# CHANGES IN VEGETATION COVER AND SOCIO-ECONOMIC TRANSITIONS IN A COASTAL LAGOON (KALAMETIYA, SRI LANKA), AS OBSERVED BY TELEDETECTION AND GROUND TRUTHING, CAN BE ATTRIBUTED TO AN UPSTREAM IRRIGATION SCHEME

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**Abstract.** According to some non-scholarly reports, Kalametiya lagoon (dry zone of southern Sri Lanka, formerly 8.9 $km^2$, now 7.5 $km^2$) had been a moderately or high salinity water body and a very important centre of prawn fishery until the late 1960s. Most of the lagoon area had remained open water until then. An upstream irrigation project, the Udawalawa irrigation scheme, came into operation in 1967, increasing the freshwater inflow to the lagoon. The flora, fauna and water quality of the lagoon was reported to have changed since then.

The lagoon now is a shallow coastal water body with low salinity water. More than 75% of the lagoon is covered by freshwater species or mangrove species characteristic for water with a low salinity: *Eichhornia crassipes*, *Typha latifolia* resp. *Sonneratia caseolaris*. There is actually no commercially important fishery in the lagoon.

The present study was carried out to assess scientifically the said changes in the vegetation within a GIS, using aerial photographs taken in 1956 and 1994 and IRS IC, PAN + LISS III satellite images of 1997 in combination with ground surveys and information from a questionnaire-based survey.

It appeared from this work that the aerial cover by *Sonneratia caseolaris* has increased by more than 30 times over the period from 1956 to the recent dates. Also, the lagoon area with open water has been drastically reduced during the same period as a result of spreading of freshwater and low salinity plant species. The results strongly suggest that the locally reported changes (fisheries decline, water salinity decrease) can be corroborated by the observed profound changes in plant cover and that upstream water works may have had strong impacts on this ecosystem, thus causing these changes.

This study couples data obtained from retrospective aerial photograph series, from spaceborne imaging, from actual ground surveys and from questionnaires amongst elderly people to reconstruct decadal environmental change, thus attempting to fill the gap of lacking historical environmental data.

**Key words:** fisheries, GIS, irrigation, mangrove, *Sonneratia caseolaris*, remote sensing, *Typha latifolia*.

## 1. Introduction

Mangroves are characteristic plant formations dominated by a set of taxonomically diverse species of trees and shrubs adapted to grow on intertidal areas of lagoons, estuaries and sheltered bays in tropical and subtropical areas (Ball, 1988;

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Saenger et al., 1983). These highly productive ecosystems provide a variety of services and goods. Nevertheless, these values have been insufficiently recognized and vast areas of mangroves are being degraded and destroyed, either intentionally or as a secondary result of other activities, as assessed globally (Saenger et al., 1983) as well as locally (Abeywickrama, 1960; De Silva and Balasubramaniam, 1984–1985).

In Sri Lanka, the total area of mangrove forests is reported to amount to around 10,000 ha, fringing about 75 riverine estuaries and 45 basin estuaries along the coastline of 1,740 km. However, a total of 21 species of true mangroves and more than 20 species of mangrove associates have been reported from these fragmented mangrove forests (Dahdouh-Guebas, 2001; Jayatissa et al., 2002) implying that the species richness of mangroves in Sri Lanka is comparatively high.

Kalamatiya lagoon (dry zone of Southern Sri Lanka) is a shallow coastal water body, which supports a mangrove forest. At present there is no commercial shellfish or finfish fishery in the Kalametiya lagoon at a significant level. According to some non-scholarly reports, Kalametiya lagoon had been an important centre for prawn fishery prior to the late 1960s. It is also reported that the cover by the mangrove tree *Sonneratia caseolaris* (L.) Engler and marsh plants in the lagoon was very small and was confined to the landward edge of the lagoon, leaving most of the lagoon area with open water. These species now cover more than 75% of the lagoon area. Intermittent netting takes place only at the southern corner of the lagoon, by local people for their own consumption. According to the people in the vicinity, these changes have taken place after the onset of Udawalawa project, a large-scale upstream irrigation scheme, in 1967 (40 km north of the lagoon).

The major objective of this study is to assess scientifically the said changes of the vegetation in the lagoon. As there are no scientific data on the vegetation, water quality and fishery for the period prior to the inauguration of the Udawalawa irrigation scheme, remote sensing by aerial photographs of the past and information collected from the local users and residents by way of a questionnaire were used to study the previous situation. The present situation was studied with recent aerial photographs, satellite images and ground surveys. The effective cause of the changes is inferred from these data, because it cannot be addressed directly.

## 2. Materials and methods

### 2.1. Study site: Kalametiya lagoon

Kalametiya lagoon is located on the southern coast of Sri Lanka extending from latitudes 6°04′26″N to 6°07′19″N and from longitudes 80°54′43″E to 80°57′25″E covering an area of 8.9 km$^2$ formerly (now 7.5 km$^2$). More than 75% of the lagoon is shallow (<0.5 m) and muddy and covered by marsh vegetation, except the southern corner at the mouth, which has open water of about 1.5 m depth (Figure 1). Kalametiya lagoon is connected to another small lagoon, viz. Lunama lagoon that

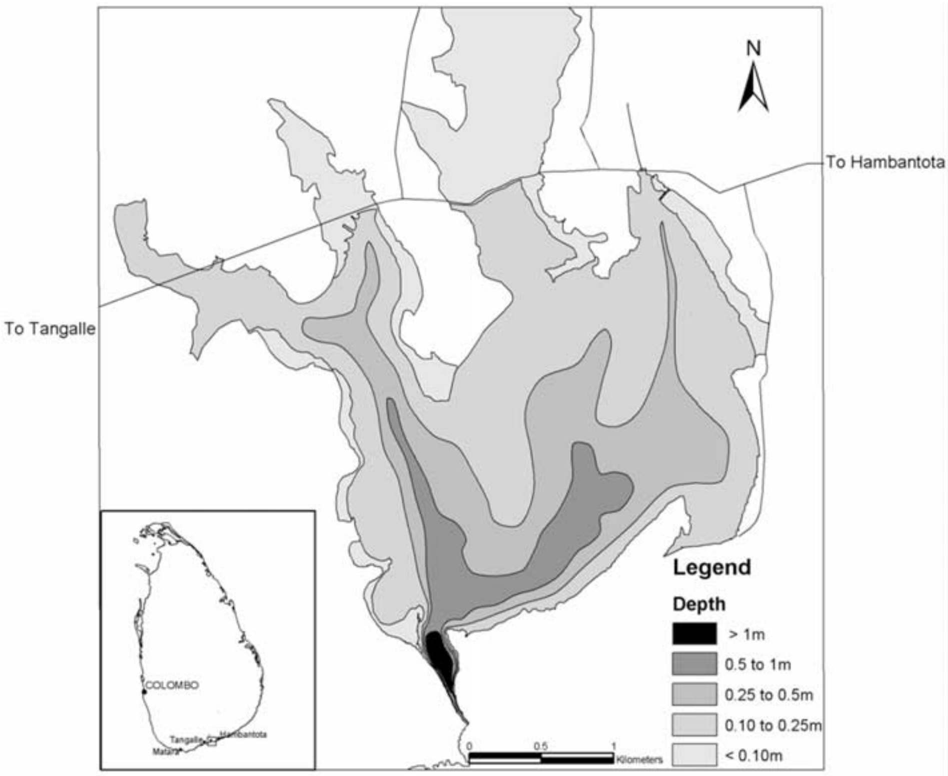



*Figure 1*. Kalametiya lagoon showing silted marshy area (depth $<0.5$ m) and the open lagoon (depth $>0.5$ m), with isobaths (m). Inset: Map of Sri Lanka showing the study area. Adapted from Jayatissa (1987) for the 1994 situation.

does not have a direct opening to the sea and is located 2 km east of Kalametiya, by a shallow canal (Figure 2). The Udawalawa irrigation scheme lies 40 km to the north of Kalametiya lagoon.

## 2.2. Remote sensing

Two sets of aerial photographs of the lagoon area; one taken in 1956 with a scale of 1 : 40,000 and the other taken in 1994 with a scale of 1 : 20,000, were used for mapping the lagoon and its vegetation. Both sets of aerial photographs were scanned and digitized using Arc view 3.2 (Esri, USA) to subsequently identify the lagoon, mangrove area and adjoining land uses. Differences in crown characteristics viz. texture, structure and tonality, are recognizable in aerial photographs and hence can be used to distinguish different mangrove species as reported by Dahdouh-Guebas et al. (2000). The characteristics, which were used to identify five assemblages or stand types of mangroves, are given in Table I. The accuracy of the identification was checked by field visits. Line coverage of aerial photographs showing the vegetation and land uses, were geocoded with standard topographical

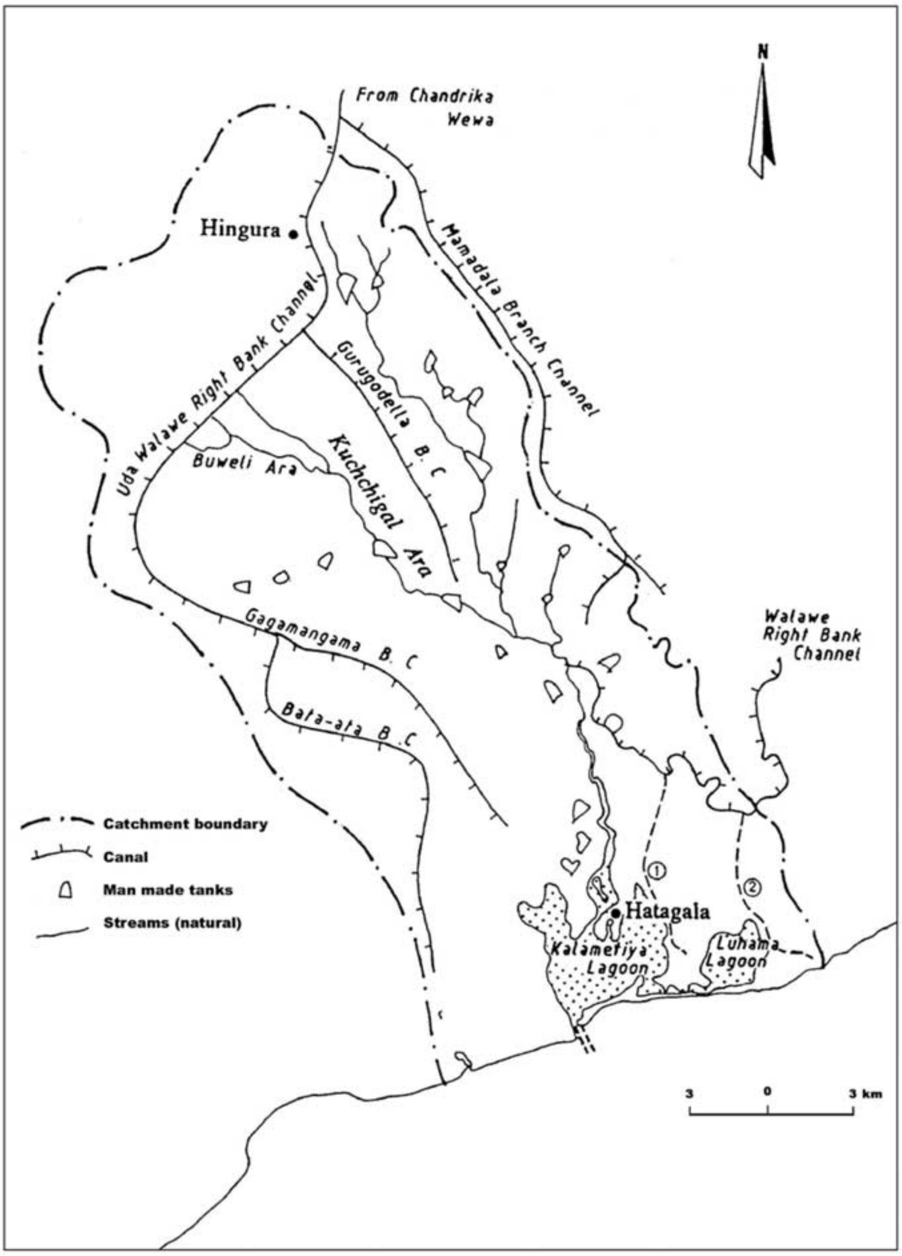



*Figure 2*. Catchment area of Kalametiya lagoon including major canals, streams and manmade reservoirs. Adapted from Liyanarachchi et al. (1995).

sheets (1 : 50,000 in scale) by using GIS software. The coverage of 1956 and that of 1994 were superimposed to obtain area statistics of changes in the mangrove cover.

Moreover, an IRS-1C PAN image of 1997 was merged with the simultaneously acquired LISS III image. The Kalametiya lagoon area was extracted from the

TABLE I. The identification key used to distinguish different assemblages/stands of mangrove species.

| Tonality | Texture | Structure | Other attributes | Species |
|---|---|---|---|---|
| Light grey | Fine grain and and blurred aspect | Discontinuous canopy | None | *Avicennia* spp. |
| Medium grey (or light grey) | Coarse grain | Discontinuous canopy | None | *Excoecaria agallocha* |
| Grey to dark grey | Coarse grain | Discontinuous canopy with irregular shapes | Often higher than surrounding trees | *Sonneratia caseolaris* |
| Dark grey | Very fine grain | Continuous canopy with crowns hardly distinguishable | None | *Lumnitzera racemosa* |

resulting image and georectified to be overlaid with the aerial photographs. The resolution merge between the images was carried out to bring together the better spatial resolution of the PAN image (pixel size is 5.8 m) and the multispectral information (green, red and near infrared bands) of the LISS III image. The extent of different types of mangrove cover was obtained by visual interpretation based on thorough ground knowledge of the study area.

### 2.3. Vegetation and environmental data

Salinity and the water level of a sampling point at the deepest point of the open water area were monitored regularly with monthly intervals during the year 1999.

Profile diagrams of the mangrove vegetation were prepared according to Davis and Richards (1933, 1934) to show the physiognomy of the mangrove forest and required data were collected along a 1 m wide band transect running from the outer margin of the mangrove cover to the inside. Five of 4 m wide transects running across the mangrove areas were also selected from physiognomically different parts of the mangrove vegetation and all the inhabiting species were recorded.

### 2.4. Questionnaire-based survey

A questionnaire was used to obtain information on the situation of the lagoon in the past from the local residents and users around the lagoon. All men and women whose age was not less than 60 years and living in the proximity of the lagoon were selected to get information. Questions were asked to get their response on the following:

1. Identity (name and address) and age,
2. Period of living in association with the lagoon,
3. Occupation,
4. Source of water used for their daily needs (i.e. drinking, bathing and washing),
5. Involvement in lagoon fishery and (if involved) the purpose of fishing,
6. Common species of fish and shellfish caught,
7. Amount of the catch per day,

8. The total number of fishermen involved in lagoon fishery,
9. Total income from lagoon fishery,
10. Other sources of family income,
11. Other uses of the lagoon,
12. Frequency of opening the lagoon mouth (breaching the sand bar),
13. Species of birds and other animals living in the lagoon ecosystem,
14. Species of mangroves and mangrove associates.

The question nos. 3–14 were asked in order to gather information to assess the situation before and after the 1965–1970 period and responses were recorded separately.

## 3. Results

### 3.1. Remote sensing

Mangrove cover on the seaward shore and silted marshy lands differ floristically. Seaward fringes of mangroves consisted of three species, *Lumnitzera racemosa* Willd., *Avicennia marina* (Forsk.) Vierh. and *Excoecaria agallocha* L. (hereafter referred to as 'mixed mangrove') whilst the mangrove cover on marshy area was dominated by a single species, *Sonneratia caseolaris*.

In 1956, the area covered by mixed mangroves was 19.5 ha whilst that covered by *S. caseolaris* was 4.5 ha (Figure 3, Table II). However, over a 38-year period (from 1956 to 1994), the mixed mangrove area has decreased down to 17 ha and the *S. caseolaris*-cover has increased dramatically resulting in 139 ha, by this species' invasion of the shallow area of the lagoon. The comparison of two maps prepared for 1956 and 1994 revealed that the area of mixed mangroves has decreased on the land between the lagoon and the sea where fishermen's houses are located, but it has increased on non-populated areas of the same strip (Figures 3–5). Area statistics of these chronological changes of the mangrove cover are given in Table II. The total area of the lagoon (892 ha) has also decreased by 146 ha which is mainly due to the expansion of agricultural lands.

In aerial photographs, it was difficult to distinguish areas with densely grown reedmace, *Typha latifolia* L. from the other areas of the marsh with helophytes (marsh plants). In contrast, the merged product (PAN + LISS III) of satellite images of 1997 helped to distinguish areas covered by reedmace *T. latifolia* as it gives a different reflection compared to areas covered by *S. caseolaris* and other marsh plants. The areas dominated by *S. caseolaris* were seen in a purple colour on the merged image with a coarse texture and in irregular shapes which represent joined or large crowns, whilst areas dominated by reedmace, *T. latifolia*, were seen in a dark pink colour with a fine texture (Figure 6). More than 50% of the lagoon area was covered by dots in a purple colour with coarse texture, representing areas being invaded by *S. caseolaris*. Patches of *T. latifolia* were also observed in these areas. Only about 20% of the lagoon area remained open water without the two species in remarkable densities.

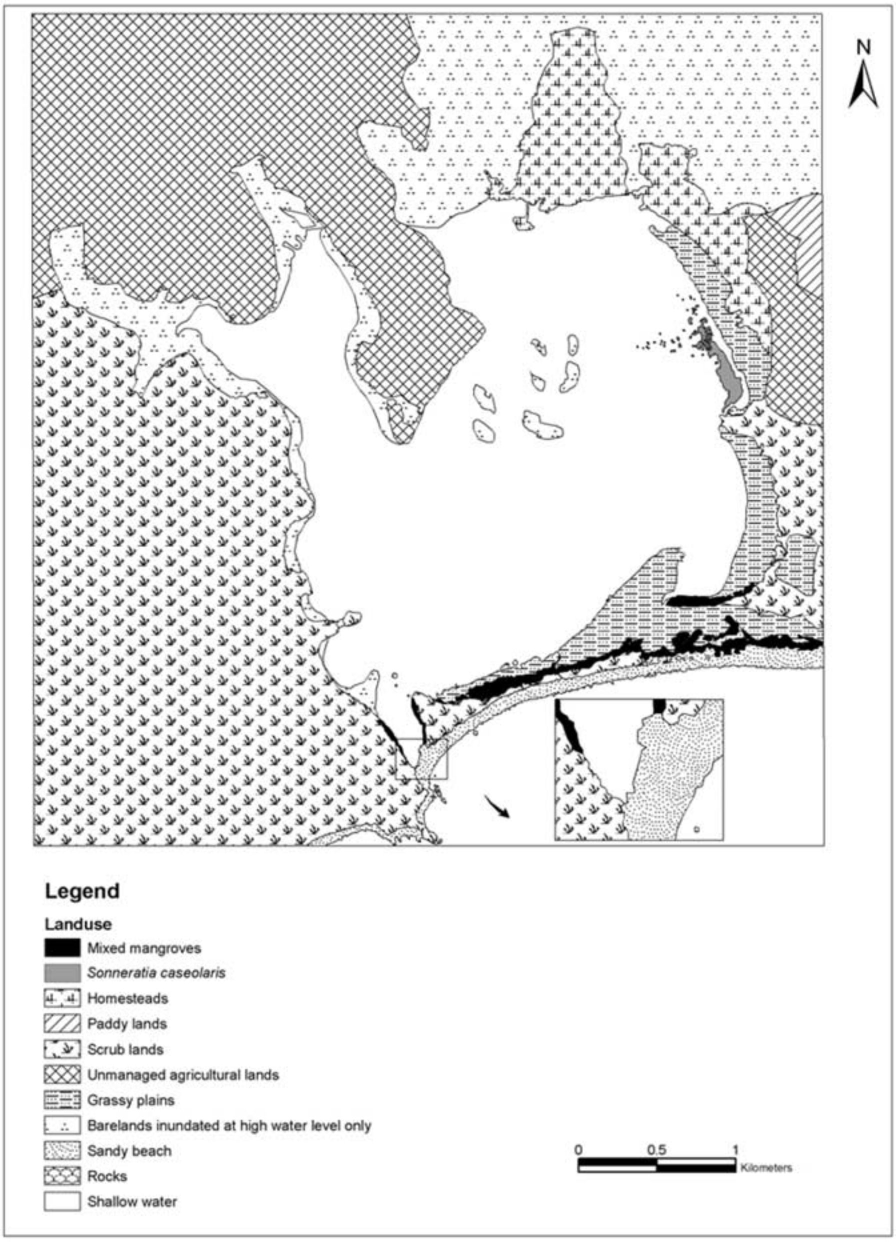



*Figure 3*. The former distribution of mangrove areas and other landuses at Kalametiya lagoon, based on the aerial photograph of 1956. Inset: The mouth area of the lagoon.

### 3.2. Ground surveys

The lowest and highest water levels recorded during the study period at the deepest point of Kalametiya lagoon were 2.25 and 3.00 m, respectively. Fluctuations of the

TABLE II. Area statistics, showing the changes of the mangrove cover of Kalametiya lagoon over a 38-year period from 1956 to 1994 (based on aerial photographs).

| | Area (ha) in 1956 | Area (ha) in 1994 | | |
|---|---|---|---|---|
| | | Disappeared | Remaining | Newly grown |
| Mixed mangroves | 19.5 | 13.0 | 6.5 | 10.5 |
| Mangrove dominated by *Sonneratia caseolaris* | 4.5 | 0.0 | 4.5 | 134.5 |

water level within this range resulted from the influx of irrigation water, rainfall and the tides or their combined effects.

The observed salinity ranges of water near the bottom and surface were 1–5.5‰ and 0–1.0‰, respectively. Monthly variations of the salinity were more appreciable near the bottom than at the surface. The mean of bottom and surface salinity values was 2.1‰.

The most common plant species recorded from selected transects are given in Table III. The profile diagram of newly grown mangroves (along the line demarcated as x-x′ in Figure 4) shows the predominance of tall trees of *S. caseolaris* with abundant pneumatophores in between (Figure 7). The elevation range of the land along the transect is less than 25 cm. The last 25–30 m of the inward end of the transect shows rather sparsely distributed trees with lower heights compared to the other areas of the transect.

Ground surveys showed that there is a liana, *Cayratia trifolia* (L.) Domin. growing in areas dominated by *S. caseolaris* in association with *Sonneratia* trees. In some areas it has grown extensively, covering crowns of *Sonneratia* trees, changing textural and spectral properties of the formation.

### 3.3. Questionnaire information

Most of the area of the periphery of the lagoon is still not highly populated and covered by scrub forests. Although 23 houses from the periphery of the lagoon were visited, only five knowledgeable men older than 60 years who had been involved in lagoon-associated activities including fishing were found. Interestingly the response of all five for the questionnaire was very similar. Information revealed by them and data collected from field studies were used to compare the present and previous (before 1965–1970 period) situations of various aspects and the comparison is given in Table IV.

## 4. Discussion

Nowadays remote sensing and GIS are extensively used in a variety of spatial studies, including vegetation analysis, and they have proved effective in assessing the extent of surface features and their variations over time. Spatial studies on mangrove vegetation rather than many other vegetation types, especially need remote

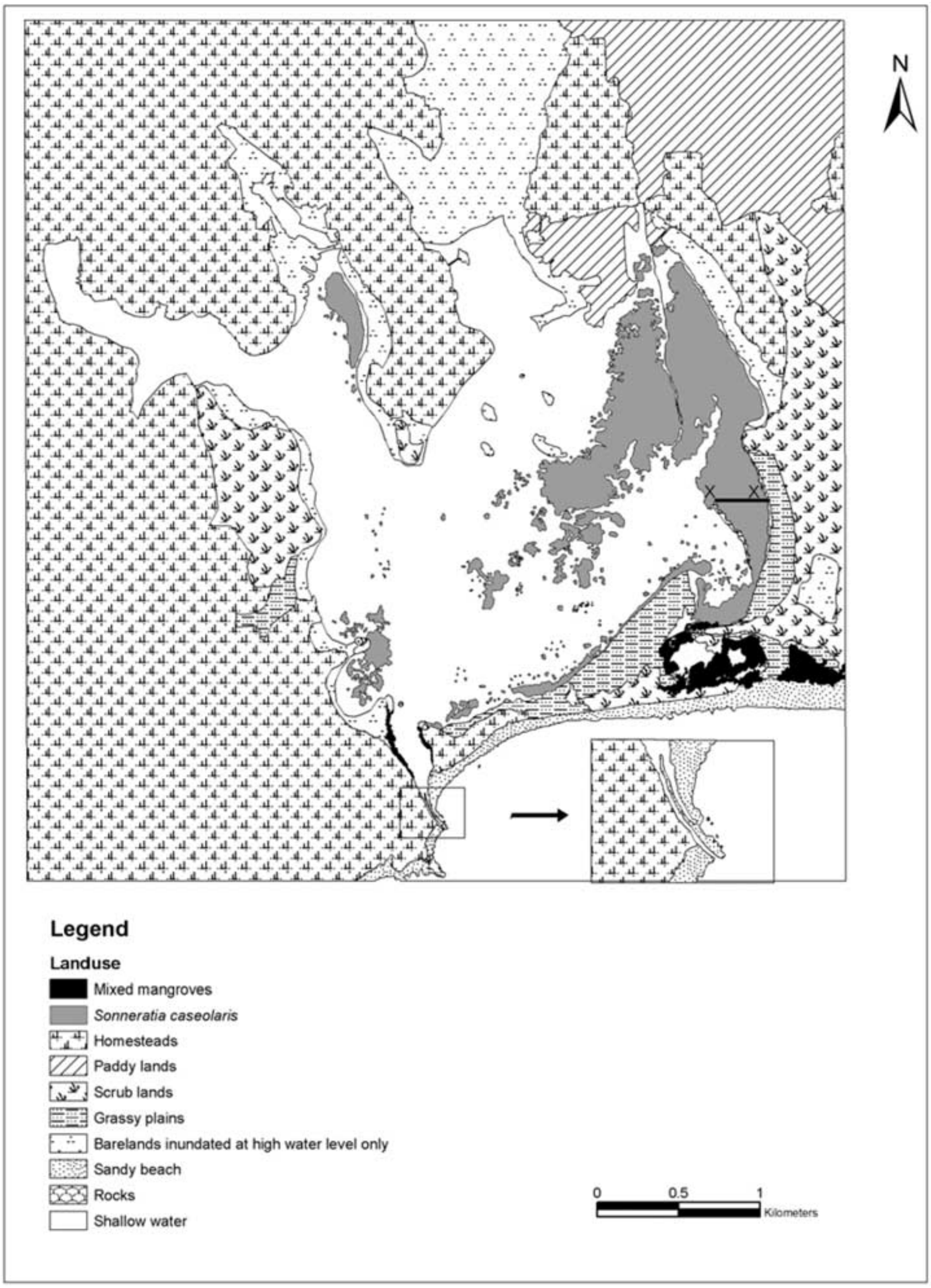



*Figure 4*. The distribution of mangrove areas and other landuses at Kalametiya lagoon, based on the aerial photograph of 1994. Transect X-X′ in the newly invaded mangrove area at the eastern bank of Kalametiya lagoon. Inset: The mouth area of the lagoon.

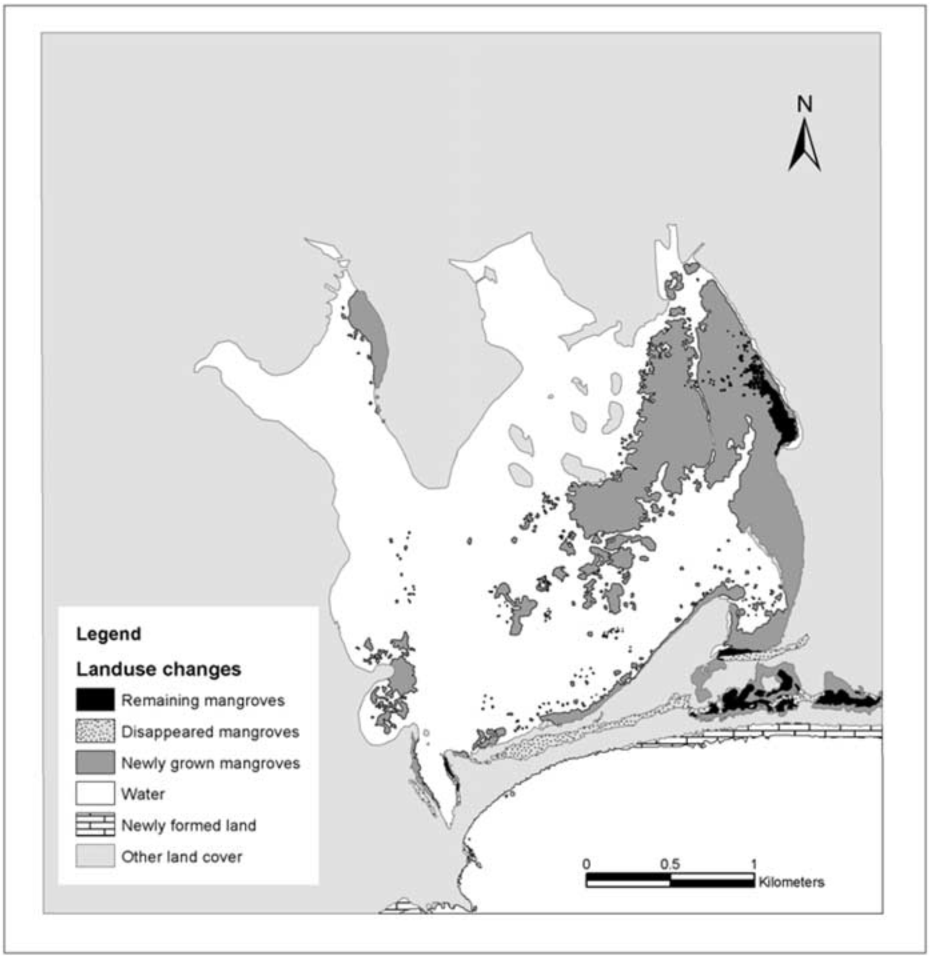



*Figure 5*. The changes of the mangrove cover and other landuses at Kalametiya lagoon from 1956 to 1994 (generated by overlay of maps in Figures 3 and 4).

sensing as they are 'difficult lands' for *in situ* studies due to the boggy nature of the soil and the extensive system of aerial roots. In this regard, Kalametiya lagoon is one example, for which even the area had not been exactly established, although its importance had been identified since 1938 when the lagoon was declared a sanctuary (Ceylon Government Gazette no. 8370 of 27 May 1938). This declaration was cancelled in 1946 because of the opposition of local residents, but it was re-declared a sanctuary in 1984 (The Gazette of the Democratic Socialist Republic of Sri Lanka No. 303/7 of 28 June 1984). At that time the approximate area of the two interconnected lagoons, Kalametiya and Lunama, was given as 1,760 acres ($\sim$712 ha) (Scott, 1989). Nevertheless, this study shows that the area of Kalametiya lagoon within the boundary declared for the sanctuary is 810 ha and Jayatissa (1987) showed that the Lunama lagoon itself is about 140 ha in extent. Except for the survey on phytoplankton and mangrove vegetation of the lagoon carried out by Jayatissa (1987), no other scientific studies on the flora have been conducted so far.

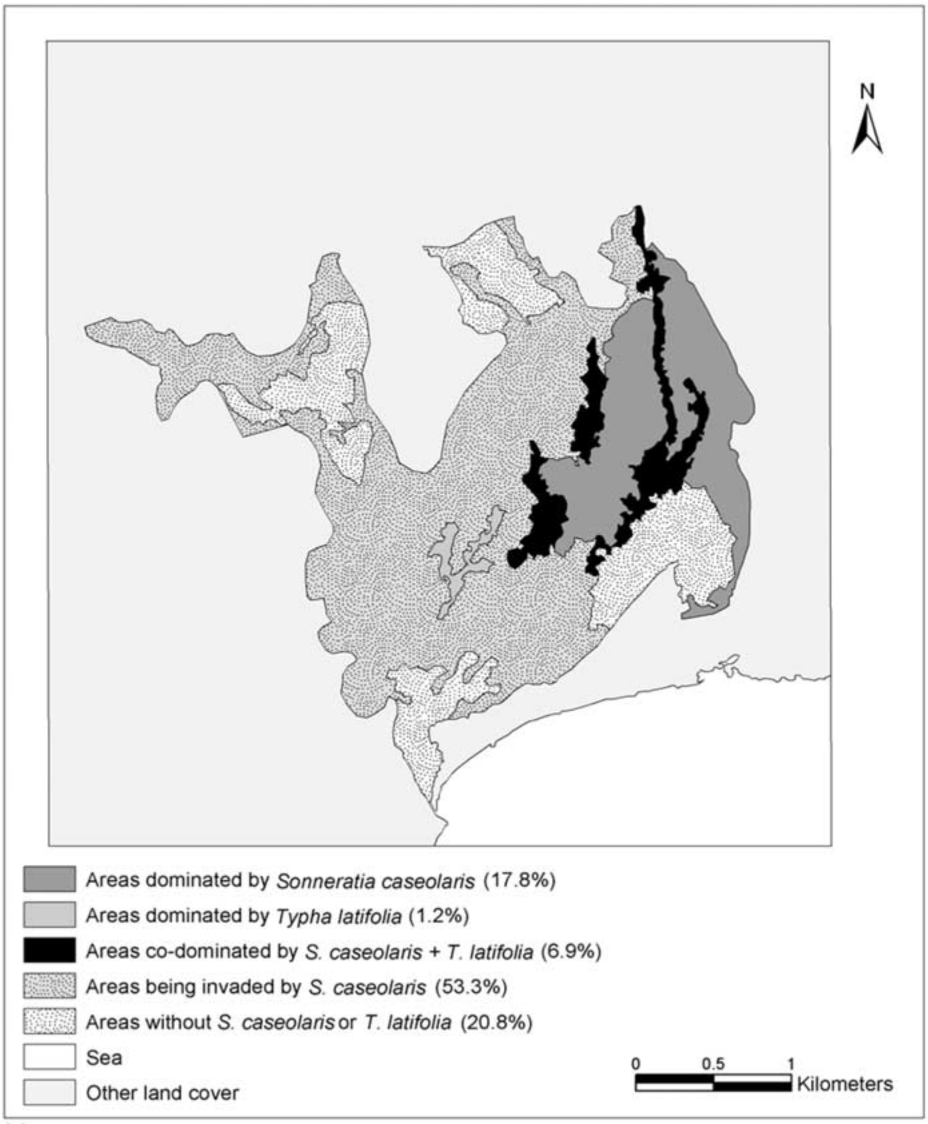
The aerial photograph of 1956 shows the Kalametiya lagoon as a water body with a mouth closed by a sand bar. Mangroves or other emergent trees were not observed in the northern sector, except in a small (4.5 ha) patch of *S. caseolaris* close to the eastern bank. Nevertheless, on the seaward bank, where the soil salinity could be expected to be comparatively higher due to seepage of seawater, a fringe of mangroves comprising three species, *A. marina*, *E. agallocha* and *L. racemosa*, covering 19.5 ha, was observed. Questionnaire information confirmed these findings.

Aerial photographs of 1994 showed that the area covered by mixed mangroves increased remarkably in non-populated areas over the last 3–4 decades and decreased in populated areas. More interestingly, the area covered by *S. caseolaris* alone had increased up to about 17% of the total area of the lagoon over the 38-year period from 1956 to 1994. This did not include the area with sparsely distributed young, isolated plants of *S. caseolaris*, as they were hard to distinguish unequivocally in aerial photographs particularly when located among reedmace, *T. latifolia*. However, the satellite images gave a particular reflectance for those areas with reedmace and *S. caseolaris*, and therefore, it was possible to establish that the lagoon area has been invaded further by sparsely distributed young plants of *S. caseolaris* up to about 53% of the total area previously declared a sanctuary. At present, altogether more than 70% of the lagoon has been invaded by a mature forest or sparsely distributed young plants of *S. caseolaris*.

According to the questionnaire information, floral change is not the only change that took place during the last few decades. The lagoon fauna, and hence fishery has also changed. Prior to the commencement of Udawalawa irrigation scheme in 1967, the closing of the lagoon mouth by forming a sand bar and opening it again had been taking place periodically. Moreover, the freshwater inflow was low and seasonal (Liyanarachchi et al., 1995). Therefore, when the lagoon mouth was open, the flow could be reverted by tidal action and seawater could enter the lagoon, resulting in a higher salinity in lagoon water. This was confirmed by the residents' observation that crystallization of salt had occurred before the new system of canals made in the Udawalawa project that grossly increased the inflow of freshwater into Kalametiya lagoon. With this increased inflow, the flooding of the northern area of the lagoon was severe and frequent. As a solution, a reinforced artificial outlet, was constructed to enable a year round outflow of lagoon water (Figure 4). Since then, the lagoon rarely directly receives seawater, only when the outflow of the lagoon to the sea gets reversed in a drought. The seepage of seawater through the seaward bank of the lagoon is not enough to increase the salinity of water in the whole lagoon to a substantial level. As a result of all these events and processes, the lagoon has been converted into a running freshwater body.

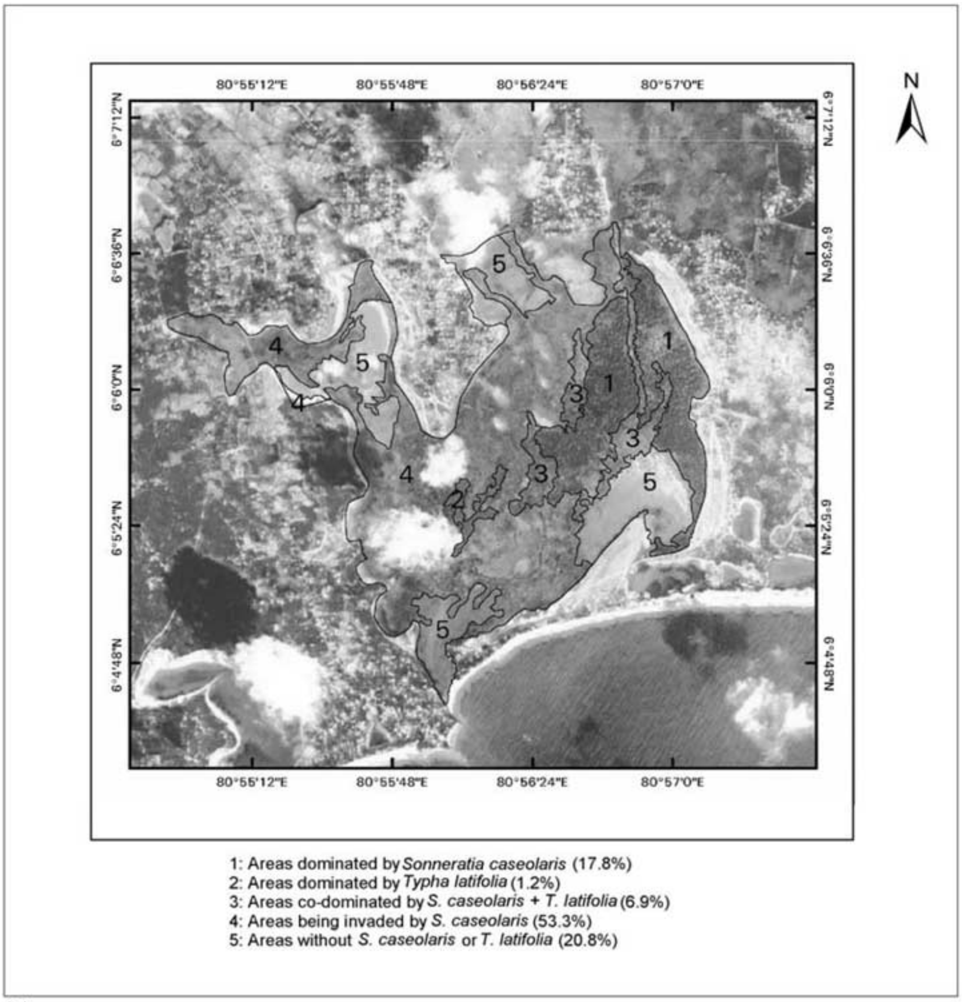
The foregoing is further supported by the information collected by the questionnaires. Besides the observed lack of salt crystallization at present, people are using the waters for bathing and washing etc., which was not done previously.

The reported change in the types of fish living in the lagoon is also meaningful and proves that the salinity has changed. Data on bird populations were unreliable as residents are unable to name most of them correctly. The reported biological changes appear to be a result of hydrological changes in the lagoon created after completion of an upstream irrigation scheme, the Udawalawa project where water was diverted to agricultural lands especially to paddy lands. This is inferred because it is the chronologically most plausible single causal event.




(a)

*Figure 6*. (a and b) Map of Kalametiya lagoon based on the merged product of IRS-1C, PAN + LISS III images taken on 10 January 1997, showing the distribution of *S. caseolaris* and *T. latifolia* (categorization was based on image interpretation).




(b)

*Figure 6.* (*Continued*)

The irrigational manipulations not only changed the hydrology and salinity regime of the lagoon but must also have increased the nutrient inflow to the lagoon and siltation, as the drainage influx comes through paddy fields. Prior to these changes, *S. caseolaris* had been restricted to 4.5 ha of the eastern corner of the lagoon. The new "environment" appears to be more favourable for *S. caseolaris* and it has started to spread dramatically throughout the lagoon. Jayatissa (1987) calculated the area covered by *S. caseolaris* in Kalametiya lagoon by using the aerial photograph taken in 1975 as approximately 25 ha. It was shown that it had been limited to the eastern boundary of the lagoon. According to the present study, it is more than 139 ha. A large number of incompletely canopied small patches of

TABLE III. The list of mangroves, common mangrove associates and most abundant marsh species recorded from the mangroves of Kalametiya lagoon. (Nomenclature according to Bandaranayake et al., 1974 and Dassanayake, 1981, 1983, 1991, 1997).

| No. | Species | Family |
|---|---|---|
| 1. | *Acanthus ilicifolius* L. | (Acanthaceae) |
| 2. | *Acrostichum aureum* L. | (Polypodiaceae) |
| 3. | *Avicennia marina* (Forsk.) Vierh. | (Avicenniaceae) |
| 4. | *Azima tetracantha* Lam. | (Salvadoraceae) |
| 5. | *Cayratia trifolia* (L.) Domin. | (Vitaceae) |
| 6. | *Clerodendron inerme* (L.) Gaertn. | (Verbenaceae) |
| 7. | *Eichhornia crassipes* (Mart) Solms. | (Pontederiaceae) |
| 8. | *Excoecaria agallocha* L. | (Euphorbiaceae) |
| 9. | *Hibiscus tiliaceus* L. | (Malvaceae) |
| 10. | *Lumnitzera racemosa* Willd. | (Combretaceae) |
| 11. | *Salvinia molesta* Flyer | (Salviniaceae) |
| 12. | *Salvadora persica* L. | (Salvadoraceae) |
| 13. | *Sonneratia caseolaris* (L.) Engl. | (Sonneratiaceae) |
| 14. | *Typha latifolia* L. | (Typhaceae) |

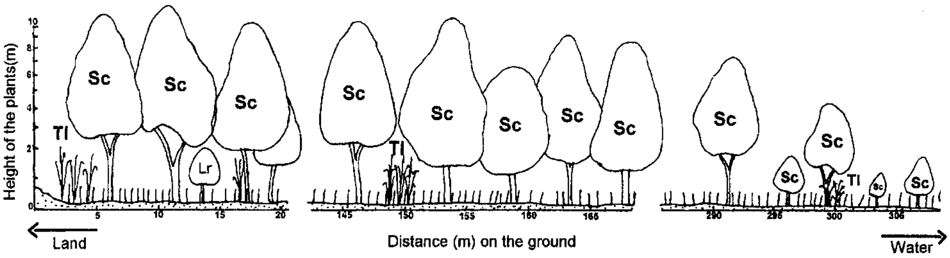



*Figure 7.* Profile diagram of the vegetation along transect X-X′ representing the newly invaded mangrove area at the eastern bank of Kalametiya lagoon. Interrupted sections have a continuous *S. caseolaris* cover. Lr = *Lumnitzera racemosa*, Sc = *Sonneratia caseolaris*, Tl = *Typha latifolia*.

*S. caseolaris* can be seen at the periphery of completely canopied area implying that the spread is continuing further into the lagoon. In Sri Lanka, *S. caseolaris* is mainly found in estuaries and low saline lagoons particularly in the wet zone and some reports also give evidence or consider that *S. caseolaris* is a low saline mangrove tree species (Abeywickrama, 1964; Banerjee et al., 1989; Aksornkae et al., 1992; Duke et al., 1998). This also provides circumstantial evidence for the change in vegetation cover in line with the salinity changes caused by diverting irrigational drainage water through this lagoon.

It can be marginally remarked that the fruit of this expanding mangrove, *S. caseolaris*, is a source of a popular fruit drink in Sri Lanka. Also, pneumatophores of *S. caseolaris* are used as an alternative for cork. However, from a commercial point of view, no attempt has been taken to use these resources.

This study clearly indicates that a decrease in salinity has occurred in the Kalametiya lagoon at a decadal time scale and the most probable and identifiable cause is the Udawalawa irrigation scheme. Very important changes in the vegetation and also the fauna caused a severe disruption in the livelihood of those people who depended on lagoon fishery.

TABLE IV. Comparison of important aspects of Kalametiya lagoon before 1970 and actually, based on questionnaire information received from Liveris Wijesuriya (age 71), Seedin Andaraweera (age 74), S.K.D. Piyadasa (age 68), W.G. David Singho (age 72) and W.G. Peter (age 60), and field surveys. (Nomenclature according to Lovett, 1981 and Munro, 1955.)

| Previous situation (before 1970) | Present situation |
|---|---|
| A large portion of the lagoon was with open water. Few small patches of *S. caseolaris*, and *T. latifolia* were found only in the northern end of the lagoon. *E. crassipes* was rare. | As seen in the aerial photographs, mangroves and marsh plants cover more than 75% of the lagoon area. *E. crassipes S. caseolaris*, and *T. latifolia* are the dominant plants. *S. molesta* and *Azolla* sp. were also rather common. |
| Lagoon water was not used for drinking, bathing or washing due to high salinity. People in the vicinity travelled a few kilometres for bathing and washing. | Lagoon water is used for bathing and washing. |
| In dry seasons, salt crystallized in the southern (i.e. seaward) part of the lagoon. Naturally crystallized salt had been collected by the people and used in cooking and salting of fish. | Salts never crystallize in the lagoon even in severe droughts. |
| The catch of shellfish in the season was in thousands of individuals per effort. The measure used in selling them was not a weight unit but volumes of basketfuls. | The catch of shellfish even during the season is few individuals per day. Usually used for own consumptions. If sold, priced by number. |
| Shellfish species caught were:<br>a. *Penaeus indicus* H. Milne-Edwards<br>b. *Penaeus monodon* Fabricius<br>c. *Macrobrachium rosenbergii* de Man<br>d. *Scylla serrata* Forskål | Only two species of shellfish are present, but in low densities.<br>a. *Penaeus indicus* H. Milne-Edwards<br>b. *Scylla serrata* Forskål |
| Commercially important fish species in the lagoon were:<br>*Liza oligolepis* Bleeker<br>*Elops machnata* Forskål<br>*Chanos chanos* Forskål<br>*Macrura kelee* Cuvier<br>*Sillago sihama* Forskål<br>*Gerreomorpha setifer* Hamilton-Buchanan<br>*Ambassis commersonii* Cuvier<br>*Therapon jarbua* Forskål<br>Except *C. chanos* all the other species are marine/brackish/coastal water species (Munro, 1955). | Fish caught in the lagoon fishery (no commercial significance):<br>*Cyprinus carpio* Linnaeus<br>*Oreochromis mossambicus* Peters<br>*Oreochromis niloticus* L.<br>The first is a native fresh water species and the other two are introduced freshwater species but now also found in brackish waters (Pethiyagoda, 1991). |
| More than 25 families were involved in lagoon fishery and depended primarily on that. | Only 6 families are involved in the lagoon fishery. It is mainly for their personal consumption. The other fishermen depend on sea fishery. |

The objective was to reconstruct a past ecological setting at a decadal scale by combining sets of remotely sensed data and circumstantial but independent, questionnaire-based evidence, thus attempting to fill the gaps in historical data. Comparison with the recent (1994, 1997) and actual situation offers a probable causal relationship to changes in vegetation and to socio-economic transitions.

Though a spontaneous background succession leading to the expansion of a helophytic species, particularly (as here) in a shallow lagoon, must be expected, the scale and the rate of this change, seen in the light of independent sources of information on salinity and faunal shifts, point at the anthropogenic nature of this change. The changes may also affect the importance of this site as a bird sanctuary, though data for this aspect could not be obtained. Predicting these changes might have been impossible, but as this system has exemplified, it should now be possible to speculate on what changes and losses could occur when diverting fresh water in significant amounts to a dry zone brackish water system.

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