, and its fortunes have been fluctuating with the movements of its terms of trade (Moore, 1990). Since 1956, the terms of trade have been on a downward trend and domestic investment has been very moderate (Kerkoven, 1990; Anderson, 1993). With a rapidly increasing population, unemployment and under-employment have been rising with no visible signs of improvement (Ratnayake, 1992). In 1977 Sri Lanka had become one of the poorest countries in the world with a per capita income of not more than US dollars 200 per annum, an unemployment rate of more than 20% of its labour force and nearly half of its population living below the poverty line (Indraratna, 1990).

Industrial policy in Sri Lanka has experienced a number of changes in recent years. These changes have culminated in the recent past in a reformation of the strategy for industrial development (Zerby, 1990; Buddhadasa, 1992). The latest and most important milestones in this process are the Industrial Policy Statement of 1987 and, most recently, the document entitled 'A Strategy for Industrialisation in Sri Lanka', published by the Ministry of Industries in December 1989. In the latter document reference is made to the NIC experience, and the policy objective of emulating this experience is explicitly mentioned (Guimaraes, 1991; Central Bank of Ceylon, 1990). Basically the argument follows that Sri Lanka needs to grow at a faster rate, to create large numbers of jobs, to diversify its economy and to strengthen its balance of payments. To achieve this it must industrialise and this industrialisation must be export oriented. This has to be done by granting incentives for exports encouraging foreign investment (Gutkin, 1988).

The success stories of the so-called NIC's, most notably Taiwan and South Korea, provide an important demonstration effect. Both these countries had, in 1960, approximately the same per capita income of US $150 as Sri Lanka (World Bank, 1987); in 1983, however, Taiwan's per capita income (at current prices) had risen to US $2,677 and that of South Korea to US $2,010, while the corresponding figure for Sri Lanka was a modest US dollars 330. It is this political and economic framework that has led to a situation in which the growth of the Free Trade Zone has been established in the island (Sri Lanka Association of Economists, 1990).

Since 1991 the pace of development in Sri Lanka has gradually accelerated (Deheragoda, 1992; Moore,1990). Gross National Product (GNP) averaged a yearly growth of 4.3 per cent between 1980-1990 (Central Bank of Sri Lanka, 1991). This increased to 4.6 per cent in 1991, and with the Government's push for a stronger free-market economy it is likely to increase in coming years (Kerkoven, 1990; Guimaraes, 1991;USAID, 1991). The rapid rate of development is especially worth noting in the Southern Province in which the study area falls. This province is noted for high unemployment levels (TEAMS, 1994) and has been targeted by the Government for industrialisation development programmes aimed at alleviating existing levels of unemployment (Marga, 1988; Atkins, 1991; De Silva, 1994; Daily News, 1994). Such development plans include a Rs.15 billion project to develop the Port of Galle (Dharmawhardana & Eliatamby, 1993a) which will entail the destruction of a large part of the coral reef in the vicinity to make way for a container terminal. This would however affect existing breeding grounds thereby endangering the livelihoods of local fishermen (Dharmawhardana & Eliatamby, 1993b).

3.8.2 The Koggala Export Processing Zone (KEPZ)

The Free Trade Zone (FTZ) is a relatively new phenomenon, though free ports or free trade areas have existed for a long time as ex-custom bonded territory where imported goods are stored (UNCTAD, 1985;1988; Kreye, 1987). In the last twenty years or so, a new concept of free zones has emerged, part and parcel of the 'export-oriented industrialisation' that has been promoted by most Third World countries since the late 1960's. In contrast to the conventional free ports, this new type of zone is a manufacturing zone where foreign investors are invited to operate their manufacturing plants to produce export goods. The duty-free privileges of the traditional 'free zone' are not only retained here but new incentives are also added to entice foreign investors. The zone has its own authority to which the central government functions are largely delegated to provide all necessary services related to export-import transactions and facilitating intra-zone production by its occupant foreign investors nearly 100% of whose products are exported abroad (World Bank, 1992).

The FTZ has two main characteristics. On the one hand it is an industrial estate where land, factory buildings, electric power, industrial water and other infrastructural elements are furnished by the host governments for the convenience of the manufacturing firms operating there. On the other hand it is an alien territory within a national authority, having a zone authority which acts as the zone government and is responsible for supplying cheap local labour and for controlling the zone workers. The combination of these factors make the FTZ system highly attractive to foreign investors.

The period before 'export-oriented industrialisation', or the period of FTZ's in Sri Lanka, which also applies to other developing Asian countries, was to promote 'import substitution' industries. This meant that they wanted to create industries which would produce goods for the domestic market and lessen imports of goods for domestic consumption, thus saving foreign exchange (Abeysekara, 1980;UNCTAD, 1985). However this policy failed with the absence of thorough going land reform and resultant poverty of the peasantry decreasing the size of the domestic market, undercutting the prospects for the newly encouraged industries. The domestic industries furthermore, did not have the competitive capacity to export industrial products in sizeable amounts to foreign markets. This development led to a shift in the late 1960's by Asian countries to 'export-oriented industrialisation', to bring in more foreign exchange and to further industrialise their countries. It should be noted that it was the negative consequences of the preceding period that forced this new policy on the country. Export-oriented industrialisation in this sense is linked with domination of the economy by foreign capital. To attract foreign capital, the host countries had to offer all they had i.e. cheap labour (De Alwis, 1994; Maex, 1985; Warr, 1987), tax incentives, low-priced factory sites all maintained through extremely repressive measures (Raghavan, 1993; Rosa, 1989; The Sunday Times, 1994; Tissaratchy, 1993; Social Justice, 1992).

Koggala Lagoon and its environs are presently undergoing a number of rapid transformations owing to changes in the economic and social conditions experienced by the country as a whole (Moore, 1990). In the current economic climate, which is geared towards rapid development, and in an attempt to encourage both further inward foreign investment and help to alleviate unemployment, a Free Trade Zone was opened in 1991 at Koggala (Koggala Export Processing Zone - KEPZ). The two existing zones are at Biyagama (established 1985) and Katunayake (established 1979) located close to the capital Colombo and adjoining the only international air-port in the country. Biyagama and Katunayake currently incorporate 124 factories and the services of 80,000 workers (see Figure 3.16). All three zones are operated by the Board of Investment, Sri Lanka (B.O.I) which is the principal statutory authority for the approval of foreign investment in Sri Lanka and under whose authority economic activities are laid down (B.O.I, 1992). Amongst other perks these zones offer no restrictions on equity ownership, attractive financial incentives and tax free holidays to interested investors.

A: Garment factory in the KEPZ.

B: Dumping of industrial waste from KEPZ onto land bordering Koggala Lagoon.

Figure 3.16 Koggala Export Processing Zone.
(Source: August 1993, V.N. Samarasekara)

To date there are 12 factories currently under operation in the KEPZ the majority of which are in the garment sector (see Figure 3.17) though none of these industries are involved in the dyeing and washing processes which would contribute considerably to toxic waste water. According to discussions with key officials at the KEPZ however, there are plans for such factories to follow (pers. comm. Kumara, 1993). Light industries such as plastics and rubber toys are also in production. Most of these use organic solvents and in the process release toxic chemicals into the environment.

To date waste water and sewage treatment in the KEPZ has been neglected. It had been proposed that effluent from the factories would be treated in-house and the treated effluent would be piped to sea. However the necessary facilities to achieve this treatment have not been completed. Meanwhile industrial wastes (plastics, pieces of fabric and food) are dumped onto a area of marshy land bordering the lagoon (see Figure 3.16). This waste is partially burnt, as evidenced by clouds of smoke that emanate from the site (Samarasekara, 1994). These waste products have direct access to the lagoon, a process which is accelerated by frequent rains in the area. Concern for the rapid social and environmental changes in Koggala as a whole since the development of the KEPZ has been expressed by local communities (see Chapter 8) and has also been highlighted in the National press (The Sunday Observer , 1993; The Island, 1993). Headlines such as " The cry of Koggala" (Samaraweera, 1994); "Martin Wickramasinghe's story book site diminish." (Perera, 1993;); " The Changing face of Koggala" (The Sunday Observer, 1993) "Koggala: Industrial estate or Twighlight Zone" (Jayachendra & Tissaratchy, 1993) illustrate the intensity of social concern.

The KEPZ was initially well received by the villages especially because of the potential employment opportunities it was hoped it would generate. However an important section of the villagers, mostly males, have become increasingly disillusioned as their expectations in terms of employment have been transformed into one of mostly frustration. Resentment directed at the authorities responsible for the establishment of the KEPZ is evident in those communities that were re-housed. These communities were fishing based, fishing from both the sea and the lagoon and they were moved to a area in the interior many miles from their homes. These people are now housed in the GN division of Eddunkele (see Chapter 8) which is agriculturally based and they face many pressing problems, the most important being the need to change their livelihoods from predominately fishing to farming. This change accompanied by the higher problems associated with introducing what is considered a lower caste into a farming caste community have created a whole host of social problems.

Figure 3.17 Enterprises registered with the Koggala Export Processing Zone

Name of Enterprise	**Collaborator**
Uniplast (Pvt) Ltd	German and Sri lankan
Martin Emprex (Ceylon) Ltd	British and Sri Lankan
Sunbird International (Pvt) Ltd	Sri Lankan
Nazu Tex International (Pvt) Ltd	Oman and Sri Lanka
Fashion Trends (Pvt) Ltd	Indian and Sri Lanka
Bontex (Lanka) Pvt. Ltd	Hong Kong and Sri Lanka
Koggala Garments (Pvt) Ltd	Sri Lanka
Koggala Manufacturing (Pvt) Ltd	USA and Sri Lanka
Young and Lanka (Pvt) Ltd	Korea
Shalanka (Pvt) Ltd	Japan and Sri Lanka
Lanka Melamine (Pvt) Ltd	Austria and Sri Lanka
J. International Creation (Pvt) Ltd	Sri Lanka

(Source: Present study)

3.8.3 Summary of Key Issues

- The KEPZ is still in its formative stages with a view to further expansion (pers. comm. Douglas, 1994) (Jayasinghe, 1993; Samarasinghe, 1993). However current development plans are proceeding with little regard for the natural resources of the area and for the different groups of people who are dependent on these resources for a living. The lack of a waste treatment system is of great concern as current means of disposal are unsustainable and if they continue will cause further conflicts to arise between competing resource users.

- Disillusionment and resentment among the residents in the area who have failed to secure employment in the KEPZ are rife. This is especially significant in view of the high unemployment levels in the area. Social tensions are also at a high and it is feared that these will escalate further.

3.9 Key Themes in the Ecology and Geography of Koggala

- Koggala Lagoon and its environs are presently undergoing a number of rapid transformations owing to changes in the economic and social conditions experienced by the country as a whole. The current economic climate is geared towards rapid development and the general trend in growing international trade and commerce in Sri Lanka has resulted in increasing population shifts towards the coasts, especially in the southwest of the island where the study area is located.

- The accelerated pace of development now experienced in Sri Lanka has also created a situation which has increased the tendency to overexploit resources, including coastal resources, beyond sustainable limits (Samarakoon, 1990; SEJF, 1993; Thiesenhusen, 1992; White & Wijeratne, 1993).This has resulted in not only environmental degradation, but also in a widening gap between the rich and the poor. In coastal areas such as Koggala, environmental problems like clear-cutting of mangrove, over-fishing, water pollution, coastal erosion and loss of biological diversity are exacerbated by the sociological problems and conflicts that have arisen due to different user groups.

- In Koggala these changes have had wide reaching implications for the fishing (see **Chapter 6**) and farming (see **Chapter** 7) communities who are dependent on the lagoon to sustain a living and major conflicts have in recent times been experienced by these two groups (see **Chapter 8**).

- In its entirety, Koggala Lagoon together with its water supply and flow, the fisheries, the mangroves, the agricultural land and the humans that depend on and coexist with these resources, comprise a large and complex ecosystem. The area and its parts are all interconnected and each part has its requirements for survival and limits of use. A combination of rapid development together with changes in the natural environment have resulted in resource user conflicts which have reached a crisis point. The trend towards abuse is increasing in Koggala and the natural potential of the area to sustain itself is already showing signs of depletion.

- From the overview presented in this chapter it is evident that the underlying theme of disruption in Koggala, in both a physical and historical sense, is a significant common factor which encompasses all other issues. Figure 3.2 illustrates the key disturbances that have occurred historically and which have contributed to the situation that exists in Koggala today.

CHAPTER 4
THE RESEARCH SCHEME AND FIELD METHODS

4.1 Introduction

The fieldwork was carried out in two main phases. The first phase ran from June 1993 to January 1994 and the second phase from April 1994 to November 1994, a total of sixteen months in the field. During this period visits were also made to Thailand and Malaysia for comparative study purposes and the results of these visits have been presented as case studies in **Chapter 1**. A further field visit to the study area was made in October 1995 and information gathered during this period has been used to update the present discussion.

The underlying theme of the research is centred on investigating: (1) the extent to which recent industrial and agricultural developments in the area have resulted in physical changes in the environment; and (2) the local perceptions of these changes and their effects on the key groups dependent on the lagoon and its environs to sustain a living. For this purpose analysis was focused on the two key resource user groups in the area: the farming and fishing communities. Given the interdisciplinary nature of the research, the methods used were thus derived from both the natural and social sciences. In the field of social sciences qualitative techniques of questioning, observation and participation were used principally and, where applicable, supplemented by quantitative techniques.

This Chapter presents a detailed account of the methodologies used throughout the research period including the problems encountered in the field. The format of this Chapter has been planned according to the stages in which the research was carried out. Section **4.2** provides an introduction to the research scheme and stresses the importance of an integrated approach in the context of the current research. Section **4.3** describes the methods used in the introductory social survey of the GN divisions bordering the lagoon which led to the choice of the sample six divisions featured in the study. A description of the methodologies used during in-depth surveys of the farming and fishing community are given in sections **4.4** and **4.5** respectively.

A central part of the thesis is the use of discussion groups as a research tool to investigate local perceptions to environmental change (Section **4.6**). The use of this method is interesting as it presents a novel approach which is not known to have been applied to wetlands in developing countries. Its application and its relevance especially in this context is expanded on in **Chapter 8.**

The methods used to assess the physical changes in the mangrove environment and the changing hydrology are given in Sections **4.8** and **4.9**. Details relating to the mapping of major land-use patterns in the study area are presented in Section **4.7**.

4.2 Introduction to the Research Scheme

4.2.1 The Need for an Integrated Approach

A description of the specific methodology used during the research period is given below.
In the overall framework of the present research, this section will present an overview of the development of social research with emphasis given to the importance of an integrated approach.

During the period of British rule in Sri Lanka (1797-1948), village studies were conducted mainly by British officers who lacked a knowledge of local languages. Therefore data was almost always collected through the assistance of Government officials employed under them who would collect the required information and translate it, interpreting it both in terms of culture and of language, and in the process biasing the data with their own subjectivity (pers. comm. Ratnapala, 1993). In addition there would be little or no involvement at all in the collection of this data by the official who had initiated the research. Sri Lankan administrators of that time, and even after independence in 1948, continued with this approach, which then shaped the methods used by them and others after them in conducting village studies (Lipton, 1972; Ratnapala, 1980).

Even today this approach is very evident in the way research relating to rural communities is conducted in Sri Lanka, and it has been heavily criticised for failing to gain sufficient insight and depth (Ratnapala, 1985;1986). As a result it is now generally recognised that such methodologies are no longer relevant to present-day circumstances which require an integrated and more 'holistic' approach (Devereux & Hoddinot, 1992). The present study, having noted the problems outlined above, sought to overcome these by adopting an interactive grass-roots level approach which relied on the involvement of local communities at every stage in the study (see section **4.3**).

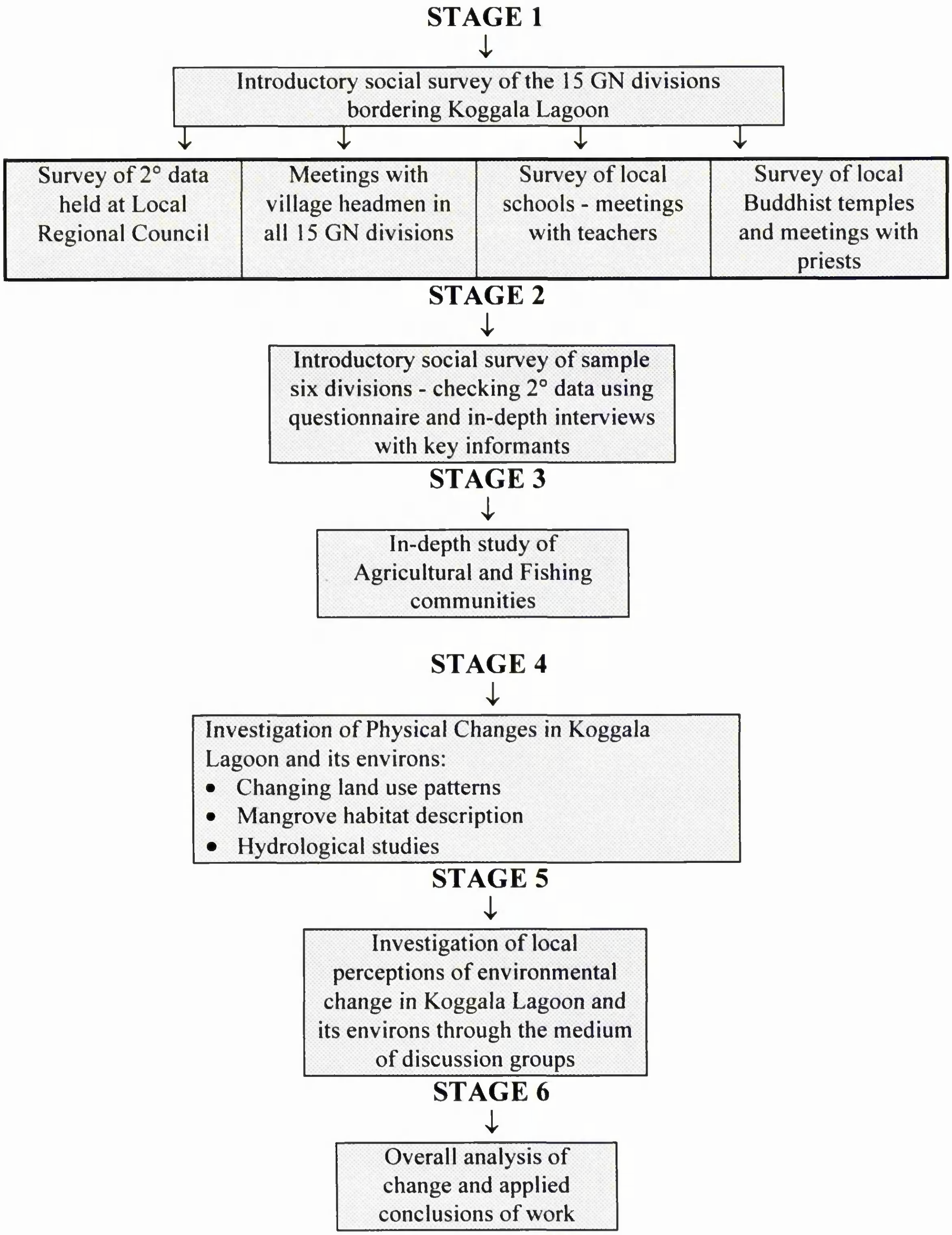
With the growing disillusionment concerning the value of formal surveys (Srinivas *et al.*1979) and the focus shifting from a reductionist one-dimensional view to a 'holistic' view of problems, there is now an increasing recognition of the need to combine the customary survey methods with techniques commonly employed in other disciplines in the social sciences (Chambers, 1978;1983;1989). Within social geography, an increasing number of researchers are conducting empirical studies which use qualitative methods (Ley, 1987; Western, 1986; Bennet & Thaiss, 1967) and there is a growing awareness of the benefits of using two or more methodologies in the same study.

This is especially relevant to rural development studies. Indeed in major expositions of methods, a principal issue has been the relative merits of 'anthropological' methods of interviewing and observation versus the questionnaire survey method (Ellen, 1984; Eyles & Smith, 1988;). According to Chambers (1983) the failing of social research is that it lacks sufficient insight. In such situations anthropological methods are often regarded as more suitable as primary sources of data. This argument is documented by means of a detailed comparison of a survey-based and an ethnographic study of Sri Lankan villages. Leach (1967) argued that the results of the social survey gloss over important features of social structure. Conversely, anthropological methods are often criticised on the grounds that the data collected lack precision and statistical significance (Warwick, 1983).

All practical methods, however, have their merits and imperfections. Therefore seeing anthropological methods and social survey research as two extremes in a continuum of research techniques is counter-productive as it diverts attention from the middle ground where an effective combination of the two research methods can be made (Reichardt & Cook, 1979; Light & Pillemer, 1982). As Whyte and Alberti (1983) observe, the two methods should be seen as complementary, the weaknesses of one being the strengths of the other. The strength of the survey method lies in its greater potential for quantification, replication and generalisation, while interviewing and observational techniques score on qualitative depth, flexibility and more detailed analyses of processes (Dey, 1993;Patton, 1990).

Following on this logic, there is a growing realisation among researchers that substantial benefits can be obtained through a combination of survey research and elements of anthropological methods of investigation enabling the researcher to obtain important information that is not generated from one method alone (Collinson, 1972). As Epstein wrote in 1973: "As far as my research was concerned I regarded the collection of quantitative data as constituting the skeleton of my material and the qualitative data provided the flesh. I found that only by combining numerical with behavioural data could I get full insight into socio-economic organisation and its change in Mysore villages."

Figure 4.1 Flow Diagram of Research Scheme



In an effort to investigate local perceptions of environmental change in the study area, the research scheme used recognised the need for an integrated approach. Qualitative techniques of observation and questioning, which are claimed to be more helpful than quantitative techniques when conducting fieldwork within separate cultures (Geertz, 1973; Jones, 1985a;1885b; Patton, 1990; Walker, 1985), were used as a complement to quantitative techniques. In addition the social and economic background of the local communities in the study area was a very important factor in the choice of the methodologies used.

Adopting a combination of qualitative and quantitative techniques had the added advantage of expanding the potential number of data sources. This proved vital in obtaining crucial information that was not forthcoming from a single method, to increase confidence in the accuracy of measurements or observations made on a given phenomenon and to test associations and types of overlap. In addition, since it was vital to the research to illuminate events in the present by reconstructing the past, historical interpretation was made possible using aerial photographs, old and current survey maps, and Government records. This historical dimension was essential to interpret the data at hand.

4.2.2 Background to methodology used

The research consisted of six main stages which have been summarised and displayed in the form of a flow diagram in Figure 4.1. At the outset it was decided that the sample GN Divisions chosen for the study would need to reflect the overall social make-up of the local fishing and farming communities situated around the lagoon. These groups should be balanced in terms of degree of dependence on the lagoon and on its resources and should be illustrative of the main castes in the area (see **Chapters 1** and **3**). In this way it appeared that a true representation of the local communities in Koggala could be made. To achieve this an introductory social survey was conducted in the fifteen GN Divisions bordering the lagoon. This introductory survey proved to be an integral part of the overall research scheme. It was intrinsic to the research as it provided a means for the author to familiarise herself further with the area and in so doing select those sample divisions in which in-depth studies would be carried out. Also worth noting is that this preliminary survey proved effective in identifying key informants.

This initial social survey relied mainly on the use of Participatory Rural Appraisal techniques (PRA). The objective here was to get sufficient knowledge, without unnecessary detail, in order to identify priorities that may require further investigation later. PRA techniques have been applied to the early phases of many projects conducted in developing countries (Chambers, 1981;1992; Lovelace *et al.* 1988; McAndrews & Chia, 1982) especially in the context of rural development projects where information is needed quickly (McCracken *et al.* 1988; Nagel, 1989; Panvisavas *et al.* 1991a).

The most important principle to understand regarding PRA is that it is not a methodology as such, rather a 'toolkit' for information-gathering under a time constraint, designed to reduce biases, (Molnar, 1989; National Environment Secretariat *et al.* 1991).The general methods of PRA that were used at this stage of the study to address the time constraint on data collection and analysis were: use of cross-checking or triangulation; extensive reliance on the availability of secondary data; and the use of detailed, but 'open-ended' interview guides to ensure pertinent issues were covered; and extensive team interaction to maintain a multi-discipliniary perspective (Hoeper, 1990; Mascarenhas, 1990a;1990b).

The strength of PRA techniques lies in the fact that by combining methods from formal surveys and in-depth participant observation studies, they attempt to lead the respondent to the questioning as well as the interviewer. This feature of the methodology is important to analyse the local conditions under which proposed intervention will be promoted, because it is conducive to collecting data relating to values, opinions, objectives and indigenous technical knowledge, as well as biophysical and economic information. Such methods also allow for re-evaluation of the hypotheses during the course of fieldwork so that questions can be adjusted in the light of new information (Mascarenhas, 1990c; Mosse, 1994; Shah, 1991; Thompson & Scoones, 1994).

PRA techniques are however short term. In general, they neither generate statistically sound survey data, nor do they provide the in-depth understanding offered by long-term qualitative research methods (McCracken *et al.* 1988). Yet, when properly used, they can generate surprisingly reliable and substantial information about particular problems of natural resource management, and in many cases are especially relevant when used in the early stages of project planning, to produce preliminary hypotheses for later testing by further research (Chambers, 1987).

4.3 Introductory Social Survey

4.3.1 Choice of Study Area

As mentioned above the introductory social survey provided an important stage for the author to further familiarise herself with the study area, and by highlighting study topics which had been missed, it enabled the original research scheme to be redefined in the process. The first stage in this survey involved the collection of secondary data relating to the local communities living around the lagoon. Relevant details were obtained from the Habaraduwa Pradeshiya Sabha (Local Regional Council) (see **Chapter 3**).

With the help of the Assistant Government Agent existing maps of the GN Divisions in the Habaraduwa DSD as a whole were consulted, and with the assistance of the resident draughtsman, an attempt was made to determine the total number of GN Divisions bordering the lagoon. This stage in the study also involved consulting relevant maps and blueprints of the area held at the Survey Department (Galle) located approximately 15 km from the study area. In addition, frequent trips were made to the study site to confirm existing information contained in the maps. Though time consuming, this stage was vital, as in determining the total number of GN Divisions bordering the lagoon, the impact area of the lagoon was established. From these initial investigations a total of fifteen GN Divisions were found to border the lagoon and were chosen as a starting point for investigation.

On the assumption that the residents of these Divisions would have some degree of dependence on the lagoon and its environs, details relating to the social make-up of the local communities was sought. Existing information held at the Local Regional Council relating to these 15 divisions comprised mainly socio-economic indicators in the following key areas: male:female ratios; employment levels; and levels of education and family size. This data is collected by the Village Headman (GN) of each Division on an annual basis, on the instructions of the Assistant Government Agent (AGA), and it is the responsibility of the GN to ensure that the data provided are accurate for their respective division.

Preliminary studies of this data showed that information collected by GN's who had served and lived in each respective division was most reliable, whereas, in situations where the GN lived outside the division or had been newly recruited, existing records were often found to be inconsistent and incomplete. Because of this shortcoming it was decided that preliminary checking of this data be made. Bearing in mind that the information sought was fairly specific and since the author had considerable prior knowledge of the range of responses, questionnaires and random interviewing techniques were the main research tools used (Casley & Lury, 1987). Figure 4.2 displays the total number of households that were interviewed in this preliminary checking of the data. This process had the added advantage of identifying key informants in each division who were able to provide valuable information relating to each division. Information was also gained from *ad hoc* conversations held with villagers. Such information was recorded in a diary that was kept throughout the research period.

Though time consuming, the checking of this secondary data pertaining to each of the sample divisions was a vital part of the research, as in at least 6 of the divisions bordering the lagoon the village headmen had been newly recruited and were therefore not very familiar with their respective divisions. In some instances, existing records had not been updated over the last five years. People selected specifically for interviewing in the fifteen GN Divisions were mainly chosen on a random basis, but in some cases certain families were selected following the recommendation of the village headmen.

In addition to this secondary data and meetings conducted with all fifteen village headmen, interviews were also arranged with local Buddhist priests and School principals in the area. Information derived from these two sources made checking of this secondary data possible. Since the majority of residents in the area are Sinhala Buddhist (see **Chapter 3**) interviews conducted with the Buddhist priests presented a very important insight into the local communities. The Buddhist priests were able to give detailed information relating to the Divisions in which they were living and also were well informed of the social and environmental problems faced by the residents of the area. Some of the more elderly Buddhist Priests were able to compare the present situation with times past thereby providing an additional historical context. Visits were also made to the Koggala Export Processing Zone (KEPZ) and meetings held with key officials supplemented this information.

On the basis of the information derived from the introductory social survey, six sample divisions (see Figure 3.1) were selected for in-depth analysis. These divisions were balanced in terms of class, caste, gender and employment and differed in their degree of dependence on the lagoon. In addition, they were also representative of the farming and fishing communities - the two major communities in the area. As mentioned in Chapter 3, there are a total of five major castes in Koggala. Caste, as in most societies where it exists, is a very sensitive topic about which rural people are very reluctant to talk in a mixed group. However, it was an important factor to consider in the selection of the sample divisions to ensure that they would reflect the wider social make-up of Koggala as a whole. After the preliminary work had been completed and the sample divisions chosen, an attempt was made to check existing socio-economic data relating to these six divisions. For this purpose checks were made using questionnaires and unstructured interviewing techniques. The total number of households interviewed for this purpose is given in Figure 4.2. During these surveys key informants in each Division, and also potential participants for the discussion groups, were identified.

The reasons for checking existing sources of secondary data have been touched on earlier in the text. The importance of this process can be further explained in terms of the rapid number of changes that Koggala is currently undergoing which have had far-reaching consequences for local communities, including loss of livelihood. Existing secondary sources of information do not reflect such changes. This can be illustrated using the GN Division of Kahanda Athireka (167A) as an example. In this division the extent of cultivated rice fields has been declining, due to problems associated with salinisation, and field surveys confirm this. However, according to official records the extent of this crop has remained the same during the last five years. Similarly official estimates seriously underestimate the number of residents in each division that are involved in different occupations. For example, the total number of farmers in the sample six study divisions is 275, whereas field surveys reveal this figure to be considerably higher and in the region of 400. A similar problem is apparent with regard to the number of fishermen in the study divisions. The reasons for this underestimation have been analysed in **Chapter 3**.

There are a number of additional reasons which explain the unreliability of existing official records. These include changes in the demarcation of the boundaries of each individual GN Division and the rapid turnover in some divisions of Grama Niladharis which make accurate records difficult to obtain. In addition the method of collection of socio-economic data by the Local Regional Council relating to the Divisions is carried out according to a rigid format on an annual basis which does not take into account the frequency of social and environmental changes and their repercussions in the interim period. Moreover the accuracy of these records depends to a large extent on the degree of commitment of the individual GN to their respective division and since these records are not checked by the Local Regional Council their accuracy in some instances is questionable.

In the context of the rapid number of transformations experienced in the study area and the emphasis of the thesis, accurate records relating to the chosen sample divisions are important. Thus this stage in the study schedule ensured full comprehensive records relating to the socio-economic framework of the local communities in the sample six divisions.

Figure 4.2 Number of families featured in the Introductory Social Survey of the Sample Six GN Divisions

Sample Divisions	**Total no. of families in each division**	**No. of families interviewed using questionnaire**	**% of families interviewed using questionnaire**
Polhena 154B	293	30	10%
Pelassa 166C	282	45	16%
Koggala Athireka 144 D	243	40	16%
Kahanda 167	209	33	16%
Harumalgoda East 149A	217	79 (38+41)	36%
Alawattukissagoda 164G	205	31	15%

(Source:Present study)

The introductory social survey work highlighted the necessity of an in-depth study of the farming and fishing community which constituted the two main groups that were dependent on the lagoon and its environs for a living. Drawing on the findings of the introductory data collected from this initial survey work, an in-depth study of the agricultural and fishing-based communities was undertaken. The methods employed in these studies are described below.

4.4 In- Depth Survey of the Agricultural Community

As outlined in **Chapter 3**, agriculture has been a major traditional activity in the study area. Following the initial social surveys carried out in the sample six divisions, it was evident that an in-depth study of the agricultural community should be undertaken in order to assess clearly the impact of agricultural activity in the region, particularly in the aftermath of the 'Green Revolution.' The main aim here was to evaluate the modifications this community had made in light of recent changes affecting the lagoon and its environs. For this purpose three target groups were identified for in-depth study: (1) Farmers, (2) Traders (involved in selling agro-chemicals) and (3) Sprayers (members of the farming community hired to administer agro-chemicals to the farming lands in the study area as a whole).

4.4.1 Case Study 1: The Farmers

Information relating to this case study relied mainly on the use of the questionnaire and in-depth interviewing techniques (Bulmer, 1983; Jones, 1985a;1985b). A total of 130 farmers living in the sample six divisions was interviewed (see Figure 7.9). All the farmers were involved primarily with rice cultivation but were also engaged in the small-scale cultivation of plantation crops such as tea and coconut. The main topics covered in the questionnaire related to the following five main categories:-

1. The use of Agro-chemicals;
2. Descriptions relating to cultivation patterns employed;
3. The use of traditional farming methods;
4. Perceived advantages and disadvantages of pesticide usage;
5. Changing land use patterns and occupations as a result of changes in the environment.

Using these main topics and the questionnaire as a guide, the farmers were interviewed in groups of 5-6. This had the added advantage of saving time and also enabled differing opinions between farmers in the group to be worked out and conclusive answers to be drawn. Thus the farmers were able to test out their views with the other farmers which would not have been possible in an isolated interview. This feature of group interviewing has been identified by many researchers as influencing their choice of this method (Hedges, 1985).

With regard to the use of agro-chemicals, farmers were questioned specifically about the type of agro-chemicals they used, where they bought their requirements of these inputs, and whether they received any training regarding their use. Though investigations were focused principally on rice cultivation, details were also obtained relating to the other plantation crops cultivated in the area. In addition, each group of farmers interviewed were questioned on the methods of cultivation they employed with specific details relating to the use of individual agro-chemicals. In this way detailed information relating to the quantities and types of agro-chemicals used were acquired.

A key objective of the study was to examine the changing pattern of agriculture and how recent changes had affected the farming community. Since an important aspect of this analysis involved a historical interpretation of events each group of farmers interviewed consisted of at least one farming member in the age-group of sixty years and over.

4.4.2 Case Study 2: The Agro-chemical Traders

Interviews conducted with the farmers revealed that they bought their main requirements of agro-chemicals from two principal traders: (1) Wimal Agro-chemicals and (2) NRM Traders. Both these outlets are registered with the Government specifically for trading in the Koggala area and they also supply smaller retail outlets (see **Appendix 3**) which come within the boundary of the study area. For purposes of the present study interviews were conducted mainly with these two groups though surveys were also conducted in the study area in smaller retail outlets which also supplied the farming community with their agro-chemical requirements.

Using a questionnaire as a guide, relevant details were obtained from the two main retail outlets relating to specific trade names of agro-chemicals sold and the manufacturing company that supplied them. In addition, a list of the most widely used agro-chemicals, with notes relating to their chemical composition was also obtained. Finally the owners and staff members of both outlets were questioned regarding the training they received from the Government and/or the companies that supplied them. They were also asked whether this training was passed on to the farming community. In addition to the information derived from surveys conducted with the main traders, meetings were arranged with the agricultural extension officer at the Local Regional Council who has jurisdiction over the study area.

4.4.3 Case Study 3: The Sprayers

Introductory social surveys of the sample six divisions revealed that two farmers were employed on an *ad hoc* basis by other farmers to spray their fields with agro-chemicals. In view of the knowledge these two farmers must have on the use of agro-chemicals and the potential and perceived impacts of their long-term use on the environment and on themselves, both farmers were targeted for interviewing. They were interviewed separately and were questioned on the variety of agro-chemicals they used, application procedures, and approximately how many fields they sprayed during each cultivation season. Since these two sprayers were employed chiefly to spray rice fields it was further hoped that they would be able to assess the extent of rice fields abandoned due to increased salinisation and flooding problems.

4.5 In- Depth Survey of the Fishing Community

The fishing community in Koggala is concentrated in those divisions located mainly around the southern borders of the lagoon (see Figure 6.3). As mentioned in **Chapter 3,** it is difficult to obtain accurate figures relating to the total number of fishermen dependent on the lagoon and associated sea. Inspite of these difficulties it has been estimated that the lagoon fishery supports the primary income of at least 500 families in the fifteen GN divisions bordering the lagoon.

There are also major differences in the degree of dependence on the lagoon on the part of the individual fishermen. For example the majority of fishermen living in the GN division of Koggala 144A are involved mainly in deep sea fishing and are not so dependent on the lagoon. Similarly, fishermen from the GN Divisions of Alawattukissagoda, Koggala Athireka 1 144D and Harumalgoda East 149A, in addition to the lagoon fishery, also engage in the capture of ornamental fish which they sell to middlemen for export. Thus, to get an accurate picture of the fishing community in the study area, representation by all groups was vital. To compare the experiences of these very different groups of fishermen, it was decided that interviewing them together would be the most appropriate technique.

A total of 150 members from the fishing community, from 62 households in the GN divisions constituting the study area were interviewed (see Figure 6.4). The fishermen were interviewed in groups ranging from 15 - 25 individuals. Unlike the farmers, fishermen work very anti-social hours so interviewing times were limited. To overcome this problem individual interview times were pre-arranged and most interviews were conducted on Full moon days (Sinhala: *Poya*) as, following the Buddhist tradition, it is customary not to fish on these days. In addition to fishermen, their wives were also included in the interviewing. A full profile of the fishing community targeted for investigation is displayed in Figure 6.5 This group was balanced primarily in terms of age, an important factor in assessing how fishing patterns might have changed over the course of time.

Using a semi-structured questionnaire, the fishing community were guided through a set of key questions relating to descriptions of methods of fishing and fish found in the lagoon, both past and present, including species of commercial importance, and reasons for the noticeable decline in catch from the lagoon. In addition they were questioned on economic details relating to ownership of boats and fishing equipment and current restrictions to fishing in the lagoon. The importance of the mangrove community and its connection with the fishery of the lagoon were also key topics of investigation.

The questionnaire was used principally as a guide and since the author was not rigidly bound to it this allowed for discussion on certain aspects that had been neglected. As with the interviews conducted with the farming community, this stage of the study enabled the identification of possible participants who would take part in the discussion groups. The results of interviews conducted with the fishing community are presented in **Chapter 6**.

4.6 Group Perceptions to Environmental Change

4.6.1 Small Groups in Qualitative Research

At present the two principal means of collecting qualitative data in the social sciences are individual interviews and participant observation in groups. In qualitative research, the realities of everyday life are analysed as they are experienced and explained by the people who live them. Such research as this yields complex linguistic data (Burgess, 1982; Glaser & Strauss, 1967; Plummer, 1983; Silverman, 1985). The use of in-depth small disucssion groups is attractive for social research because they provide data from a group of people much more quickly and at less cost than would be the case if each individual was interviewed separately. They can also be assembled at much shorter notice, a factor which has influenced the choice of this technique especially in developing countries (Panvisavas *et al.*1991a;1991b). However the price one pays for the ease of conducting such groups is the fact that they are not fixed in natural settings. As such there is some uncertainty about the accuracy of what people say. This point emphasises the preference for more natural settings when these are crucial to the research.

The key strength of conducting these groups comes from the opportunity to collect data from group interaction. When all goes well, focusing the group discussion on a topic brings forth material that would not come out in either the participant's own casual conversations or in response to the researchers own pre-conceived questions (Morgan, 1988; Stewart, 1990). However the down side to this is that the problem with relying on group interaction is never knowing whether or not it mirrors individual behaviour (Janis, 1982). The point here is that individual behaviour is subject to group influence.

A fundamental contrast between in-depth small discussion groups and conducting individual interviews is that in-depth groups allow members sufficient space and time to develop and contest ideas and arguments presented by other members of the group (Harrison & Burgess, 1994). There is a substantial body of knowledge about the structure and the processes which operate within small groups (Bion, 1961; Berne, 1966; Blumberg *et al.* 1983; Durkin, 1981;Heap, 1977). A further strength of in-depth small discussion groups lies in the fact that, by meeting on consecutive occasions, the researcher would have already established a certain rapport and trust with the group members enabling them to contribute more effectively to the discussion. This provides opportunities for the clarification of responses, for follow-up questions, and for the probing of responses. Respondents can qualify responses or give contingent answers to questions. Individual interviews however have been criticised for manipulating individuals into revealing more than they would consciously wish to reveal to a stranger.

Compared to individual interviews the strength of in-depth discussion groups lies in the ability to observe interaction on a topic. Another advantage is that the participants' interaction among themselves replaces their interaction with the interviewer, leading to a greater emphasis on the participants' points of view. Summarising these strengths, the use of individual interviews produces an opportunity to collect data from individuals concerning topics of interest to the researcher. However they are less suitable when it is clear that interpretation of individual experiences and collective values are deeply and strongly felt and in such circumstances the use of the in-depth group discussion is a more appropriate research tool.

Drawing on the merits of this technique, the present study sought to investigate people's perceptions of environmental change in the chosen six sample divisions bordering Koggala lagoon. Since this topic would require a methodology that would be able to explore ideas that are deeply held, consisting of individual experiences and collective beliefs, the use of the in-depth small discussion-group was adopted. Comments on the success and problems of this approach in a developing country like Sri Lanka have been made in **Chapter 8**.

4.6.2 Planning for Discussion Groups

Once-only group interviews were held in each of the sample six divisions on separate occasions between June 1993 and July 1994. The use of 'once-only' groups in these circumstances provided a forum for the participants to share and test out their views with others. These groups consisted of members of each GN Division identified as potential participants from the surveys conducted previously. These individuals included Buddhist priests from the GN divisions of Kahanda and Polhena and individuals who were identified following the advice of key informants. In addition to this, certain individuals who displayed an interest in participating during introductory surveys were invited to join. On average a total of 30 people attended the 'once-only' groups.

Discussion was initiated by the researcher who began by introducing the major theme of the study i.e. environmental changes in Koggala and its environs. As the discussion which was initially dominated by a few key individuals progressed, the researcher who played the role of the mediator was able to lead the discussion by asking direct questions of individuals but not interfering with the selection of topics or the way in which the discussion developed. In this manner the researcher had a significant role in keeping within limits the content of what was discussed in the group.

Group interviewing provided a forum in which the participants could share their views with others rather than responding in an isolated interview. These once-only groups were conducted primarily as a filtering device for gaining access to different communities. This helped the identification of individuals who might be willing, and also best able, to function in the in-depth discussion groups, thus overcoming many of the problems involved in recruitment. The use of this technique was attractive in that group interaction produces data and insights that would be less accessible without the interaction found in a group. In many ways it presented a good indication of the initial response to the in-depth discussion groups to be carried out later in each of the divisions.

After two repeated sessions, groups were restricted to an optimum size of 25 representative individuals. Smaller groups proved unsuccessful for a number of reasons, the most significant being that they required a greater contribution from individual participants and the whole functioning of the group could easily be disrupted by dominant individuals. Groups larger than 25 on the other hand proved difficult to manage. Though earlier it had been anticipated that the presence of Buddhist priests would be an advantage, the example of these 'once-only' groups proved otherwise. In almost all examples, the presence of these priests somewhat hampered discussion as most participants felt uncomfortable talking in their presence and in addition were neither comfortable to disagree nor interrupt them. Using these 'once-only' groups as a guide, the final selection of participants to take part in the in-depth discussion groups was made.

4.6.3 Site Selection and Data Collection

Since the participants of the discussion groups were sacrificing their own time to attend and were not receiving any kind of remuneration for this, it was decided that a venue be arranged which would be convenient to them. For this reason, local schools were used as a meeting place, which proved very useful especially during the monsoon months. On occasion groups were held outside and conducted within the vicinity of the residents' homesteads which had the added advantage of providing residents with the familiarity of their own surroundings.

The principal means of capturing observations in a discussion group was through audio-taping. These discussions were analysed later and coded for recurrent themes and manners of expression (Strauss, 1987) (see **Chapter 8**). It had been suggested that video-taping would have been a useful means of recording each session but this was abandoned as this would almost certainly have affected the participants' behaviour and performance in the discussion, because of the intrusive nature of video-taping, and also given the background of the participants i.e. that of a relatively isolated rural community.

4.6.4 Conduct of the Discussion Groups

The participants of the discussion groups were all from relatively isolated rural backgrounds and had not been exposed to any research projects prior to this. Given the sensitive and emotive nature of the study, a number of steps were taken to protect these individuals. It was emphasised that participation in the discussion groups was to be held strictly confidential and would not be used for any purpose other than that stated at the outset.

At the beginning of each discussion group, after the traditional greetings, it was clearly stated that the research had nothing to do with the Government though some officials were present in some of the groups. Establishing a role that the participants in the discussion group could understand was very important. The literature on survey research in developing countries is full of examples of how respondents often misinterpret the role of the researcher (Feliciano, 1964). Who the researcher is perceived to be is actually more important than his or her actual role (Provinse, 1963). This problem was quickly overcome after initial introductions were exchanged and roles were thus clarified. Many of the people present were known to the researcher as the daughter of D. Samarasekara, a resident of the area. Because of this, many of the problems researchers encounter in village entry were overcome. This is a very important point as researchers have encountered this problem time and time again. Local people when approached are extremely reluctant to reveal the details of their economic life (Martin, 1956). Often they regard anything they think may be connected with 'government' with "an appreciable degree of reserve and suspicion" (Ward, 1964: 45). An additional factor that helped in this regard and in gaining the trust of the participants was that the author and her family were known to the participants as residents of the area. Thus at the outset, a very free and open atmosphere was established. Many of the difficulties interviewers experience are clearly related to this suspicion, and much time and skill is required to try to eliminate people's doubts and fears (Devereux & Hoddinot, 1992).

Group discussions were held between August 1993 and January 1994 in each of the sample six divisions under investigation. Due to the rapid number of changes over a relatively small time scale they were reconvened again between April 1994 and October 1994 and again in November 1995. During these discussions, it was the role of the researcher to ensure that a secure environment was created, i.e. one in which the people felt they could talk freely. For this reason and drawing from experience, it was decided to conduct two discussion groups without the presence of the village headmen, and also without any representatives from the Habaraduwa Pradeshiya Sabha (Local Regional Council), simply because the participants in this instance spoke more freely in their absence. It was also the role of the researcher to keep to the key themes in mind and not to let support groups develop.

Running parallel to the discussion groups in each of the sample six divisions, discussions with key officials were held independently at the KEPZ and also at the Board of Investment in the capital Colombo (responsible for the KEPZ). Here the groups were considerably smaller and ran for shorter periods of time.

4.7 Mapping of Land-use in the Sample Six GN Divisions

Following surveys conducted with the agricultural community, which indicated an intensification of agricultural activity in the study area particularly in the aftermath of the 'Green Revolution, an attempt was made to determine current agricultural land-use patterns in the sample six divisions. To achieve this, base maps of each of the study divisions, compiled from existing maps held at the Local Regional Council, were enlarged onto sheets of A2 size plain paper. It should be noted that there are no existing maps relating to the individual GN divisions constituting the study area. As a result the base maps consisted simply of a basic outline of the divisions. Using these as a guide field visits were made to each individual study division noting major and minor roads, homesteads and places of interest such as local Buddhist temples and schools. After this initial exploratory visit, individual land-use types were outlined onto the maps during a more intensive study where the author was accompanied by a trained draughtsman and a surveyor from the Survey Department in Galle. Land-use patterns were categorised using a qualitative scale estimating percentage abundance of each crop type and classified accordingly.

The study area consists of the following main land-use types: tea; rubber; coconut; abandoned and cultivated rice paddy land; cinnamon; and mixed cultivation (i.e. an equal representation of two or more crop types). In addition, areas of undisturbed forest were also noted. The validity of these land-use maps was then tested by employing the participatory rural appraisal (PRA) methods outlined in section 4.2.2. This enabled those residents of the community already successfully identified as key informants stemming from the farming community to check this preliminary information. The importance of the use of farmers' indigenous knowledge in monitoring agricultural resources has been widely acknowledged in the literature (Ashby *et al.*1987; Barker *et al.* 1977; Chambers & Ghildayal, 1985; Chambers *et al.*1989; Chambers &

Jiggins, 1986; Farrington & Adrienne, 1988; Fujisaka, 1991; Hayami, 1981; Maurya *et al.* 1988; Rhoades, 1990; Warren *et al.* 1995).

Methods included presenting copies of base maps of each division which contained only key features such as major roads and sites of local importance such as schools. The main informants were then requested to sketch clearly existing land-use patterns from memory, drawing on their unrivalled knowledge and experience of their individual divisions. Sketch maps of the village and its resource base were useful tools for interactive discussions with local people who were able to show where different kinds of resources existed and to what extent they were being used now and in times past. Using this information, and information derived from field surveys conducted by the author, replicate maps were compiled. These maps were further checked by the key informants, and noting any further changes, final versions of the maps were drawn.

4.8 Mapping of Fringing Mangrove Community

The mangrove complex in Koggala has been subjected to various disturbances over the years, most of which can be attributed directly to human interference (see **Chapter 5**). Based on the indispensable role of the mangrove complex especially in relation to the fishery of the lagoon, a central aim of the research was to obtain an accurate picture of the current status of the fringing mangrove bordering the lagoon. Here an attempt was made to assess comparative rates of change. The study was conducted in two phases using a combination of comprehensive ground surveys in the field and photo-interpretation of aerial photographic cover of the area as a historical baseline. The main objectives of this aspect of the study were to identify the former extent of mangrove coverage from aerial photographs and from ground surveys to delineate the current distribution of mangroves bordering the lagoon.

4.8.1 Field Survey

Given the historical importance of the lagoon as a landing site for Catalina and Sunderland planes engaged in reconnaissance activities during the Second World War (see **Chapter 3**), aerial photographs of the study area exist for the following years 1956;1965;1974;1983;1988 and 1994. At the start of the research, these aerial photographs were not made available to the author. This was mainly for security reasons, due to the presence of a fully operational military air-base situated on the southern borders of the lagoon. This meant that the study area fell within the confines of one of the restricted zones in the country. Therefore field surveys were conducted first. The study area was classified according to Lugo and Snedaker (1975) employing the method modified by Cintron *et al.* (1985). Two types of mangrove community exist in the area, 'island' and 'mainland fringing'.

Study sites were selected around the lagoon and were representative of these main mangrove types. Mangrove habitats on the mainland and islands were accessed both by boat and overland. Specimens of the species encountered were identified using descriptive literature and taxonomic keys (Blasco, 1984; Dassanayake & Fosberg, 1980; Watson, 1928), as well as comparing them with the specimens in the National Herbarium at Peradeniya Botanical gardens, Sri Lanka. Enumerated species were categorised into true mangrove and mangrove associated species (Saenger *et al.* 1983).

Using a topographical map of the area with a scale of 1:50 000, which was enlarged to a scale of 1:20 000, the mangrove bordering the lagoon was divided into checkpoints. At each checkpoint, observations and data collection were made to achieve the above objectives. This was largely of a qualitative nature to estimate the extent of mangrove cover. In addition, detailed habitat notes were also made taking into account possible factors for the present status of the mangrove e.g. the proximity of human settlements. After the initial field surveys were completed, the data gathered in the field was transferred onto a base map of the area. The completed base map was then checked with the help of the residents in the surrounding villages. In most cases, these people were from the fishing community and as such were very familiar with the identification of the different mangrove species, and additionaly were able to offer their own explanations for the presence or absence of a particular species.

4.8.2 The Photo-interpretation Study

After the initial period of field study, the necessary photo-interpretation work was undertaken. As was mentioned above the study area is covered by a series of black and white panchromatic film photographs taken at the following dates and scales: 1956 (below 1:5000), 1965 (below 1:5000), 1974 (below 1:5000), 1983 (1:20000), 1986 (1:10000) and finally 1994 (1:25000). These photographs were eventually made available to the author and photo interpretation work was carried out using a pocket stereoscope. The mangrove belt was classified into different forest types based on photo tone and texture. Tones are shades of grey divided into light, medium, and dark tones. Texture refers to the structure of individual objects visible on photos, divided into coarse, medium, and fine. Using a combination of information gathered from the intensive field surveys and photo-interpretation studies, a final modified map was drawn, the contents of which were routinely checked during the entire duration of the research period monitoring any changes.

The last stage in this analysis involved comparing the final version of the map illustrating the present status of the mangrove resources in the area with the earlier evidence from the aerial photographic cover. It should be noted that the quality of these photographs, particularly those taken in the period between 1956-1974, is not up to standard. In addition they do not cover the entire area of the lagoon. However these photographs proved useful in providing trends in changes in cover and more importantly provided an important historical base-line (see **Chapter 5**).

4.9 An Analysis of the Changing Hydrology of Koggala Lagoon

Flooding of water from Koggala Lagoon into surrounding areas is causing severe problems to the local communities, having both wide-scale social and economic repercussions (see **Chapters 6, 7,** and **8**). The problems with flooding in the lagoon have been attributed to sand mining which resulted in the destruction of a 'naturally' formed sand bar located at the southern borders of the lagoon (see **Chapter 5**). Previously, water levels, particularly during the monsoon period, had been controlled by members of the farming community digging a small passage in the sand bar to provide a means for the flood water to escape. Now this situation has been reversed and sand bought in with the tides accumulates under the Kataluwa bridge blocking the outflow of the water from the lagoon, making it impossible to breach manually as was the case before. As a result, during the rainy season, the flooding of agricultural land, village homesteads, and roads is now widespread.

An attempt was made to investigate the impact of the destruction of the sand bar on flooding levels in the lagoon. As mentioned in **Chapter 3** there have been no systematic hydrological studies of Koggala Lagoon apart from those associated with the Warrabokke saltwater exclusion scheme, which was commissioned in the early 1980's (**Chapter 5**). Existing data is limited to daily water level recordings at the main anicut located on the northern borders of the lagoon by the Irrigation Department. The recording of this data was initiated in 1988. For purposes of the present study, data was collected from 1988 to September 1995. This data set reflects a period of approximately seven and a half years, a total of twenty nine months before the sand bar was removed and a further forty five months after the removal. Using a combination of this data and daily rainfall and wind speeds covering the same period an attempt was made to establish the effects of the destruction of the sand bar on flooding levels in the lagoon. Analysis of this data is presented in **Chapter 5**.

4.10 Summary

- The methods used throughout the study stem from both the natural and social sciences and reflect the inter-disciplinary character of the research. Emphasis was placed on the importance of involving local communities in the research process and the value of this approach is further discussed in **Chapter 8**.

- Surveys conducted with the farming and fishing communities relied heavily on the local knowledge of these two key groups. Interviews conducted with them allowed individuals and groups to participate in the research process. A similar procedure was followed in the physical analyses where these individuals assisted by checking the data collected. Discussion groups conducted during this period played an important role in analysing environmental changes and their impacts on the study area. These are further discussed in **Chapter 8**.

- This chapter describes the research methods used and provides a introduction to the analytical component of the thesis which is presented in **Chapters 5 - 8**. **Chapter 5** focuses on recent hydrological and environmental changes and the effects of these on the two communities are then analysed in **Chapters 6** and **7**. Finally in **Chapter 8** group perceptions to these environmental changes are discussed.

CHAPTER 5
KOGGALA LAGOON 1: ENVIRONMENTAL CHANGE

5.1 Introduction

This Chapter examines the main environmental changes that have taken place in the study area, in an overall attempt to investigate the impacts such changes might have had on key biological resources. For this purpose, emphasis has been placed on the fringing mangrove complex and on recent changes to the hydrological environment of the lagoon. By analysing the current status of the mangrove complex in the study area (Section **5.3**), an assessment is made of prevailing conditions and stress factors. Similar attention has been given to the hydrological aspects of the lagoon (Section **5.4**) which are affecting local resources-use patterns. An evaluation of the present situation and implications for the future are summarised in Section **5.5**.

5.2 The Mangrove Ecosystem in Sri Lanka

5.2.1 Occurrence and Area

Tansley and Fritsch (1905), in their study of the flora of the Ceylon (Sri Lanka) littoral, provide one of the earliest descriptions of the species composition of the mangrove formations in the country. They regard *Rhizophora, Bruguiera,* and *Sonneratia* as the most common species. Other noteworthy reviews of the mangrove formations on the West coast are given in Balasubramaniam *et al.* (1984), Amarasinghe and Balasubramaniam (1992) and Trimen (1974). In Sri Lanka, mangroves are discontinuously distributed along the coastline, being absent along exposed shorelines, particularly in the southwest, south and northeast. Over 60% occur on the northwest coast, in the Puttalum Lagoon and the Dutch and Portugal bay areas (UNEP, 1986a). In addition, mangrove resources are largely distributed through the coastal lagoons in the country and on the shores and inlets and sheltered embayments around the coastline (Pinto, 1986; Silva, 1985).

There is a considerable difference of opinion as to the total area of mangrove coverage. The comparability of the published data is variable, depending on the techniques of measurement and the definition of 'mangrove forest'. For instance, in 1969, the total area for the country was estimated conservatively at 8,000-10,000 ha (Aruchelvam, 1968). Samarakoon and Pinto (1986) suggest from remote sensing studies that there are 6,296 ha of mangroves in the districts of Colombo, Amparai, Gampaha, Trincomalee, Batticaloa and Puttalam alone. According to Scott (1989a) the total area for the country is likely to be close to 10,000 ha and, according to GOSL (1987), the total area for the whole country is 12,189 ha, or 5-10% of the country's sheltered tidal habitats. A FAO/UNDP inventory estimated the total area of mangrove vegetation as 8,000 ha (FAO, 1986).

The most recent forest survey however, gives the mangrove areas in Sri Lanka as 6,877 ha (Legg & Jewell, 1992). A list of the extent of the mangrove habitat in the country, according to this survey, is given in Table 5.1 below. It should be noted however that the Divisional Forest Officer, Galle, who is carrying out a study of mangrove vegetation has estimated the areas of mangroves in the Kalutara, Galle and Matara districts to add up to 100ha, 600 ha and 200 ha respectively. Interestingly, the 1992 survey did not record any mangrove areas in these three districts. This discrepancy may be explained by the fact that the 1992 survey was based almost solely on satellite imagery and may not have been able to capture some of the narrow areas fringing the lower reaches of rivers. The destruction of mangroves may also have contributed to this decrease. One can therefore assume that the 1992 estimate of 6,877 ha is too low, yet even making allowance for this low estimate, the total area of mangrove in the country represents a very small fraction of the forest area of the country as a whole (Wijesinghe *et al.* 1993).

Table 5.1 Extent of mangrove habitat in Sri Lanka according to 1992 Forest survey

District	**Extent of mangrove (hectares)**
Batticaloa	1672
Puttalum	1641
Mannar	1321
Trincomalee	982
Hambantota	379
Mullativu	149
Kilinochchi	139
Gampaha	64
Ampara	53
Total	**6877**

(Source: Legg & Jewell, 1992)

5.2.2 Mangrove Composition

Twenty eight mangrove and mangrove-associated species have been described by UNEP (1986a), while GOSL (1987) lists 14 mangrove species and 12 mangrove associates. The genera *Rhizophora, Avicennia, Excoecaria, Luminitzera* and *Aegiceras* are distributed island-wide. *Xylocarpus granata* Koen. occurs on the west and the east coasts; *Bruguiera cylindrica*Bl. occurs only on the west coast, *Ceriops tagal* is absent from Jaffna, and *Nypa fruticans* occurs only in the south west of the island (Aruchelvam, 1969).

The small tidal range of less than one metre (75cms) limits Sri Lanka's mangrove range and also zonation patterns. Thus mangroves occur on a narrow intertidal belt and extend less than a kilometre landwards from the mean low water tidal level (Wijesinghe *et al.*1993). More obvious zonation may be seen in estuaries, deltas and tidal creeks (GOSL/ESCAP, 1985; GOSL, 1987).

5.2.3 Mangrove Functions and Values

Mangroves have a variety of different uses as food, fodder, firewood and construction materials, and in some cases mangroves are an integral part of small industries. Amarasinghe (1988) describes in detail local resource-use patterns in human communities living along the west coast of Sri Lanka. Some species, such as *Rhizophora, Bruguiera* and *Avicennia,* are commonly used as firewood. People around the Puttalum Lagoon prefer the charcoal of *Rhizophora* for its high heat and low smoke (CEA/Euroconsult, 1994a). About 80% of fishermen living in mangrove areas depend on these fishing grounds for their subsistence, especially in 'brush-pile fisheries' (Sinhala: *mas athu*). Here branches of mangrove species are used to create artificial breeding sites for fish and crustacean species. In the Negombo Lagoon, this type of fishery accounts for more than 80% of the total catch of fish and shellfish. More than 750 brushpiles are operated annually and about 250 families derive their income from this source (Amarasinghe, 1988; Samarakoon & Zon, 1991). Thus over-exploitation of the mangrove may not only have adverse effects on the productivity of the lagoon but also directly affect the generally poor fishing communities. Local residents in Rekawa Lagoon use mangroves as a source of wood for fuel for lime kilns, cooking, and house construction (Ganewatte *et al.* 1995).

The economic value of mangroves, especially to small rural communities, is high but has not been estimated accurately. Examples of valuable economic uses include tannin extraction from *Rhizophora mucronata* and *Ceriops tagal* to tan fishing nets and sails of traditional fishing craft. In 1986 it was estimated that approximately 12,000kg of dried *Rhizophora* bark was collected from Dutch Bay (Samarakoon & Pinto, 1986). Mangrove timber is also used to construct the outriggers of traditional fishing craft.

5.2.4 Mangrove Habitat Destruction and Degradation

Increasingly in Sri Lanka it has been the case that mangroves have not been given due attention in terms of rational exploitation and as a result of this neglect a considerable proportion of mangrove areas has been lost for more 'profitable' alternative land uses, especially coconut and rice paddy cultivation, and urban development (Amarasinghe, 1989; Lowry & Wickramaratne, 1989; IIED, 1992).

Many mangrove swamps, notably those in Jaffna, Batticaloa, Trincomalee, Puttalum and Negombo, are threatened by excessive extraction of fuelwood and timber for construction and reclamation for housing development, particularly in densely populated areas such as Negombo (Scott, 1989a; Samarakoon & Zon, 1991). According to Jayawardena (1987), threats are most serious in the arid areas on the west coast near Puttalum Lagoon where mangroves have been impoldered extensively for coconut and banana plantations and salt pans. As a result of increasing population pressure, all these usage patterns have intensified and only a few extensive stands of mangroves still exist in the estuary (CEA/Euroconsult, 1994a). *Rhizophora* and *Avicennia* species are heavily exploited to obtain charcoal for bakeries, for firewood and pole productions.

As yet, the large-scale transformation of mangrove swamps to brackish water ponds for aquaculture has not occurred in Sri Lanka. Some 300 ha of shrimp ponds have been constructed in the mangroves (e.g Negombo and Chilaw). A further 1,000 ha have been leased for expansion of aquaculture, but most of this land is situated where mangroves have already been degraded (Scott, 1989a).

In the Madu Ganga area, barrages have been built to prevent salt water intrusion to rice fields and this has affected mangroves. Near Colombo mangroves have been converted for residential and industrial areas, and they are increasingly being used for recreational purposes, particularly along the south-western coast. Pollution from human sewage seems to be a significant threat, and this has been implicated in the defoliation and death of *Rhizophora apiculata* at one location. On the Southwest coast, the organic by-products of anaerobic decay of coconut husks have been suggested as the cause of the disappearance of *Nypa fruticans,* which was previously abundant in the area (Jayawardena, 1987; GOSL/ESCAP, 1985). Reclamation projects for housing have also resulted in large-scale losses of mangrove areas. For example, housing and office development on Crow island in Mattakkuliya destroyed a 22 ha mangrove forest at the mouth of the Kelani river. Its impact on fisheries, and likely losses to coastal communities have not been studied and the lands' usefulness for housing over the long term is doubtful (Olsen *et al.*1992).

Other threats of varying importance in different areas of the country include reductions in freshwater inflow due to upstream irrigation projects, increased sudden sedimentation due to upstream erosion, run-off of agricultural fertilisers and pesticides, and pollution by urban and industrial effluent.

5.3 The Decline of the Fringing Mangrove in Koggala Lagoon

5.3.1 Species Composition and Structure

The present distribution pattern of the mangrove resources in Koggala Lagoon is shown in Figure 5.1, which was compiled from intensive field surveys conducted throughout the research period, monitoring any changes taking place during this time. A comparison between the present distribution and that of the last forty years has been attempted using aerial photographic cover of the lagoon and its environs and blueprints of the area stemming from as far back as the turn of the century (see **Chapter 4**).

The mangrove complex in Koggala extends over a very narrow intertidal area on the edges of the lagoon. This belt is no longer as continuous as the earlier photographic cover indicates. In particular, along the southern borders of the lagoon, the existing mangrove forest was extensively cleared in preparation for the establishment of the KEPZ. Aerial photographs illustrate this area as having previously existed as a very thick belt. The remaining mangrove stands in Koggala which fringe almost all the islets within the lagoon exhibit a diverse range of species. However, most mangrove stands are heavily exploited with old and large trees almost entirely absent.

Plots taken at sample locations around the lagoon show varying species composition from one plot to another. This is not unusual given the different number of micro-habitats in the area. The true mangrove components are most commonly represented by *Rhizophora apiculata, Bruguiera gymnorhiza, Sonneratia caseolaris* and *Ceriops tagal* (see Figure 5.2). In drier more elevated areas *Excoecaria agallocha* is more common. The observed variation in species from one location to another is quite distinct.

The floristic composition of the true mangrove and mangrove associates is given in Table 5.2. None of these species are endemic to the area and thus none can be listed as endangered. However, given the limited extent of this vegetation type in the country as a whole and its important protective, productive and buffering function, the preservation of this vegetation type is fully justified. Fringing mangroves such as *Rhizophora mucronata* and *Bruguiera gymnorhiza* are the dominant species in Koggala and form a narrow band around the shoreline. Less dominant mangrove species mixed with other vegetation grow inland from the fringing

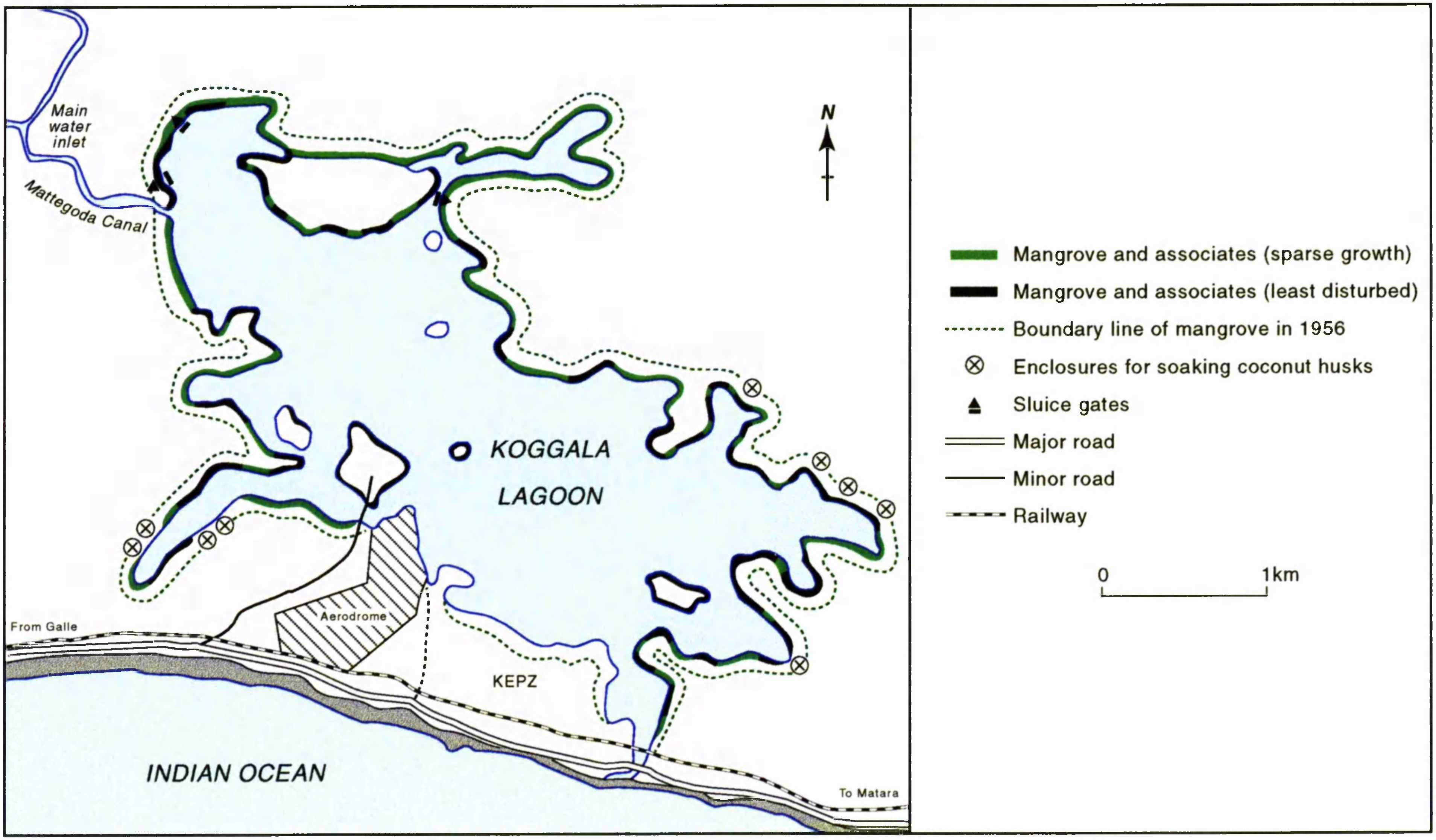


Figure 5.1 1956 and present distribution of the fringing mangrove complex in Koggala Lagoon

mangroves and form an additional band around the lagoon. This mixed mangrove scrub is common throughout the lagoon.

Table 5.2 List of Mangrove and mangrove associates bordering Koggala Lagoon

Vernacular name	**Latin name**
Kadol	*Rhizophora mucronata* Lamk.
Kadol	*Rhizophora apiculata* BL.
Manda, mada gas	*Avicennia marina* (Forsk.)Vierh.
Malkadol	*Bruguiera gymnorhiza* (L.) Lamk.
Gon Kaduru	*Cerbera manghas* L.
Karen koku	*Acrosticum aureum* Linnaeus
Punkanda, Rathugas	*Ceriops tagal* (Perr.) C.B Robinson
Ikilli, Katu-ikilli	*Acanthus illicifolius* L.
Kirilla	*Sonneratia caseolaris* (L.) Engler
Thela	*Excoecaria agallocha* L.
Etuna	*Heretiera Littoralis* Dryand. in Aiton
Kalawel	*Derris scandens* (Roxb.) Benth.
Heen kadol	*Aegiceras corniculatum* (L.) Blanco

(Source: Present study)

5.3.2 Resource Status

Field surveys conclude that the mangrove resources of Koggala Lagoon have been subjected to various disturbances over the years, most of which can be attributed directly to human interference. This has resulted in a marked decline in extent and species composition. According to discussions with local residents the mangrove formations in Koggala once existed as thick belts fringing the periphery of the lagoon and encircling the many islets within it.

These formations have now dwindled, both in terms of species numbers and coverage, as demonstrated by aerial photographs of the area. The alluvial swamps have been converted into paddy fields and the relative dominance of *Rhizophora mucronata* and *Rhizophora apiculata* indicates a high exploitation pressure and disturbance of the remaining fringing mangroves (pers. comm. Liyanage, 1993). Not a single area of the mangrove forest is still intact. Every part has experienced some form of human disturbance. In all study plots, felling of the mangrove by local residents was recorded. Figure 5.1 illustrates the boundary line of the mangrove complex in 1956 compared with the present-day distribution. Reduction of this area is due to conversion, particularly for agriculture. Mangrove degradation is primarily caused by exploitation for fuelwood and housing materials.

A: Fringing mangrove (mainly *Sonneratia caseolaris*) on southern borders of Koggala Lagoon.

B: Mangrove cut down for fuelwood.

Figure 5.2 Mangrove species and their uses in Koggala.
(Source: September 1994, V.N. Samarasekara)

The quantity and quality of water reaching Koggala Lagoon also has critical impacts on the mangrove. The destruction of the sand-bar at the mouth of the lagoon has resulted in elevated salinity levels in the lagoon which cannot be tolerated by *Sonneratia caseolaris* and this has resulted in declining populations.

The most exploitative impacts on the mangrove complex, given the relatively small extent of mangrove bordering the lagoon, are summarised below. Fuelwood collection both for home use and the firing of local bakeries is probably the most serious. As a result of the heat retention properties of mangrove wood over other types, the demand is much higher, especially among local bakeries who require a constant supply (see Figure 5.2).The collection of mangrove twigs for traditional brushpile fishing, use of mangrove bark (*Rhizophora mucronata*) for the extraction of tannin, clearing of mangroves for homestead cultivation and reclamation for agricultural and industrial purposes are other causes for the dramatic decline and disappearance of the mangroves in Koggala Lagoon. Moreover, in addition to the impacts described above, which have collectively contributed to the reduction in mangrove coverage, it should be noted that a large area of mangroves on the southern borders was cleared to make way for the KEPZ.

5.3.3 Stress Factors and Issues

In summary, the mangrove complex in Koggala has been affected by a variety of human activities. The main factors are, unsustainable harvesting and conversion to other uses. Recent impacts have resulted from settlement expansion; tourism and industrial development; increased levels of traditional uses, and elevated salinity levels which some species are unable to tolerate. The increased industrialisation of the area means pollution problems may arise if standards are not maintained, especially in the KEPZ (see Chapter 3). As a consequence of these main threats, the once contiguous mangrove belt along the shores of the lagoon has been substantially reduced. Further depletion of the mangroves would no doubt have adverse effects on the lagoon ecosystem and on its productivity.

5.4 The Hydrological Environment

Coastal lagoons are ephemeral systems that in most cases are present for considerably less than 1000 years (Barnes, 1979).There are several natural processes that may lead to their destruction which include sediment transport through tidal inlets (Bruun, 1978; Bhogal & Costa, 1989) and by the gradual colonisation of mangrove vegetation in tropical latitudes (Mann, 1982). Littoral transport may eventually close the tidal inlets temporarily (Webb *et al.* 1991) or permanently. Such circumstances produce changes in the ecological structure and function of coastal lagoons (Nienhuis, 1992).

In contrast to estuaries, coastal lagoons generally have a relatively small entrance channel in relation to the lagoon's volume. In addition, they are usually shallow, with a mean depth of 1-10 metres, and, in tropical areas subject to wet and dry periods seasonal variation during the year can be great. Wetlands represent the aquatic boundary for many terrestrial (emergent) plants and animals. They also represent the terrestrial boundary for many aquatic (submersed) plants and animals. Hence small changes in hydrology can result in significant biotic changes. When hydrologic conditions in wetlands change even slightly, the biota may respond with massive changes in species composition and richness and in ecosystem productivity (Mitsch & Gosselink, 1993).

5.4.1 Hydrology, Tides and Currents

The water movement of Koggala Lagoon is influenced mainly by tidal exchange and from river run-off. The tides and currents affecting its coastal areas are very strong and currents have been known to reach speeds up to $1m^{-1}sec^{-1}$ and average about $0.25\ m^{-1}sec^{-1}$ (Swan, 1983). These currents influence beach geology, offshore water depth, shelf morphology, and the direction and incidence of waves offshore. Tidal range reaches a maximum of about 70cm and tidal currents tend to move eastward along the coast away from the study site and then northward once they flow around the Southeast tip of the island.

During the rising tide, the tidal currents flow into the lagoon through the inlet located on the southern border (see Figure 3.1). The saltwater mass that passes in through this entrance penetrates into the middle of the lagoon where it mixes with the freshwater that has been deposited as run-off from surrounding freshwater inlets located on the northern area of the lagoon to create a brackish environment. The same water mass that enters the lagoon from the southern main inlet, during ebb tide, is discharged into the sea. Some of this water, and its accompanying sediment, remain near the mouth, especially during weak coastal currents. Water flows back with receding tides from this point following the same course as when it entered.

The flow of freshwater and seawater into the lagoon has a direct impact on its salinity, creating a predominantly brackish water environment. At times of heavy rainfall, an influx of freshwater from the inlets situated on the northern areas of the lagoon, together with those that drain agricultural land, cause salinity to drop, especially when the lagoon is not open. When rainfall is sparse, and the mouth to the sea is open, salinity may rise significantly in the lagoon. Variation in salinity is therefore seasonal with corresponding periods of high salinity during the dry south west monsoon season and low salinity during the wet northeast monsoon season. In addition, when the lagoon mouth is open to the sea, salinity can also increase in the lagoon, especially during high tides (De Alwis & Dassanayake, 1993).

The water movement of the lagoon can be differentiated into the following sub-areas:-

1.The southern sub-area which covers the area from the mouth of the lagoon extends under the bridge into the main body of the lagoon. This region covers a large area with very high salinity due to the periodic incursion of seawater. Water exchange with the sea here is dominant. Tidal currents are relatively fast. These conditions result in the observed high salinity here (De Alwis & Dassanayake, 1993; De Silva *et al.* 1994);

2.The central sub-area is a typical brackishwater area;

3.The northern area is defined by its varying salinity and is mostly turbid and generally lower in salinity. During the dry season, the salinity of the surface layer becomes higher due to freshwater influx and stagnation of seawater. During the rainy season, the salinity decreases (De Silva *et al.* 1994).

5.4.2 Hydrological History

Hydrology data relating to Koggala Lagoon are limited. It has been estimated that the lagoon has a catchment of $64km^2$ (pers. comm Seneviratne, 1994) and is fed by freshwater inlets located mainly on the northern side of the lagoon. The major freshwater input comes from the Mattegoda canal (see Fig.3.2) which together with three connecting freshwater streams, discharge into this relatively shallow basin which opens into the sea. According to Arumugam (1969), the run-off from the Koggala basin is 7.77 x 106 m^3 during the Maha season (September - March) and 9.12 x106 m^3 during the Yala season (April - August), giving a annual total of 16.9 x106 m^3. The net groundwater recharge is estimated at 60% of gross infiltration of rain water, leaving 1.27 x106 m^3 as net mean annual groundwater recharge. This amount is approximately the fresh groundwater resources available for sustainable extraction.

The lagoon connects, via a narrow 300 metre long canal, locally known as the Pol Oya, with the sea. Excess water in the past would leave the lagoon through this canal at the mouth of which existed a 'naturally' formed sand bar that regulated the periodic inflow and outflow of water. During the dry season (December to March), the lagoon would be closed at the mouth, shut off from tidal influences and hence from sea water intrusion. Easy breaching would take place at the start of the rainy season as soon as the level of water in the lagoon reached approximately 0.4m above mean sea level. After manual breaching, which usually occurred quite early on in the season due to farmers digging a passage for the water to exit from the lagoon, the water level would drop, and inundation of the inland marshes and rice fields would be avoided. This is how the farming community had traditionally controlled salt water inundation of their rice fields given the inefficiency of badly designed irrigation schemes.

Thus, the lagoon is a typical tidal coastal wetland which for most periods of the year experiences tidal dynamics. Maximum tidal fluctuations are in the region of 75 cms. Tidal water exchange movements mainly occur in the southern parts of the lagoon, close to Pol Oya. High tides in combination with minimum freshwater inflow (no counteracting pressure) during the dry season, account for periods of maximum tidal influences and sea water exchanges well up to the northern lagoon limit.

5.4.3 Hydrological Interventions

As revealed in Chapter 3, the lagoon outlet to the sea was controlled by a bund at the start of the Second World War. In the late 1940's this bund was removed by the farmers who were unable to cultivate their rice land due to inundated fields and the subsequent salinisation of the land. Because of this, during the 1960's and 1970's, several dykes were constructed in the northern parts of the lagoon, intended to reduce and avoid salt water intrusion on to the rice lands surrounding the lagoon.

The main water works concerned with the lagoon is the Warabokke Salt Water Exclusion Scheme, constructed by the Irrigation Department in 1983 and situated on the NW part of the wetland. This scheme sought to prevent the intrusion of saline water into neighbouring rice land, and the regulation of the water levels in the catchment area. The scheme consists of an eight bay-flap sluice gate at the inflow of the Warabokke Canal and a two bay-flap sluice gate at the inflow of the Heen Canal into the lagoon. In addition, an eight bay sluice gate at Kerena opens and closes due to water pressure variations, all of which regulate the flow of water from a number of fresh water streams. The scheme was commissioned to serve about 710 ha of rice fields of which, however, only 400 ha are under cultivation due to increasing salinity levels. In the Kerena anicut, 120 ha of the original 360 ha of rice lands have been abandoned. Salinity and waterlogged conditions further add another 100ha of abandoned fields adjacent to the lagoon. According to the farming community, the number of paddy fields in the area being abandoned because of salinity and inundation problems are on the increase (see **Chapter 7**).

A: Lagoon outlet to sea under Kathaluwa bridge blocked with sand.

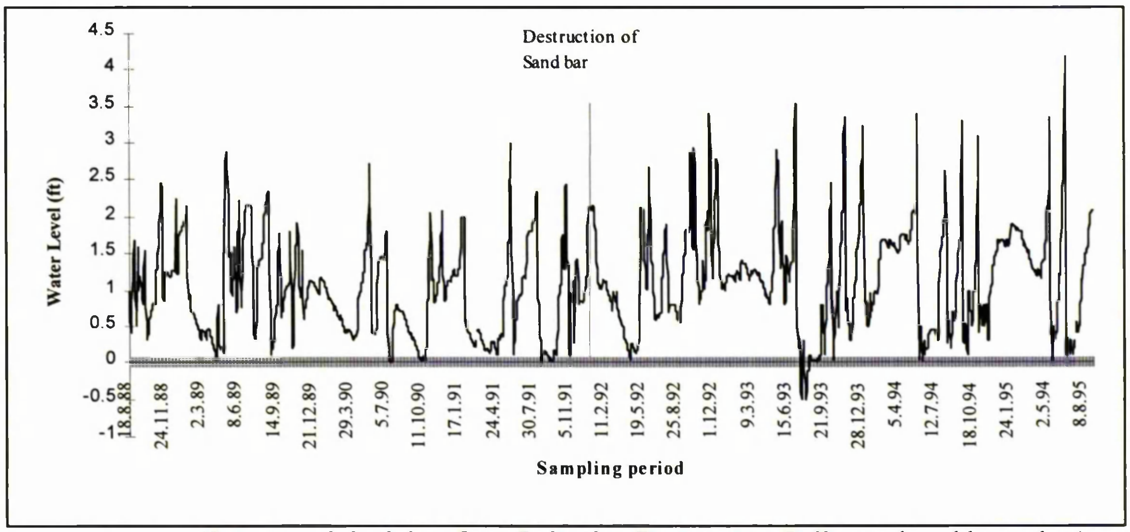
B: Heavy mechanical equipment used to remove sand blocking the lagoon outlet.

Figure 5.3 Blocking of lagoon outlet to sea as a consequence of sand bar destruction. (Source: September 1994, V.N. Samarasekara)

5.4.4 Coastal Features and Environmental Impacts

In May 1992, a foreign contractor (Danhoff) illegally removed sand from the 'naturally' formed sand bar at the mouth of the lagoon. This sand was used to construct a rock wall along the south west coast extending from Weligama to Galle in an effort to arrest coastal erosion, and for which they had a contract with the Coast Conservation Department (CCD). However this contract did not permit them to extract sand from Koggala (pers. comm. Lokuhettie, 1993). As a result of this action, irreparable damage was done to the stability of the sand bar. Initially sand bought in with tidal currents completely blocked the outlet under the Kathaluwa bridge. Consequently manual breaching is no longer possible because of restricted access. Presently breaching of the blocked outlet only occurs at the height of the flood levels. Attempts to open the mouth of the lagoon during the rainy season are today seldom effective, even by mechanical means (see Figure 5.3) because the lagoon outlet becomes blocked soon after it has been opened. Naturally this has caused concern amongst local resource users and environmentalists since the lagoon's hydrology, salinity, and thus ecology, have changed dramatically.

Figure 5.4 Water levels in Koggala Lagoon 1988-1995.



(Source: original data from Irrigation Department Galle, analysed by author)

At present water levels in the lagoon during periods of heavy rainfall are the highest on record (see Figure 5.4). Manual breaching of the blocked outlet is no longer possible, which results in inundation of the surrounding rice fields and homesteads with saline water (see Figure 3.8). The various irrigation water works constructed in the early 1980's are unable to control water levels in the lagoon and as a result approximately 500 ha of previously productive rice fields can no longer be cultivated. The economic loss to the farming community has been large but as yet unquantified (see **Chapter 7**). In addition inconvenience has been caused by the flooding of village homes and roads rendering them inaccessible for days on end. Prolonged flooding of rice fields not only hampers land labour but it also stops drainage flushing and thus adds to salinity problems. Rice cultivation on the alluvial plains in the northern and north western corner of the lagoon has almost completely ceased and the abandoned fields have been rapidly transformed into marshes.

Farmers and officers of the Irrigation Department are of the opinion that the aggravation of the salinity problem in the rice fields is a direct result of the destruction of the sand bar (pers. comm Seneviratne, 1994) which they believe had acted as a barrier to the direct intrusion of sea water into the lagoon. Even during the Monsoons and the high tides the intensity of sea water intrusion was somewhat controlled. Now if the expanses of sand blocking the outlet to the sea are finally breached, sea water intrusion occurs in greater quantity and penetrates further into the lagoon.

5.4.5 Analysis of Flooding in Koggala Lagoon

There is limited data relating to the hydrological aspects of Koggala Lagoon as the lagoon has not been previously analysed for this purpose. Table 5.3 summarises existing sources of data that were used for the present investigation.

Table 5.3 Summary of existing data sources used in the analysis of flooding in Koggala Lagoon.

Values recorded daily at 6.00am and 17.00pm	**TIME PERIOD**
1. Water levels in Koggala Lagoon (Irrigation Department, Galle)	18.8.88 - 30.9.95
2. Number of sluice gates open (Warrabokke Salt water exclusion scheme)	18.8.88 - 30.9.95
Values recorded daily at 6.00am	
1. Precipitation levels in the study area (Meteorology Department, Galle)	18.8.88 - 30.9.95
2. Wind speeds in the study area (Meteorology Department, Galle)	18.8.88 - 30.9.95

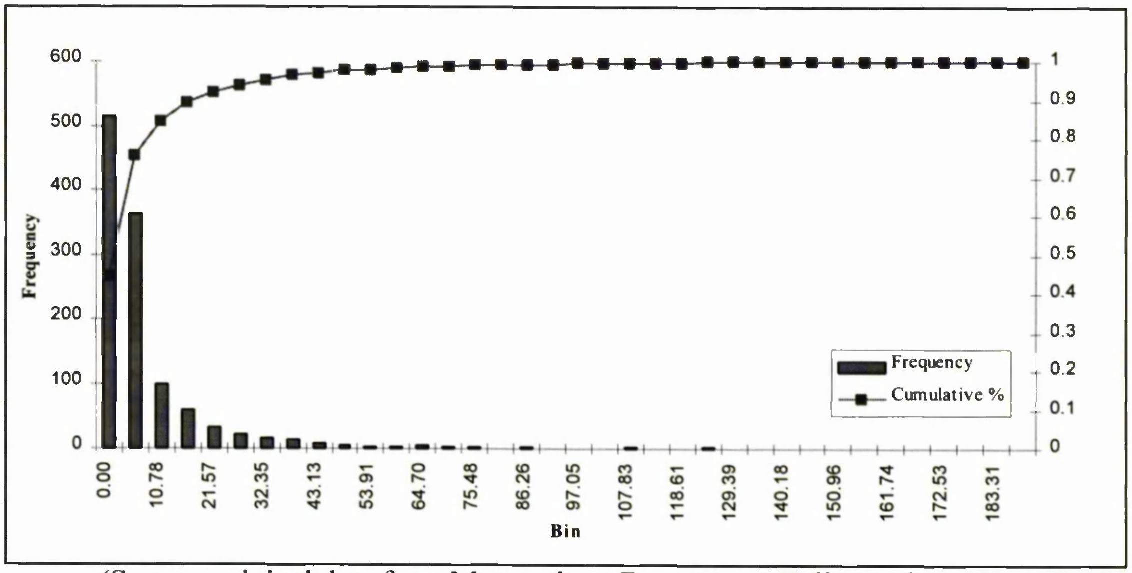
(Source: Present study)

Existing data spans a total period of seven and a half years including twenty nine months before the sand-bar was removed (18.8.88 - 30.12.91) and a further forty five months after (1.1.92 - 30.9.95). The recording of water levels in the lagoon is carried out by a resident of the community employed by the Irrigation Department solely for this purpose, and for the last eight years this recording has been effected by the same man. The unit of measurement utilised to measure the fluctuating water levels in the lagoon consists of a pole divided into ten divisions, each consisting of twelve inches which is further subdivided into units of ten to facilitate easy recording. Since there was some doubt as to the degree of accuracy of these demarcations on the measuring pole it was decided not to convert these sections into metric divisions and to analyse the data in the original format and in the units that were used to record it. In this way it was hoped that the probability of further inaccuracy and introducing further possible errors would be reduced.

The main aim of this exercise was to establish trends and to discover if a relationship existed between the removal of the sand bar and flooding levels in the lagoon. To achieve this, a combination of descriptive statistics were applied to this data. It should be noted here that it was not the purpose of the research to attempt a definitive study of the hydrology of the lagoon nor to monitor or predict flooding regimes, but merely to ascertain the impact the removal of the sand bar had on flooding, which in the experience of the local residents is a recent phenomenon. The removal of the sand bar and flooding in the lagoon is an example of one of the many environmental changes to the area and it is in this context that investigations seeking to highlight its importance have been undertaken. The main findings of this analysis are summarised below.

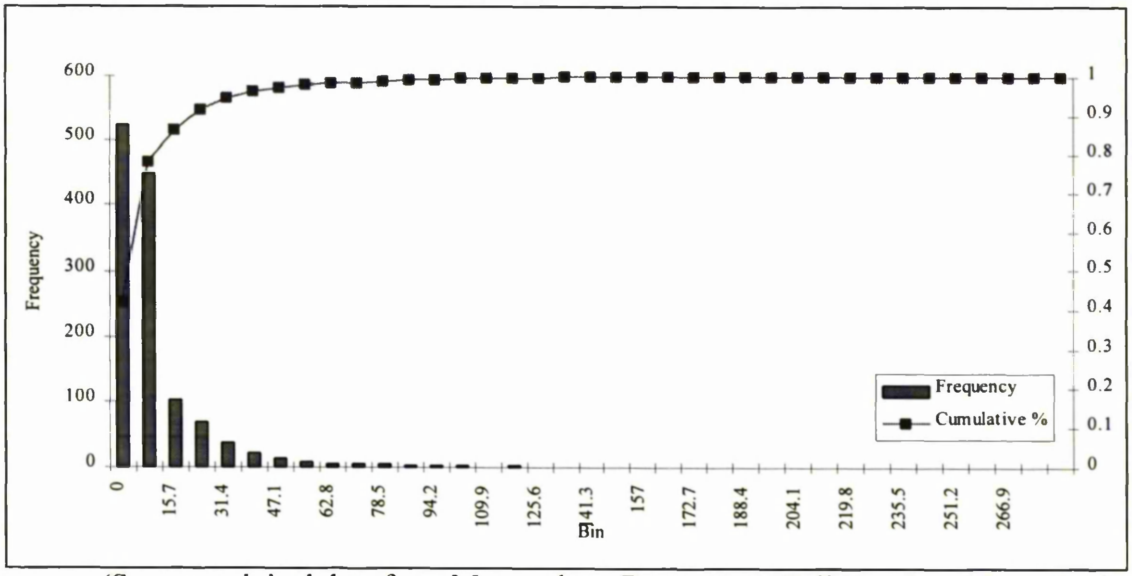
Since changes in precipitation patterns have an influence on water levels in the lagoon descriptive statistics were applied to this data to investigate if there had been any changes in patterns of rainfall over the time period in question. Such statistical analysis included the use of mean, standard error, standard deviation, skewness and cumulative percentage and frequency. In a similar manner wind speeds in the study area were analysed. However statistical analysis of both these data sets showed no significant differences throughout the time period under investigation. Figure 5.5 and Figure 5.6 illustrate the cumulative percentage and frequency of precipitation at sample intervals (Bin) before and after sand mining was initiated from the sand bar.

Figure 5.5 Cumulative % and Frequency of precipitation at sample intervals **before** destruction of sandbar



(Source: original data from Meteorology Department-Galle, analysed by author)

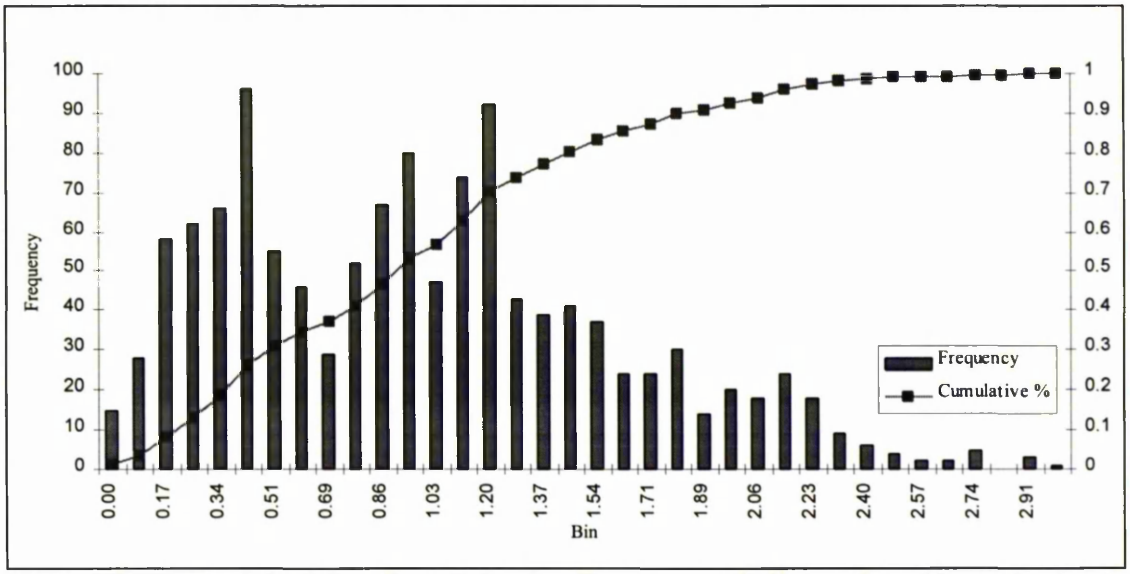
Fig.5.6 Cumulative % and frequency of precipitation at sample intervals **after** destruction of sand bar



(Source: original data from Meteorology Department-Galle, analysed by author)

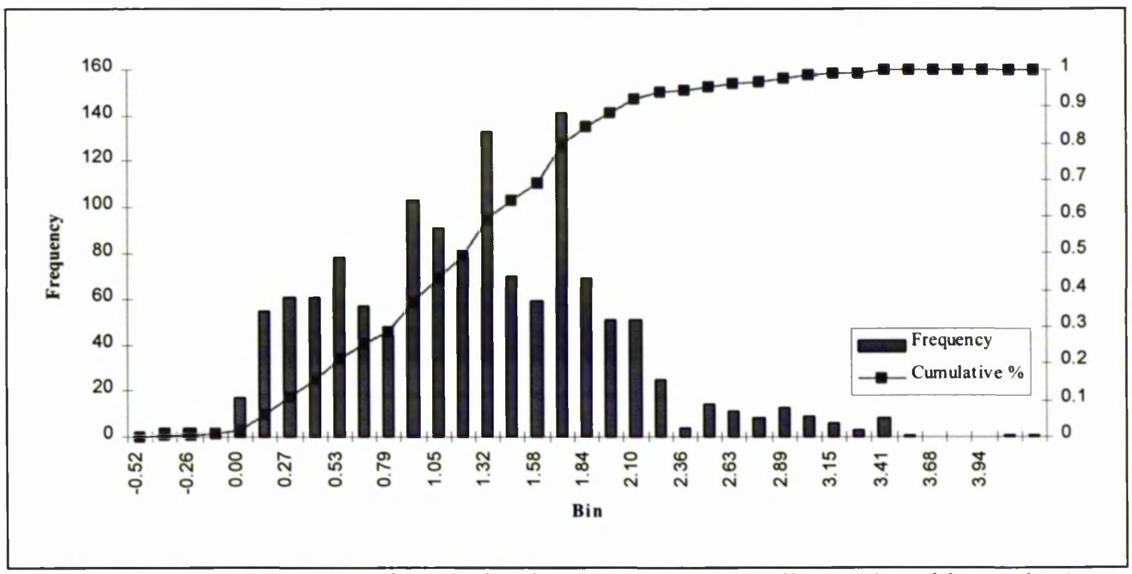
Similarly descriptive statistics were applied to the water levels in the lagoon recorded at 6.00am and 17.00pm and, since there was no difference shown between these data sets for the purposes of the present discussion, attention will be focused on water levels in the lagoon recorded at 6.00am (see Figure 5.7 and Figure 5.8).

Figure 5.7 Cumulative % and Frequency of water levels at sample intervals **before** destruction of sandbar



(Source: original data from Irrigation Department-Galle, analysed by author)

Figure 5.8 Cumulative % and Frequency of water levels at sample intervals **after** destruction of sand bar



(Source: original data from Irrigation Department- Galle, analysed by author)

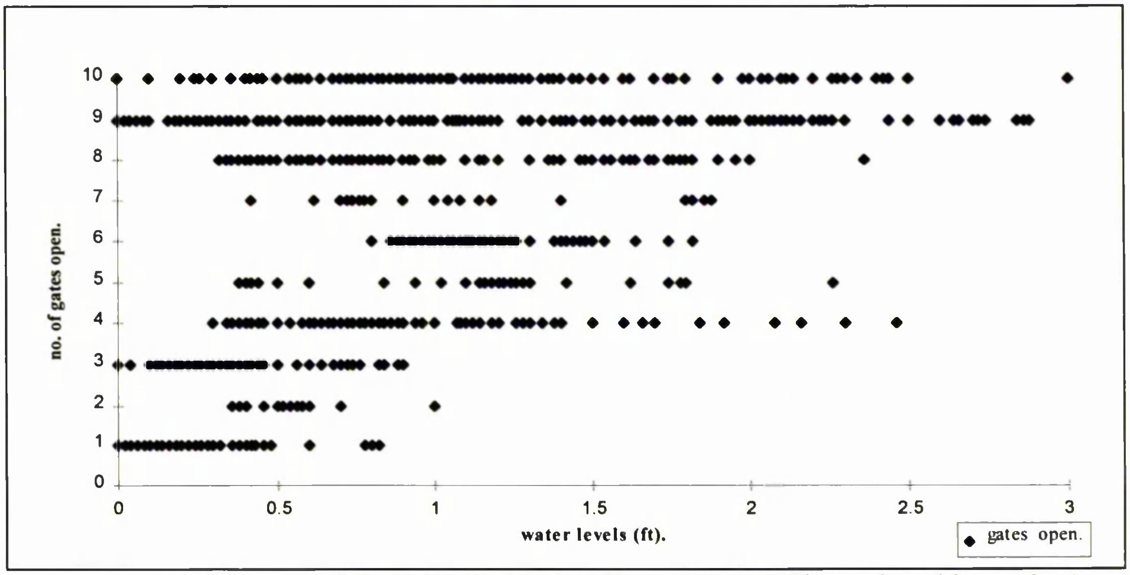
Thus given that all other factors are constant, statistical analysis of water levels recorded at 6.00am revealed mean levels in the lagoon to be higher after the removal of the sand bar. For example, the mean level recorded at 6.00am during the period before the sandbar was removed was 0.95 ft whereas the mean level recorded at 6.00am during the period after the sand bar was removed was a corresponding 1.19 ft. The standard deviation which is a measure of dispersion from the mean was also analysed. Before the sand bar was removed this figure was 0.61 as opposed to 0.72 after the sand bar was removed. The lower value recorded before the sand bar was removed indicates that there is a lower level of variance in water levels at this time. This lower variance in water levels can be explained by the fact that in times before the sand bar was removed manual breaching of it meant that excess water in the lagoon would exit via the outlet over a few days, as opposed to the current situation which requires mechanical means to breach it bar. Under such circumstances water exits from the lagoon into the sea much more rapidly and in greater intensities than before.

Skewness is a measure of the extent to which the bulk of values in a distribution are concentrated to one side or the other of the mean. If the bulk of the values are less than the mean, the distribution is said to be positively skewed. If there are more values greater than the mean, the distribution is negatively skewed. Thus the higher the degree of skewness the further it moves away from the normal distribution. Skewness is an important concept in geographical statistics, because very many of the variables measured in geographical studies have highly skewed distributions (Ebdon, 1977). Skewness values relating to water levels in the period before the sand bar was removed was 0.55 (2 sig.figs) and after 0.43 (2 sig.figs). Both these figures are very high. This fact has very important consequences. First it casts doubt upon the advisability of applying parametric statistical tests to these data and secondly a high degree of skewness is one sign that sample data are not normally distributed and are therefore unlikely to come from a population which is normally distributed.

The cumulative frequency of the flooding levels before and after the sand bar was removed also displayed marked differences, showing a higher frequency of periods of time when the water level in the lagoon was at higher levels after the removal of the sand bar than during the period before its removal (see Figure 5.5 and 5.6).

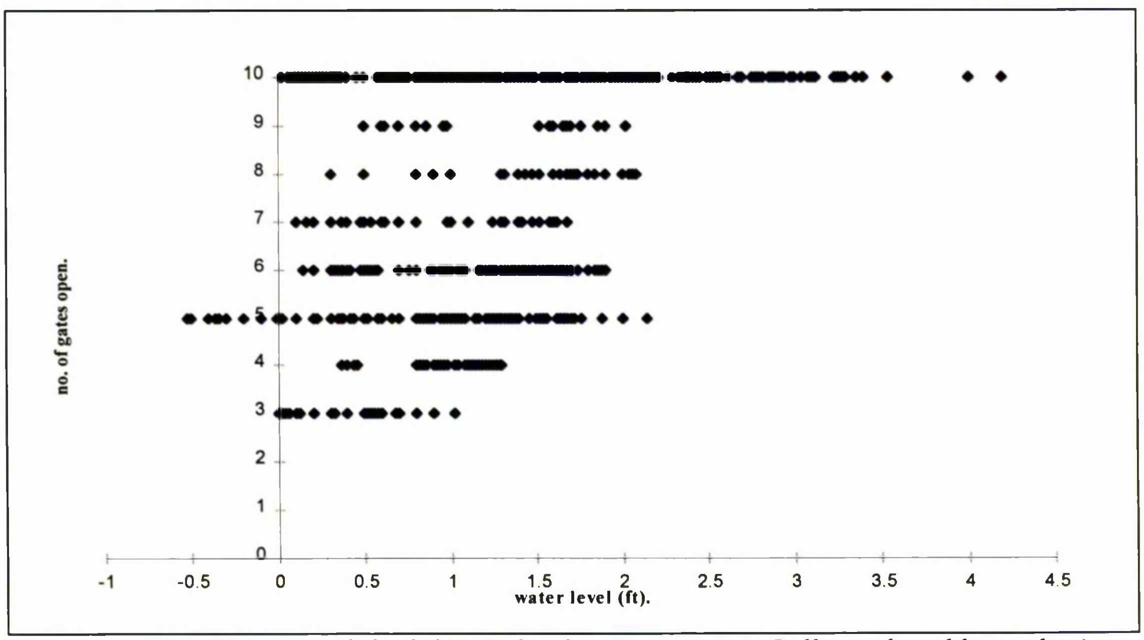
Scattergrams were constructed illustrating the water levels in the lagoon and the number of sluice gates open before and after the sand bar was removed (see Figure.5.9 and Figure 5.10). These scattergrams showed that the number of gates open does not have any effect in determining the water level in the lagoon. This applies for the period before and after the sand bar was removed and basically substantiates what the local residents had said about the ineffectiveness of these irrigation schemes in controlling the level of water in the lagoon.

Figure 5.9 Scattergram demonstrating the relationship between water levels and the number of sluice gates open **before** the destruction of the sand bar



(Source: original data Irrigation Department Galle analysed by author)

Figure 5.10 Scattergram demonstrating the relationship between water levels and the number of sluice gates open **after** the destruction of the sand bar



(Source: original data Irrigation Department Galle analysed by author)

Problems involved with a direct comparison of the existing data

The main reasons which make a direct comparison between water levels in the lagoon before and after the sand bar was removed problematic are discussed below. Water levels recorded for the period 18.8.88 - 30.12.91, which relates to the period before sand mining was initiated from the sand bar, can be described as the expected values and correspondingly water levels for the period after the sand bar was removed (1.1.92 - 30.9.95) are taken as the observed values.

To complete a chi-square analysis a direct comparison must be made between the expected and observed values and to do this sampling intervals between both sets must be in the same range. However in the case of the existing data, both sets do not follow this pattern. The range of fgures in the 'expected' data set (0 - 2.91) is smaller than the observed data set (-0.52 - 4.07); which has a far greater range of values. It should be noted that minus values recorded after the sand bar was removed are as a result of the water level in the lagoon dropping dramatically and to much lower levels when the outlet is cleared using mechanical means. Since the local communities are no longer able to manually dig a exit for water to escape from the lagoon, water in the lagoon builds up and stays at higher levels than before and when it is finally let out the water levels fall much more dramatically than before.

An important restriction to the use of the chi-square test in the context of the present data is that it should not be employed in situations where there are many categories for which the expected frequency is small. This applies to the present data where the bin categories are greater than two and more than 1/5th of the expected frequencies are less than five, and some less than one. Even combining categories until the offending expected frequencies have been suitably increased would make nonsense of the underlying research hypothesis. The bin categories in the observed and expected data sets are not directly comparable and this can be illustrated by the fact that approximately 40% of the frequency values in the expected range cannot be used because they relate to values of 5 and less. In spite of the shortcomings associated with statistical analysis of water levels, there is substantial evidence to suggest that there is a positive relationship between current flooding levels in the lagoon and the destruction of the sand bar.

5.4.6 Water Quality

Water quality in the lagoon has been monitored by the National Aquatic Resources Agency in Sri Lanka (NARA) periodically between 1991 and 1993. More recently in 1994 a water quality programme was undertaken by the University of Ruhuna. The present discussion relies mainly on these two source of data. In spite of the shortcomings associated with using two sets of data and the inconsistencies associated with the recording of this data, the overall conclusions that can be made are summarised below.

The rapid outflow of lagoon water into the sea during the rainy season, combined with the flow of sea water into the lagoon during the monsoons and high tides, causes high variations in most physio-chemical properties. Salinity in the lagoon exhibits considerable seasonal fluctuations ranging from 3% to 15.5% (De Silva *et al.*1994) exhibiting a steady rise since the removal of the sand bar. This trend in elevated salinity levels is also apparent in the northern most areas of the lagoon (De Alwis & Dissanayake,1993; De Silva *et al.*1994). There has been a substantial increase in salinity levels within the lagoon from 1992 which has been linked to the destruction of the sand bar (De Alwis & Dassanayake, 1993).

The lagoon receives sediment with the influx of fresh water from a number of inlets. In addition it also receives solid matter from the sea through Pol Oya. Due to the influx of surface run off, highest total suspended matter values were recorded in the rainy season. The pH of the lagoon's waters shows a wide range from acidic to alkaline conditions. The influx of different ions into the lagoon, along with rain water, is illustrated by a wide range of conductivity and ion concentrations. In general, the lagoon water chemistry can therefore be classified as highly dynamic, varying with rainfall and intrusion of sea water.

Agro-chemicals used in the surrounding rice and tea lands have direct access to the lagoon (see **Chapter** 7). Though the impact of this pollution has not been adequately studied it is known that some marine organisms, such as molluscs and crustaceans, are particularly susceptible to pollution from pesticides (Abeysekara, 1988). The pesticides used in Koggala belong to some of the most toxic groups and chemical analysis elsewhere suggests that they have the potential to impact sensitive tropical marine ecosystems (Readmen *et al.* 1992). Two fish kills in localised points of the lagoon, together with sightings of malformed fish, also indicate that the agro-chemicals may be affecting certain groups of organisms. These fish kills have coincided with periods of increased agricultural activity.

High accumulation of ions, such as ammonium and nitrate, are reported from the lagoon water. Ammonium ions showed an 8-fold increase, whereas for nitrate ions a more than 100-fold increase was seen. The high levels of these ions could also indicate the presence of chemical inputs[1] used in the surrounding rice and tea lands (CEA/Euroconsult, 1995b; De Alwis & Dassanayake, 1993; Urban Development Authority, 1992; Lanka Hydraulics Institute, 1992). Accumulation of these substances in the lagoon is probably a result of reduced flushing and water exchange capacities from 1992 onwards.

Due to the influx of surface run-off, the highest total suspended matter values are recorded during the rainy seasons. High Dissolved Oxygen (DO) values are observed year around, indicating a high aquatic photosynthetic activity; and pH values show a wide range, from acid

[1] Analysis of sediment and water samples from the lagoon collected by the author in 1995 are presently being analysed by Bremen University. Initial analysis indicates the presence of the pesticides Lindane and Endosulfan in the lagoon.

to alkaline. The prevailing elevated BOD levels in the lagoon could be due to the stagnation and decomposition processes in localised areas in the lagoon as a result of retting coconut husks (De Alwis & Dissanayake, 1993; De Silva *et al.* 1994).

5.4.7 Industrialisation and the KEPZ

Presently the most serious threat to Koggala Lagoon from the KEPZ is the indiscriminate dumping of industrial waste on a narrow strip of marshy land bordering the lagoon (see **Chapter 3**). Also worth noting is the increasing number of industrial outlets that have established themselves in recent times in the close vicinity of the KEPZ. Because these outlets do not fall within the jurisdiction of the KEPZ, and are based on privately owned property, they are free to operate as they wish with little regard for the environment. In this connection it should be noted that some of these outlets have established themselves close to the borders of the lagoon and have begun discharging effluents directly into it. The long term effects of such dumping are likely to have a negative impact on the ecological functioning of the lagoon.

5.5 Summary of Key Themes

- The wetland system of Koggala Lagoon and its environs has served multiple uses including fishery, agriculture, and habitation, all of which have expanded with increasing urbanisation and industrialisation of the area. However, during the recent past there has been visible degradation of the ecological complex, stemming from increased settlement, intensification of fishing pressure, increased industrial activity, and general habitat destruction, all of which are undermining the ability of the wetland ecosystem to support these multiple uses. The combined effects of these changes have been heartfelt by the resident fishing and farming communities who are dependent on the lagoon and its resources. The effects of these changes on these two groups are dealt with separately in **Chapters 6** and **7**.

- Salinisation of low-lying farming lands due to salt water intrusion has always been a problem, stimulated by human intervention in Sri Lanka's coastal areas. Some development activities, such as the construction of canals during the colonial period, led to such problems, (Baldwin *et al.* 1991). Paddy fields covering nearly 15,000 hectares in the Galle district are affected by salinity during high tides that extend their influence 10-15 kilometres into the interior in some places (TEAMS, 1994). Engineering structures built to contain saline intrusions have not been effective.

- The problems outlined above correspond exactly to the situation existing in Koggala. The engineering structures designed to control saline inundation have not been effective (see

Chapter 7). As a result of this, prior to the destruction of the sand bar, and as a result of the ineffectiveness of the irrigation schemes, local resource users would manually breach the sand bar during periods of heavy rainfall to prevent the inundation of their rice fields with saline water. The destruction of the sand bar has further aggravated what was already a problem, but one that had been traditionally controlled. Now, manual breaching of the blocked outlet is impossible as a result of restricted access. Today mean flooding levels in the lagoon are the highest on record and to date there have been no definite plans to halt or reverse this development. This flooding, combined with elevated salinity levels, have contributed to large-scale transformations in the ecology of the lagoon and its environs.

- Interviews conducted with the fishing community (see **Chapter 6**) list amongst other changes a loss of commercially important traditional freshwater fish species unable to tolerate the elevated levels of salinity, and certain species of seagrass vital in the lifecycle of certain fish species. Pronounced coastal erosion is now observed at the outlet. To summarise, today the problems of flooding and subsequent salinisation of land have reached a crisis point affecting local communities and resource users alike (see **Chapter 7**).

- The mangrove community in Koggala is of great importance in maintaining the ecological balance, nutrient flow and productivity of the lagoon and adjacent areas. Apart from its functions as a nursery chamber for fish and shellfish species, including the economically important penaeid shrimp species, and its role as wildlife habitat, especially as a habitat for resident and migratory birds (Samarasekara, 1992), it supports the fisheries in the lagoon and adjacent sea. It also supplies detritus and nutrients.

- Over the years, and particularly in the recent past, the mangrove complex in Koggala has been affected by a variety of human activities. Recent impacts have resulted from changes in the ecological system of the lagoon, settlement expansion, industrial development, and increased levels of traditional uses. Consequently, the once continuous mangrove belt along the entire shore of the lagoon has been drastically reduced. Further depletion of mangroves would undoubtedly have adverse impacts on the lagoon ecosystem and on its productivity.

- The noticeable decline in catches of fish and crustaceans in the lagoon has been attributed to the increasing quantity of agro-chemicals used in the surrounding rice paddy fields and plantations which have direct access to the lagoon. The large quantities of agro-chemicals used in the surrounding rice paddy fields together with the cinnamon, coconut and tea land have direct access to the lagoon. Though the impact of this pollution has not been adequately studied it is known that some marine organisms, such as molluscs and crustaceans, are particularly susceptible to pollution from pesticides and, since the pesticides used in Koggala belong to some of the most toxic groups, concern has been expressed as to their impacts on sensitive tropical ecosystems. Two fish kills in localised points of the lagoon, together with sightings of malformed fish, may be an indication that the agro-chemicals are affecting the lagoon's organisms. These fish kills have coincided with periods of increased agricultural activity.

- The complaints of the fishermen about reduced catches could also be due to over-fishing, and excessive chopping of mangrove wood for fuelwood and traditional fishing practices. More recent impacts to the lagoon stem from the KEPZ. Since the necessary facilities to treat industrial waste have to date not been achieved, waste from the factories is dumped into an area of marshy land directly bordering the lagoon. The combined effects of these pollutants seeping into the lagoon may be responsible for the decline in catch experienced by the fishing community and also the occasional fish kills that have occurred in the past. Further increases of such inputs might well endanger human health through bio-accumulation in the food chain.

- Pollutants enter the lagoon waters from a great number of sources, including settlements located around the lagoon, agriculture and industrial activity. Economic development is expected to cause an increase in this load, unless water treatment is applied to sewage and industrial waste.

CHAPTER 6
KOGGALA LAGOON 2: THE FISHING COMMUNITY

6.1 Introduction

Koggala Lagoon and the adjacent coastal waters have supported traditionally a diverse fishery, including a wide range of fish and crustacean species (**Chapter 3**). The lagoon and the sea supplement agriculture in the study area, and for most communities living on the borders of the lagoon, fishing has been their main source of income. This chapter is based on surveys and interviews conducted with the fishing community in the sample six divisions and the aim of it is to analyse the past and current role of the fishing community in relation to key environmental changes. By comparing their present position with times past, an attempt has been made to discover the degree to which changes in the natural environment have affected this key group and the various adaptations they have had to make in light of some of these changes.

In Section **6.2** an overview of the contribution of coastal fisheries in Sri Lanka is given and Section **6.3** provides an introduction to the key changes affecting the fishing community in the study area. The findings of the in-depth study of the fishing community are given in Section **6.4.** It includes relevant details relating to traditional methods of fishing, current restrictions to fishing and perceived reasons for the decline in fish and crustacean populations. Finally a summary of key themes is given in Section **6.6**.

6.2 Coastal Fisheries in Sri Lanka

In Sri Lanka as a whole 98% of fisheries production are accounted for by small-scale coastal fisheries (Baldwin *et al.*1991; UNEP, 1986a). About 78,000 people are directly involved in fishing and the industry supports a total of around 330,000 ancillary workers, distributed among 371 fishing centres and 961 fishing villages (Olsen *et al.*1992). Fishing is the most important economic activity connected with the coastal region, and many communities depend on it for their livelihood. Artisanal fisheries employing the use of simple fishing gear is the prime economic activity on most of Sri Lanka's estuaries and lagoons and provide thousands of rural inhabitants with their livelihoods (Amarasinghe, 1992). Fish constitutes 65% of the animal protein in the diet of the human population and 13% of the total protein intake of Sri Lankans (Olsen *et al.* 1992).

Over 90% of the total fishing population belongs to the marine sector and the marine fisheries have supplied over 97% of the total fish production during 1987-1988 (Baldwin *et al.*1991). In 1981, fish accounted for 2% of Sri Lankan export earnings (Anon, 1992). Total production of marine fisheries in the early 1980s was 183,000 tonnes, of which 41,000 tonnes was demersal fish and the rest pelagic. According to recent statistics (1991) the total marine fisheries production was 174,231 tonnes. The fastest growth of the fisheries sector occurred during the 1977-1983 period when fish production increased up to 8.4%, exceeding the overall growth rate of the country (Joseph, 1993).

Coastal fishery resources are defined as those occurring up to 30 nautical miles from the coastline and a survey conducted in Sri Lanka between 1978-80 estimated a total biomass on the coastal shelf and adjacent areas as 75,000 tonnes (Baldwin *et al.*1991). Coastal fish production has been estimated to be 159,151 tonnes and the offshore and deep sea production was estimated at 15,080 tonnes. The amount harvested from coastal coral reefs has never been calculated as a separate category. However, adding the catch data for 1989 from categories such as large demersals, Carangids and Scombrids, indicates that reef and reef-associated species comprise about 15% of the total fish landings (Rajasuriya *et al.*1995). According to Amarasinghe (1992) inland fisheries presently account for 20% (27,000-30,000 t yr^{-1}) of the total fish production in Sri Lanka. It is thought that coastal fisheries may have reached the maximum sustainable yield but there is scope for expansion in offshore and inland fisheries (UNEP, 1986a).

Prior to the last two decades, fishing in Sri Lanka was primarily carried out using non-motorised craft such as dugout canoes, catamarans and log craft using non-destructive fishing techniques such as angling and gill-netting. However, recently introduced techniques, such as bottom-set nets used to catch spiny lobsters and reef fish, cause severe damage, especially to reefs. Current rates of exploitation may have a negative impact on the resources. Blast fishing using explosives is commonly practised in many parts of the country, being most prevalent in the southern coastal waters in the Galle district (Rajasuriya *et al.*1995). Fisheries in estuaries and lagoons are very important especially for local communities and include harvesting fish, crustaceans and molluscs (see **Chapter 2**). In the Malala Lagoon, which falls within the confines of the Bundala National Park in the deep south, fishing is primarily confined to using cast and gill nets, partly operated from small canoes for catching fish and prawns (CEA/Euroconsult, 1993a). Average daily catches for fisherfolk are between 5 - 6 kilos and each fisherman earns about Rs.125 a day. The profit margin could be much higher if the middlemen were cut out (CEA/Euroconsult, 1993a).

The economic value of the Negombo Lagoon has been described by CEA/Euroconsult (1994g). The fishery organisms of particular importance include finfishes and crustacean species, consisting mainly of shrimps and crabs. In addition a wide range of fish species are captured from the lagoon both for consumption and for export as ornamental fish and as aquaculture seed. The total estimated annual value of fishery production in Negombo Lagoon is Rs. 150 million (CEA/Euroconsult, 1994g). This provides a primary income for more than 3,000 traditional lagoon fishermen and supporting a total population of about 15,000. Similarly in Puttalum Lagoon 40,000 people are either directly or indirectly dependent on fishing for their livelihood (Dayaratne *et al.* 1995).

The status of estuarine fisheries in the island has been summarised by a number of authors and relevant examples include Dayaratne *et al.* 1995; Jayasuriya, 1985; Jayawardena, 1992; Samarakoon, 1986; Samarkoon & Zon, 1991 and Wijerathna & Costa, 1987. Other work on estuarine fisheries includes Bruin (1971) and Fernando (1973) on prawns; Fernando (1965), Pillai (1967), Jayakody and Costa (1988;1994) and Jayawickrema & Jayakody (1991) on brackish water fish; Raphael (1977), Ramanathan (1969) and Jayawickrema (1992) on *Chanos chanos* fry in Mannar, Puttalum and Negombo. Prawns fished in lagoons are an important export commodity. Other important commercial species include *Scylla serrata, Holothuria scabra* and various bivalves (GOSL/ESCAP, 1985). Coastal and inland fisheries are thus significant as a source of foreign earnings, food and employment. The latter two categories are especially relevant to local communities. The key fisheries of Sri Lanka are derived from lagoons and estuaries, coral reefs, nearshore shallow coastal waters and deeper offshore waters. These fisheries are dependent upon habitats, especially in lagoon, estuarine and nearshore areas.

6.3 Key Changes Affecting the Fishing Community

Koggala Lagoon has had a well-earned reputation traditionally amongst local communities (see **Chapter 3**) for its rich populations of prawns and crabs which entered the lagoon from the sea where they matured, and were eventually caught for consumption or retail. However, in recent years the local fishing community has experienced a noticeable decline in these populations, the consequences of which are having severe economic repercussions. Their complaints of continued reduced catch over the years have intensified in recent times and it may be due to the increasing quantities of agro-chemicals used in the rice paddy fields and plantations which border the lagoon. These chemicals eventually enter the lagoon through inlets draining the rice fields. In addition, over-fishing and excessive cutting of mangrove trees for local fishing practices, and more significantly for fuelwood purposes, contribute to the reduction of breeding grounds for fish, prawns and crabs.

Recent industrial developments in the area have also exacerbated these problems. Dumping of industrial waste (plastics, fabric, food) stemming from the 80 ha KEPZ is perhaps of greatest concern. The most recent threat to the lagoon and its resources however has been the destruction of the 'naturally' formed sand bar at the mouth of the lagoon. Since it was removed, early in 1992, the recruitment of commercially important species from the lagoon has been hampered due to strong tidal currents which draw these species out in their juvenile stages, before they have had a chance to mature. The fishermen have further been impacted by fluctuating water levels which put a limit on the number of days they are able to fish and the loss of traditional freshwater species which are unable to tolerate the elevated salinity levels in the lagoon resulting from the destruction of the sand bar (see **Chapter 5**).

6.3.1 An Introduction to the Fishery of Koggala Lagoon

Fishing in Koggala Lagoon is a partially modernised income-generating activity almost exclusively carried out through small-scale operations at subsistence level. Fishing practices are mostly traditional, and fishermen use small non-mechanised open outrigger boats (Sinhala: *oru*). Accurate figures relating to the number of fishermen in the area are difficult to obtain since registration of boats and gear involves a payment which many fishermen try to avoid (see **Chapter 3**). As a result, the number of fishermen obtaining an income from this wetland tends to be underestimated. Inspite of this it has been suggested that the lagoon fishery supports the primary income of a total of at least 500 fishing families, from 15 GN divisions situated around the perimeter of the lagoon. Introductory social surveys conducted in these fifteen divisions supports this. In spite of the local importance of the lagoon there have been no systematic studies relating to its fishery. Due to this paucity of data relating to the annual fish catch from the lagoon and associated sea, existing information is based on estimates and from discussions with the local communities.

Although it is the traditional role of the men to catch the fish, women assist before and after the fishing activity in many ways. Essentially the role of women in the process of fishing is largely restricted to mending and cleaning nets and the only point at which men and women co-operate in the production process is in taking the fish out of the nets. In divisions where fishermen engage in the capture of aquarium fish, women clean plastic packing bags and assist in packing the fish. This apparent split between fishing, which is a male-dominated activity, is part of a culturally accepted division of labour found amongst the fishing communities in Sri Lanka (Stirratt, 1988).

The fishery organisms in the lagoon of particular importance are the finfishes and the crustaceans, and as such the lagoon serves two coastal fishery aspects: penaeid shrimp stocks and pelagic stocks harvested by gill and cast nets. The shrimps are of great significance to the fishery and utilise the lagoon as a refuge and nursery area. The penaeid shrimps captured include the white shrimp (*Penaeus indicus*) (Sinhala: *kiri issa*), tiger shrimp (*P. monodon*) (Sinhala:*kala issa*), flowery shrimp (*P. semisulcatus*) (Sinhala: *kurutu issa*) and the tidal shrimp, *Metapenaeus dobsoni (Sinhala: veli issa)*. The crabs of economic importance include the mud crab (*Scylla serrata*) (Sinhala: *kalapu kakuluwa*) and the swimming crab (*Portunus pelagicus*) (Sinhala: *sienakkali*). In addition to this, a wide range of fish species are captured from the lagoon both for consumption and for export (ornamental fish) (see Figure 6.1).

According to field studies, ornamental fish collectors began operating in the area in the last two decades. This activity is carried out by scuba divers who collect reef organisms which are sold to private companies engaged in the export trade. In the fifteen GN divisions bordering the lagoon a total of 150 people are directly involved in ornamental fish collection. Their main targets are juvenile and sub-adult angelfish (Pomacanthidae). In addition they collect various butterfly fishes, clown fish, wrasses, anthids, etc. A list of the species commonly encountered with sale prices derived from field surveys is given in Figure 6.1. The destructive fishing methods employed in the collection of reef fish include fishing with explosives and the use of moxy nets which have caused extensive habitat destruction and depletion of high value species in the area (Lanka Hydraulics, 1992; Rajasuriya *et al.*1995; White & Rajasuriya, 1995). These activities have also contributed to the degradation of the fringing coral reef in Koggala (Lanka Hydraulics, 1992). Further information regarding the fringing coral reef in Koggala is given in **Chapter 2.**

Figure 6.1 Ornamental Fish caught in Koggala Lagoon and adjacent coastal area

Scientific name	**Common name**	**Price per fish (Rs.)**
Acanthurus leucosternon	Powder Blue surgeonfish	120.00
Acanthurus lineatus	Striped Surgeonfish	17.50
Chaetodon auriga	Thread-fin Butterfly fish	15.00
Pomacentrus similis	Blue Damselfish	12.00
Pomacanthus annularis	Bluering Angelfish	25.00

(Source: Present study)

The fishery stocks as a whole are supported by intricate food webs based mainly upon seagrasses, mangroves, detritus, and soft mud substrata. The small pelagic fishery stocks (plankton feeding herring and sardines) are sustained by plankton growths resulting largely from nutrient discharges from Koggala Lagoon during the rainy seasons. Almost all the higher value fishery organisms harvested from the lagoon reproduce at sea and in their early floating stages (plankton) are carried into the lagoon by the tidal currents. A connection between the lagoon and the sea is therefore essential for sustainable fishery production within the lagoon.

6.3.2 Profile of the Fishing Community

The degree of dependence on the fishery of Koggala Lagoon as a major source of income differs considerably among the communities living in the divisions bordering it. For example, in Kahanda and Polhena, which are more agriculturally based, fishing is carried out mostly for personal consumption as a supplement to agriculture which in an economic sense is far more important. Whereas in divisions such as Harumalgoda East, Alawattukissagoda and Koggala Athireka I, fishing is engaged in on a much larger scale and family incomes are highly dependent on it (see Figure 6.2).

Interviews were conducted with the fisherfolk in all six sample GN divisions. However the major focus of the present study was on Koggala Athireka I, Harumalgoda East and Alawattukissagoda where the fishing community is concentrated. Information in this section is based on interviews conducted with a total of 150 fishermen (see Figure 6.3). In total these divisions comprise an estimated 80% of the population of the study area dependent upon fishing. The constituent villages which make up each of these divisions is given in Figure 6.2 below which displays the constituent traditional fishing villages in the sample six divisions.

The major conclusions on the socio-economic status of the fisherfolk featured in the surveys are that the majority of them are dependent on the lagoon for their income and their generally low level of education restricted them from obtaining alternative employment (see Figure 6.4). A study of the educational levels among the fishermen interviewed revealed that 9 % had no schooling at all, 48 % had completed primary education, while 33% had completed secondary education and 10% had education higher than secondary level. According to available information these figures correspond to figures for the study area as a whole. The corresponding figures for the whole country are 10.3% without formal education, 31% with primary education, 47.4% with secondary education, and 11.2% with education above secondary level (Central Bank of Sri Lanka, 1994). More than 90% of their income is spent on consumption, while the national average is 65%: this means that households dependent on the lagoon fishery are not in a position to tolerate large restrictions on their daily livelihood activities.

Figure 6.2 Traditional fishing and farming villages in the sample six study divisions

Sample six study divisions	**Traditional constituent fishing villages**	**Traditional constituent farming villages**
Polhena 154B		Polhena; Thoragoda; Bataketiya
Palessa 166C	Jambrissa.	Palessa;Kerena.
Koggala Athireka 1144D	Koggala Janapadaye; Magalthota; Gudumulla; Riladukanda.	
Kahanda 167		Pedurugoda; Ranagahagoda; Kahadagama; Ganegoda; Boraluketiya; Dawaniyawatta; Welituduwa; Etambagahagoda; Koralegoda.
Harumalgoda East 149A	Duwamalalagama; Harumalgoda east.	
Alawattukissagoda 164G.	Alawattukissagoda; Gurukanda.	

(Source: Present study)

Figure 6.3 Total number of members from the Fishing community interviewed

GN division	Total no. of families in each division	Official figures relating to the number of fishermen in each division	Estimate of number of fishermen in each division (from field surveys)	No. of fishermen interviewed from each individual GN division
Polhena 154B	293	5	15-20	10
Palessa 166C	282		35	15
Koggala Athireka 1 144D	243	28	70-80	30
Kahanda 167	209	4	10-15	10
Harumalgoda East 149A	217	98	135-40	55
Alawattukissagoda 164G	205	44	65-70	30

(Source: Present study)

Figure 6.4 Profile of members of the fishing community featured in the in-depth survey

Sample size:	62 households (Total no. interviewed - 150)
Age structure (%) of those interviewed:	
Males 0-15 years	7 (5%)
15-65 years	79 (53%)
> 65 years	33 (22%)
Females 0-15 years	
15-65 years	27 (18%)
>65 years	4 (3%)
Average family size:	5
Average monthly income:	
• Fishing:	Rs. 1500-2000
Degree of dependence on lagoon and resources (%):	
• Fishing alone:	97(64%)
• Fishing and Firewood:	32(21%)
• Other:	21(14%)
Main Fishing methods employed(%):	
• Cast nets:	45(30%)
• Cross nets	12(8%)
• Brush piles	29(19%)
• Crab traps	20(13%)
• Gill nets:	33(22%)
• Hook and line:	11(7%)
Economic restrictions to fishing in the lagoon.	
• Lack of suitable equipment e.g. fishing nets with varying mesh sizes/boat size	62(41%)
• Middlemen	88(59%)

(Source : Present study).

6.4 In-Depth Study of the Fishing Community

The communities associated with fishing in the Koggala Lagoon and targeted for in-depth study were all from traditional fishing villages and of fishing heritage (Ahubudhu, 1994). The elders in these communities reminisce about the years gone by when their entire family income was derived from the lagoon fishery. Though they now acknowledge that the lagoon fish and shrimp catches are being gradually depleted, members of these communities still identify themselves primarily with being fishermen and the lagoon fishery as integral to their lifestyle and identity.

6.4.1 Traditional Methods of Fishing

Fishing is carried out by the use of outrigger canoes made out of wood. Due to the generally shallow nature of the lagoon in localised areas, fishing is also carried out without the use of craft. The fishing methods employed in this wetland are highly specialised in some instances and are generally well adapted to the ecological conditions. Some of the more important gear and methods are shown in Figure 6.5.

Brush-pile fishing (Sinhala:*Mas-athu*) is a traditional fishing method commonly employed by the fishing community. It is a fish aggregating device made from branches of mangrove which are used to make a enclosure ('an artificial mangrove') which passively attracts fish who feed on the algae that form on the surface. The whole enclosure containing the community of prey and predatory fish is harvested at intervals of 2-30 days. An interval of 30 days enables the community to develop, while harvesting at very short intervals only enables the capture of transients. This method of fishing has traditionally been very common in the lagoon. However it is very destructive as it also captures juvenile forms, thereby depleting potential stocks. Presently it is used almost exclusively as a means to capture ornamental fish. A variation of the method described above is the *'athul vatti kramaya,'* (Sinhala: 'enclosure-system'). Prawns are normally caught in the lagoon using cast nets (Sinhala:*vissi dhel*) and fetch high prices (sometimes as much as Rs. 300 per kilo).

6.4.2 Restrictions to Fishing

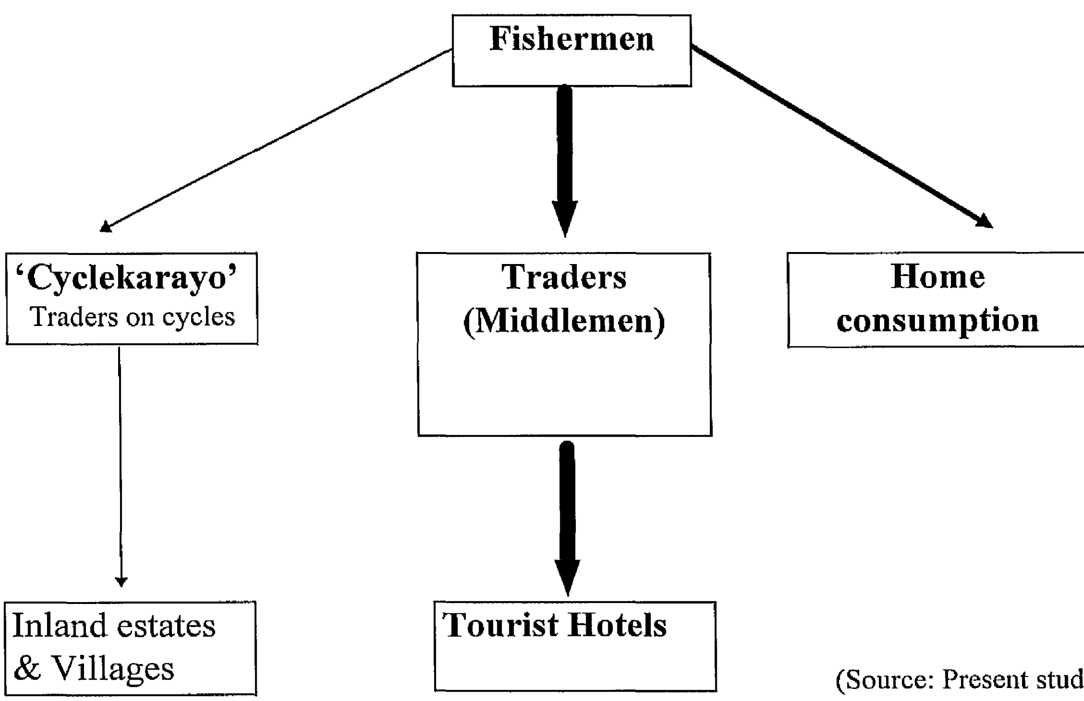
Most of the fisher families interviewed were restricted, because of their economic conditions, to small mud-built houses and complained of inadequate water and toilet facilities (see **Chapter 3**). Most of them possessed their own boats which cost in the region of Rs. 800-1500 and either a cast net or gill net. It would seem that the lack of different nets with varying mesh sizes places a serious limiting factor on their possible earnings from the lagoon. A common complaint was that the nets currently in their possession were not able to accommodate the

Figure 6.5: Cast net fishing, Harumalgoda East 149A.
(Source: July 1994, V.N. Samarasekara)

different species of fish found seasonally in the lagoon. This factor is important as it also presents a limit to over-fishing on the part of the fishermen. Most of the fishermen fish in the lagoon 4-5 times a week on a regular basis. Daily incomes from fishing are difficult to quantify as they fluctuate according to prevailing weather conditions. However if weather conditions remained consistent throughout the month and it was possible to fish on an average of twenty days, daily incomes for a good catch of fish could be up to Rs.150. In comparison, on bad days it could be as low as Rs. 30-40. Many fishermen admitted that though it was very helpful if they were accompanied by someone else during fishing trips, this was uneconomical as valuable space is taken up in the boat restricting the size of the catch they are able to bring home.

The fish caught in the lagoon are sold almost exclusively to traders (middlemen) who buy the entire catch from the local fishermen from two central collection points (see Figure 6.6). The catch is then sold by these middlemen mainly to tourist hotels in the vicinity. Interviews conducted with the local fishing community indicate that the practice of selling fish to middlemen (traders) is where they feel they make the biggest loss. According to these fishermen the traders are able to capitalise on the fact that by fishing throughout the night the fishermen would have sacrificed sleep and therefore would not be in a position to sell by themselves the fish they had caught. Thus they were faced with no alternative but to sell their catch to the traders. In addition to this factor the relative small size of the catch caught by the fishermen imposed a further problem which induced them to sell their catch to the middlemen.

Figure 6.6 Diagram of the distribution of captured fish



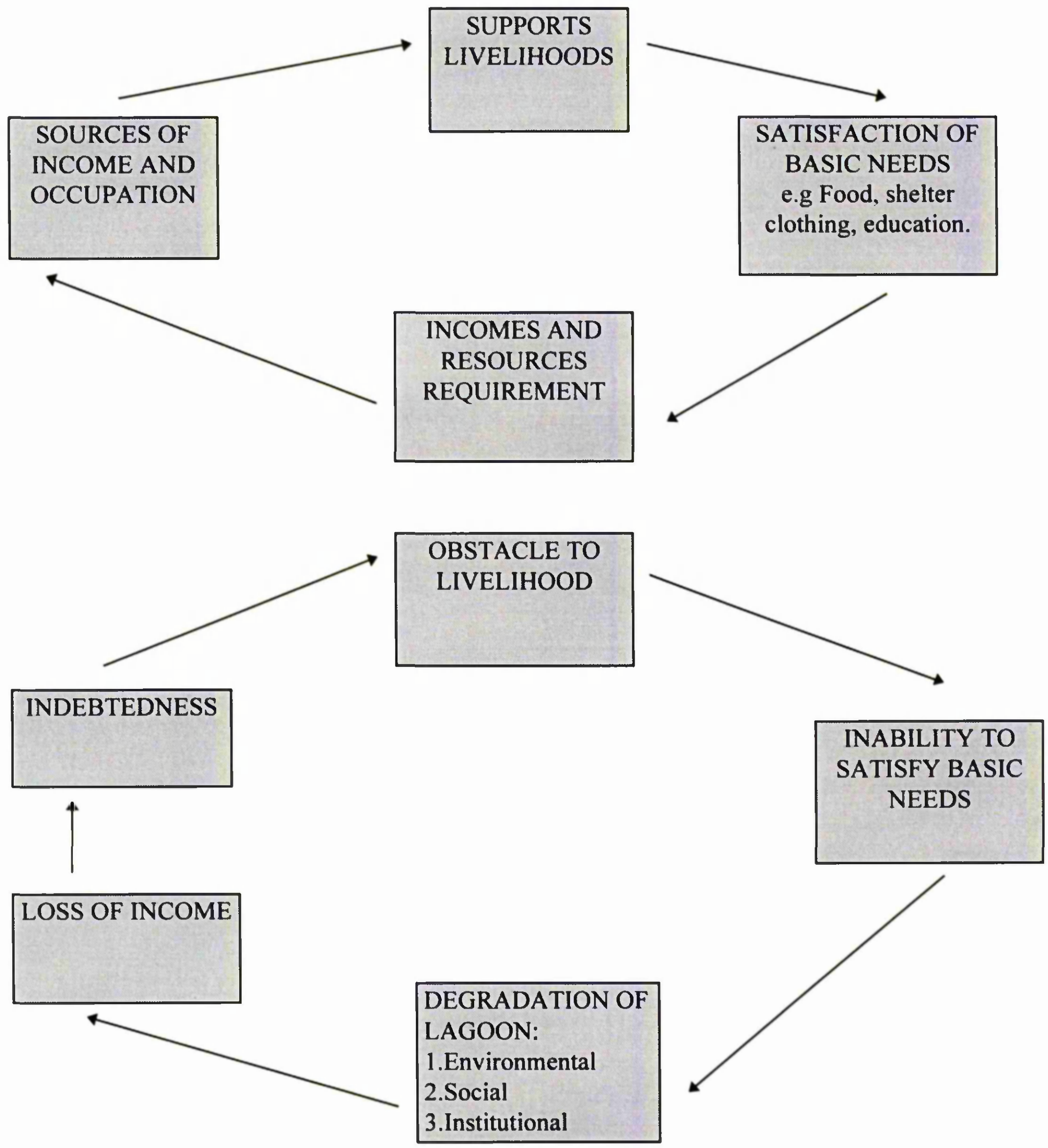
(Source: Present study)

In spite of these problems, almost all of the fishermen interviewed had tried to sell their catch directly to the tourist hotels without the involvement of middlemen. However when the traders become aware of this they would offer the hotels Rs. 20-30 less per kg. Thus ultimately the fishermen were forced to go through the middlemen. This is a source of constant anger and tension amongst the fishing community who feel they are helpless in a situation where they are faced with no alternatives. This feeling of animosity between the fishermen and the traders (middlemen) was re-inforced throughout the discussions. The 'cunning' acts of the traders recounted by many of the fishermen include instances when the traders would wait for the fishermen around the lagoon itself.

At other times when individual catch from the lagoon was very small some fishermen sold their entire catch to '*cyclekarayo*'. These are very small-scale traders who deal in the small-to-medium sized fish which they sell from their bicycles in the villages. According to the group interviews conducted with the fishermen, it is no longer economically viable, as it had been in the past, to depend solely on fishing in the lagoon as a main source of income (see Figure 6.7). The main reason for this was because the new and rapid changes in the water levels in the lagoon consequent to the destruction of the sand bar, had put a limit to the number of days they could engage in fishing. In addition to this, fishing and laying of nets at the mouth of the lagoon had become impossible as a result of the strong tidal currents experienced there since the removal of the sand bar. The strong tidal patterns not only damaged nets but also had the effect of drawing out both juvenile and adult forms of commercially important species from the lagoon into the sea thus depriving the fishermen of this potential catch.

In the opinion of the fishermen the elevated salinity levels in the lagoon have also resulted in the decline of some traditional freshwater fish species. This view has been backed up by field surveys conducted within the research period. **Appendix 1** illustrates fish species sampled in the lagoon during 1991 (Samarasekara, 1992) and most recently during the research period (1993-94), verified during interviews conducted with the fishing community. Since 1992 there have been substantial changes in the composition of the populations of fish species in the lagoon. Many of the traditional species such as *Channa striata* (murrel), generally associated with freshwater environments, are now rarely found in the lagoon, while many new species able to tolerate the elevated levels of salinity are becoming increasingly evident.

Figure 6.7 Cycles of Interaction between Fishery Productivity of Koggala Lagoon and the livelihood of the Fishing community



(Source: adapted from Samarakoon & Zon, 1991)

Sarotherodon mossambicus was frequently cited by the fishermen as an example of what was previously a common species in the lagoon that is now very rare. According to them, the raised salinity levels in the lagoon has had the effect of diminishing the extent of formerly abundant lily pads (Nymphaceae) which had served as breeding grounds for this species, resulting in its overall decline. In a similar fashion, it is the belief of the fishermen that many of the plant species upon which other fish depend for feeding and breeding have also declined being unable to tolerate the elevated salinity. Another restriction to fishing in the lagoon was the absence of thick growths of the seagrasses (Sinhala: *pendaratta*) which previously had been very abundant in the lagoon (Samarasekara, 1992). These seagrass species, mainly as a result of their density, were used to align the fishing nets to facilitate a specialised method of fishing.

6.4.3 Perceived Reasons for Declining Fish and Crustacean Populations

A survey of opinion amongst the fisherfolk revealed that they ranked pollution as the main reason for depletion of fishery resources (see Figure 6.8). Based on field surveys conducted with the fishing community, the decline of fish and crustacean stocks within the lagoon fall within the main categories listed below.

Structural Complexity

Under this category, the fishing community cite the loss of nursery areas (seagrasses, fringing mangroves) and the loss of lagoon depth as a result of sedimentation. The bund and sluice gates built in the 1980's as part of an elaborate salt water exclusion scheme, designed to prevent saltwater from intruding into the surrounding rice fields (see **Chapter 3**) have been constructed in such a way that will lead to the eventual sedimentation of the northern branch of the lagoon. Presently it is filled with layers of mud and since it was first constructed, populations of fish and prawns have dwindled in this area. The continued unsustainable extraction of mangrove timber has also affected the area of nursery sites in the lagoon.

Dynamic Stability and Resilience

The accumulation of nutrients in the lagoon (De Alwis & Dassanayake, 1993) are attributed to the indiscriminate use of agro-chemicals by the farming community in the surrounding rice paddy and plantation lands and also as a result of the 'retting' of coconut husks in localised areas of the lagoon. The dumping of industrial waste in recent times is another perceived contributory factor responsible for the skin lesions commonly seen on fish in the lagoon, localised fish kills and declining catches. In addition, the reduction of daily tidal exchange and flushing of sediment from the lagoon when the lagoon outlet to the sea is blocked leads to the water stagnating for longer periods of time, which according to the fishing community, perpetuates this whole process.

Figure 6.8 Opinions of fishing community on the status of the lagoon fishery and its resources.

	Opinion (%)	
Resource status:	**Yes**	**No**
Have fish and crustacean stocks declined over the years?	**100**	-
Perceived impacts to lagoon fishery:	**Ranked in order of severity (1-7)**	
• Brush-pile fishing	7	
• Pollution (agricultural, domestic and industrial)	1	
• Mangrove felling for fuelwood purposes and resultant reduction on breeding grounds	3	
• Changes in the water level in the lagoon since the removal of the sand bar and strong tidal patterns experienced at the mouth of the lagoon	2	
• Elevated salinity levels	4	
• Reduction in density of seagrasses	5	
• Sedimentation	6	

(Source: Present study)

6.5 Knowledge of the Ecological Role of Natural Coastal Resources

The results of the interviews conducted are presented separately with respect to the following four areas:

1. Generation of species regarded as important to the fishery of Koggala Lagoon;
2. Factors contributing to the continued existence of populations of organisms important to the fishery;
3. The relationship between commercially important species in the lagoon and aquatic and fringing vegetation forms;
4. Value of the vegetation types in the wetland and their perceived ecological role.

6.5.1 Mode of Generation of Fishery Organisms

Two major modes of reproduction by many of the commercially important species of fish were recognised by the fishermen interviewed. It was held that valuable species such as *Monodactylus argenteus* (Sinhala: *Kapu henda*) were produced from filamentous green algae (*Chaetomorpha* sp.) (Sinhala: *nool parsi*). This statement was backed up by the fact that in years when the growth of filamentous green algae was extensive, the fish species in question were also abundant. The thick and extensive mats of seagrasses also had some contribution to make towards the generation of these fish.

In the case of shrimps, different species had contrasting forms of generation. Tiger shrimp and flowery shrimp were produced from pieces of decaying wood. The white shrimp was produced from a combination of mud and decaying vegetation, since they generally occurred where the mud was soft and covered with seagrasses. However in all cases, acknowledgement of the importance of the connection with the sea for the recruitment of these species was made. Twenty nine per cent of fishermen interviewed stated that in recent times with the blocking of the mouth of the lagoon that was now so difficult to breach and the subsequent changes in water levels they had experienced a substantial decline in shrimp catch.

6.5.2 Perceived Factors Influencing Populations of Fishery Organisms

The most important factors influencing population sizes of the commercially important species were perceived as freshwater inflow; filamentous green algae; seagrasses; sea water; and sedimentation. Freshwater inflow from the various inlets feeding into the lagoon was considered to be a very important factor in regulating population size. The more elderly fishermen interviewed (22%) referred to specific drought years when the lagoon water became too saline, which had the effect of destroying seagrass communities that were essential in their role as breeding grounds for these species. Because of their perennial nature, seagrasses were generally held to be important with respect to the continued sustainablity of the fishery stocks. A total of 7% of the fishermen interviewed cited reduced seagrass-bed coverage as a significant impact on the lagoon fishery. All the fishermen interviewed stated that a continued connection with the sea was seen as vital to the sustainability of fish and crustacean stocks. It was pointed out that fishing was good in the lagoon when '*kabba*' (fluorescent planktonic organisms that shone when the water was disturbed) occurred. These planktonic organisms were introduced through the mouth of the lagoon.

Four per cent of the fishing population interviewed stated that the increased sedimentation of branches of the lagoon due to badly constructed bunds and sluice gate systems had resulted in diminished fishing grounds. Examples of previously productive areas of the lagoon which had now filled up with sediment making them redundant were frequently cited throughout the course of discussions (see **Chapter 5**). Overall, the one major cause of depletion of fish and crustacean stocks in the lagoon was attributed to perceived pollution problems (49%), associated mainly with agricultural waste. Since agro-chemicals used in the surrounding rice paddy land had direct access to the lagoon, rehabilitation of the fish populations in the lagoon would require co-operation on the part of the farmers. Furthermore the obstruction created by dams, gates, anicuts etc. all contributed to the fish not being able to swim up river - a factor vital in the life cycle of many commercial species.

6.5.3 Relationship Between Fishery Organisms and Vegetation

Seagrasses, filamentous green algae and mangroves (see **Chapter 5**) were the main classes of vegetation that were perceived to be associated with the fishery organisms in the lagoon. There was general consensus that the continued sustainablity of fish and shrimp populations in the lagoon were dependent on them. The fact that many juvenile forms of fish were commonly encountered in mangrove areas confirmed, in their opinion, the vital role such communities had as breeding and nursery grounds for commercially important species. In addition there was a high degree of awareness concerning the role that the mangroves play in shore protection and stabilisation. One elderly fishermen pointed out that the only thing protecting his house, which was located on the very borders of the lagoon, was a thin strip of mangroves directly in front of it. These had a buffering effect against the wind and further stabilised the soil.

6.5.4 Mangrove Uses

The uses of the mangrove vegetation was varied and differed according to the various values assigned to them. For instance, fishermen using mangrove branches as part of brush pile fishing accorded highest value to mangroves from the point of view of their indispensability for construction of their fish aggregating devices. Similarly those groups that were landless regarded the intertidal areas as the only potential sites for their temporary houses. In such circumstances they considered the mangroves as extremely valuable in stabilising and providing support for fill material, as wind breaks and for protection against erosion.

Interviews conducted with the fishing community relating to the fringing mangrove community revealed that most information was limited to the true mangrove species, mainly *Rhizophora* spp. and *Ceriops* spp. Tannins extracted from these mangroves are used widely to dye and strengthen fishing nets giving them long term durability. Though the tannin extraction process is time consuming, the results are highly effective. The process involves removing part of the bark from the trees in a non-destructive manner. According to the fishermen interviewed this does not appear to harm the tree since these particular species grow very quickly. The bark is then pounded to a pulp and boiled together with the fishing nets. This has the effect of imparting the dye from the bark to the nets. Fishermen who engage in sea-fishing also protect their nets in a similar manner.

Mangrove timber is generally favoured in house construction as the wood is relatively stronger and more resistant to insect attack. For this reason it is used widely in the construction of pillars and rafters for which *Avicennia* spp. are generally favoured. It is also used to construct the outriggers of the traditional fishing boats (Sinhala:*oru*) employed by the fishermen. In addition to the important uses of mangrove species listed above many species are valued for their medicinal properties. The economic uses of mangrove are listed in Figure 6.9.

In spite of the recognition of the important ecological role the mangrove community plays, at times when it is not possible to engage in fishing, some fishermen are forced out of sheer economic necessity to cut the mangrove bordering the lagoon and sell it as fuelwood (see **Chapter 5**). Since charcoal made from mangrove wood has the added advantage of retaining heat for a longer period of time there is a great demand for it especially from bakeries in the area. The fishermen emphasised that the felling of the mangrove only took place when they were faced with absolutely no other alternative and felling of the mangrove by fishermen was much less than in previous times when brush-pile fishery was more popular. Presently, in the opinion of the fishermen interviewed, the mangrove complex was increasingly under threat from unemployed youths in the area who worked in gangs to cut the mangrove wood which they would sell to local bakeries and groups involved in the production of illicit liquor (Sinhala: *Kassippu*).

6.6 Summary of Key Themes

- The natural productivity of the wetland ecosystem is presently under serious threats stemming from existing and prospective resource-use conflicts. A significant human population is directly dependent upon the fishery stocks for employment and income. But at the same time the national thrust towards industrialisation is increasing and because of available infrastructure the area has become exceedingly attractive for industrial and residential development and this has further polarised the fishing community. Accelerated development has also impacted the extent of the fringing mangrove complex bordering the lagoon.

Figure 6.9 Human uses of Mangrove and associated species used by the Fishing Community

Vernacular name	Latin name	Use, lifeform and habitat
Kadol	*Rhizophora mucronata*	house posts, frames,screens (fishing), masts, fuelwood, charcoal, tanning for the preservation of fishing nets, small scale reclamation
Manda, mada gas	*Avicennia marina*	webbing in fish traps, brush pile fishing, dug out canoes, boat fittings, drums, rice mortars, fuelwood, dyeing (bark), small scale reclamation
Heen kadol	*Aegiceras corniculatum*	Poles
Malkadol	*Bruguiera gymnorhiza*	fuelwood, poles, brushpile fishing, medicinal use
Gon Kaduru	*Cerbera manghas*	Mask making
Karen koku	*Acrosticum aureum*	roofing, fishing screens and fences
Punkanda, Rathugas	*Ceriops tagal*	webbing for fish traps, fuel, tannin,dye for colouring and preserving nets and poles
Ikilli, Katu-ikilli	*Acanthus illicifolius*	lye derived from ash used in soap making, medicinal use
Kirilla	*Sonneratia caseolaris*	beverage and dessert, cork is made from the roots.
Thela	*Excoecaria agallocha*	fish poison, carpentry, flots, poles, outriggers, oars
Hambu-pan	*Typha augustifolia* L.	mats
Elu-pan	*Lepironia articulatau* (Retz.) Domin.	mats
Gal-ehi	*Cyperus corymbosus* Rottb.	mats
Indi	*Phoenix zeylanica* Trim.	hats
Midi	*Premna serratifolia* L.	Ayurvedic medicine
Hatavaria	*Asparagus racemosus* Willd.	Ayurvedic medicine
Eramusu	*Hemidesmus indicus* (L.) Ait. f.	Ayurvedic medicine

(Source: Present study)

- Human-induced stresses on the lagoon and its environs include continued mangrove denudation and destructive fishing methods. The role of the lagoon as a sink for agro-chemicals used in the surrounding rice and plantation land may also have impacted the lagoon (De Alwis & Dassanayake, 1993), causing concern for the sustainability of the lagoon and its key resources. Increasingly it is the case that current resource-use patterns in the light of these changes are no longer sustainable.

- The diverse fishery of Koggala Lagoon which has provided the primary income to over 500 fishing families living in those divisions bordering the lagoon has been threatened by key disruptions (see **Chapter 3**). These disruptions combined with increasing fishing pressure by local communities has resulted in the overuse of coastal resources. From the various discussions and interviews held with the fishing community in the study area it is clear that the fishery in Koggala Lagoon is under growing threats from natural changes such as sedimentation, nutrient accumulation, and over-fishing. Nevertheless it still supports more than 600 jobs.

- Mangroves are widely harvested for subsistence and commercial-scale operations. Some species e.g. *Rhizophora, Bruguiera,* and *Avicennia* are commonly used as firewood. People around the lagoon prefer the charcoal of *Rhizophora* for its high heat and low smoke. However the mangrove complex is threatened and the organised extraction of firewood for domestic use and firing of bakeries and illicit distilleries cannot be sustained at present levels. Despite the level of knowledge and understanding demonstrated by the fishermen regarding the mangrove complex and its important role in sustaining their fisheries, prevailing economic conditions ultimately dictate the fate of the mangrove. The economic value of these mangrove uses is clearly high and partial harvesting of mangroves for the activities described above if carried out at locally sustainable levels, would be acceptable. However the future costs incurred by coastal residents if unsustainable abuses continue and mangrove stocks continue to decline are already taking their toll.

- The destruction of the sand bar at the mouth of the lagoon has irreversibly changed the ecology of the lagoon and its environs, with the effect of wiping out some commercially important freshwater species (see **Appendix 1**). In addition to this, because of strong tidal currents and fluctuating water levels, fishing in the lagoon alone is no longer an economically viable option open to this community. This has forced many of the fishermen in the study area to engage in deep-sea fishing. Their present economic conditions result in further problems since to fish in the sea they need bigger vessels that they cannot afford.

- The decrease in size of fish caught in the lagoon during the past two decades has been accompanied by a decrease in yield. Evidently a number of fishermen operating in the wetland still find it profitable to continue their activity despite their depleted catches. This situation has been brought about by the increasing export demand for shrimp, crab and ornamental fishes. The over-exploitation of the fishery of the lagoon and its associated resources will not only adversely influence the large number of fishermen who are actively engaged in lagoon fishing, but also their dependants and those who are engaged in marketing of the collected fish. The adverse impact on the nursery function of the lagoon is already reflected in the declining proportion of catches of penaeid shrimps, which have an obligatory estuarine stage.

- The fishing community displayed a highly developed awareness and understanding of the ecological processes that maintain the stocks of fishery organisms so important to them. This was especially true of the understanding that resource users had of life cycles of organisms critical to their economic activity. Only in isolated instances did superficial observation combined with narratives of elders, determine belief.

CHAPTER 7
KOGGALA LAGOON 3: THE FARMING COMMUNITY

7.1 Introduction

Incomes in the study area are low. This also applies to the whole area covered by the Habaraduwa Divisional Secretariat (Wanigaratne, 1992; TEAMS, 1994). Reliance on the land and the sea are therefore very important to local communities, and as a result, changes in these natural resources are reflected in family incomes.

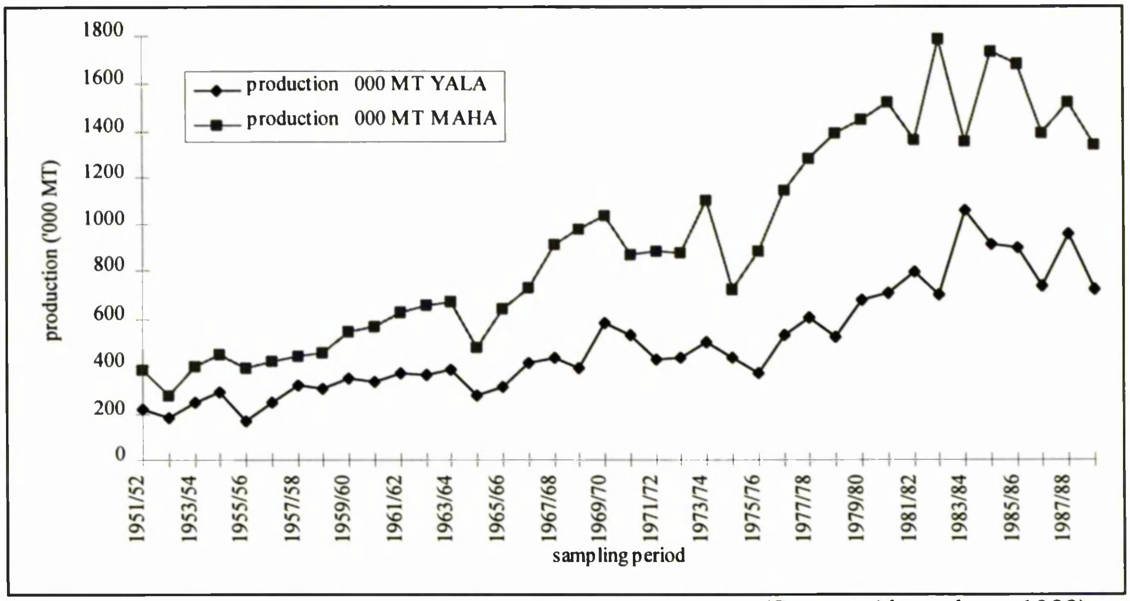
Many of the changes Koggala Lagoon and its environs have undergone (see **Chapter 5**) have affected traditional resource-use patterns. This chapter deals with the effects such changes have had on the farming community living in the sample six divisions. It is based on in-depth surveys conducted with three principal groups: farmers; traders; and sprayers (those directly involved in applying agro-chemicals) in an attempt to analyse the past and current role of the farming community.

Section **7.2** sets the scene in the study area with an overview of the changing pattern of agriculture. Here an attempt has been made to provide the relevant historical background associated with the development of new technologies relating particularly to rice production, commonly known as the 'Green Revolution.' Attention is also given to the potential environmental effects of the use of agro-chemical inputs. In this context the development of these new technologies and their impacts in the study area are discussed. An account of current agricultural land-use patterns in the sample six divisions based on field surveys is presented in Section **7.3**. Section **7.4** outlines case studies of three fundamental components of the farming community in the study area: the farmers; the sprayers; and the agro-chemical traders. Finally a summary of key themes is presented in Section **7.5**.

7.2 The Changing Pattern of Agriculture in Koggala

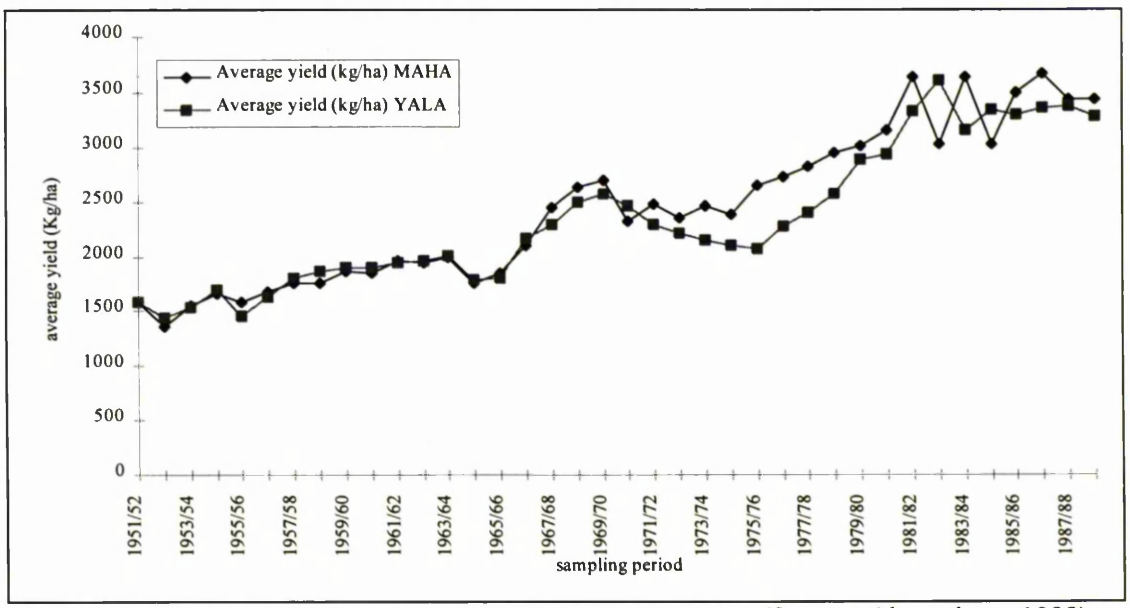
Agriculture in many developing countries, particularly in South and Southeast Asia, is increasingly dependent on the use of chemical fertilisers and pesticides (Dixon, 1990; Farmer, 1977; Goodell, 1984; Hayami *et al.* 1985 ; Herdtz & Capule, 1983; Hossain, 1988; Knox & Agnew, 1994; Rigg, 1989; Sanchez, 1983; Shiva, 1993; Thiers, 1994). In 1985, the pesticide market for the ASEAN countries was about $ 498 million. Indonesia and the Philippines had the highest growth rate in pesticide usage from 1980 to 1985 with increases at 30% and 60% respectively (Magallona, 1994).

Figure 7.1 Production of Rice Paddy ('000 MT) in Sri Lanka 1951-89



(Source: Abeysekara, 1988)

Figure 7.2 Average Yield (kg ha^{-1}) of rice paddy in Sri Lanka 1951-1989



(Source: Abeysekara, 1988)

In Sri Lanka the use of pesticides in the food crop sector in the last couple of decades has meant that rice paddy output has doubled and production has maintained an annual acreage growth rate of little over 2% (see Figure 7.1). At present, the average national yield during the Maha season (September - March) is around 3.6 t ha^{-1} compared to the average of about 2 t ha^{-1} obtained in the sixties (see Figure 7.2) (FAO, 1988; Ranaweera *et al.* 1990; Widanapathirana, 1990). With this growth in yields there has been a parallel growth in pesticide use (Abeysekara, 1988, 1990; Dept. of Agriculture, 1990; Gangoda, 1988). Similarly in India, pesticide use has increased markedly from about 2,000 tonnes annually in the 1950's to over 80,000 tonnes annually in the mid 1980's. Correspondingly, some 80 million hectares of India's cropland is presently estimated to be under pesticide use, as compared to a mere 6 million hectares in 1960 (Abraham, 1987).

In turn this has generated increasing concern about pollution of the environment by pesticides especially in connection with the introduction of new crop varieties (Barrios & Barrios, 1990; Chapman & Harris, 1990; Clunies-Ross & Hildyard, 1992; Conway & Pretty, 1991; Day, 1991; Dissanaike, 1993; De Silva *et al.* 1991; Duel *et al.* 1979; Getzen, 1973; Gips, 1987; Kandel, 1993; Lawrence & Karuppuarachchi, 1986; Link, 1993; Norris, 1982; Perera, 1988; Pretty & Conway, 1989; Racke, 1992; Sethunathan *et al.* 1991; Tejada *et al.* 1994; Turco & Konopka, 1990; USEPA, 1990; Viswanathan & Misra, 1988; Watts, 1993).

Rice is one of the most important crops in the tropics. About 144.1 million hectares are devoted to its production world-wide and 50% of the global population are rice eaters (Barker *et al.* 1986; Bray, 1986; Castillo, 1978; Chandler, 1979; Grist, 1975; Hayami & Ruttan, 1985; Magallona, 1994). In addition rice paddy is generally considered to be one of the major contributors to pesticide pollution, largely as a result of the high application rates associated with it. In some cases farmers treat their fields with pesticides as much as five or six times during one cropping season, although two applications may only be required (Tejada *et al.* 1994; Biswas, 1994). The risks posed by pesticide residues draining into rivers and lakes and the resultant effects of bio-accumulation and depletion of beneficial organisms, such as fish, have been highlighted by a number of authors (Antazo & Magallona, 1982; Cagauan, 1990; Coleman-Cooke, 1965; Fischer, 1995; Habito, 1990; Hanazato & Kasui, 1995; Magallona, 1989; Medina *et al.* 1993; Peterson & Batley, 1993; Prot & Matias, 1990; Reddy *et al.* 1994;1995; Stevens, 1994; Tejada & Bajet, 1990; Tejada *et al.* 1990;1994; Tejada & Magallona, 1985; Thrupp, 1994;Van Straalen, 1994; Varca & Magallona, 1987; Wang *et al.* 1988; Wijayasiri, 1993).

There can be little doubt that in a number of cases the introduction of modern pesticides to traditional agriculture has resulted in new, and often more serious, pest problems than before. Repeated applications of synthetic pesticides have generated pesticide-resistant pests world-wide. There are now at least 450 species of insects and mites, 10 species of plant pathogens, 48 species of weeds resistant to one or more products (Georgiou *et al.* 1983; Pimbert, 1991). Moreover subsistence farmers in developing countries are often untrained in pesticide use and lack capital resources to implement proper pesticide handling and application procedures. They are often forced to rely on other uninformed farmers for advice on pesticide selection and use

(Ames *et al.* 1993; Arumugam, 1992; Bull, 1982; Dinham, 1993). As a result pesticide related health problems are commonplace (Alwis & Salgado, 1988; Arumugam, 1992; Brouwer *et al.* 1994; Fernando, 1988; Ferrer & Cabral, 1994; Foo, 1985; Forget, 1993; Harrish, 1991; Jeyaratnam, 1990; Jeyaratnam *et al.* 1982; Kagan, 1995; Maroni & Antonella, 1993; McCracken & Conway, 1987; Morgan, 1989; Moses, 1989; Rola, 1989; WHO/UNEP, 1989; WHO, 1990).

The response to pesticide-induced problems is often intensified pesticide usage. This leads eventually to environmental side effects such as pesticide residue build-ups in non-pest organisms, loss of predators and other natural enemies of the pest and the emergence of pest resistance varieties together with fishery and wildlife loss. Pesticide residues have been detected in water samples from the Citarum basin, West Java, where environmental problems such as water pollution by agricultural wastes have increased considerably (Djuangsih & Salim, 1994). Although the levels of residues are still relatively low, they may already be causing changes in both terrestrial and aquatic systems.

From earliest recorded times the inhabitants of Koggala had been involved in agricultural pursuits mainly centred around rice paddy cultivation (Ahubudhu, 1994). Indeed a majority of existing paddy lands today are demarcated on Survey maps dating as far back as the early 1850's. In the past, patterns of cultivation were dependent on traditional varieties of rice, several of which were noted for their medicinal properties (see Table 7.1). However, with the success of plant breeding programmes in the 1960's aimed at increasing crop yields, popularly termed as the 'Green Revolution', many of these traditional varieties have been replaced by hybrid varieties (see Appendix 2)(Abeysekara, 1986; Alauddin, 1991; Bayliss & Wanmali, 1984; Conway, 1990; Gunadasa, 1972; IIRI, 1975; Sen, 1974; Sendhira, 1980). These varieties (HYV's) are capable of producing very high yields when supplied with adequate fertilisers, water and disease protection. In comparison to the HYV's the traditional varieties had low yields and were limited by poor soil fertility and a deficiency of nitrogen which is greater in the tropics than elsewhere. However these low yields were compensated for by the high genetic diversity of varieties that had evolved by selection over a very long period of time which gave an inbuilt resistance to drought or disease (Tivy, 1992).

Prior to the introduction of HYV's in Sri Lanka in the early 1960's, the entire extent of rice paddy grown was represented by about 150 different indigenous varieties (Corea, 1973; Hameed *et al.* 1977; Jayawardena, 1987). These varieties were low yielding, i.e. not more than

Table 7.1 List of traditional varieties of rice that had been cultivated in the study area and their perceived values

LOCAL NAME	NOTES
Heenati	Noted particularly for its medicinal properties. It is still cultivated by some farmers for home consumption.
Gonabaru	A popular variety in the past among farmers best grown on dry land.
Nandu vee	Noted for its small sweet smelling grains and very long stalk as the local name itself suggests.
Heendikkhi	One of the first varieties to disappear from the area due to its comparative low yields.
Balamawee	Has a shorter harvesting period and as a result was generally grown in the Yala season (April - August).
Kalukaharamana	This variety was not as common as the others in the area.
Kombila	This variety was noted for its relatively high resistance to disease/pests etc.
Suwandel	As the local name suggests this variety was valued for its 'sweet aroma.'
Rattaranwee	Translated it means 'golden rice,' and was highly favoured for its colour and flavour.
Kuruluthudu	A long-grained rice which is shaped like a bird's beak, as the local name suggests.
Dhanahala	This variety was popular as a result of higher yields, it was also valued for its medicinal properties.
Herath	Used in the development of some of the new hybrid varieties because of its relatively high resistance to disease/pests etc.
Mawee	One of the last varieties to disappear and was also used in the development of hybrid varieties.
Hetapanduru	One of the first varieties to disappear because of its low yields.
Alwee	This variety which lasted longer in the area grows best on dry lands.
Kuruwee	A small-grained variety.
Polayal	A relatively rare variety.

(Source:Present study)

20-25 bushels[1] per hectare at the most, but generally showed a high degree of resistance to pest and diseases. According to field surveys conducted in the study area a total of 14 indigenous varieties had been traditionally cultivated (see Table 7.1). By the early 1970's less than half of these were still being farmed. Now, apart from a scattered plot of *Heenati* which is still valued for its medicinal properties, the older varieties are no longer cultivated. It should be noted that

[1] One bushel of rice = 20.87kg.

when these traditional varieties were replaced by HYV's yield was the guiding factor. Other factors were not important in an economic context. The effects of the introduction of these HYV's dating from the 1960's on rice production are shown in Figures 7.1 & 7.2.

The introduction of the HYVs in the study area, which included B.G 350 and B.G 351 (see **Appendix 2**), brought with them new intensive farming techniques involving high chemical inputs. The effects of the prolonged use of some of these agro-chemicals in the rice land and also in the surrounding tea, rubber, cinnamon and mixed cultivation, have not been properly analysed. However chemical analysis elsewhere suggests they have the potential to impact adversely on sensitive tropical marine ecosystems (Readmen *et al.* 1992). These agro-chemicals have direct access to the lagoon through the various inlets and streams which flow from the rice paddy fields and other cultivated land mentioned above. The popular belief, also supported by surveys conducted in the area (see **Chapter 8**) is that the declining fish population in the lagoon can be attributed to this factor. Sightings of malformed fish and recent fish kills in the lagoon which coincided with periods of increased agricultural activity are further evidence of this phenomenon (see **Chapter 6**).

7.3 Agricultural Developments in Koggala

Together with fisheries, agriculture is the main traditional income-generating industry for the people in the area, and it is their major source of income. Land use in the administrative division of Habaraduwa which includes the study area consists predominantly of rice paddy (2,166 hectares); tea (1,661 hectares); coconut (1,314 hectares); rubber (304 hectares); and cinnamon (243 hectares) (TEAMS, 1994). Rice paddy cultivation has traditionally been widely practised in the divisions situated to the north of the lagoon. However the extent of this crop has declined seriously due to a combination of factors including poorly sited and badly maintained irrigation schemes (see **Chapter 3**), and most notably in recent times, increased salt water inundation. This problem of salt water intrusion has also been identified in other areas of the Habaraduwa division together with frequent flood damage and the poor maintenance of irrigation schemes as reasons for low productivity of rice paddy in the region (TEAMS, 1994). Though a number of attempts have been made from time to time to combat the problems stated above, because of a lack of thorough study and planning, they have been largely unsuccessful and in some instances have had the reverse effect (see **Chapter 3**).

7.3.1 Land Tenure Methods

Thattumaru is a method of land tenure whereby the right to cultivate a given rice paddy field is changed periodically among those claiming ownership to the undivided field (Codrington, 1950; Gooneratne, 1975; Peiris, 1976). This system of normally annual changes is prevalent mostly in the wet zone (Obeysekara, 1966) and common to all the sample six divisions. Though not much research has been conducted on this system the highly adverse effects that it brings about have been generally accepted. The system itself differs from division to division. However one common feature is the frequency of conflicts it has generated. Most farmers interviewed realise the disadvantages associated with the system but no serious attempt has been made to resolve them. In addition, opinion is divided among researchers on the best way to resolve the problems inherent in the system. Some argue that productivity should be the sole criteria, others the harmony of the village, i.e. to avoid social conflicts. In spite of these differences all parties are in agreement that the system is heavily flawed (Peiris, 1978).

In Kahanda and Polhena about 30% of the total rice paddy land operates under this system. It is generally true for other areas in Koggala but the spread is slightly less. Sometimes a farmer gets a chance to cultivate a particular paddy land under the system after 3 or 4 years. As a result of this farmers are unwilling to invest time and resources to improve the rice land on a long-term basis which ultimately affects potential yields. This is perhaps best explained by the example of preparing bunds and contours on the paddy fields. There is a general reluctance on the part of farmers who are part of this system to invest the time and effort in preparing the rice fields as it will be the next farmer who will see the benefits of the system. In a similar manner channels are not properly cleared.

7.3.2 Agricultural Land-Use Patterns

The main land-use patterns found in each of the sample six divisions are displayed in Figures 7.3-7.8 which are based on field surveys conducted during the research period. In the sample six divisions most residents are engaged in rice paddy, coconut, tea, cinnamon, rubber and mixed cultivation, but to varying degrees. There is a considerable disparity between official figures relating to the extent of these crop types and those collected during field surveys of the area. These discrepancies are largely due to the fact that in recent years there have been many changes in the demarcation of the boundaries of the divisions as well as changes in the placing of officials which have contributed adversely to the reliability of official statistics.

From field surveys conducted during the research period, it can be seen that coconut cultivation is more important in Harumalgoda East, Alawattukissagoda and Koggala Athireka 1, situated on the southern borders of the lagoon, while in Kahanda, Polhena and Palessa, situated on the northern borders of the lagoon, rice paddy, tea and mixed cultivation are more common. Cinnamon, which is the fifth most important plantation crop in the Habaraduwa division, is widely cultivated in Palessa. This is significant since Sri Lankan cinnamon exports comprise

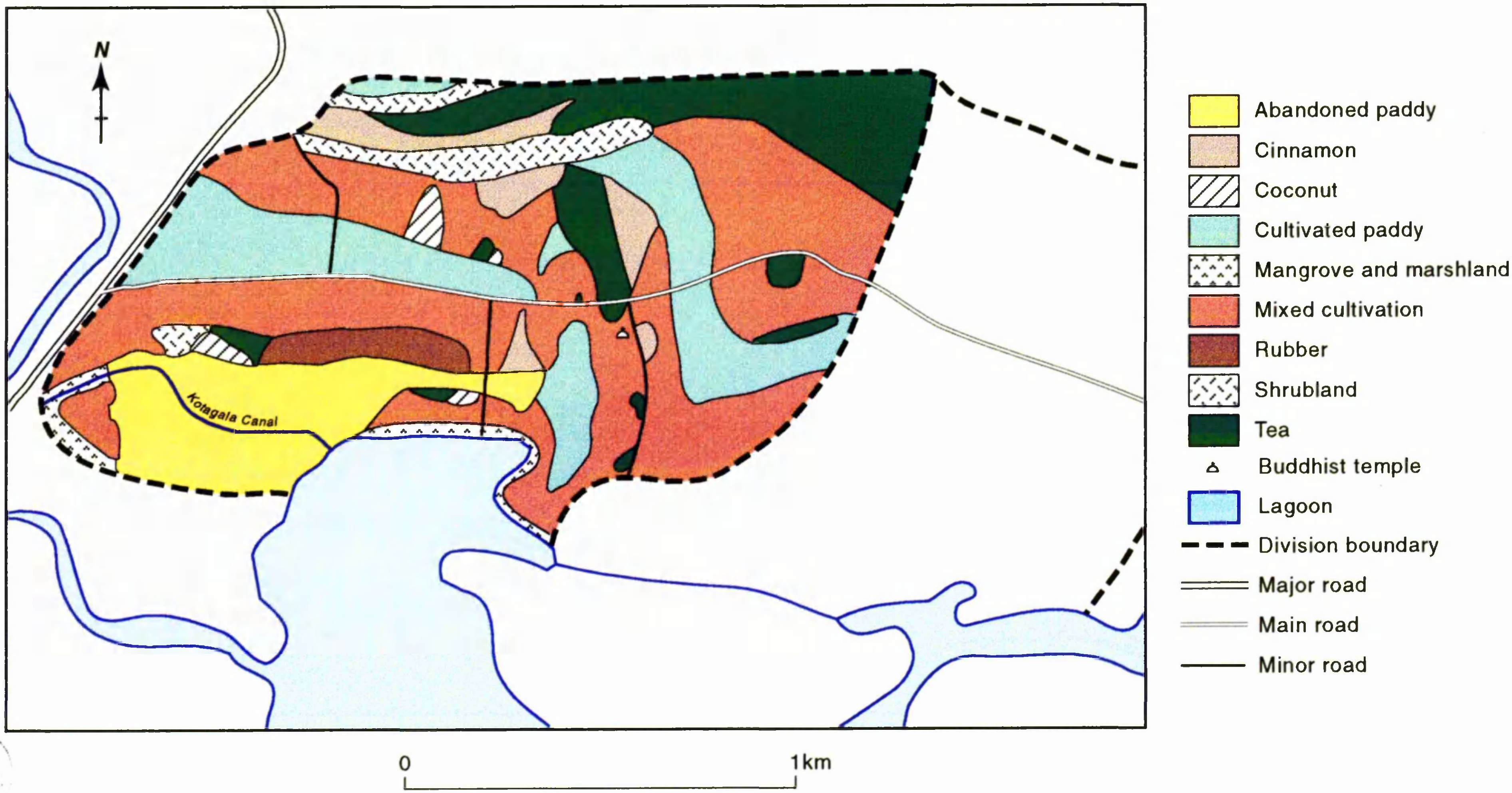


Figure 7.3 Land Use Map of Polhena 154B

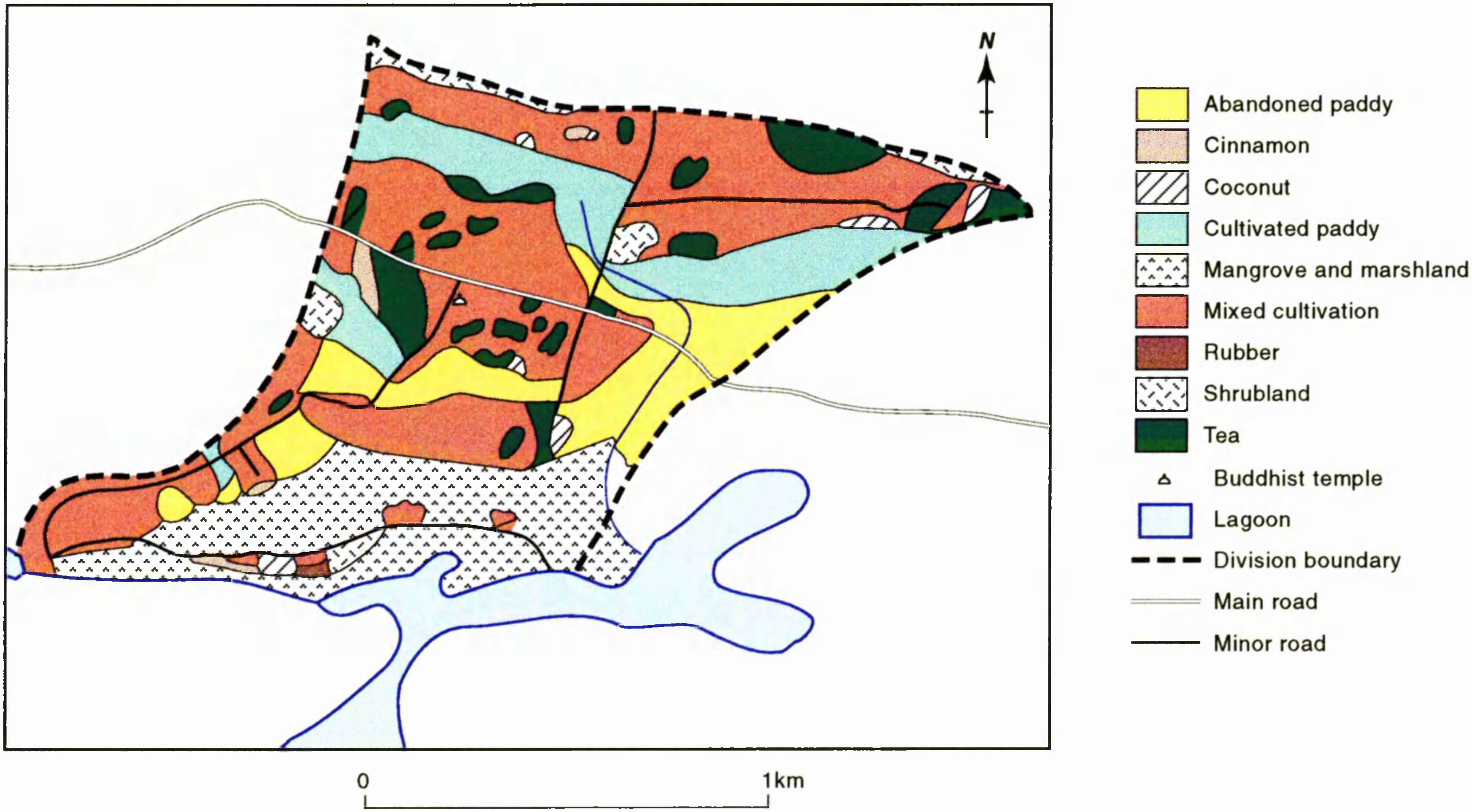


Figure 7.4 Land Use Map of Kahanda 167

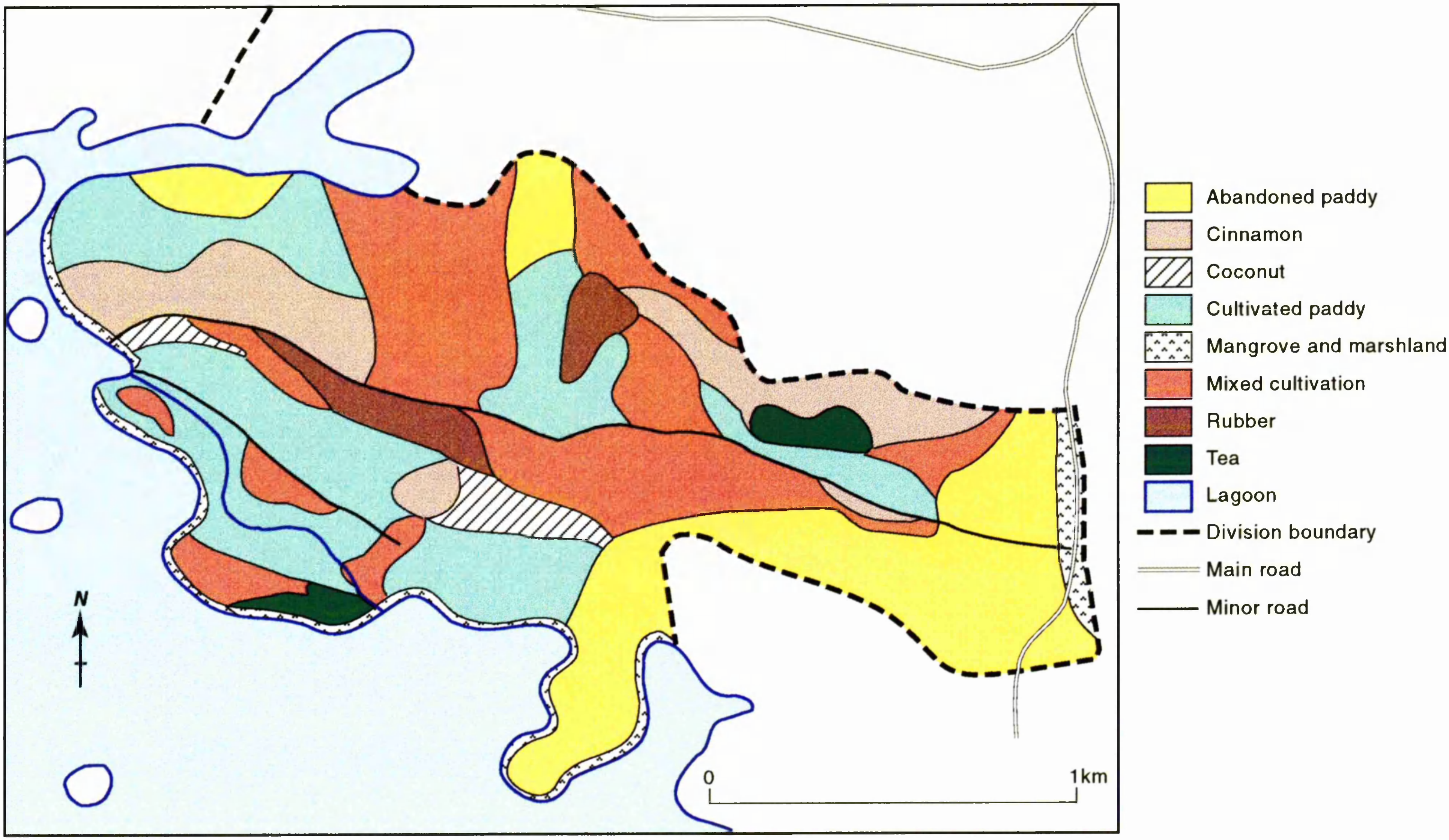


Figure 7.5 Land Use Map of Palessa 166C

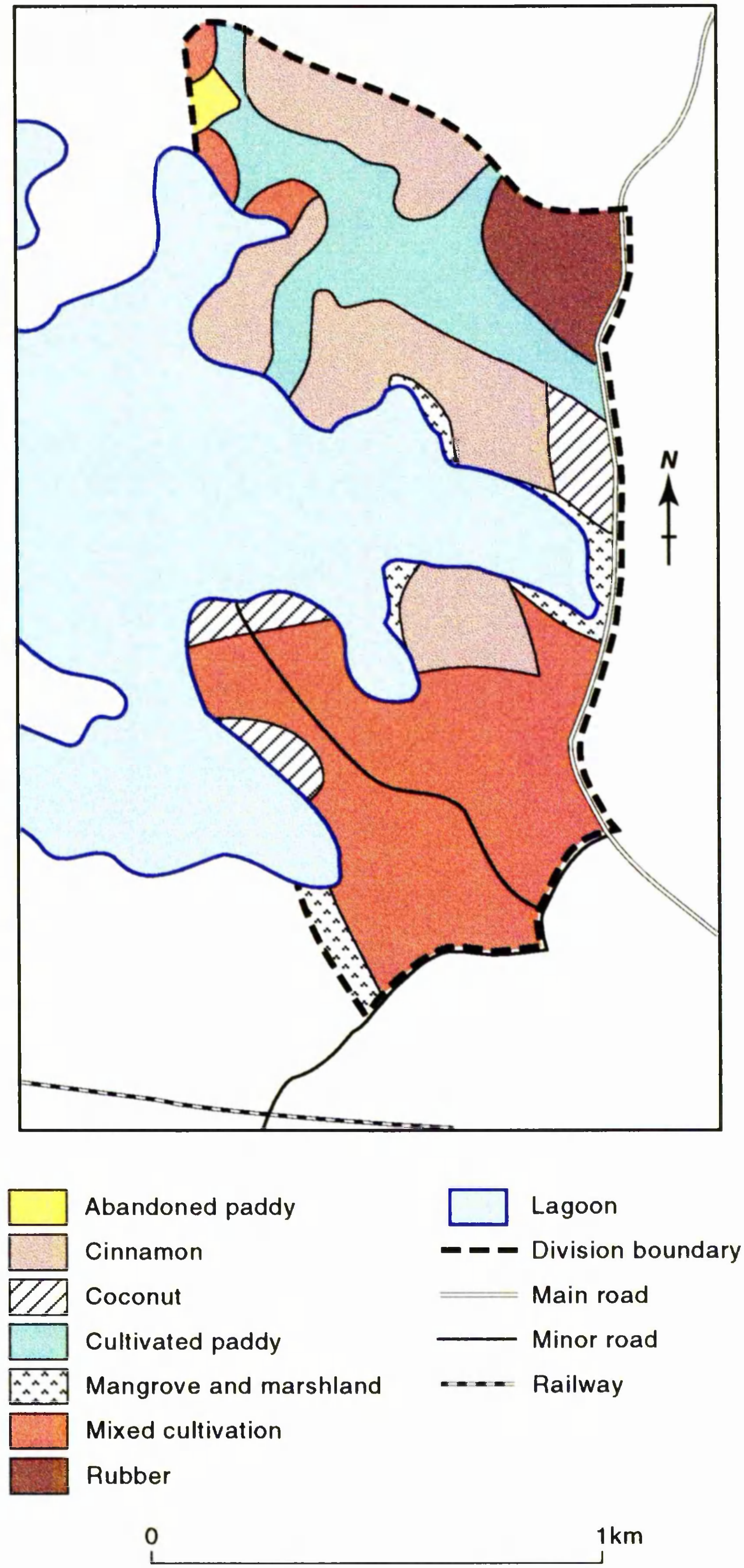


Figure 7.6 Land Use Map of Alawattukissagoda 164G

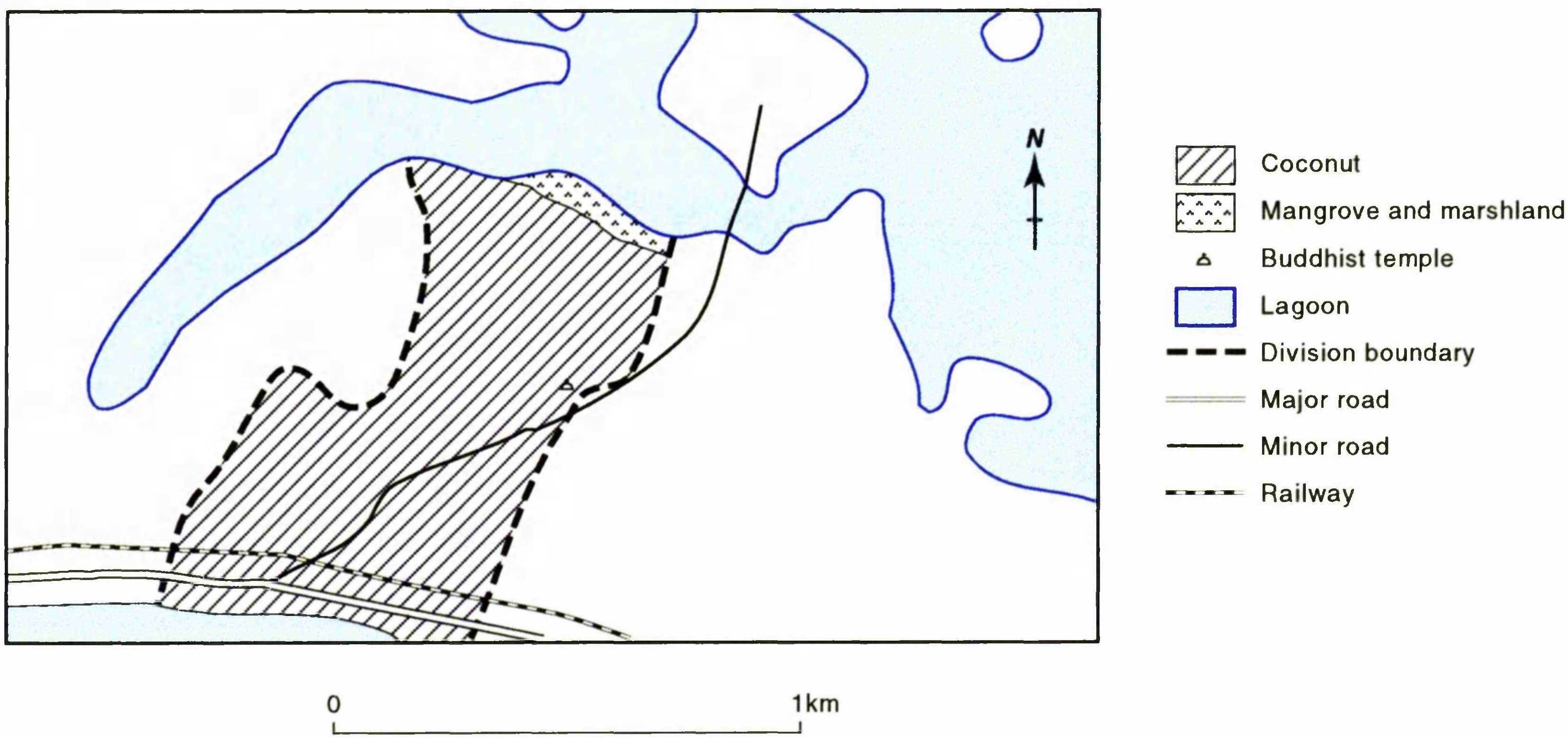


Figure 7.7 Land Use Map of Koggala Athireka 1 144D

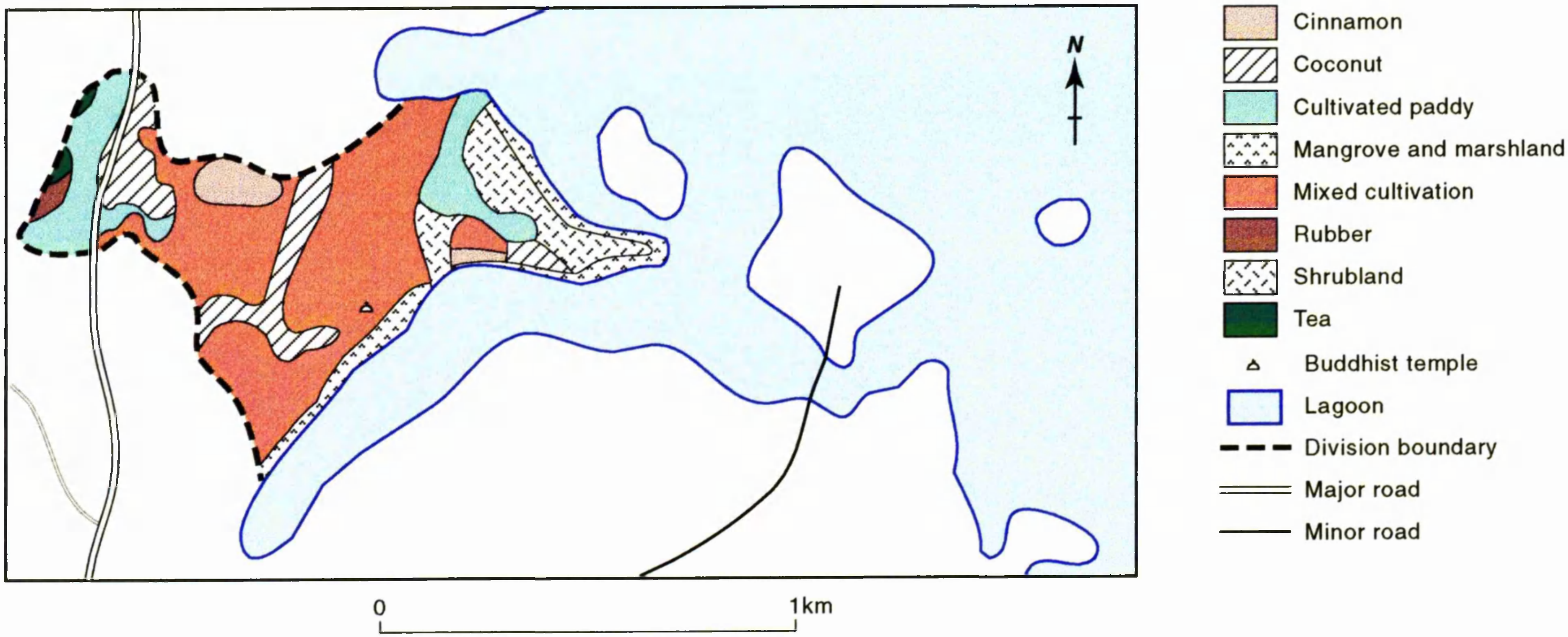


Figure 7.8 Land Use Map of Harumalgoda East 149A

over 70% of the world market (TEAMS, 1994). There are two stills located in Pelassa and Alawattukissagoda where cinnamon oil is extracted for sale in nearby Galle town.

The hectarage under tea in the Southern Province as a whole has increased during the last decade (TEAMS, 1994) despite a general decline in Sri Lanka. The yield in the Southern province (1200kg ha^{-1}) is also higher than the national average (1000kg ha^{-1}) (Baldwin, *et al.* 1991). In the study area the cultivation of tea is commonly maintained under smallholdings of less than half an hectare, in most cases in the gardens surrounding village homes. Coconut cultivation is usually found combined with other minor crops except in scattered areas as plantations. It is generally a small holders crop and mostly meets the demands of domestic and local consumption.

Saltwater intrusion into the rice paddy land bordering the lagoon has always been a serious problem (see **Chapter 3**) and various schemes have been established to reduce this. However this problem has grown worse in recent times since the removal of the sand bar at the mouth of the lagoon. Now, rice paddy cultivation is seriously affected by the uncontrolled inflow of seawater through the mouth of the lagoon which has raised the water levels in about 500ha of rice paddy land bordering the lagoon, forcing many farmers to abandon rice paddy cultivation altogether. The overall economic loss to the farming community as a result of this has been extensive. The extent of previously productive rice paddy land in the sample six divisions which has been abandoned due to the problems described above is displayed in the land-use maps. In Kahanda and Polhena only one third of the rice paddy land in the divisions has not been affected by flooding. The remaining two thirds have become uncultivable.

Home gardening in the past had been promoted by the agricultural authorities covering the study area, and until recently was practised by a majority of families in the sample six divisions. This small-scale cultivation of vegetables was largely for sale and provided an important additional means of income to a number of families. Some of the farmers interviewed had been involved in gherkin cultivation projects for a company exporting these vegetables. These projects required very high inputs of agro-chemicals all of which were provided by the sponsoring company and had been initially very profitable. However, interviews conducted with the farming community reveal that the recent flooding of homesteads which is now experienced in the area has resulted in the scale of home gardening being gradually reduced. In addition cattle, water buffalo, goats and poultry are also raised by residents of the study divisions.

7.4 The Farming Scene in Koggala

In Koggala, rice paddy cultivation is predominantly confined to smallholdings often less than 1 hectare in size, maintained mostly by tenant farmers. Interviews conducted with the farming community indicate that this group is no longer able to rely on the cultivation of rice paddy alone as their sole means of income, as had been the case in the past. The rising costs of agro-chemicals on which they are dependent and the phasing out of Government subsidies on them, lack of ownership, and external environmental pressures that are beyond their control (see **Chapter 8**), have meant that many of the farmers are compelled to engage in additional forms of employment to supplement the income they get from rice paddy cultivation. It is in this context that a survey of the farming community was undertaken, in an attempt to investigate the changes experienced by this key group and the various adaptations they have had to make.

7.4.1 Case Study 1: The Farmers

The following discussion is based on interviews and questionnaires conducted with a total of 130 farmers living in the sample six divisions (see Figure 7.9). All the farmers who figured in the survey were engaged chiefly in rice paddy cultivation though they also cultivated tea, but on smaller plots of land. They also took part in the small-scale farming of vegetables along the contours of rice paddy fields, mostly for home consumption.

Figure 7.9 Number of farmers interviewed during survey

GN division	Official figures relating to the number of farmers in each division	Estimate of number of farmers in each division (author's field surveys)	No. of farmers interviewed from each individual GN division	% of farmers interviewed from each individual GN division
Polhena 154B	55	75-80	25	31%
Palessa 166C	140	150-60	30	19%
Koggala Athireka 1 144D	-	10-15	5	33%
Kahanda 167	63	90-95	35	37%
Harumalgoda East 149A	17	30-35	15	43%
Alawattukissagoda 164G	-	55-60	20	33%

(Source: Present study)

With the introduction of new hybrid varieties of rice it has become essential to use agro-chemicals, and it was the opinion of all the farmers interviewed that they have been reduced to a state where they cannot expect to achieve productive yields without their use. With regard to the economic viability of pesticide use, the farmers pointed out that the overall cost of the chemical inputs required to sustain the HYV's, and the frequency with which they have to be used, placed them in a very difficult situation. One farmer quoted a common village saying to sum up the situation by stating it was like 'holding onto a tiger's tail.'

Another farmer illustrated the various issues being raised by explaining that a field which required one bushel of rice to cultivate would in turn yield between 12-18 bushels of rice without the use of agro-chemicals. Yet the same field would yield 42-48 bushels of rice if the recommended doses of agro-chemicals were used (see Figure 7.10) . However, when the latter yield was compared with the total investment on agro-chemicals the whole exercise seems uneconomical, especially given the escalating prices from one season to the next. All the farmers interviewed bought their requirements of agro-chemicals from the two main trading outlets - Wimal Agro-chemicals and NRM Traders, and relied to a lesser extent on smaller shops situated closer to them. The reason for this was that if they visited either of the two main trading outlets they had the added advantage of being able to ask questions from the traders who were supposedly knowledgeable on the use of the products.

Figure 7.10 Estimated rice yields in the study area

	Approximate yield from one bushel of rice	**Ideal conditions**
Pre - Green Revolution	6-8	12
Green Revolution	24	36-48
Post sand bar destruction and flooding	5	30*

(Source:Present Study)

* this figure relates to areas where flooding is not a problem.

The agro-chemicals commonly used by the farming community are listed together with notes relating to the their potential environmental effects, regulatory status and the active ingredient in Figure 7.13 and 7.14. Eighty two per cent of the farmers interviewed were very familiar with the different types of pesticides made available to them. According to them this was due to intense promotion. The farmers revealed that virtually every medium is used to persuade them to use agro-chemicals. They named sales representatives, billboards, newspaper and journal advertisements, radio and t.v and posters. However, 56% of the farmers interviewed felt that these marketing practices were not consistent with sensible pesticide use and pest control. As a result of this, brand names are generally favoured over standard generic names and 49% of farmers interviewed were not aware of the identity of the active ingredient in the pesticides they were using.

Box 7A A summary of Agricultural practices relating to rice paddy cultivation and the use of agro-chemicals.

Stage 1

Approximately four weeks after the first harvest the paddy fields are sprayed with Gramoxone (Paraquat) which is a total herbicide (see Figure 7.11). After this the fields are irrigated and the water is let out approximately three days later.

Stage 2

The ground is tilled shortly after stage one using a hand tractor and very rarely this operation is done using water buffalo and a harrow (see Figure 7.11). The ground is then levelled using a mammoty (hoe). Sometimes this is done by the use of a tractor fixed with a levelling gadget.

Stage 3

Using a hoe the paddy fields are divided into plots averaging ten square metres, the plots are made following the topography of the land and are separated by channels to facilitate easy drainage of water. A permanent bund is built around the paddy to provide a path on which to walk without having to step on the rice plant beds. At this stage fertilisers containing Nitrogen (N), Phosphorous (P) and Potassium (K) in the following proportions- 5:15:15. are applied to the soil at the rate of 100kg per hectare.

Stage 4

Germinated rice seeds are broadcast and after a period of 7-14 days during which time the seedlings are about 3-4 inches above the surface a mixture of 36% 3,4 D.P.A (herbicide) is applied to the paddy. This is a relatively costly exercise which poor farmers avoid. Instead the latter wait for about 21 days and then apply a herbicide according to their choice (see Table 7.14). When the weeds have died out the fields are maintained in a semi-flooded state with irrigated water for at least 2-3 days.

Stage 5

Fertilisers containing Urea, Phosphate and Potash are used at this time by farmers who did not use them earlier.

Stage 6

45 days after sowing fertilisers containing N:P:K at the rate of 75kgs per hectare is applied to the rice plants in the following proportions - 30:20. At the time of flowering insecticides are administered to the plants.

- The insecticides/fertilisers and herbicides used vary according to each farmers individual preference.

(Source: Present study).

A: Post harvest spraying of rice field in Polhena 154B with Gramoxone.
(Source: April 1994, V.N. Samarasekara)

B: Rice field in Kahanda 167 tilled using a harrow driven by water buffalo.
(Source: May 1994, V.N. Samarasekara)

Figure 7.11 Farming methods in Koggala.

Box 7A summarises the agricultural practices followed by the farmers in the study area with special emphasis on the application of pesticides on rice paddy. It should be noted here that it is very difficult to assess exactly the application rates of pesticides as these depend on the individual farmer but generally they are employed whenever the plants are being attacked. However there are two main phases when insect attack is especially high, this is when the plants are very young or when they are flowering and the seeds are in the process of being formed.

Since some chemicals have relatively long periods of residual effects (Prot & Matias,1990; Tejada *et al.* 1994), it is generally recommended that their application be stopped at least two weeks before harvesting. However interviews conducted in this regard suggested that non-adherence to this requirement was extremely high. The present survey indicated that about 50% of the farmers in the study area have harvested paddy lands within a period of one week of applying agro-chemicals. This also applies to crops grown on village homesteads. These findings were later confirmed during discussions held with the agricultural extension officer at the Local Regional Council.

A majority of the farmers interviewed (68%) expressed concern over the environmental effects such prolonged pesticide use had on soil structure, which they believed had changed significantly for the worse (see Figure 7.12). According to one farmer owning paddy land in the Maswela *Yaya* (Sinhala: tract) in Alawattukissagoda, when agro-chemicals were not employed during the cultivation season within 2-3 days of broadcasting the rice paddy, earthworms and other ' friendly organisms' were observed in the soil. This he believed had the effect of making the soil more fertile. However, since the introduction of pesticides such organisms are rarely seen and it was one of the contributing factors accounting for the observed changes in soil structure. Chlordane, which is available to farmers in the study area, is highly toxic to earthworms (Bull, 1992). Gramoxone (Paraquat) was cited on more than one occasion as being especially harmful in this sense. Most of the other farmers interviewed narrated similar experiences.

Similarly 57% of the farmers were concerned about the species specificity of some of the pesticides they were using. For example farmers recalled that in the past when they were not using agro-chemicals, rice paddy fields and interlocking fields would be filled with small fish and also crabs which they believed helped combat insects harmful to the crops they were cultivating. Now according to the farmers interviewed these organisms are no longer present. Thus from the discussions it was very evident that the majority of farmers felt that the reduction of many of these 'friendly' organisms was as a direct result of the intensive use of pesticides.

During the interviewing process the older farmers described nostalgically some of the traditional methods of farming their fathers had employed in the past. Most of this indigenous knowledge relating to traditional agriculture is knowledge that has been passed down from generation to generation. In some instances this cultural knowledge is passed on as folk wisdom or folk tales or else as rituals and religious practices. For example, to guard against weed control in the rice paddy fields, farmers would first flood the fields and, using the heavy stem of a banana plant, they would push the weeds below the surface of the water. This ingenious process had the effect of suppressing the growth of the weeds and in so doing allowed the rice seedlings to grow without competition. Flooding of the rice paddy fields was another ingenious method by which the farmers traditionally controlled their rice paddy from insect attack. Both the methods outlined above are still carried out in the study area.

Figure 7.12 Perceived Reasons for the observed decline in rice production in the study area

Perceived Reason for decline in Rice Production	**% of Farmers interviewed sharing this opinion**
Changes in rainfall i.e. rains did not come on time and started when the farmers were ready to harvest the fields.	**8%**
Contours and bunds not properly built - mainly as a result of '*Thattumaaru*' system.	**15%**
Increasing salinisation of land.	**55%**
Increased resistance to chemical means of control.	**22%**

(Source: Present study)

It had also been common practise to guard rice fields from insect attack by providing perches to attract birds to forage there. Similarly torches made from rags soaked in coconut oil would be placed on poles in the paddy fields in the hope that the insects that were attacking the rice paddy would be attracted to the light and so destroyed in the process. In addition to some of the methods outlined above, it was very common for farmers to perform prayers and also to employ charms handed down by tradition to safeguard their crops. Young coconut leaves would be used in these rituals and even today they are often seen hanging in many rice fields prior to cultivation. Often all cultivation activities would begin on astrologically selected auspicious days preceded by some of the rituals listed above. However it should be noted that, though some of these traditional farming methods outlined above still continue, it is on a much smaller scale. Today a vast majority of farmers in the study area are dependent on chemical means of pest control.

The increasing number of rice paddy fields being abandoned in the area as a result of salinisation problems is a matter of major concern. In the past terracing was used to prevent the brackish water from the lagoon entering the paddy fields but this is no longer effective. In Polhena for example, there are a total of 75 hectares of rice paddy, of which 50 hectares have been adversely affected by salinisation problems and can no longer be cultivated. According to the farmers living in this division this number is steadily on the rise. In the village of Duwamalalgama which is situated in the GN division of Harumalgoda East a small group of farmers have developed ingenious methods to prevent salt water affecting their crops. Examples of such methods include making contours as high as two feet so that the root systems of the seedlings escapes saline inundation. A new hybrid variety locally known as '*Mawee*' is being gradually introduced to the area on an experimental basis as it has a greater tolerance to salinity and the stalk of the plant is relatively stronger and taller than the varieties presently used.

7.4.2 Case study 2: The Agro-Chemical Traders

The following account is based on interviews and visits to Wimal Agro-chemicals (Titthagalla) and NRM Traders (Angulugaha), the two main outlets registered with the Government, specifically for trading in agro-chemicals in the Koggala area (see Figures 7.13 and 7.14). Both these outlets are responsible for supplying agro-chemicals directly to farmers and to smaller retail outlets falling within the boundaries of the study area (a list of traders selling agro-chemicals which serve the study area are given in **Appendix 3**). In addition to these two main sources, supplementary information was obtained from interviews arranged with the Agricultural Extension Officer based at the Local Regional Council office.

A total of nine main manufacturing companies supply Wimal Agro-chemicals and NRM Traders with agro-chemicals and related products. These are displayed in **Appendix 4,** together with a list of smaller shops which also sell agro-chemicals within the boundaries of the study area. Though both main outlets sell broadly the same agro-chemicals covering rice and tea cultivation, NRM Traders has a wider selection of pesticides and fertilisers for use in vegetable gardening. A comprehensive list of the main agro-chemicals used by the farming

Figure 7.13 Agro-chemicals used in Koggala with notes on potential environmental effects and status as assessed by the World Health Organisation (WHO)

ACTIVE INGREDIENT	WHO STATUS (WHO, 1995)	ENVIRONMENTAL EFFECTS
Paraquat	Solid Class II Moderately Hazardous	A potential groundwater contaminant. Moderately toxic to birds and aquatic invertebrates, and slightly toxic to fresh water fish (Johnson, 1980).
Propoxur	Class II Moderately Hazardous	Propoxur is toxic to fish as well as other animals that eat fish (Hartley & Kidd, 1983). Birds feeding on propoxur treated areas may be killed (Thomson,1985). It should not be applied to tidal marshes or estuaries and should be kept out of streams and lakes (Thomson,1985).
Endosulfan	Solid Class II Moderately Hazardous	Considered extremely toxic to aquatic life (Peterson & Bailey, 1993). Endosulfan can be transported over long distances and has been found in surface water outside the spraying season. The Natural Wildlife Federation warns that birds feeding in treated areas could be killed.
Fenthion	Class Ib Highly toxic	Highly toxic to birds (McEwan,1979) and moderately toxic to fish (TOXNET,1985). As a result of its persistence and therefore ability to bio-concentrate it should be kept out of lakes and streams, and should not be applied where run-off is likely to occur.
Lindane	Solid Class II Moderately Hazardous	Highly toxic to some aquatic organisms, bees and certain beneficial parasites and predacious insects. Residues of lindane have been found world-wide. Evaporation and air transport of lindane play a major role in environmental contamination (Smith, 1991).
Chlorpyrifos	Class II Moderately Hazardous	Highly toxic to freshwater fish, aquatic invertebrates and estuarine and marine angio-sperms (US EPA,1989). It is known to accumulate in the tissues of aquatic organisms at very low levels (Racke, 1992, Howard, 1991)
Carbofuran	Class Ib Highly toxic	Very toxic to fish, birds and wildlife and toxic to a variety of beneficial invertebrates. It has a high potential for groundwater contamination. Run-off may cause pollution of lakes and streams (Tomlin, 1991).
Monocrotophos	Class Ib Highly toxic	Potential for groundwater contamination. One of the most toxic pesticides to birds. Highly toxic to birds and modestly toxic to fish (Meister,1992).
Metamidophos	Class Ib Highly toxic	Highly toxic to terrestrial organisms. Detected in soil run-off water only in the first five irrigations (Smith, 1991).
Parathion	Class Ia Extremely toxic	Parathion is highly toxic to birds and moderately toxic to fish and aquatic invertebrates (Worthington,1987). Sunlight can convert parathion into the active metabolite paraoxon, which is more toxic than parathion.
Dimethoate 40% EC	Class II Moderately Hazardous	Very toxic to birds and highly toxic to fish and aquatic invertebrates (Montgomery, 1993).
MCPA	Class II Moderately hazardous	Moderately toxic to wildfowl, slightly toxic to freshwater fish (Tomlin, 1991).
3, DPA 36% Propanil	Class II Moderately hazardous	Moderately toxic to fish and acutely toxic to birds (Tomlin,1991).

(Source: Present study)

Figure 7.14 List of Agro-chemicals used in Koggala with notes on active ingredient, use and regulatory status

TRADE NAME	ACTIVE INGREDIENT	USE	REGULATORY STATUS
Gramoxone	**Paraquat**	Herbicide	Paraquat is a restricted use pesticide and in UK is subject to the following restrictions:sales and record keeping (Jan1986), labelling, storage, and transport (Apr 1982) (EXTOXNET, 1993).
Unden EC 20% *	**Propoxur**	Insecticide	Propoxur is currently registered by the US Environmental Protection Agency as a general use pesticide. Must bear the signal word 'danger' or 'caution' (EXTOXNET, 1993).
Endosan EC 35% *	**Endosulfan**	Insecticide	Endosulfan is classified as highly toxic substance and carries the word 'danger' on the label (EXTOXNET,1993). Endosulfan use in UK is subject to the following restrictions:sales and record keeping (Jan1986), clothing precautions (Aug1984), and labelling (Apr.1982) (Watterson, 1988).
Lebaycid EC 50% *	**Fenthion**	Insecticide	Classified by the US Env. Protection Agency as a restricted use pesticide and may not be used on food crops (Berg,1988).
Gammex	**Lindane**	Insecticide	The use of Lindane products in USA for direct application to aquatic environments is prohibited (UN,1994). EPA requires a warning statement on labels due to carcinogenicity (EXTOXNET,1993).
Mackphos 200	**Chlorpyrifos**	Insecticide	The Environmental Protection Agency (EPA) has established a 24-hr re-entry interval for entering crop areas treated with emulsifiable concentrate. Products containing chlorpyrifos must bear the signal warning or caution (Meister,1992).
Curaterr 3% granules	**Carbofuran**	Insecticide	Approved for use in the UK with special controls; full protective clothing must be worn. Liquid formations of carbofuran are classified as Restricted use pesticides. The EPA has formulated a ban on granulated forms (USEPA,1991).
Baurs Monocrotophos	**Monocrotophos**	Insecticide	Not cleared for use in the UK but manufactured here. Voluntary cancellation in the USA in 1988 (Briggs, 1992).
Tamaron EC 60% *	**Metamidophos**	Insecticide	Not approved for use in UK(EXTOXNET,1993).
Bayer Folidol E605	**Parathion**	Insecticide	As a result of its highly toxic nature it is classified as a restricted use pesticide (Meister,1992). The EPA intends to cancel all uses of Parathion in the near future. Products containing Parthion must bear the signal word 'danger'. Parathion use in UK is subject to the following restrictions;sales and record keeping; clothing precaution and labelling (EXTOXNET,1993).
Red Star Dimitox 40	**Dimethoate 40% EC**	Insecticide	Must bear the word 'warning' (Meister,1992).
Mackwoods M40	**MCPA**	Herbicide	Classified as a restricted use pesticide by the US EPA (EXTOXNET,1993).
Red Star Weedex 36	**3, DPA 36% Propanil**	Herbicide	Products containing propanil must bear the signal word 'danger' (Meister,1992).

(Source: Present Study)

* Percentages shown indicate the percentage of the active ingredient in the compound, as noted in trade label.

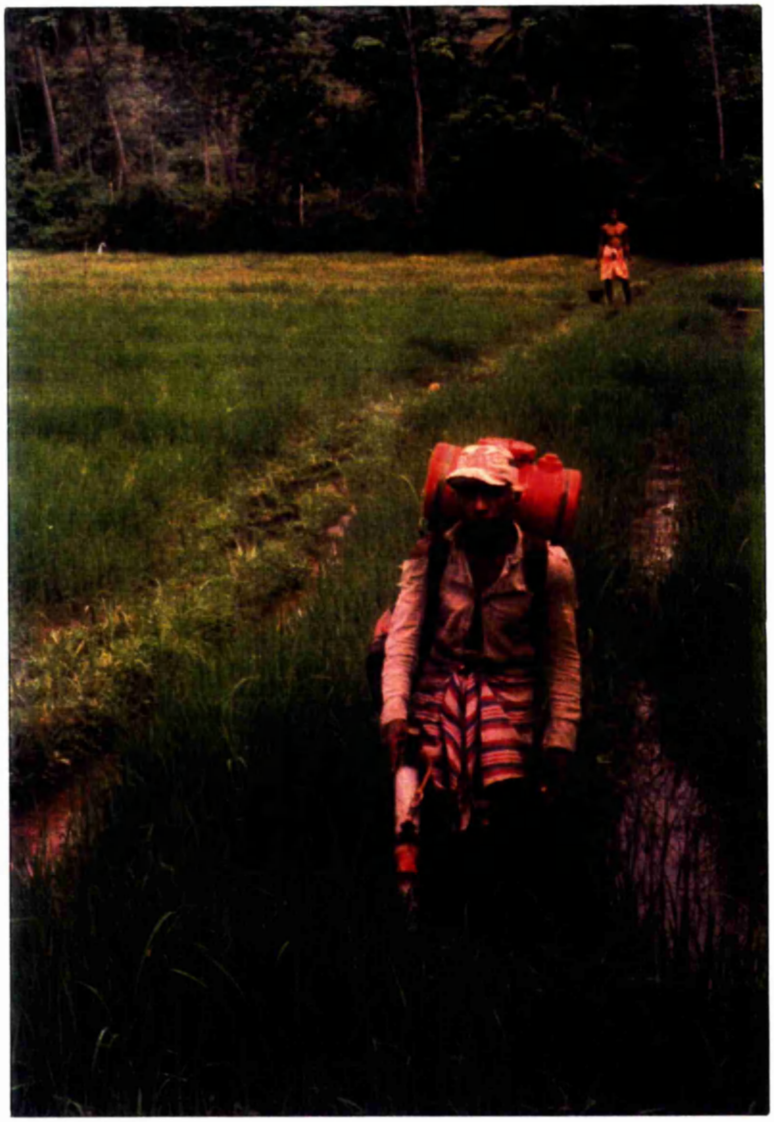
community based on interviews conducted with the main retail outlets in the study area and confirmed by the farmers themselves is shown in Figure 7.13. In both outlets training relating to application procedures and safety aspects of the agro-chemicals sold is limited to workshops sponsored by the manufacturing companies that supply them. These workshops are held approximately twice a year in the Labuduwa Agricultural Training Centre in Galle and occasionally at the Agricultural Centre in Gannoruwa in Peradeniya. Though both outlets have Government permits to indicate they have had adequate training relating to the agro-chemicals they sell, the opinion of the shopkeepers is contrary to this. In the opinion of the traders the vast majority of farmers buy agro-chemicals on the basis of the information given by salesmen and also through hearsay. On occasions farmers have been known to describe a particular infestation and also to bring affected plants to the shop in order to select the appropriate chemical. The influence of advertising (e.g. posters, newspapers and television) by manufacturing companies is also an additional factor.

The traders maintain that when agro-chemicals are sold details relating to safety aspects or health precautions are not given as they feel that the instructions given on the label are adequate. The same is also true for application methods, doses, etc. which are not given unless specifically requested by the farmers. Thus, in these circumstances, it is not surprising to see used pesticide containers being utilised in village homes and also a lack of protective and safety measures being taken by those people directly involved in using agro-chemicals.

7.4.3 Case Study 3 : The Sprayers

The spraying of agro-chemicals on large areas of rice paddy fields and tea land within the study area is commonly performed by two farmers, K.A Sunil and K.G Dharmasena, who are employed on an *ad hoc* basis for this purpose. Both these farmers own their own hand pumps for spraying and have been involved in spraying agro-chemicals for at least ten years. The following account is based on in-depth interviews conducted with them.

In spite of not having any formal training in the recommended applications and safety aspects relating to the agro-chemicals they use, both farmers claim, that since they have been using the same agro-chemicals every season, they have the necessary experience and training regarding the appropriate dosages to be used. During busy periods in each season, they could be spraying rice fields continuously for up to 5 hours per day, despite the fact that poisoning through the skin is more likely in the heat of the day (Dinham, 1993). In this time they would need to refill the tank which holds the agro-chemicals on a average of about 22-30 times. Both farmers believe that the hand pumps they use to administer agro-chemical are much more economical to use than machine-operated pumps. Unlike machine-operated pumps, they feel that the chemical is not carried by the wind to the same extent.



A: Spraying pesticides on rice fields in Polhena 154B with motor operated sprayer.

Figure 7.15 Pesticide use in Polhena 154B.
(Source: July 1994: V.N. Samarasekara)

This is a real problem with machine-operated pumps which spread the chemicals over a wider area affecting households in the vicinity with the overpowering smell of chemicals.

According to these two farmers a problem they faced was the quality of the pesticide application equipment they possessed. The sprayers were in bad condition and leaked. Though sprayers can be hired from the agricultural extension service located at the Local Regional Council this was an added expense which they could not afford. Both the farmers interviewed did not use any protective clothing while administering agro-chemicals to the rice fields (see Figure 7.15). This had been observed by the author during field surveys where these farmers had been observed using backpack sprayers with no eye protection or footwear. They were also observed chewing betel and also smoking while handling the spraying equipment. When questioned about this obvious lack of safety measures, both farmers admitted that they were aware of the risks associated with not using protective clothing, especially face masks. However due to the hot and humid conditions under which they had to work this made wearing protective clothing a further hindrance. The only safety measure they took was not to spray against the wind.

Both farmers are also aware of the ill-effects of the agro-chemicals they use. This was demonstrated by K.G Dharmasena who recounted one occasion when he washed his spraying equipment after a days work in a nearby stream, and observed within minutes of doing this a number of dead fish floating on the surface of the water. Surveys revealed that the empty cans and bottles of pesticides are carelessly disposed of. Both sprayers admitted that they generally sold the empty containers to shops in the area who in turn would sell them to members of the community.

As a result of this continued exposure to agro-chemicals both men feel that their health has suffered a great deal. They both complain of boils and eczema-like patches on their skin. K.A Sunil believes the nylon belt which he places across his shoulder to hold the spraying tank in place has done the most harm as it holds the spray close to his skin. In addition, the constant mixing of agro-chemicals before application also means that they come in close contact with his body. K.G. Dharmasena suffers from weak eyesight and can no longer read. He firmly believes that his loss of vision is linked to the chemicals he has been handling over the years.

7.5 Summary of Key Themes

- The farming community in Koggala has over the years been subjected to many disruptions which have resulted in changes in traditional patterns of farming and resource use. Together with environmental constraints, this has meant that the traditional role of the farming community has been increasingly marginalised. The destruction of the sand bar, and its effects on flooding and subsequent salinisation of rice fields in recent times, has accelerated the rate at which this marginalisation has taken place. The introduction of hybrid varieties of rice in the 1970's and associated intensive farming techniques involving the use of agro-chemicals are also of major significance.

- The study area suffers from all the problems commonly associated with agro-chemical use in the developing world. Unavailability of protective equipment and misinformation lead to pesticide misuse and overuse. In response to pesticide resistance, farmers use stronger doses and increasingly frequent pesticide applications. While no systematic research is available except what has been observed, anecdotal reports of farm-worker poisonings and pesticide residues on food are common to the study area.

- The increasing costs of chemical inputs forces marginal farmers into serious economic difficulty. In addition to these problems, the Sri Lankan bureaucracy and market system encourage pesticide use which ultimately leads to abuse. The aggressive promotional drives undertaken through the mass media and attractive advertisements and labels have contributed significantly to the increased use of pesticides seen today in the study area. Under trade liberalisation policies witnessed during the past ten years, the availability of pesticides has not become a constraint (except for increasing prices) to those using these substances. The study area is an example of this where the trading activities of agro-chemicals has become significant.

- Many of the agro-chemicals used are of a hazardous nature and belong to some of the most toxic groups. The potential harm done by these chemicals is made worse by the lack of safety precautions taken by the farmers as a direct result of inadequate training given by the manufacturing companies. Though individual farmers have responsibility for their own safety, and should ensure as far as possible that they use the products in accordance with sensible and recommended standards, they are only able to exercise these responsibilities, insofar as they have access to full, correct and usable information.

- In addition to the health risks for farmers and consumers, the high costs of pesticides and other inputs associated with 'modernization,' together with increasing salinisation of rice paddy lands in the study area, they are eroding the economic viability of agriculture in the region. As input prices increase and government subsidies are removed, farming is becoming less and less viable. The universality of this problem is evident in the literature (Byres, 1983; Geradin, 1985; Hansara & Shukla, 1991; Sharma & Dak, 1989; Weerahewa & Gunawardena, 1990; Weir, 1981; Wolf, 1986; Wong, 1987).

- The yields of the HYV's when compared with the overall investment on agro-chemicals are not economically viable. Together with this the abandoning of rice paddy cultivation in many areas due to salt water inundation (see **Chapter 5**), the traditional role of the farmers is changing. Plans to build an airport on previously productive rice paddy land which have been abandoned due to salinisation problems (pers. comm Lokuhettie, 1993) further illustrates how traditional rice paddy farming is slowly on its way out in the study area. Increasingly it is the case that the farmers can no longer depend on agriculture as their primary source of income as had been the case in the past. Consequently they are forced to look for other sources of income mainly as casual labourers (see Chapter 3). For many their hopes are reflected in the KEPZ but the reality is that very few have been able to secure jobs there.

- **Chapters 6** and **7** have discussed at length the many problems the Fishing and Farming communities in Koggala have been facing. These problems, of a contrasting as well as a interacting nature have figured prominently in the Discussion groups that were held. In **Chapter 8** an analysis is made of these group perceptions of environmental change, especially those stemming from the Discussion groups.

CHAPTER 8
KOGGALA LAGOON 4: AN ANALYSIS OF GROUP PERCEPTIONS OF ENVIRONMENTAL CHANGE

8.1 Introduction

This chapter presents the key findings of discussion groups conducted with the local communities in the sample six divisions, in an attempt to assess local perceptions of environmental change. The main aim of conducting the discussion groups was to assess perceptions of wetland values, to encourage participants to provide an historical framework on which to assess the rate of environmental change, and finally to explore reasons which could account for some of the observed changes. A central objective of this process was to initiate local-level adaptive planning for the lagoon and its environs. The chapter represents the final stages in the overall analysis of environmental change in Koggala Lagoon and its environs. It presents in detail, the knowledge, cognition and awareness of the key people who have a stake in the lagoon and its environs. These people ultimately pay the price for any transformations which have an impact on local resource use.

The structure of this chapter is as follows. Section **8.2** outlines the framework for understanding environmental change in the study area and describes the analytical setting of the discussion groups. Section **8.3** discusses the value of the group discussion as a research tool in the context of conducting research in developing countries. The key findings of the discussion groups are presented in Sections **8.4, 8.5** and **8.6**. Lessons learned from this experience, and their broader implications for wetland management, are discussed in Section **8.7.**

8.2 A Framework for Understanding Environmental Change

Using examples from South and Southeast Asia, Chapter 2 demonstrates that more people than ever before are dependent on coastal areas. Pressures on South and Southeast Asian coastal resources are severe and natural resource depletion in the coastal zone along with environmental degradation are becoming serious problems. This situation is reflected in Sri Lanka as a whole and is particularly relevant to the study area.

In its entirety, Koggala Lagoon, together with its water supply and flow, the fisheries, the mangroves, the agricultural land and the humans that depend on these resources, represent many of the coastal resources and ecosystems typical of Sri Lanka's southern coast. The coastal resource systems are diverse and rich in both ecological and economic terms with the area and its parts interconnected, each part having its requirements for survival and limits of use. Unfortunately, the trend towards abuse is increasing in Koggala (see **Chapter 3**). Since the population in this region is rising, competition over limited resources is more keen and signs of depletion are evident.

During the recent past, the multiple uses this wetland system has served, which include fishery, agriculture and habitation, have expanded with increasing urbanisation and industrialisation of the area. This has led to visible degradation of the ecological complex, stemming from increased settlement, intensification of fishing pressure, increased industrial activity and general habitat destruction. All these factors are undermining the ability of the wetland ecosystem to support its multiple uses. Thus the natural productivity of the wetland is presently under serious threats stemming from existing and prospective resource use conflicts. The combined effects of these changes have been heartfelt by the resident fishing and farming communities who are dependent on the lagoon and its resources.

To summarise, the experience of Koggala Lagoon represents a classic example of conflict over access to the 'natural' resources in the area. It presents the constraints and opportunities facing the local communities in ongoing struggles over the environmental foundations of their livelihood which have been affected by ecological transformations largely beyond their control.

8.2.1 Analytical Setting of the Discussion Groups

One of the major problems facing Koggala Lagoon is the rapid decline and deterioration of its coastal resources - a problem common to the coastal areas of most of South and Southeast Asia. Traditionally the area has supported a largely subsistence-level economy based on agriculture and fishing. However, in the last two decades, the new economic opportunities generated together with rapid development activities have heavily impinged on the available natural resources. It is in the context outlined above that a study of group perceptions to environmental change in Koggala was undertaken drawing from preliminary findings of surveys conducted separately with the agricultural and fishing communities in the sample six divisions. A scheme illustrating the relationship between the present investigation and the overall context of the research is shown in Figure 8.1.

It is essential that an assessment of environmental change in Koggala must involve the local communities living in the wetland area as they are the primary user groups. These local communities parallel the natural resources with their livelihoods and are aware of the problems

Figure 8.1 Scheme illustrating the relationship of the present investigation in the overall context of the research.

Stage 1

↓

Assessment of extent of Environmental Change in Koggala Lagoon

Stage 2

↓

An Evaluation of the Effects of Observed Environmental Changes

Stage 3

↓

1.Farming Community

2.Fishing Community

Stage 4

↓

An Analysis of Group Perceptions to Environmental Change

Stage 5

↓

Community based planning for Wetland Management of resource depletion and environmental degradation. With this in mind it was the aim through discussion groups to:

- Assess local perceptions of wetland values;

- Provide an historical framework on which to assess the rate of environmental change. Here local communities were encouraged to share their own analysis of the history of environmental change in the area by creating an 'ethnoecological history'. This was used primarily to gain an historical perspective of the manner the local communities and the 'natural' resources had interacted over time. In this way an identification of the environmental problems of the area could be made by encouraging the local communities to think how recent environmental changes might have affected their lives;

- To investigate social factors which could account for some of the observed environmental changes.

This chapter describes the outcome of group discussions carried out with and by local communities living in the sample six divisions (see Figure 8.2). In addition, supplementary information was gathered from meetings with members of the community that had been re-housed in preparation for the KEPZ. These residents, who were all from a fishing background, were moved to Eddunkele, a village well into the interior of Koggala and re-housed in a farming community - a cause of great social tensions. It was decided that meetings with key individuals from this community highlighted in preliminary surveys as informants would provide a useful means of checking the data that emerged from the discussion groups conducted in the sample six divisions. These informants still continued to depend on the lagoon and the sea as their main source of income despite of the great distance they had to travel from this village to fish there. Discussions were also held in the KEPZ and BOI, (Board of Investments - responsible for the KEPZ) in Colombo with key officials. These ran for shorter periods of time and were used as a means of checking information gained from the discussion groups held in the sample six divisions. Lessons learnt in the light of this experience and its broader implications for wetland management plans in the area are discussed in **Chapter 9**.

Discussion groups were conducted in all of the sample six divisions over the research period and details relating to the planning, size and conduct of these groups are presented separately in Chapter 4, together with details relating to individual group composition and participant selection. The discussions were conducted in Sinhala, the local language understood by all participants.

A: Discussion Group 3 - Koggala Athireka 1 144D.
(Source: October 1993, K. Issacs).

B: Discussion Group 2 - Duwamalalagama (Harumalgoda East 149A).
(Source: September 1994, V.N. Samarasekara).

Figure 8.2 Group Discussions in the Study area.

Each meeting was recorded and transcripts were prepared which were later translated into English. This chapter will present the key findings of the groups.

8.3 The Group Discussion as a Research Tool

Despite the recognition of the cultural embeddedness of environmental values (Burgess & Gold, 1985; Cohen, 1976), empirical social research in this field is narrow and limited in its focus (Burgess *et al.* 1988). It would seem that a lack of methodology is the main reason behind this shortcoming as it is now recognised that quantitative analyses are not suitable media for discovering peoples feelings and meanings for the environment (Burgess *et al.* 1988). The problem with surveys is that they are composed of a series of questions used to elicit verbal answers in a face-to face interview. In addition there are problems with the way questions are framed and answers interpreted which reveals little about the social and cultural contexts in which values, perceptions and opinions have been shaped. Therefore a methodology seeking to explore people's perceptions of environmental change in Koggala had to take into account personal, social and cultural meanings of perceptions as they are expressed in ordinary conversations.

In applied qualitative research, more attention has been given to group discussions (Banks, 1957; Walker, 1985). They have been used widely, particularly in the developed world, as a means to investigate environmental values (Burgess *et al.* 1988), media research (Burgess *et al.* 1991; Morley, 1980; Silverstone, 1985; Corner *et al.* 1991) and as a means to explore social constructions of Nature (Harrison *et al.* 1994). In sharp contrast, such an approach has been neglected in developing countries where its use has great potential as a research technique which can be readily adapted to fit a wide number of circumstances. For example, in the case of Koggala, the use of the group discussion as a means to understand group perceptions has important implications for resource management programmes. This can be illustrated by the question of whether researchers are sufficiently capable of correctly identifying the problems on which research had to be done, a topic which repeatedly arises in management programmes of this nature. The relevance of this question emerges when it is recognised that usually such individuals are not as dependent on the resource as the local communities there, and are thus not very capable of understanding the repercussions of the loss or depletion of the resource.

In spite of this recognition, the prevailing system of management planning in Sri Lanka, which also applies to most parts of the developing world, enables research to be carried out by individuals whose perceptions of a resource are very different from those of traditional users. Given this background, an understanding on the part of resource managers of local perceptions is crucial especially in the context of the overall implementation of sustainable management plans. This has been summarised by Samarakoon and Palliyaguru (1988:3), who use the example of mangrove ecosystem management. They state: " a mangrove ecosystem manager basing his outlook on ecological functions may avidly push for protection of this vegetation. The mangrove user such as an artisanal fisherman bears the immediate cost by losing access to a resource. If a decision is taken to protect mangroves without consideration given to needs of the artisanal fisherfolk, the result will be another unenforceable law in the face of which mangrove extraction will continue anyhow."

Given the inadequacies of conventional research approaches which have been highlighted in **Chapter 4**, the emergence of participatory research facilitated through the use of the discussion group provided a means to make the research relevant to the socio-economic context, as well as providing a learning process for those being 'researched.' The local communities in Koggala constitute a rural group who are not accustomed to being heard in the public arena. The use of the discussion group provided a means to change that attitude as repeated discussions showed. Talking, and being heard, in these groups were very valuable exercises in gaining self-confidence, which helped them to clarify and explain their views better.

8.4 Group Perceptions of Environmental Change - An Analysis

In-depth surveys conducted separately with the fishing and farming communities revealed that members held very different sets of beliefs and attitudes both about the scale and the causes of environmental change in Koggala. These were in accordance with the individual degree of dependence each of the groups had on the lagoon. Measures had been taken at the start to incorporate a combination of members from the two main communities in each of the groups. This was done to present different resource-user views together, and to avoid groups concentrating only on those changes that affected them and thus developing into support groups. By combining members of the two main communities together, it was hoped that a variety of viewpoints would emerge adding a further stimulus for discussion. In this way it was more likely that the participants, by listening to different viewpoints, would be able to resolve differences of opinion amongst themselves and emerge with reasonable management options. The composition of each of the six discussion groups is displayed in Figure 8.3.

One of the primary aims of conducting the discussion groups was for the participants to be able to come to their own analysis of their conditions. In this connection the use of visual aids and diagrams were employed to enable them to analyse and act on the basis of their own

Figure 8.3 Composition of Discussion Groups

	Dates convened	Age group years	No. of males	No. of females	Farming participants	Fisher participants
Discussion Group 1 Kahanda /Polhena	25.10.93 17.10.94 (29.10.95)	0-15 15-65 >65	1 8 6	0 6 4	22	3
Discussion Group 2 Duwamalalgama	5.8.93 28.9.94 (4.11.95)	0-15 15-65 >65	0 10 7	0 4 4	5	19
Discussion Group 3 Koggala Athireka	15.10.93 21.7.94 (1.1.95)	0-15 15-65 >65	0 8 6	0 6 5	4	21
Discussion Group 4 Alawattukissagoda	18.10.93 6.10.94	0-15 15-65 >65	 11 4	 5 3	16	6
Discussion Group 5 Pelassa	18.10.93 6.10.94	0-15 15-65 >65	 8 5	 6 3	18	5
The KEPZ / B.O.I	14.7.93 21.7.93 11.9.94					

(Source: Present study)

knowledge, priorities and diverse needs. Figure 8.4 shows a generalised scheme displaying the stages in the analysis of group perceptions. At the beginning of each of the Discussion groups, the participants were encouraged to share their own analysis of the different uses the wetland had to offer to each of them, and whether they perceived such uses had been affected over the years. They were encouraged to compare their present situation over ten year periods extending as far as they could recall. In these cases, the knowledge of the participants 65 years and over was most valuable. The information they had to offer was often backed up by younger members of the group who recalled their own fathers having narrated similar stories. Here an attempt was made to establish local perceptions to wetland values. It should be noted that detailed accounts of wetland uses by the fishing and farming community based on in-depth studies are given in **Chapters 6** and **7** respectively.

In stage two of the analysis, participants were asked to list examples of any environmental changes they had experienced and were presently experiencing which in their opinion had an affect on the uses they derived from the wetland. Here the discussion was focused on the theme of the history of environmental change in Koggala, the effects such changes had on their own individual lifestyles, and also any adaptations they had to make over the years in connection with these changes.

The **third** and final stage in the overall analysis was centred on an active collection and exploration of management options which, in the opinion of the participants, might help to reconcile some of the problems with which they were faced, and which might lead to the sustainable management of Koggala Lagoon. A central objective here drawing from experience from interviews and surveys conducted with the farming and fishing communities was to examine traditional ethnoecological knowledge regarding the key resources for sustainable use. Broadly defined, ethnoecological knowledge included local assessments of pressing management issues. In the context of the present study the value of this approach is in elucidating ways in which traditional knowledge and western science might be effectively integrated in management plans.

The value of such local-level adaptive planning through the use of the discussion group as a research tool in developing countries is discussed in section 8.2.

Figure 8.4 Scheme showing stages in the analysis of group perceptions of environmental change in Koggala.

Stage 1

$\downarrow$

Local Perceptions to Wetland values

Stage 2

$\downarrow$

Possible Causes for the Observed Changes in the Environment and the History of Environmental Change in Koggala

Stage 3

$\downarrow$

Identification of Management Priorities

8.4.1 The Role of the Researcher

It was mentioned in **Chapter 4** that the author and her family were known to the residents of the study area and thus to the participants that took part in the discussion groups. Consequently the influence that this factor could have on the participants behaviour and responses during these groups was an important one that had to be considered from the outset. The benefits associated with this fact meant that the author had a broader understanding of the issues relating to the research which helped to further contextualise it. Moreover, given the nature of the research and the emotive and sensitive issues that were being discussed, being known to the participants meant that they were able to relate easier to the role of the researcher whom they did not perceive as a threat. This factor is important in light of recent events and the high degree of mistrust towards outsiders from the area. Overall it meant that the author was better able to understand issues raised in the groups and the reasons behind them.

Probably the only major disadvantage of being known to the participants stemmed from the fact that certain individuals may have perceived the author as a possible agent for change given factors such as social background, and this may have been the reason that certain issues were raised more than others. However this is a problem that all interviewers face and, given the sensitive nature of recent events, this was expected. Trial discussions which were conducted in all six sample divisions prior to the research to ensure that the participants could function in a discussion (**Chapter 4**) highlighted these issues and they have been noted in the present discussion.

8.5 Local Perceptions of Wetland Values

Participants in each of the discussion groups from the farming community held very strong negative feelings about the impact of the destruction of the sand bar at the mouth of the lagoon on flooding and subsequent salinisation of their rice lands. Several of these participants expressed anger and appeared clearly resentful about recent events which they felt had reached a crisis point and were quite beyond their control (see Box 8A). Such participants when asked to assign values to the wetland area and to rank them in order of preference highlighted as a priority the need to take the necessary action to prevent further flooding of their rice lands and also village roads and homesteads. These participants, primarily because of their present circumstances, could not see beyond this as they felt inundation of their rice land from the lagoon had undermined their only productive asset and their traditional role as farmers. Similar accounts of traditional affinities for fishing were also recorded by the fishing community.

Box 8A Examples of perceptions of Koggala Lagoon held by participants from the farming community

- ***"Flooding from the lagoon has always been a problem but one which we have been able to control in the past - now we have lost everything."***

- ***"The recreation value of the lagoon means nothing to us now. This is reserved for the wealthy Colombo-based crowd. Now when we look at the lagoon we are constantly reminded about the extent of what we have lost."***

(Source:Present study)

The non-farmers in the groups pointed out that by restricting the farmers ability to grow rice paddy this also affected them because as carpenters and shopkeepers they were dependent to a certain extent on the income generated by farm households. As the discussion progressed, these farmer participants admitted that prior to the removal of the sand bar in times when they were able to farm their lands they had viewed the lagoon as a sink into which excess irrigation water would flow. They recalled how in the past they would manually breach the sand bar, without damaging it, in order to prevent inundation of their rice fields and ensure that the water in the lagoon would recede to an appropriate level. They also claimed that, though the breaching of the sand bar was done mainly with the interests of the farmers in mind, the fishing community also benefited. This was because, at the time the sand bar was breached, the ensuing tidal inflow also ensured the recruitment of larval forms of commercially important species, thus regulating the size of populations and supporting the productivity of the lagoon.

After much questioning, the farmer participants did eventually admit that in the past they had benefited from using some of the wetland resources. For example, the mangroves bordering the lagoon were often employed for fencing and general building purposes and also as a source of fuelwood in times of shortage. In addition these participants said they also bought fish caught from the lagoon for consumption at home which constituted an important part of their diet. They did not admit to fishing in the lagoon in the discussion groups though surveys conducted with the farming community (see **Chapter** 7) confirmed that some farmers did this on a very sporadic basis. This obvious denial may be attributed to the fact that there is a lot of hidden tension between the farmers and the fishermen who are from two different social castes (see **Chapter 3**) and fishing is generally considered to be associated with a lower caste. Some of the women participants highlighted the value of the lagoon as a means by which they could soak coconut husks, a stage necessary in the preparation of coir. They were also able to harvest the reeds growing on the banks of the lagoon which they could make into mats and baskets at home which they could then sell, providing an additional source of income.

Generally, the fishermen's perceptions of the value of the lagoon were more positive, largely due to the fact that their livelihoods were highly dependent on the catches of fish and crustacean species from it. They assigned greater worth to the lagoon and listed a number of different values for the lagoon and its mangrove resources, which are summarised in Fig. 6.9. The medicinal values of some of the wetland associated species were noted especially for their value in the traditional system of natural medicine (Sinhala: *Ayurveda*) prevalent in the country.

Similarly, participants from the fishing community were able to describe in detail the various methods of reproduction of the species they were dependent on and factors that influenced population sizes. They described different seagrass species as being important in the reproductive stages of certain fish species and the ecological role of the mangrove community in providing a nursery and breeding grounds for fish and crustacean species (see **Chapter 6**). They were in agreement with the farmers over the serious problems caused by the destruction of the sand bar. They admitted that though initially they had noticed an improvement in catches of crustacean species as a result of increased recruitment from the sea, more recently they had noticed a decline in commercially important traditional freshwater fish species. Moreover the strong currents now experienced at the mouth of the lagoon not only damaged their nets making fishing impossible in this area but they also had the effect of drawing out juvenile forms of commercially important crustacean and fish species thereby depriving them of a potential catch.

The least important wetland value offered by the participants of the groups convened was the cultural importance of Koggala as being the birthplace of Martin Wickramasinghe, one of the country's leading authors. A museum built in his honour situated in the vicinity was put forward as a potential wetland value in all the discussion groups convened. Here participants argued that since Martin Wickramasinghe wrote about one of the islets within the lagoon (*Madol Duwa*) this was a factor which bought a number of visitors to the area and which warranted its inclusion as a potential value of the wetland.

8.6 Environmental Change in Koggala

Participants were invited to list the various environmental changes they identified as being important in Koggala Lagoon and those factors which they believed to be responsible for these perceived changes (see Table 8.1). These individual changes were then debated and following this the participants were asked to rank them in order of importance. The ranking of these changes and associated values are summarised in Table 8.2.

Table 8.1 Perceived environmental changes in Koggala and associated factors accounting for them.

Key environmental changes in Koggala	**Perceived factors accounting for environmental changes**
Declining populations of fish and crustaceans.	Pollution stemming from agro-chemicals that flow into the lagoon; Increased felling of mangrove resulting in reduction of breeding sites for commercially important species; pollution from decomposition processes as a result of soaking coconut husks ; over-fishing.
Changes in soil structure causing problems in the cultivation of crops.	Increased levels of agro-chemicals; increased pest resistance; loss of friendly organisms e.g. earthworms.
Fish kills and sightings of diseased fish in the lagoon.	Pollution from excessive use of agro-chemicals; elevated salinity levels which the fish are unable to tolerate; KEPZ dumping of waste materials on borders of lagoon.
Changing hydrology of the lagoon and elevated salinity levels.	Destruction of 'naturally' formed sand bar.
General mangrove decline in mangroves habitat especially *Sonneratia caseolaris.*	Increased levels of '*mas-athu*' (brushpile fishing*);* felling of mangrove for fuelwood purposes; increased salinity levels which *Sonneratia caseolaris* is unable to tolerate.

(Source: Present study)

These environmental changes were then discussed individually in terms of how they affected the participants. The most common impact as a result of some of these changes was the general loss of livelihood and changes in traditional roles as experienced by the farmers, who because of their present circumstances were increasingly compelled to look for alternative sources of income, for example as casual labourers (see **Chapter 7**). The presence of the KEPZ initiated a very different set of viewpoints. It should be noted here that a very small number of inhabitants especially males from each of the divisions had been successful in securing employment in the KEPZ which had caused a great deal of resentment against the KEPZ and this fact may have biased their opinions.

Table 8.2 Group Ranking of Environmental Changes in Koggala.

	Ranking of the most significant environmental changes in Koggala lagoon by Discussion group participants					
Key Environmental Changes	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Average Ranking**
Declining populations of fish and crustaceans	3	1	1	4	3	**2**
Changes in soil structure -causing problems in the cultivation of crops	2	5	5	2	2	**3**
Fish kills and sightings of diseased fish in the lagoon	4	2	3	3	4	**3**
Changing hydrology in the lagoon after the sand bar removal	1	3	4	1	1	**1**
General decline in mangrove habitat especially *Sonneratia caseolaris*	5	4	2	5	5	**4**

(Source: Present study)

8.6.1 Observed Changes in the Environment

At the outset, participants were encouraged to reconstruct the history of environmental change in Koggala in the form of a time line analysis. Here an attempt was made to provide a historical baseline and thus a means to assess comparative rates of change. The aim of using the time-line analysis was to identify past trends and to put a perspective on current issues. Participants from Koggala Athireka 1, which is located on the southern most borders of the lagoon, began by describing the effects of coastal erosion over the years. They referred to a coconut estate located along the shorefront extending from the bridge along the Galle Matara road. Apparently this estate was called the 'Eight-thousand estate' (Sinhala: *Ata dahey watta*) which referred to the number of coconut trees which made up the entire estate. Participants pointed out that over the last thirty years the rate of coastal erosion had been so extensive that now apart from a few coconut trees along the sea-front the remaining part of this estate had been completely eroded away. In their opinion, the removal of gravel-sand along the beach shore was a major contributory factor which accelerated the rate at which the fine sand, which had nothing to adhere to once the gravel had been removed, was washed away. Another participant added that the rate of coastal erosion is so large that in his lifetime he recalled the bridge at the mouth of the lagoon being replaced three times.

A participant in his early seventies from the same division recalled how during the entire war period local inhabitants of the area were re-housed and prevented from entering the lagoon. From 1942 to the early 1950's the local inhabitants were restricted from the area (see **Chapter 3**). He recalled how a fence made from galvanised iron pipes and barbed wire was constructed around the lagoon and its environs which demarcated a boundary into which they were not allowed to enter. However inspite of this they recalled how their fathers would surreptitiously enter into the lagoon at great personal risk and fish throughout the night. The catch in those days was much greater than in present times, with prawn and other crustacean species in greater abundance. According to this same participant, fish catches today are not even one third of what they used to be compared with even twenty years ago. In a like manner, several participants pointed out that during the same time the lagoon accommodated several bird species. Some of these bird species are observed today, but such populations are about 90% less abundant.

The participants in the discussion groups that were from the fishing community were quite vocal about the causes of declining fish and crustacean species, fish kills and fish diseases, problems of over-fishing and the increased levels of competition between the fishermen. In Discussion group 2, which was held in Duwamalalgama, a traditional fishing village, one participant, who was a fisherman by trade, directed his anger at those participants from the agricultural community. The relevant excerpt from the transcript of that discussion group translated into English is given below:

> Young fisherman: *" One of you was speaking about fish diseases, but it is the farmers who have to take some of the blame for this. They use all types of poisons to get rid of the insects that destroy their crops and it is these same chemicals (Sinhala:visa beheth) that flow into the lagoon and in a similar fashion kill all life there. You have only to look at the people who spray these chemicals who are covered with burnt eczema like patches all over their bodies to see how they have been affected over time with continued spraying. Of course these chemicals would have the very same effects on the fish living in the lagoon. To understand this you do not have to go to school; it is common sense. "*

Another participant spoke about the problems created when the outlet to the sea is blocked and the water in the lagoon stagnates until the outlet is cleared which now required using mechanical means. At such periods the fish were more likely to be infected with diseases and it was common to see them floating dead on the surface of the water. This phenomenon had not occurred in the past when the inlet was breached manually by the residents on a more regular basis than at present. A similar occurrence has been reported in coastal lagoons in Mexico with similar tidal inlet problems (Torres- Moye *et al.* 1993).

When the word was circulated about dead fish found in the lagoon, households would refrain from buying fish for long periods of time which placed the fishermen in a very difficult financial position. In addition to these perceived fish diseases, the fishermen participants described how in recent times they had noticed the occurrence of a parasitic organism affecting the fish in the lagoon that according to them had reached epidemic levels. During the discussions held in Duwamalalgama, one participant actually left the group to collect a specimen for the author to examine. According to them this organism had not existed before the destruction of the sand bar, but now it was found throughout the lagoon moving in swarms parasitising populations of fish and thus posing a further restriction to fishing in the lagoon[1].

Another participant expanded on this point and spoke of the dangers of consuming diseased fish and the fear she had of feeding her children fish which she perceived to be contaminated. After this comment, much attention was focused on 'disease ridden fish' found in the lagoon. One fisherman participating in the discussions argued in some instances that the 'diseased fish' which had been referred to are in actual fact fish species that are dying because they are unable to tolerate the elevated levels of salinity in the lagoon. Various other explanations for the diseased fish and fish kills came from several participants, both men and women, the majority of whom felt that pesticides and chemical fertilisers used in the surrounding lands were largely to blame. According to participants in Discussion Group 1, since the destruction of the sand bar the water level in the lagoon rose to very high levels and stagnated for longer periods, thereby forming a slimy rust like colour on the surface. They believed such areas represented sites where the agro-chemicals were concentrated and thus most dangerous.

Similarly in Discussion Groups 1 and 3, fear was expressed about the presence of the KEPZ and the possibilities of effluent from the factories sited there entering the lagoon and polluting it. According to the participants their views on this subject were justified as they were aware of the illegal dumping of waste materials from the KEPZ on a narrow strip of marshy land bordering the lagoon which had direct access to the lagoon (Samarasekara, 1994). They were aware of pollution problems in lagoons situated across the country which had been adversely

[1] Samples of this organism were collected by the author and sent to Denmark where they were analysed by Dr. Niel Bruce, curator of Crustacea, Zoological Museum, Unversity of Copenhagen. It was confirmed that the specimen belonged to the isopod family Corallanidae, and the genus *Corallana* Dana, 1853. The presence of this genus is common in mangrove habitats where they are known to be opportunistic micro-predators and symbionts.Swarms of Corallanidae have twice been known to have caused the collapse of shark fisheries, but no explanation was found for these sudden population increases.

affected by uncontrolled dumping of waste materials and cited as examples of this problem Lunawa Lagoon (see **Chapter 2**) and Beira Lake in Colombo which had been highlighted recently in the national press. It should be noted that during discussions in Duwamalalgama, participants claimed that they had heard of plans to construct pipelines diverting effluent from the KEPZ into the lagoon.

A farmer expanded on the point about the general fears of the agro-chemicals they were using when he narrated how, in times before the introduction of agro-chemicals, he remembered how the rice fields were full of small fish and crabs which were helpful in controlling pests. Now such 'friendly' organisms were hardly seen, something he attributed to the use of pesticides. An angry fisherman answered this farmer by stating:

> *" If this were the case, was it a surprise that the same menace had spread to the lagoon, where the livelihood of so many fishermen was based."*

It was obvious from the discussion that a growing conflict existed between the fishermen and the farmers on the use of agro-chemicals and their perceived environmental effects.

Attention was then focused on the destruction of the 'naturally' formed sand bar at the mouth of the lagoon, flooding problems this had created, and the effects these changes were having on the participants. In the opinion of all the participants this constituted the most recent impact on the lagoon. Participants from the farming community were most vociferous and they began by describing how events leading up to the removal of the sand bar took place (see Box 8B). Opinion was divided amongst the participants in the various discussion groups regarding the background relating to the destruction of the sand bar and often conflicting views were offered.

Participants from Discussion Groups 1, 5 and 4 were generally of the opinion that the KEPZ officials were solely responsible for the mining of sand from the sand bar. They maintained that this sand was used in the construction of roads in the KEPZ. However, according to the participants from Discussion Groups 2, 3 and 6 - sand was removed from the middle of the sand bar by contractors employed by a Danish company (Danhoff) who were working together with the CCD (Coast Conservation Department) in a project designed to arrest coastal erosion along the South western part of the coast. This sand was apparently required in the construction of a rock wall they were building along the coast in an attempt to arrest coastal erosion. According to these participants initially sand was only removed by this group but then later sand was also removed for the KEPZ. This was watched by inhabitants of the area who evidently reported this to the Police. Both explanations were subsequently verified by the author by checking with the relevant authorities and the latter explanation was found to be closer to the truth, though KEPZ officials refused to admit they had also been responsible for using sand mined from the sand bar. What is of interest here is the way in which different groups of people have interpreted these recent events. Blaming the KEPZ solely for the destruction of the sand bar represents the extent of the resentment felt against this group.

The problems caused by the destruction of the sand bar were discussed at length. Participants from both communities acknowledged the severe problems they were facing in terms of flooding of homesteads and village roads. Those from the farming community described how saline inundation of their fields, which had reached catastrophic heights, was a problem they had been experiencing throughout, but one they had previously been able to control. They described how various government-initiated irrigation schemes constructed in the early 1970's and again in the 1980's (see **Chapter 5**), which were meant to help them, had fallen far from this aim and had even contributed to worsening the situation. A general mistrust of government officials and the people they hire to do public work was very evident throughout the discussions. It should be pointed out that the participants were aware of the presence of some Government officials in some discussions and, by speaking in the past tense whenever such remarks were made, they were careful to make it appear that no offence was meant to those Government officials present. Participants in the discussion groups also included members that had been associated with this work through *'shramadana'* which translates as free labour[2]

The following excerpts from transcripts of the discussion groups illustrates some of the points outlined above and the general feelings of the participants:

> Participant from farming community: " *The whole trouble with the flooding of rice paddy lands is due to the wrong positioning of the sluice gates. They are not properly controlled. The way I see it, whoever was responsible for the construction of them was only concerned of the money they could make from the job - no thinking has gone into it. This is a terrible shame and what a waste of money - not one of these engineers thought about the rice paddy land and how it would be affect. As a result now it is impossible to cultivate a large extent of it. These so-called engineers were only interested in the money they could make and as a result they increased the work to extents much more than was required (Sinhala: Wawagena kewa - which translates literally as make the money grow). (Sinhala: Mona aparadayakda - what a shame).* "

> Retired School Teacher: " *No proper investigations were carried out before the bund construction was initiated. The sluice gates were placed in the wrong places and also at wrong heights - what a waste of money ! No*

[2] *Shramadana* is a scheme wherby local communities, particularly in village areas, are encouraged to work on certain days on commuity projects which are supposed to be for the benefit of the community as a whole.

concern was shown for public interest. In the Dedu- kadulla area the water flow is not controlled properly, the water surface, perhaps due to stagnation has formed a rusty layer.....and no rice can grow there- they should have known that, but instead they all acted like Water buffaloes[3]*. "*

Elderly Male Farmer: " *Everybody is talking about the bund and what is wrong with it but none of you were there when it was constructed - I helped build the bund with my own hands by voluntary labour (Sinhala: Shramadana) and if we were allowed to carry out the work on our own none of these problems that we are talking about now would be here. If the know-it-alls (Sinhala: Mahadanamuttas's) of the government had listened to what we had to say instead of dismissing us we would not be in the mess we are in today. This should be a lesson to us all, if we are to avoid similar situations we have only to depend on ourselves because nobody else cares."*

One participant summarised the present situation by saying:

"In the old days a few farmers did all the work necessary to breach the sand bar in a matter of just a few hours with their mamotees (hoes). Now the devastation they have caused has opened an avenue for a few suckers to make mountains of money (Sinhala: salli kandu). Those responsible for removing the sand bar have robbed us of so much. The fish, prawns and crabs - juvenile and adult forms all get washed into the sea, leaving us with hardly any fish to catch. On top of this so many fishermen compete with each other to catch whatever remains."

Considerable attention was given to the estimation of paddy lands abandoned due to flooding problems, a problem which the participants felt affected them all. Box 8B displays a selection of quotes illustrating such points. Participants from Duwamalalgama claimed that, in their division, the cultivation of rice had been given up completely almost two years ago. Similarly, in the discussion group conducted in Polhena, participants estimated that 50 ha of rice paddy land had to be abandoned due to flooding problems and this figure was gradually increasing.

Box 8B Examples of pertinent comments from Participants

- **How can you eat fish without rice? (Sinhala: *Buth nathuwa malu kanne kohomadha*?) (Farmer from Kahanda).**
- **If the fence and the bund which are there to protect the rice plants take part in destroying them to whom should we complain? (Sinhala: *Welath Niyarath goyam kanawanam api kata kiyanada*?) (Farmer from Kahanda).**
- **In the old days one throw of the net into the lagoon would fill our boats with shrimp and fish (Sinhala: *Eh kale dela eka parahk vissikarama orua pirena tharam isso, malu allanava* (Fisherman from Duwamalalagama).**

(Source: Present study)

[3] Water buffaloes are often regarded as stupid and are often used in this context in village jokes. Here a comparison is made with the building contractors suggesting they used little thinking.

The mangrove complex and the impacts exerted on it was another topic that was discussed at length. Here participants, mainly from the fishing community, displayed a deeper understanding of the ecological role of these communities, and the various functions they served in terms of providing nursery and breeding grounds, their role in shore stabilisation and protection. However, inspite of this high recognition of the value of these resources, the mangrove complex in Koggala is increasingly under threat from unsustainable uses. One participant suggested that heavy fines should be given to those caught felling the mangrove; other members of the group remarked that all of them at one time or another had cut down the mangrove for fuelwood purposes so they were all equally to blame for its decline.

8.6.2 Social Implications of Environmental Change

A full socio-economic profile of the communities living in the sample six divisions was given in **Chapter 3**. For purposes of the present discussion it should be emphasised that the participants are all from a rural background analysed in earlier chapters. They face a multitude of economic, and social problems. Unemployment is high with low occupational diversity and income. Moreover a majority of the members of the communities are on welfare schemes. Education and health problems add to the general low standard of living.

The aim of introducing this topic to the discussion was in an attempt to assess the degree to which changes in the environment were affecting the participants in a social and economic sense. At the start, attention was paid to the loss of livelihoods and changing roles. They were invited to share their experiences of adaptations and various changes they in turn were forced to make in recent times as a result of some of the changes discussed above. Initially discussion was focused on the growing problems of unemployment in the area. Most of the residents had high expectations from the KEPZ in terms of possible employment prospects. But in reality their chances of employment had become little more than a farce. In most cases, from each division, only 15-20 young women had been employed to work in the garment factories. Apparently, in most of these cases, the reason the people were not granted employment was because they lacked the minimum qualifications required (Grade 8). Similarly participants in the discussion groups related how members of their families, themselves included, had applied for work at the KEPZ but had been refused. The frustration at not being able to secure employment in a location so close to them and being faced with no other viable options was a constant source of tension in the groups.

Together with the general lack of employment prospects at the KEPZ, the employment situation was equally unreliable in neighbouring estates and tea factories. The demand for casual labour in the villages, except during harvesting or cultivating periods, was minimal and during the long interim period it is now increasingly difficult to find work. Participants commented on how droughts were now much more frequent than in the past, making it difficult to cultivate even the little parcels of land that they have. This theme of changes in climatic patterns was consistent throughout all the groups convened. According to participants, the timing of the onset of monsoon seasons was less dependable now, something which is critical for successful planting and harvesting of rice. Another participant ended this statement saying: "....even the Gods are angry with us for all the evil we do - but this is our fate." Several others dwelt on the same theme of the anger of the Gods because of the evil doings in the area (Sinhala: *aparada weda* - evil acts; *pau-wada*-sinful acts).

The majority of participants agreed that school attendance was very low and drop-out rates were very high. The reason for this was largely due to the difficulty in providing the necessary finances to cover the cost of books, clothing and other essentials. They argued that it was more economical for their children to assist their parents at home or look for part time casual labour. Families were increasingly forced to stop sending their children to school because of the financial hardships encountered. In many cases they lived on a day-to-day basis. One participant summed up the general feeling of woe and the various hardships they were experiencing by saying they were basically paying for past sins (Sinhala: *kala kala de, pala pala de*). This is a very common Buddhist saying in the villages that translates as: " whatever one does has its own retribution - good acts lead to good results and *vice versa*."

Another topic that figured in the discussion was the problem of illicit brewing (Sinhala: *kassipu*) and how members of the community, because of their present economic conditions, were engaging more and more in drinking and gambling. This widespread indulgence in drinking represents an expression or manifestation of the frustrating and hopeless situation facing the whole community. Discussions with the Community Medicine Division of Ruhuna University, confirmed that increased levels of alcoholism among local communities in Koggala was a cause of concern and had been recognised as a major problem (pers. comm. Fonseka, 1993).

Participants from the discussion group convened in Koggala Athireka 1 regarded the problems associated with flooding of village homesteads and roads of major concern. They expressed their concerns that it took only two periods of heavy rainfall for their lands and homesteads to be completely flooded. This hampered their movements for long periods. The main road that they depended on especially in times of emergencies became impassable for days at a time.

In the last few years, the natural resources in Koggala have generated new economic opportunities for the inhabitants. In particular, the lagoon, which is set in idyllic surroundings, is attracting tourists in increasing numbers and also local visitors who visit the Martin Wickramasinghe Folk Arts Museum. Participants in the discussion groups were divided over whether or not the increasing number of tourists would have an impact on their lives. However they were quick to point out that tourism would offer more income and offer them more economic opportunities compared to fishing and agriculture. The participants were aware that tourism may be a means to diversify the local economy. They also expressed concern over the ill-effects tourism could bring which could further add to environmental and social problems in the area. They named Hikkaduwa, located about 25 km from the study area, as an example of the potential drawbacks tourism could bring to the area.

Participants from the farming community described how it had been suggested by officials at the Local Regional Council that they should plant coconut instead of rice on their abandoned rice fields. However this was not an option that they were willing to accept. They identified themselves as rice farmers - a traditional role they found difficult to change. Additionally they did not have the means to institute this change.

8.6.3 The KEPZ and the B.O.I.

Meetings at the KEPZ and the B.O.I involved discussions with a much smaller number of key officials. At the KEPZ participants included Mr. Lal Kumara (resident project Manager), Mr. B.A Douglas (Manager Investor Services), Mr. T. Fernando (Environmental Standards), and Mr. Ranjith Kalansooriya (Factory Manager). At the B.O.I participants included Mr. Tissa Fernando (Senior Manager - Environment) and Mr. Sunil Fernando (Environment). Meetings with these key officials ran for considerably shorter periods of time. Attention was focused mainly on key themes that had developed from the discussions held with the local communities in the sample six divisions.

It should be noted that because of the sensitive nature of the study and the coverage in the national press (see **Chapter 3**) during the research period highlighting the lack of environmental protection measures taken by the KEPZ (Samaraweera, 1994; Jayachandera & Tissaratchy, 1993), dumping of waste materials from the KEPZ onto marshy lands bordering the lagoon (Samarasekara, 1994), and the problems associated with the destruction of the sand bar meetings with these officials were often strained. Information was not as forthcoming as had been the case with the discussion groups held in the sample six divisions. Topics of discussion with these two key groups centred on the perceived benefits the KEPZ would bring to the local communities and how far these had been realised; whether the presence of the KEPZ had impacted local subsistence based activities; and what steps had been taken to protect the lagoon and its environs from activity within the KEPZ.

Both the B.O.I and KEPZ officials insisted that the underlying aim of the KEPZ was to provide employment to an area known for its high unemployment rates. The reason that some members of the community had not been able to secure jobs here was because the zone was still in its formative stages. The employment prospects of locals would eventually be realised but this would take time. Both groups were also not aware of any changes the KEPZ had bought to subsistence based activities centred on the wetland. They denied any involvement in illegal dumping of waste materials on the borders of the lagoon even though the authors photographic evidence indicates otherwise. They felt the 'scare-mongering' tactics that were used in the national press about environmental standards only served to hamper progress. The Resident Manager of projects at the KEPZ pointed out that more concern should be focused on those industries located in the vicinity of the KEPZ which were operating with no regard for the environment. They admitted that the necessary treatment facilities for waste materials stemming from the factories had not been completed yet. But they had plans to treat such materials within the KEPZ itself and pipe the treated effluent to sea. The Environmental Impact Assessment (EIA) for this proposed treatment plan was completed and they were now just awaiting its acceptance from the Central Environment Authority. In the meantime, in their opinion, they were operating fully within legal limits.

8.6.4 Group Dynamics

It should be emphasised in instances where the discussion was dominated by certain individuals, steps were taken by the author who intervened and passed the discussion to other participants in the group. In this way it was hoped that the discussions would reflect the complete social diversity of the groups and not certain individuals. This was an important factor especially in terms of the formulation of management plans relating to the area, where it was vital that all participants were able to voice their opinions and to resolve conflicts into workable solutions.

8.6.5 Summary of Key Themes

- The participants of the discussion groups were selected after much planning and introductory work in each of the six sample divisions (see **Chapter 4**). In this way it was hoped that the groups chosen would reflect the ideas and opinions of all the members of the community.

- Discussion groups conducted with the local communities in the sample six divisions reveal that they equate the 'natural' resources in the area as their 'rice-pot,' and are quick to point out that they would not consciously destroy their means of livelihood. They are aware of the problems of resource depletion and environmental degradation and point to 'outside agents' and new technologies as the main causes of the current environmental instability they were experiencing. While they do not view all such persons as negligent, they often cite such outsiders as being generally unaware and insensitive to local conditions.

- The discussion groups revealed the importance of biases in perception by the participants who use qualitative criteria on which to assess the environmental changes and their causes. Moreover they are influenced by memorable instances. This was obvious in the case of group perceptions of the KEPZ and its potential impacts which were dramatically portrayed. They cited the experience of pollution problems affecting lagoons in Colombo and the experience of the existing Free Trade Zones in Biyagama and Katunayake.

- In assessing how the natural coastal resources in the area have changed they stated that in traditional times they depended on coastal resources in a symbiotic manner without any significant ecosystem impairment. Since technologies were rather unsophisticated in those days and not, in their opinion, environmentally damaging, resources were exploited in a sustainable manner. In recent years the introduction of new technologies, and the increasing demand for some of these natural resources beyond subsistence levels has led to large transformations in the ecology of the area and to dwindling resources. The level of scare-mongering amongst local communities concerning the activities of the KEPZ represents the general mistrust these communities have against the authorities.

- Meetings with the officials at the KEPZ and the B.O.I however proved less successful. Given the sensitive nature of the topic, these officials were unwilling to meet as originally planned as discussion groups. In fact the only reason meetings were allowed between them and the researcher at the KEPZ and the B.O.I was because of the researcher's involvement in the Environmental Impact Assessment of the proposed sea out-fall to be developed from the KEPZ (Samarasekara, 1994).

8.7 Local Level Adaptive Planning for Management

8.7.1 Wetland Management Priorities: Resolution of Conflicts

In all of the group discussions, each of the participants were encouraged to put forward options to improve local livelihoods and manage the wetland site. These options were debated and then ranked, bearing in mind each option's objectives, results, advantages and disadvantages. A summary of these management options is given in Figure 8.5.

Given the high degree of local resentment and the number of unresolved conflicts concerning the lagoon, it took a long time for the participants to consider workable management options for the wetland as a whole. However, during the course of the discussion, the participants pointed out that any management options for the wetland should take into account the following:

- The loss of livelihood amongst the farming community since the destruction of the sand bar;
- Afforestation of the fringing mangrove complex;
- The activities of the KEPZ.

It was agreed that these preferred management proposals would provide a basis for negotiation within the community and with Government authorities.

Participants from the farming community emphasised the direct losses they were now facing from flooding. This included a significant loss of livelihood with increasing numbers of rice fields being abandoned due to salinisation of land and also the destruction of infrastructure and housing. By compensating them for their loss of cultivable lands by providing them with additional lands to farm they argued that it would substantially improve their livelihoods, benefit the next generation, and increase the agricultural production of the whole area. However if this did not materialise they would want compensation in the form of a welfare packet which would also benefit the whole community.

Figure 8.5 Group Ranking of Management Options

	Ranking of Management Options by Discussion group participants					
Wetland Management Options	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Average Ranking**
Coastal Defence Works - planning for mitigating effects of sand bar destruction.	1	1	1	1	1	1
Mangrove restoration, management and replanting.	5	3	3	3	4	4
Monitoring and Evaluation of water quality.	4	2	2	4	5	3
Restoration of abandoned rice fields or exchange these lands with cultivateable areas - including compensation for loss of livelihood.	2	4	5	2	2	2
Community Welfare package.	3	5	4	5	3	5

(Source: Present study)

Local fishermen, and in particular ornamental fish collectors, expressed their concerns over potential changes in water quality and further disturbances associated with the KEPZ. The ornamental fish collectors were especially concerned that plans to divert effluent from the KEPZ to the sea would result in reduced visibility which would impose a major restriction on them.

The female participants in the groups were generally more concerned with health and education issues. Health care facilities were a priority and they were keen that their children stay on at school for higher-level studies. In addition to the proposals listed above, participants agreed to reforest the lagoon shore. Discussions elicited a list of the social and ecological benefits that could be expected: firewood supply, beautification of the lagoon, and a habitat for important migratory bird species.

A central objective of this participatory process was to initiate local-level planning of the wetland that would take into account local needs, perspectives, capacities and aspirations. The use of Discussion Groups in this context highlighted the following:

- The quality and depth of information generated on local livelihoods and their relationships with 'natural' resources were much richer than that generated by more conventional survey and questionnaire-based studies. Moreover this information was obtained in a relatively shorter period than most conventional management plans formulated by outside experts;

- The majority of the participants had a very good understanding of wetland ecology and of how development activities impacted the lagoon. Complex issues such as changes in water quality, sedimentation and the perceived causes for such changes were also well understood. Participants were able to establish causal links between recent outside interventions and their detrimental effects;

- Local communities are willing to take care of the wetland's ecology provided their legal and traditional rights are recognised and they receive compensation for their losses. The participatory nature of the planning process revealed not only the participants' ability to identify problems but also elicited a range of management options to reconcile the conflicting interests between local resource users;

- The participants cited an important target group within the community that could be especially motivated to assist in management plans. This group is the 15-25 year old males, who, given the high unemployment rates in the area, are in need of important occupational training.

8.7.2 Overall Summary

- Wetland management in Koggala can be sustainable ecologically, economically and socially only if the overall management scheme can be made sufficiently attractive to local people for them to adopt it as a long-term livelihood strategy. From the outset, the formulation of wetland management plans should be based on interactive dialogue to understand people's priorities, needs and knowledge. In this connection it is vital that there is an acceptance that a divergence of perception exists between different groups of resource users who have a number of different priorities.

- The preparation of wetland management plans should aim to be the beginning of a long partnership between external institutions and local communities. The most difficult task will be implementing the wetland management plan by assisting communities to establish or strengthen local institutions and providing them with the required legal, technical and scientific tools. The whole process should empower local communities to manage natural resources in the context of modern realities.

- Research endeavours in rural communities should accommodate the assumption that local communities have the potential to contribute to solving their problems and the role of the researcher is to assist those communities in determining their situation and role in directing initiatives.

- In this chapter the important role group discussions have played in the research on perceptions of environmental change in Koggala are summarised. Knowledge of group perceptions of environmental change is vital for listing wetland management priorities which will help the formulation of appropriate management plans (see **Chapter 9**).

CHAPTER 9
COMMUNITY-BASED PLANNING FOR WETLAND MANAGEMENT: TOWARDS AN INTEGRATED SCHEME

9.1 Introduction

This Chapter examines feasible management strategies for the sustainable use of Koggala Lagoon and its environs, with an emphasis on the participation of local communities. It is based on the collective findings of interviews and surveys conducted with the Fishing (**Chapter 6**) and Farming (**Chapter 7**) communities, discussion groups conducted with residents of the sample six divisions (**Chapter 8**), and ecological surveys which outline the major environmental changes and their impacts (**Chapter 5**). The principal aim of this Chapter is to present a set of recommendations towards an integrated management plan for this key wetland based on the findings of the thesis. The urgency of this has been emphasised in **Chapters 5-8**.

Using examples from South and Southeast Asia, Section **9.2** presents an overview of wetland management issues and limitations in existing approaches. This section ends by highlighting the need for an integrated 'holistic' approach. The role of local communities in the integrated management of wetland ecosystems is reviewed in Section **9.3** and the need for changes in current ways of thinking is discussed. Finally, an assessment is made of major environmental issues and options relating to the study area (Section **9.6**) and the way forward for sustainable management (Section **9.7**).

9.2 Wetland Management - A Review

The continued degradation of wetland ecosystems, particularly those in coastal areas, is amongst the most pressing environmental problems today. The destruction and degradation of wetlands world-wide have been massive during the 20th century, and the rate of wetland loss has been highest in recent decades, despite the existence in most countries of institutions with a mandate to manage wetlands (Dugan, 1990; Prentice, 1995). The past twenty years have seen a steady decline in the vast wetland resources - more than 5 million km^2 that lie in the tropics and sub-tropics (see **Chapter 2**). As the biological, social and economic impacts have been felt by society, the conservation community, and increasingly the development assistance community have come to acknowledge the importance of maintaining the functions and benefits of the remaining wetlands (Pirot, 1995; Maltby, 1986;1991a).

In recognition of the importance of wetlands and the environmental social and economic consequences of wetland loss, a growing number of countries have initiated national programmes to address wetland conservation and management needs. In support of this work, many international organisations have increased substantially their investment in wetland conservation and management (Maltby & Dugan, 1994; Maltby, 1991c). Wetlands International, the World Wide Fund for Nature (WWF) and the International Union for the Conservation of Nature (IUCN) are the major pioneers in this which strive together to support the work of the Ramsar Convention (Dugan, 1993).

The concept of 'wise-use' (International Convention for the Conservation of Wetlands-Ramsar Convention), which has assumed increasing significance in recent years has been used by the Ramsar Working Group on Criteria and Wise Use, for the development of guidelines for member states in their implementation. These include both establishment of national wetland policies and also priority actions, since it is recognised that policy development is likely to be a long-term process. However, the success of the development of 'wise use' depends to a great extent on the active participation of local people, as in most developing countries the rural economy is closely dependent upon the productivity and hydrological benefits of wetlands (see **Chapter 2**). The successful implementation of the principle of 'wise-use' in wetland management lies in its ability to address the institutional, political and social, rather than merely the ecological factors, no matter how important these are (Pirot, 1995).

Dugan (1990) outlines five principal factors contributing to existing institutional inefficiency in wetland management. Such factors include: sectoral organisation of wetland management; limited availability of management techniques for protected wetlands; shortage of qualified staff; inadequate legislation; and limited resources. He suggests possible ways by which these problems may be addressed and these include:

- establishing effective operation of cross-sectoral structures which will bring together all concerned parties for co-ordinated action;

- improving human capacity to manage wetlands;

- improving legislation and the funding base.

There is undoubted progress in understanding the ecological functions of wetland ecosystems and how it is vital to maintain, or enhance them, as natural ecological functioning units. But this role is being seriously weakened due to inappropriate planning and management approaches which fail to maintain the functional integrity of the ecosystem which results eventually in degradation. Though there are complex and powerful issues both at the local and global level that must be addressed, necessary attention should also be paid to the underlying causes of environmental degradation (Pirot, 1995). Maltby (1989) summarises the major obstacles that must be overcome in our understanding of wetlands which thus influence the way we manage them:-

1. Current knowledge of processes, functions, values and the development of evaluation processes is heavily biased towards the developed world and especially to the United States. In particular, there is little or no account taken of situations where human populations rely on wetlands for immediate resource needs.

2. Wetlands are extremely diverse, they do not all perform the same functions, and values of similar wetlands may vary considerably according to geographical position and socio-economic context.

3. The measurement of values generally lacks a common scale. Whilst there are real economic values (such as hunting, natural grazing for harvested species or flood protection) which can be attributed to wetlands, the basis for calculation of these is often disputed and some qualities have indefinable economic values.

4. The driving force maintaining wetland functions often originates outside the immediate area and the benefits may be realised elsewhere within a different administrative area or even another country.

The sound management and conservation of wetlands is thus crucial in developing countries where concern for environmental quality is increasing rapidly and especially where the survival of local communities, as well as genetic resources, is linked inextricably with wetland functioning (see **Chapter 2**) (Maltby, 1991a;1991b). Similarly Burbridge (1994) emphasises the need to adopt an integrated approach in management that considers bio-physical, socio-cultural and economic factors and the need to incorporate these three factors into the planning and management of wetlands. Yet, in spite of the significant headway made in wetland management, there are admittedly gaps that must be filled. These are especially pertinent to the South and Southeast Asian region.

9.3 The Role of Local Communities in Wetland Management

Wetlands play a central role in the lives of rural communities in much of the developing world. This has been illustrated in **Chapters 1** and **2** with examples from the South and Southeast Asian region. They have been utilised wisely by local communities for centuries, who, in the process, evolved community codes, systems and beliefs in using and conserving the resources which were internalised within social, economic and religious practices (Gujja & Pimbert, 1995b). However, despite this close dependence upon 'natural' wetland ecosystems, the recent past has seen several factors combine to increase pressure upon these resources and decrease the benefits obtained. These have indirectly, and in some cases directly, undermined the role of local communities who have been marginalised in the process. Therefore, in relation to some of the changes which have been outlined in **Chapter 2**, most wetland systems are no longer capable of supporting the demands placed upon them.

Throughout Africa and Asia numerous examples are described in the literature of the importance of involving local communities in the management of wetland ecosystems, and the need to incorporate such communities in management schemes to ensure they are successful in the long term. Recent reviews which draw examples from around the world include Rose (1994) and Lazarus (1994). Relevant case studies relating to South Asia include Gujja and Pimbert (1995a), who describe the outcome of a participatory planning exercise carried out with local communities in a wetland site (Ucchali complex) in Pakistan. Participatory Rural Appraisals were carried out in several villages to develop wetland management plans for the area and the study highlights the importance of local communities in planning for sustainable management. Similarly Liyanage (1995) highlights the success of a participatory planning exercise between local fishing communities and the Sri Lankan Forest Department in an effort to conserve the Seguwanthive mangrove on a sustainable basis. Similar examples from Nepal are given by Bhandhari (1994a;1994b;1995).

In Southeast Asia, pertinent examples include the Yad Fon (Raindrop) Association which was established in Thailand in the late eighties. The aim of this project is to upgrade the quality of life and degree of self-reliance of the villagers through people's participation. Other examples from Thailand include Panvisavas *et al.* (1991a;1991b) and Rittibhonbhun (1995). Khan (1994) provides case studies in Thailand, Vietnam and Malaysia of recent initiatives involving local communities with the key objective of demonstrating that local people, institutions and international agencies can work together effectively to manage mangrove resources. In like manner, Castillo (1991) documents the involvement of municipal fishermen as potential research partners in assessing socio-economic aspects of coastal resources and local communities. Tungpalan *et al.* (1991) highlight the important role of women in fishing villages in the Philippines and their potential roles in coastal resources management.

In Indonesia community-based management schemes are underway in the Taka Bone Rate National Park (Alder *et al.* 1995). Wickam (1995) provides an overview of community participation in wetland conservation in the Dantau Sentarum Wildlife reserve in Indonesia. Participatory activities used in the community-based strategy include the development and improvement of sustainable income-generating opportunities for local people. The development and improvement of management strategies and techniques to protect the resources base and the promotion of existing and new institutional structures to improve the management and protection of the natural resources are also among them. Recently the effects of community-based resource management in the Sai Bury river basin, Thailand, have been highlighted (Flos, 1994). Other important case studies include Hendro, (1994); O'Callaghan, (1994); Addun *et al.* (1995); McManus, (1995) and White *et al.*(1986).

In an African context, noteworthy examples include Gichuki, (1995); Dugan, (1990); Chileshe, (1995) and Thole & Dodman, (1995). In addition to this there has been significant progress in regional and international meetings on the role of local community participation. It should be noted that the term 'community-participation' has been variously described, but for purposes of the present discussion it is taken to mean the active involvement of people in decision-making regarding activities that have a direct effect on them and involves empowering local people in the management of their resources (Oakley, 1989).

Increasingly it is now accepted that an integrated programme which combines public awareness, education and community participation is needed to provide an understanding of, and support for, the sustainable management of wetlands. Recognition of the role of local people beyond the development phase together with a strong policy framework relating to the community-based management of wetland resources may provide an optimal long-term solution and further contribute to the successful management of wetlands. According to the 1994 Ramsar Convention Manual, community consultation and participation are critical in wetland management (Davis, 1994). Though recognising local support is a pre-requisite for effective action, raising local awareness alone is not enough. In the case of Koggala, the local communities display a wide and very thorough knowledge of the functions and benefits of the wetland ecosystem that supports them and the dangers of over-exploitation. But these same communities that are dependent on the lagoon and its resources house the poorest members of society. Despite their understanding of the resource, they are forced to overuse it to meet their basic family needs.

Inspite of major advances in thinking, the reality is still quite different and Wetland Management particularly in parts of Asia and more significantly in Sri Lanka is to a large extent still largely based on the 'protection' and law enforcement approach. These are structured around the traditional view of wetland management and conservation which was primarily focused on efforts to preserve biodiversity (Gujja & Pimbert, 1995a; Dugan, 1988). Here management schemes have been based on attempts to conserve wetlands in order to protect migratory birds and other species. However, the pressures to develop wetlands and, on the other hand to preserve them as ecosystems, are both approaches which have marginalised the role of local communities, whose traditions have effectively conserved wetlands for centuries.

There is a considerable confusion over both the meanings and implications of terms such as 'decentralised management', 'tenure' and 'participation'. For example, 'community participation' is normally viewed as a favour or concession tool to the local communities. 'Participation' is usually interpreted as some sort of public relation tool and according to Gopal (1994) this term has been variously applied by different people in different contexts and mostly in ways convenient and acceptable to those who manage the resource. Wetland Management therefore is now being challenged both conceptually and operationally. These challenges are particularly acute in Asia where the future of management schemes depend on the extent they can contribute to meeting basic human needs. The necessity to review existing approaches have been pointed out by amongst others the World Bank, which has been calling for reform in the way aquatic ecosystems are managed: " We must fundamentally change the way we think about and manage water. The lessons of collective experience demonstrate that we must make a decisive break from past policies to embrace a new approach that is comprehensive, market oriented, participatory, and environmentally sustainable" (Serageldin, 1995).

For the above approach to work, there have to be methodological shifts from the way wetland management has been perceived in the past. This is especially significant in Sri Lanka where despite a renewed interest in wetland conservation in recent times, there still exists a perception of local communities as being part of a problem as opposed to being part of the solution. This has been highlighted in the case study of the Belanwilla-Attidiya Sanctuary (CEA/Euroconsult, 1993) and the Bundala sanctuary (CEA/Euroconsult, 1993a). Despite claiming to have recognised as a priority the involvement of local inhabitants in the management and conservation of these wetlands, the role such communities will actually play in the management scheme is marginal and limited to the final stages of the plan.

Thus it is vital that there is a move away from the current way of thinking. To this end conceptual shifts identified by Gujja and Pimbert (1995a) include:

- changing the traditional approach of considering local communities as part of the problem to considering them as part of the solution.

- recognising local people as major stakeholders and not merely as passive beneficiaries.

- ensuring that wetland management schemes are perceived as a means of simultaneously improving ecosystems and local livelihoods.

Operational shifts should be informed by the notion that local communities can carry out most, if not all, the planning and management functions normally undertaken by outside 'experts' (Gujja & Pimbert, 1995a).

Group discussions carried out in Koggala highlight the ability of local people to:

- analyse their natural resources and understand their limits of use.
- offer possible solutions for management problems.

Genuine people's participation in wetland management implies new roles for conservation professionals and other outsiders. These roles all require a new professionalism with new values, methods and behaviour (Chambers, 1993; Pimbert & Pretty, 1995). Thus the challenge for external institutions and professionals promoting wetland conservation and management is to become more enabling in their relationships with local communities living in and around wetlands. A paradigm shift is needed from a 'top-down', blueprint approach towards a 'bottom up', people-centred, process-oriented, approach (Pimbert & Pretty, 1995). It should be emphasised, however, that community participation cannot be the ultimate answer to all the problems associated with the wetland degradation outlined in **Chapter 2**. Nevertheless, it should be seen as an effective means to empower local communities to take control of their resources in a sustainable way and thus to benefit from the wetland areas in which they live. In these circumstances, the use of the group discussion is seen as a valuable research tool which can be adopted in developing countries.

9.4 An Assessment of Environmental Issues and Management Options

In some developing countries where industrialisation is in progress, there has been a marked decline of that segment of the population that is directly dependent on traditional agriculture and harvesting of natural resources as an occupation and income. However, this is not the case in Sri Lanka where the segment of the population that relies on natural resource-based activities has remained relatively unchanged. In this context, depletion of existing natural resource bases resulting from a combination of activities, including unintegrated development activities and environmental changes, can have devastating effects on traditional resource users. This imposes severe economic hardship, aggravating poverty, and compelling these segments of the population to be increasingly dependent upon the state. In Koggala, the local communities dependent on the lagoon and its resources are representative of such traditional resource user groups. As revealed by discussion groups in the sample six divisions, the rural communities in Koggala are aware that traditional practices which were once sustainable under different demographic and social conditions also play a part in the gradual degradation of the resource. Therefore they are receptive to other approaches to resource use which are environmentally sound, sustainable and more productive in the long term.

One of the clearest lessons that can be drawn from the development experience in Sri Lanka is an increase in poverty among populations dependent upon agriculture and fisheries because of inadequate attention to equity issues. Frequently, development purportedly for the benefit of the poor and the unemployed has had the opposite effect. In many instances the side effects of development have eroded the productivity of linked ecosystems (Samarakoon, 1995).

The present study has identified a number of issues that have a profound effect on the sustainability of the coastal resources in the area and hence the sustainable utilisation of the coastal resources of Koggala Lagoon. The nature and extent of these issues vary widely However, they collectively contribute to undermining the quality and functional integrity of this coastal ecosystem and pose an increasing threat to the sustainable use of its natural resources. These issues will be discussed following a brief overview of the development of coastal management in Sri Lanka.

9.4.1 Current Status of Wetland Management in Sri Lanka

Since Sri Lanka's coastal waters have been used by colonial and naval powers over a long period of time, there is a wide variety of coastal structures that have been left behind by them. The Portuguese and Dutch forts, jetties and canals still bear testimony to the intense activity along the coastal zone in colonial times. The relatively higher proportion of pressure on the south-western coastal lowlands has also led to the launching of coastal protection programmes in these areas particularly during the last century (Bandara, 1989). The problems involved in the management of the coastal zone have been discussed at some length by authors such as De Alwis (1980), Amarasinghe (1978;1985), Amarasinghe and De Alwis (1980) and the Marga Institute (1982;1985) while detailed accounts of the environmental management and planning for the coastal and marine zone are given in UNEP (1986a).

An increasing number of countries in tropical Asia have developed coastal management programmes governing a portion of their coastal areas, but no country in the region has a longer history of coastal management than Sri Lanka (Lowry & Sadacharan, 1993). Building on a number of reports and studies in the early 1960's seeking solutions to coastal erosion problems, Sri Lanka established a Coast Conservation Division (CCD - later Department) in 1978, and enacted a Coast Conservation Act in 1981 (Act no.57) which came into operation in 1983 (Kahawita, 1993). The act required a permit to be obtained from the Director of Coast Conservation for any 'development activity[1]' in the coastal zone. The Act defined the coastal zone as "the area lying within a limit of three hundred metres landward of the mean high water line and a limit of two kilometres seaward of the mean low water line and in the case of rivers, streams, lagoons, or any other body of water connected to the sea, either permanently or periodically. The landward boundary extended to a limit of two kilometres perpendicular to the straight base line drawn between the natural entrance points thereof and included the waters of such rivers, streams and lagoons, or any other body of waters so connected to the sea."

The first-generation coastal zone management programmes were mandated by the Coast Conservation Act of 1981, which entrusted the CCD with primary responsibilities for policy formulation, planning , research, administration of the permit programme, and the construction and maintenance of shoreline protection works. The Coastal 2000 strategy signifies a second-generation coastal resource management programme with a broader vision and is based on the realisation that the scope of ongoing coastal zone management activities needs to be expanded through an identification of long-term goals and made more holistic and multidisciplinary. It outlines the present status of coastal management in Sri Lanka and provides the rationale for a second generation coastal resources management strategy. It analyses the demographic, economic and environmental context that sets the conditions for resources management. The

[1] 'Development activity' is defined in the Act as any activity likely to alter the physical nature of the coastal zone in any way and includes the construction of building and other structures; the deposition of waste or other materials from outfalls, vessels and by other means; the removal of sand, seashells, natural vegetation, seagrass or other substances; dredging and filling; land reclaiming and mining or drilling for minerals, but does not include fishing.

second volume of Coastal 2000 stresses the outstanding issues in coastal resources management, with a view to identifying the necessary strategies for their solution. They include issues such as the lack of adequate institutional arrangements, the need for clarity in the definition of coastal boundaries, environmental degradation caused by accelerated development activity, and the unrealised potential for economic alternatives (Olsen *et al.* 1992; Bandara, 1993).

More recently it has been argued that coastal resources management initiatives have not been able to achieve the desired results at the local and community levels inspite of the fact that such initiatives have been based on rational and well thought out national policies. The main reason for this failure has been the inability to mobilise the support and commitment of the local communities for implementation (White & Samarakoon, 1994). The primary factors contributing to this situation have been summarised by Wickramaratne and White (1992). Given this background, Special Area Management (SAM) planning and techniques have emerged as a successful method of managing development in complex settings and are being tested in a number of sites around Southeast Asia (White, 1991). The SAM planning process, which is a specific activity of the Coastal 2000 strategy, is based on the recognition that existing planning, legislation and institutional implementation mechanisms alone are insufficient. It accepts the need to integrate the local community at the centre of the planning and implementation effort, thereby making them the custodian of the resources being managed (Wickramaratne & White, 1992). Two SAM sites have been chosen on the southwest of Sri Lanka and the purpose of SAM in both sites is to resolve competing demands on resources by planning for optimal and sustainable use (pers. comm. White, 1993).

In 1990, Sri Lanka ratified the International Convention of Wetlands of International Importance (Ramsar Convention, 1971) and nominated the Bundala sanctuary for inclusion in the convention's list. The Department of Wildlife Conservation acts as a contracting party for the government of Sri Lanka for this convention. It is the principal Government institution that has been involved with wetland protection, mainly because of its vested interest on the protection of dependent wildlife. There are a number of agencies, institutes and universities involved in wetland studies. However due to a lack of an overall co-ordinating body, in the past there has been considerable duplication of work. With the growing realisation of the non-existence of a national wetland policy and the inadequate current legislation available for their protection which is 'borrowed' from different institutions with other vested interests (see Box 9A), the Central Environment Authority launched a Wetland Conservation Project in 1990. The aim being to pursue its long term objectives to conserve and manage Sri Lankan's wetlands and their gene pool, and to strengthen the institutional capabilities in conceptualising,

Box 9A Government bodies with a jurisdiction over the study area

The Central Environmental Authority (CEA):

- Formulates and co-ordinates environmental policy of various agencies in long range planning and management. Recommends land use schemes and basic management policies for natural resources with an emphasis on fisheries, wildlife, forestry and soil; specifies standards, norms and criteria for environmental management, monitoring of environmental conditions, and initiates research and the dissemination of information; co-ordinates environmental impact assessments of development projects and the licensing of pollution discharges, primarily of industries mandated to assist Divisional Secretaries to set up "Environmental Councils" to address problems of water pollution, waste disposal and other environmental issues at the Divisional level.

The Ceylon Tourist Board (CTB):

- Implements coastal tourist development projects; recommends and enforces tourism policies and guidelines affecting the coastal zone; provides information on development plans, proposed and adopted tourism policies and guidelines affecting the coastal zone.

The Forest Department:

- Oversees the use and management of forest resources; has responsibility for the management and conservation of mangrove forests larger than 50sq. ha. in area.

The Irrigation Department:

- Responsible for irrigation system engineering, design, construction, operation and maintenance.

The Ministry of Fisheries and Aquatic Resources Development (MFARD):

- Co-ordinates and monitors all activities relevant to fisheries and other aquatic resources; formulates policy guidelines and recommends management plans; implements development projects for fisheries and organises co-operative societies.

The National Aquatic Resources Agency (NARA):

- Conducts research and development, monitoring and research co-ordination functions, disseminates information and provides advisory and consultant services concerned with marine and inland aquatic resources management.

The Department of Wildlife Conservation (DWLC):

- Responsible for protecting wildlife through the enforcement of the Fauna and Flora Protection Ordinance and the management of protected areas. All the endangered species of animals and migratory and local birds which live and nest in Koggala are protected under the Ordinance and protective enforcement is the responsibility of the DWLC.

Other Government bodies with secondary responsibilities within the coastal zone include the Ceylon Fisheries Association; the Ceylon Fisheries Harbour Corporation; the Board of Investment; the National Water Supply and Drainage Board; the Water Resources Board; the Geological Survey Department; the Low-lying Areas Reclamation Board; the Urban Development Authority and the Sri Lanka Land Reclamation and Development Corporation.

(Source: adapted from Ganewatte *et al.* 1995 and CEA/Euroconsult,1991)

implementing and monitoring natural resource management (Dissanayake, 1993). This joint project between the Netherlands Government and the Government of Sri Lanka is currently being facilitated through co-operation between the Central Environment Authority (Sri Lanka) and Euroconsult (Netherlands). A step towards improved co-operation between such groups and co-ordination of activities was attempted in 1990 when a National Wetland Steering Committee was established (CEA/Euroconsult, 1991).

9.4.2 Institutional and Legal Framework

The use and management of the natural resources in Koggala are affected by various national and local institutions and laws. Traditionally it has been the case of a 'top-down' approach by the Government. This had limited success in managing natural resources in relation to the needs of local people. Koggala is no exception in that national actions have not been well co-ordinated or focused on the problems of the communities in the area. The management of coastal resources involves many government institutions, as in the case of other natural resources in Sri Lanka. Responsibilities are sometimes unclear and conflicting. The primary management responsibility, however, rests with the Coast Conservation Department (CCD) presently placed within the Ministry of Fisheries and Aquatic Resources Development (MFARD). The CCD is responsible for:

- Formulating and implementing coastal protection and management activities;
- Regulating development within the prescribed "coastal zone" through a permit system;
- Evaluating development projects through discretionary environmental impact assessments;
- Preparing and implementing the Coastal Zone Management Plan and;
- Conducting surveys in co-operation with other agencies.

To assist with management decisions and recommendations, the Coast Conservation Advisory Council advises the Director of Coast Conservation on all development activities in the coastal zone. This council reviews the Coastal Zone Management Plan **(CZMP)**, environmental impact assessments (EIA) and requests for permits. The CZMP, established in 1990, provides the framework to manage resources in the coastal zone. One main constraint faced by the CCD is its limited legal jurisdiction.

The government of Sri Lanka has a number of laws regarding the use and protection of natural resources. The laws having a particular relevance to the study area are presented in Box 9B. These laws provide some legal framework for protecting resources. However, enforcement of these laws is sometimes difficult. Adding to enforcement problems is the 'top-down' bureaucratic approach to legally based natural resource management. A 'bottom-up' enforcement strategy could help make enforcement of these laws much easier and more effective. In addition, political considerations at the provincial level undermine the efforts of the centrally based government departments that are attempting to reduce the adverse impacts of human activities. Thus there is very little, or no, implementation of existing laws (Rajasuriya *et al.* 1995).

Box 9B Government Law enforcing bodies and laws relevant to coastal areas

The Seashore Protection Ordinance, Gazette No. 7710 (1929):
- bans the removal of coral, sand, and other substances;

The Fauna and Flora Protection Ordinance, Gazette No. 8675 (1940):
- protects threatened and endangered wildlife;

The Fisheries Ordinance, Gazette No. 12304 (1961):
- bans the use of destructive fishing gear and supports sustainable fishing activities;

The Tourist Development Act No.14 (1968):
- authorised the CTB to regulate services and prevent indiscriminate and unplanned development in resort areas. This act has implications for tourism development in Koggala;

The Natural Heritage and Wilderness Act (1980):
- was amended in 1988 to require Environmental Impact Assessments and licences for in duties potentially producing air, water and/or land pollution.

The National Environmental Act No.47 (1980) and Amendment No. 56 (1988):
- (a) established the CEA and made provisions regarding its powers, functions and duties,
- (b) made provisions for the protection, management and enhancement of the environment, and for the prevention, abatement and control of pollution. The Amendment calls for tighter environmental quality control, the establishment of a CEA fund, CEA officers and an Environmental Council made up of senior offices from relevant Ministries with environmental responsibilities;

The National Aquatic Resources Agency (Research and Development) Agency Act No. 54 (1981):
- established the NARA to ensure the application of science and technology to the conservation of aquatic resources in the inland water, coastal wetlands and offshore areas, disseminate information, and provide advisory and consultant services;
- **The Coast Conservation Act No. 57 (1981):**
- (a) requires CCD to develop a Coastal Zone Management Plan, regulate and control activities within the coastal zone, and formulate and execute coast conservation projects;
- (b) defines coastal zones to include some portion of the water areas of lagoons, estuaries and rivers,
- (c) established uniform procedures for permit applications without distinction between development activities undertaken by private and state sectors;
- (d) encouraged collaboration among various government agencies involved in research and development activities within the coastal zone;
- (e) specified penalties for violation of the law;
- (f)authorised the Director of the CCD to demolish unauthorised structures and
- (g) established horizontal links between the law and other parallel legislation.

The 1988 Amendment to the Coast Conservation Act No. 57 of 1981:
- (a) authorised the Director of the CCD to delegate powers, duties and functions to government agents or public officers of any administrative district which contains a portion of the coastal zone, (b) banned the mining and collecting of coral, (c) authorised the seizure of boats engaged in illegal activities, and (d) granted the public the right to use any beach;

The Forest Ordinance (1945) Amendment No.13 (1966) and Act No.13 (1988):
- makes illegal the harvesting, possession, sale and transport of timber without a permit and provides the legal authority to prosecute offenders. This has particular relevance to mangrove forests and their illicit harvesting.

The Marine Pollution Prevention Act No. 59 (1981):
- authorised the Marine Pollution Prevention Authority to prevent, reduce and control pollution in Sri Lankan waters;

The Specified Tourist Services Code (1984):
- provides for the classification, registration and licensing of all tourism related establishments.

(Source: adapted from Ganewatte *et al.* 1995 and CEA/Euroconsult, 1991)

Continued wetland degradation in Sri Lanka can thus be attributed to the following main factors:

- Overlapping and confused Government responsibilities in the face of the existence of a multiplicity of ministries and departments that share responsibilities;
- Failures in legal enforcement;
- A general lack of community participation and more importantly inadequate opportunities available for such participation in the development and decision making process;
- Failures in reflecting the true value of wetland functions;
- Insufficient research conducted on wetland functions in terms of market values;
- Inadequacies in the E.I.A process.

9.5 Summary of Key Themes

The many pressures on natural resources in Sri Lanka are leading to rapid changes in ecological conditions. As is the case in most coastal areas in the country, the natural resources in Koggala are also not being used in a sustainable manner. Often it is the case that agencies charged with the management of these natural resources are overloaded with demands from groups seeking to exploit these resources (Baldwin, 1991; Olsen *et al.* 1992; UNEP,1986a). In these situations both the well devised legal codes designed to protect the environment and the traditional uses by local populations tend to be overridden by more powerful, often, short-term economic considerations at the cost of long term ecological use and benefits of the natural resources (White & Wijeratne, 1993; Chua, 1991; Samarakoon, 1986). In recognition of the environmental, social and economic consequences of wetland loss and the importance of sound management especially where the survival of local communities are linked with wetland functions, many countries have initiated national programmes for wetland management needs. However there are still many obstacles to be overcome, including economic and political forces which favour economic development.

There are two main failings associated with current management systems relating to wetland ecosystems in South and Southeast Asia. The first relates to the failings of conventional measures of economic costs which fail to deal effectively with the variety of benefits from wetland ecosystems, and the inability of the economic sciences to express these costs and social costs in a meaningful way. The second major failing concerns decisions taken at the national level which bars the access of local communities to the decision-making processes and how these policies translate into land-use patterns at the local level.The findings of this thesis suggest that the continued destruction of wetland ecosystems in South and Southeast Asia, and particularly Sri Lanka, stems from a failure to deal effectively with these issues.

It is now generally recognised that science alone cannot achieve the sustainable management of wetland resources (Burbridge, 1994; Dugan, 1988;). At the same time, resource-use policies which are not based on scientific analyses are ineffective and often harmful (Riggs, 1995). Therefore a broader research methodology is required that encompasses the interconnections between the natural sciences and public policy. The findings of the present study stress the importance of the design of research activities which builds on community participation at the *earliest stages*. This stage is significant as it reveals that expertise also lies outside the scientific community.

Though it is increasingly accepted that an integrated approach that combines public awareness, education and participation is needed for the sustainable management of wetlands, the reality on the ground is very different, particularly in Asia where wetland management is largely based on the traditional protection and enforcement approach. Thus there have to be methodological and operational shifts from the way wetland management has been perceived in the past to a people-centred bottom-up approach. The use of the group discussion presents a novel approach that offers an opportunity for local communities to participate in this process.

9.6 Priorities for Management: An Analysis of Relevant Issues

9.6.1 Coastal Resources Management Issues

The present study has identified a number of issues that have a profound effect on the sustainability of the coastal resources in the study area (see Table 9.1). The major management issues can be divided broadly into four categories:

- Population pressures;
- Problems caused by decreasing environmental quality and environmental changes;
- Problems relating to resource exploitation;
- Legal/institutional issues.

The nature and extent of these issues vary widely but they combine, and thus pose, an increasing threat to the sustainable use of the natural resources in the area.

Existing environmental problems in Koggala can be divided into two general groups. Those which are generated within the area itself as a consequence of human use of space or resources, and those which originate from actions outside the area but which have consequences or impacts on the processes and systems found within it. Problems within the area resulting directly from the use of the environment and resources include resource depletion and environmental degradation and loss, which in turn lead to competition for space and conflicts between alternate users.

9.6.2 Analysis of Environmental Issues

Salinisation of Agricultural Land

Although agricultural productivity studies have not been conducted in Koggala itself, they have been conducted in the Habaraduwa division where the study site falls. Relevant details have been described in **Chapter 3** . To date, approximately 500 hectares of rice paddy land has had to be abandoned due to increased soil salinisation and this figure is gradually increasing. The salinisation of agricultural land is a factor which threatens the livelihoods of a significant segment of the farming community. Action is therefore required to address this problem which has now reached a critical stage.

Erosion and Flooding

Erosion at the mouth of the lagoon is significant and the rate of this erosion and its effects have increased with the destruction of the sand bar. Direct losses from flooding in the lagoon are difficult to assess but include substantial economic losses felt by the agricultural community as a result of deprivation of cultivable land. Indirect losses in fishery productivity because of changes in hydrological patterns are also difficult to estimate, but experience elsewhere in the world provides an indication of the potential magnitude of this problem. In addition flooding of village roads and homesteads severely impacts on local communities.

Deforestation of Mangroves

Felling of the mangrove complex continues unabated despite an awareness of the ecological role such communities play in sustaining the fishery productivity of the lagoon. Present levels of use cannot be sustained.

Fisheries Depletion

Data relating to the fish catches of the lagoon and associated sea do not exist. However fishing in the lagoon supports the primary income of over 500 families in the study area. Interviews with the fishing community indicate a noticeable decline in catch and size of fish over the years, particularly so in recent times. Destructive fishing methods such as brush-pile are thought to have had some long term effects, as has potential pollution from agro-chemicals which drain into the lagoon. The biggest threat to fisheries occurs from over-fishing and habitat degradation. Coastal developments and the destruction of habitats are a greater cause for concern.

Table 9.1 Management Problems and their effects in the study area

Problems	Effects
ENVIRONMENTAL ISSUES	
Increasing population	Additional competition for limited resources.
Salinisation of surrounding rice paddy land	Poorly designed irrigation drainage systems exacerbated by destruction of sand bar and subsequent flooding of lagoon.
Cutting of mangroves	Use of mangrove wood as fuelwood; traditional fishing methods and house construction.
Coastal erosion	Exacerbated by increased tidal input and lack of protection at lagoon mouth.
Pollution of lagoon	Agro-chemical run-off; decomposition processes from retting of coconut husks; KEPZ
Sedimentation of lagoon in northern branches	Decreased flushing capabilities as a result of irrigation structures.
SOCIO-ECONOMIC	
Low shrimp and fish productivity	Over-fishing; unsustainable methods of fishing; degradation of sea grass beds; possible pollution; decrease in breeding grounds.
Declining reef fish population	Possible over-fishing for the ornamental fish trade; sedimentation.
Loss of rice lands	Saline inundation of rice fields.
Inability to cultivate homesteads.	Flooding problems.
Poverty.	Declining natural resource base; lack of alternate sources of income; reliance on government welfare schemes.
INSTITUTIONAL AND LEGAL	
Ineffective law enforcement	Overlapping responsibilities; political interference; difficulty in detecting violations.
Socio-economic inequalities	Employment of non-locals in KEPZ.
Ignorance of laws and ordinance by enforcement personnel	Lack of awareness of degradation of resources.
Poor co-ordination among agencies at the Divisional level	Lack of understanding among Government agencies regarding responsibilities and functions.
Lack of Fisheries and Farming Co-operatives	Lack of organisation on the part of communities.

(Source: Present study)

Potential Impacts from the KEPZ

The newly established KEPZ has already started dumping waste materials stemming from its factories onto a narrow stretch of marshy land bordering the lagoon, the long term effects of which are of considerable importance. The increased levels of industrialisation within the KEPZ and adjacent areas are also worth noting.

9.6.3 Analysis of Social Issues

Resource Use Issues

Conflicts between stakeholders over resource rights and uses are endemic to the region. The most notable conflict pitted local communities against the KEPZ to the point of hostility. Without well-defined and enforceable community and individual resources rights, institutions are not accountable to the local communities. They do not have to be concerned about the distribution of benefits and costs to them. Most stakeholders in the region have concluded that the authorities in the KEPZ have been instrumental for a number of problems they are facing. As such the local communities assign a direct cause and effect relationship between the activities of the KEPZ and declines in fisheries and agriculture because the most significant effects of these declines have come in recent times and coincide with the establishment of the KEPZ and the destruction of the sand bar.

Low Incomes and Poverty

The communities in the study area have become dependent on public welfare schemes for a portion of their income. Viable options for livelihoods are thus essential to make the community more productive and less dependent on the government.

Lack of Institutional Co-ordination

Several government departments and agencies operate in the Koggala area. The activities of these institutions need to be integrated and decentralised at the local level so that better management and co-ordination can be accomplished. All the government institutions are centrally controlled through delegated authority.

9.7 The Way Forward for the Sustainable Management of Koggala Lagoon

One of the major problems facing Koggala Lagoon is the rapid decline and deterioration of its coastal resources - a problem common to the coastal areas of most of South and Southeast Asia. Traditionally the area has supported a largely subsistence-level economy based on agriculture and fishing. However, during the last decade the natural coastal resources in Koggala have generated new economic opportunities which together with rapid development and human activities (see **Chapter 5**) have resulted in changes in resource availability. This in turn has affected the traditional subsistence based activities in the area. The effects of some of these changes on the farming and fishing communities are dealt with separately in **Chapters 6** and **7**.

The natural productivity of the wetland is presently under serious threat from existing and prospective resource-use conflicts. A significant human population is directly dependent upon the fishery stocks for employment and income, but at the same time the national thrust towards industrialisation is increasing, and because of available infrastructure, the area has become exceedingly attractive for industrial and residential development. With the accelerated pace of development, there is a tendency to over exploit resources, including coastal resources, beyond sustainable limits. This has resulted in not only environmental degradation, but also in a widening gap between the rich and the poor. In coastal areas, such as Koggala, the main issues revolve around key environmental problems, like clear-cutting of mangrove, the lagoon fishery and water pollution. The uncontrollable flow of sea water through the mouth of the lagoon and the effects this has had on rice cultivation and coastal erosion, and the loss of biological diversity are also connected issues.

The conclusions from this study are that a wetland such as Koggala must be managed if it is to continue to serve its multiple uses. A summary of the main problems, resource-use conflicts, and management issues are given in Table 9.2.

A primary objective in the preparation of a management plan for the area should be to incorporate multiple uses within the framework of ecosystem structure and functioning. Such a systems approach has been used by Samarakoon (1995) and combines essential characteristics that coastal ecosystems share with all other systems, namely linkages, structural complexity and dynamic stability.

Table 9.2 Summary of the main Problems, Resource use conflicts and Management issues

Problem	**Conflict**	**Remedy**
Habitat degradation stemming from destructive over fishing, lack of alternate employment.	Optimisation of ecosystem biodiversity and thus fishery income **Vs** loss of income and occupation in the absence of alternatives.	Preparation of a fishery management plan based on ecosystem considerations with community participation.
Maintenance of adequate tidal exchange, flushing, dynamic stability and resilience.	Maintaining link with sea **Vs** loss of opportunity for farmers cultivating rice.	Coastal works at lagoon outlet.
Controlling discharge of agro-chemicals and potential pollutants from KEPZ.	Loss of no-cost discharge of pollutants **Vs** enhancement of ecosystem biodiversity.	Pursue initial idea of waste discharge from KEPZ through sea-outfall and monitor agro-chemical usage.

(Source: Present study)

Linkages

Koggala Lagoon is linked both to the land and the sea. The interaction of freshwater and seawater is a fundamental process that determines the scale of the harvestable biodiversity of the ecosystem. The major inference is that this system cannot have an existence independent of the sea, and yet this connection should be controlled.

Structural Complexity

The ecosystem consists of the following interacting parts: connecting freshwater inlets, seagrass beds, mangroves, reed beds, and soft mud bottom. Collectively they support populations of microscopic plants, animals and bacteria that mediate the flow of energy to those components of biodiversity which give economic value to the system. The equilibrium in structural complexity is associated with the dynamics of the system.

Dynamic Stability

Coastal wetland ecosystems are highly dynamic. Loss of dynamism however entails stagnation of water which is a problem Koggala Lagoon has experienced in recent times. Loss of dynamism also has repercussions on biodiversity.

Given this background, the general objective of a management scheme relating to Koggala lagoon should be to maintain ecosystem structures and functions while supporting harmonious multiple uses. In this context the planning criteria include:

- The identification and utilisation of development opportunities which would contribute to local incomes and substantially increase employment (including self-employment) opportunities;
- Prevention of adverse side effects that could deplete ecosystem yields and functions;
- To ensure equity, particularly by guaranteeing that the interests of all segments of present and potential future resource-users are protected.

A summary of the main management recommendations that have been recognised during the course of the present study are given in Table 9.3.

Table 9.3 Summary of main Management Recommendations.

Lagoon and shrimp fishery
• Control mangrove harvesting to help maintain productivity of lagoon. • Monitor water quality of lagoon and also the freshwater inlets that drain into the lagoon from the surrounding agricultural land for agro-chemicals and other potential pollutants. • Organise a Fishermen's Society with an emphasis on representation from the fishermen solely dependent on fishing in the lagoon to monitor and manage the lagoon fishery. • Alter or remove existing redundant irrigation schemes. • The lagoon outlet must be maintained in a way that allows a free but controlled connection to the sea - this may involve major coastal engineering work.
Restoration of Agricultural land
• Use existing Farmers' organisations to discuss problems, issues and how to deal with them at the local level. • Monitor trends in water flow and salinisation. • Explore possible crop diversification to include salt tolerant plants. • Examine existing irrigation schemes.
KEPZ and associated development activity
• Ensure development within KEPZ complies with CCD regulations especially with regard to waste disposal and environmental norms. • Use community inputs to approve hotel and tourism development and monitor to ensure social compatibility.

(Source: Present study)

9.7.1 Summary

Though local participation in wetland management has been advocated in recent times (see **Section 9.3**), the reality in developing countries such as Sri Lanka is that it is still promoted from above and not initiated by local people themselves. Therefore the effectiveness of this participation is questionable. Group discussions amongst local communities in Koggala have demonstrated that for wetland management plans to be productive in the long term, recognition should be given to the importance of involving local communities at the earliest stages of the planning procedure itself.

In order to deal with the numerous problems associated with wetland environments, this thesis has attempted to demonstrate the importance of understanding the human dimensions of the problem. In the case of the study area, group discussions have highlighted the importance of resolving conflicts among different resource-user groups. The use of this method has further illustrated the potential value of integrating local communities into management planning by encouraging them to initiate schemes based on their unrivalled knowledge of the area in which they live. In this context, the important role of group discussions in wetland management planning appears to be vital.

Koggala Lagoon and its environs have undergone a number of environmental changes common to most Asian coasts. These have had significant social and economic repercussions especially on the local farming and fishing communities as described in earlier chapters. In view of the rapid changes now taking place in this area, this thesis has emphasised the urgency of introducing appropriate management planning. Given the inadequacies of approaches to wetland management in Asia in the past, recognition must be increasingly given to participatory approaches which acknowledge the importance of local communities and their role in management planning. A participant from a discussion group conducted in Duwamalagama succinctly summed this up in the following manner:

> ***" Magha hondhata thibeynam,***
> ***yanta dhesath penaynum,***
> ***kima badhiwala yanne man mulavu ayekse?"***
>
> ("If the road ahead is clear,
> and you have two eyes to see the way,
> why stray into the jungle like a person who has lost his way?")

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APPENDIX 1

A list of Fish species encountered in Koggala Lagoon **before** and **after** the destruction of the sand bar, based on ecological surveys and interviews with the fishing community

Family/Species	English name	Sinhala name	Present in 1991	Present in 1994
Megalopidae				
Megalops cyprinoides	Tarpon	Heya	Y	Y
Cyprinidae				
Rasbora daniconius	Striped rasbora	Dandiya	N	Y
Puntius sarana		Pethiya	N	Y
Puntius filamentosus	Filamented barb	Pethiya	Y	N
Puntius cumingii	Cumings barb	Pothayo		
Cyprinius chola	Swamp barb	Kota ipilla	N	Y
Puntius bimaculatus	Redside barb	Ipilli kadaya	Y	Y
Capoeta amphibia	Scarlet banded barb	Mada ipilla	N	Y
Horadandia atukorali	Horadandia	Hora dandiya	Y	N
Cyprinus laubuca	Blue Laubuca	Tatu dandiya	Y	N
Cyprinus carpio I	Common Carp	Rata pethiya	Y	N
Esomus thermoicos	Flying Barb	Ravul dandiya	Y	N
Puntius vittatus	Silver Barb	Podi pethiya	N	Y
Bagridae				
Mystus gulio	Long-whiskered Catfish	Anguluwa	Y	N
Mystus vittatus	Striped Dwarf Catfish	Iri ankutta	Y	Y
Siluridae				
Ompok bimaculatus	Butter Catfish	Walpoththa		N
Clariidae				
Clarias brachysoma E	Walking Catfish	Magura	Y	N
Oryziidae				
Oryzias melastigma	Blue Eye	Handa titteya		
Syngnathidae				
Microphis ocellatus	Oscellated Pipefish	Punchi ata theliya		
Microphus brachyurus	Short-tailed Pipefish			
Centropomidae				
Ambassis commersonii	Common Glassfish	Kahilla	N	Y
Ambassis dayi				
Carangidae				
Caranx sexfasciatus	Six-banded Trelly	Inguru parava	N	Y
Caranx sansum			N	Y
Monodactylidae				
Monodactylus argenteus	Mono	Kapuwa/Kapuhenda	N	Y

Cichlidae				
Etroplus maculatus	Orange Chromide	Kaha koraliya	Y	Y
Etroplus suratensis	Pearl Spot	Koraliya	Y	Y
Sarotherodon mossambicus I	Tilapia	Tilapia	Y	Y
Elotrididae				
Eleotris fusca	Brown Gudgeon	Puwakbadilla		
Gobiidae				
Glossogobius giuris	Bar-eyed Gobi	Weligouva	Y	N
Anabantidae				
Anabus testudineus	Climbing Perch	Kavaiya	Y	N
Channidae				
Channa gachua	Brown Snakehead	Parandal kanaya	Y	N
Channa striata	Murrel	Loola	Y	N
Mastacembelidae			N	Y
Mastacembelus armatus	Marbled Spinyeel	Gan theliya		
Mugilidae				
Liza ceramensis	Ceram Mullet	Godaya	N	Y
Lutinidae				
Lutianus argentimaculatus	Red Snapper	Thambalaya	N	Y
Clupiedae				
Ehirava fluviatus	Malabar sprat	Ehirava	N	Y
Anguillidae				
Anguilla bicolor	Level -finned eel	Kalu aandha	N	Y
Cobitidae				
Lepidocephalicthys thermalis	Common spiny loach	Ehirava	Y	Y
Belontidae				
Trichogaster pecoralis	Snakeskin gourami	Theppilli	N	Y
Centropomidae				
Lates calcarifer	Barramundi	Modha/Kaduwa	N	Y
Aplocheilidae				
Aplochcheilus parvus	Dwarf panchas	Udda	N	Y
Aplochcheilus dayi	Days killifish	Uda Mandeya	N	Y
Hemiramphidae				
Zenachopterus dispar	Half beak	Morella	N	Y
Heteropneustidae				
Heteropneustes fossilis	Stinging catfish	Hunga	Y	Y
Engraulidae				
Anchoviella commersonii	Commerson's Anchovy	Halmessa	N	Y
Elopidae				
Elops machnata	Giant Herring	Mannawa	N	Y
Leignothidae				
Gazza minuta	Toothed Pony Fish	Mas penna		Y

Leiognathus fasciatus	Banded Pony Fish	Penna		Y
Belonidae				
Tylosurus strongylurus	Round Tail Alligator Gra	Diya maralla	N	Y
Muraenesocidae				
Muraenescox cinereus	Silver Congo Eel	Mudu Iuhulla	N	Y
Dorosomidae				
Nematalosa nasus	Long Ray Bony Bream	Katugoiya	N	Y
Cyprinodontidae				
Panchax lineatus dayi	Striped Top-minnow	Hanada nalaya		
Panchax melastigma	Estuarine Top-minnow	Diyapita handaya		
Gerridae				
Pertica filamentosa	Long-rayed Silver Biddy	Golaya		Y
Sphyraenidae				
Sphyraena obtusata	Blunt-jawed Sea Pike	Theliya/Uluwa	N	Y
Dussumieridae				
Spratelloides japonicus	Blue Sprat	Ahirawa		N
Tachysuridae				
Tachysurus caelatus	Engraved Cat-fish	Anguluwa	N	Y
Thraponidae				
Theropon jarbua	Crescent Perch	Iri bataya		Y
Mugilidae				
Liza macrolepsis	Mullet	Godeya	N	Y
Batrachoidiformes				
Batrachus grunniens	Frog fish	Munda	N	Y
Hemirhamphidae				
Hyporhamphus gaimardi	Half-beaks-gar fish	Marandha	N	Y
Clupeidae			N	Y
Macrura kelee	Five spot herring	katu massa	N	Y
Meridae				
Mene maculata	Moonfish	Panna	N	Y
Sillagimidae				
Sillago sihama	Silver whiting	kalanda.	N	Y
Gobiidae				
Glossogobius biocellatus	2-spot goby	kunduppura	Y	N
Ophiocephalus punctatus	Green snakehead	madaya	Y	N

(Source: Present study).

APPENDIX 2

List of hybrid rice varieties cultivated in the study area (1990/1991)

1. B.G. 34-8 (3 months)
2. B.G. 276-5 (3months)
3. B.G. 300
4. B.G. 272-6
5. B.W. 302
6. B.G. 34-6 (3.5 months)
7. B.G. 941
8. B.G. 350
9. B.W. 351
10.B.W.267-3
11.B.G. 379-2 (4 - 4.5 months)
12.B.G. 400.1
13.B.W. 400
14. H4

(Source: Agricultural Implementation Programme, Galle 1990-1991)

APPENDIX 3

List of traders selling agro-chemicals in the study area

• Mr. K. Ediweera - N.R.M. Traders, Dorape, Angulugaha.
• Mr Sarath Ediweera, - Uswatte, Dorape, Angulugaha.
• Mr T.G. Amarasiri, - Kosduwa, Happawana, Wanchawela.
• Mr Chimlaka Vijayaba, Gunawardena, Polkoratuwa, Meepe, Habaraduwa .
• Pitiduwa Pradeshikayo, **Heenatigala**, **Talpe**.
• Harishchandra Gunasekara - **'Senasuma'**, Meepe, Habaraduwa.
• Mr M.P. Premachandra, Singha Agencies, Angulugaha.

(Source: Present study)

APPENDIX 4

List of agro-chemicals and manufacturing companies available in the study area

TRADE NAME	ACTIVE INGREDIENT	USE	MANUFACTURING COMPANY
Gramoxon	**Paraquat**	Herbicide	MACKWOODS
Unden EC 20% *	**Propoxur**	Insecticide	BAYER
Endosan EC 35% *	**Endosulfan**	Insecticide	
Lebaycid EC 50% *	**Fenthion**	Insecticide	BAYER
Gammex	**Lindane**	Insecticide	
Mackphos 200	**Chlorpyrifos**	Insecticide	MACKWOODS
Curaterr 3% granules	**Carbofuran**	Insecticide	BAYER
Baurs Monocrotophos	**Monocrotophos**	Insectide	BAURS
Tamaron EC 60% *	**Metamidophos**	Insecticide	BAYER
Bayer Folidol E605	**Parathion**	Insecticide	BAYER
Red Star Dimitox 40	**Dimethoate 40% EC**	Insecticide	ANGLO-ASIAN
Mackwoods M40	**MCPA**	Herbicide	MACKWOODS
Red Star Weedex 36	**3, DPA 36% Propanil**	Herbicide	ANGLO-ASIAN

(Source: Present Study)

* Percentages shown indicate the percentage of the active ingredient in the compound, as noted in trade label