

## ECOLOGICAL STUDIES IN THE ITURE ESTUARY MANGROVE FOREST IN GHANA

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### ABSTRACT

*The study assessed the floristic composition as well as aspects of the structure of the mangrove vegetation of Iture estuary with the view to determining any possible changes in these attributes over the past few years. The density and basal area of the trees/shrubs were estimated using the Point-Centred Quarter Method. Seedling/sapling density was estimated in thirty 5 x 5 m contiguous plots. Land-use was assessed by observation, while the effects of pollution and over-cutting were assessed using the standardized site description and site rating criteria developed for the Global Environment Facility's (GEF's) Large Scale Ecosystem Project for the Gulf of Guinea. The flora consisted of five mangrove species in three genera, as well as eight mangrove associates. The densities of *Rhizophora*, *Avicennia* and *Laguncularia* trees and seedlings/saplings were all considerably lower than density values recorded for the same area 15 years ago. The densities of dead seedlings/saplings were also significantly higher than those of living seedlings/saplings. The current most significant land-use was salt mining. The estuary had a poor site rating, suggesting that it was under severe stress. The main stress factors were over-cutting of wood and garbage dumping. It is envisaged that the combined effects of wood extraction and salt mining will lead to further degradation of the mangrove forest.*

### INTRODUCTION

Mangroves are a group of higher plants which have been remarkably successful in colonizing the intertidal zone (MacNae, 1968; Lugo and Snedaker, 1975), especially along the more sheltered regions of the tropical and subtropical coastlines. They have been variously described as "tidal forests", "mangrove forests" and "mangal".

The values and uses of mangrove resources are many and of great importance to the socio-economy of the human communities that live in

the mangrove areas. These include direct products harvested from mangrove forests such as prawns, fishes, mud crabs, gastropods and bivalves, timber and honey (Little, 1980), as well as amenities provided by the resources, such as mangrove forests acting as seaward barriers against coastal erosion (MacNae, 1968) and providing spawning and nursery grounds for many marine prawns and fishes. Also, the living resources of the mangrove ecosystem contain "candidate genes" for seawater tolerance which through recombinant DNA experiments

can be transferred to other species of importance to coastal communities (Swaminathan, 1991, 1992).

In spite of these numerous benefits and uses of mangroves, coastal ecosystems including the mangrove environment are threatened by an ever-increasing anthropogenic pressure. Human activities that have profound influence on coastal ecosystems include agriculture, industry, aquaculture, forestry, tourism, housing and human settlements, fisheries, salt and sand winning, disposal of domestic and industrial wastes, dumping of hazardous and unwanted material and recreation. Traditionally, mangroves have been a forgotten ecosystem neglected by scientists, undervalued by governments and destroyed by developers.

The mangrove of Ghana occupies a narrow, non-continuous coastal area and occurs principally in lagoons which extend from the eastern to the western parts of the country along a coastline of some 550 km long. Mangrove products and the mangrove environment have traditionally been used by the local people who live in the mangrove areas for a long time. Nevertheless, mangrove areas in Ghana have received practically no attention in terms of rational utilization. Exploitation of mangrove resources, especially for wood, fish, crabs and oysters is very intense. About 70% of the mangrove forest of the country has been lost through deforestation (I.I.E.D., 1992). Some mangrove areas have been lost due to their conversion into other land uses, notably agriculture, salt production and housing. Lawson (1986) and Singh (1987) have reported the use of about half of the area potentially occupied by mangroves near the mouth of the Densu River near Accra for salt production.

Interest in the mangrove environment in Ghana is recent. Thus, data on it are very scanty but include descriptive accounts by White (1982), Lawson (1986), Commission of European Communities (1987), Agyepong (1991) and Sackey *et al.* (1993), and some quantitative information on aspects of the ecology of selected mangrove areas, including the man-

groves in the Iture estuary, by Sackey (1994). The report by Sackey (1994) indicated that indiscriminate harvesting of mangrove wood and garbage dumping was widespread in the Iture estuary, and these activities were likely to have profound effect on the structure and productivity of the mangrove vegetation. Fifteen years on, the indiscriminate wood extraction has continued, and relatively recently, portions of the area formally occupied by mangroves have been dedicated to salt production. Also, water-drainage relations are among the most important factors affecting mangrove forest structure and functioning. Hence, the recent flooding of the Iture estuary in July, 2009 together with the indiscriminate wood extraction is likely to have a profound effect on the structure of the mangrove of the area. This study, therefore, sought to assess the floristic composition as well as aspects of the structure of the mangrove vegetation of the estuary with the view to determining any possible changes over the past few years. The findings of the study are expected to provide useful information on the ecology of the estuary that will draw the attention of all stakeholders to the ecological state of the mangrove resource and stimulate intensive research into its proper management, as well as other mangrove ecosystems of the country.

## **MATERIALS AND METHODS**

### **Study Area**

The Iture estuary is approximately 3 km from Cape Coast on the Cape Coast-Takoradi trunk road. It lies approximately at latitude 5° 05' N and longitude 1° 20' W. The Iture mangrove community is influenced by two water systems, the 'Sweet River', which supplies freshwater to the estuary and the adjacent sea, which feeds the estuary with salt water, and has a permanent access to it through a man-made bridge. Thus portions of the estuary are subjected to the daily tidal influence of the sea.

### **Field Data Collection**

The field work in the estuary was undertaken in August, 2009. The density and basal area of the mangrove vegetation were estimated using the

Point-Centred Quarter Method (PCQM) described in Cintrón and Nonelli (1984). In this sampling method, points to be sampled are located randomly along a transect line. At the sampling point, four quarters are established by crossing the compass direction of the transect line with a perpendicular line. The distance from the sampling point to the midpoint of the nearest tree in each quadrant is measured. The four distances are averaged. The mean of the four distances is empirically the square root of the mean area per tree (Cottam and Curtis, 1956). The total stem density is obtained by dividing the mean area per individual into the unit area on which density is expressed. The mathematical proof of the workability of the method is given in Morisita (1954).

Twenty sampling points each were randomly established in both the *Avicennia* zone at the backswamp and the *Rhizophora* belt along the banks of the mangrove creeks and river channels. The distance from the sampling point to the midpoint of the nearest tree measuring  $\geq 2.5$  cm in diameter in each quadrant was measured with a tape measure. The diameter of the nearest tree was also measured with an electronic digital caliper. The species of the nearest tree was also noted. Seedling/sapling density was estimated separately for the backswamp and the *Rhizophora* belt in thirty 5 m x 5 m contiguous plots. Land-use of the mangrove area and the reproduction/fruiting phenology of the mangroves flora were determined by observation.

The effects of pollution and over-cutting on mangroves were assessed using the standardized site description and site rating criteria developed for the Global Environment Facility's (GEF's) Large Scale Ecosystem Project for the Gulf of Guinea (Anon., 1996). In this method, the site is assessed visually for the presence of obvious pollution by assigning scores of 0, 5 or 10 to answers to five questions that give an idea of the presence of pollution. The remaining thirteen questions provide a general guide to the amount of stress, both pollution-induced and natural, to which the site is subjected. The answers to these latter questions are assigned

scores of 1, 3 or 5. High scores reflect a polluted site under stress, while low scores reflect an unpolluted site not suffering from stress. The scores are summed to yield site ratings which are interpreted as follows: 10 - 20: Site is unpolluted and not under stress; 21 - 30: Site is relatively unpolluted and/or under little stress; 31 - 50: Site is moderately polluted and/or under moderate stress, and; > 50: Site is heavily polluted and/or under severe stress.

#### Data Analysis

Density and basal area data were analysed using the procedure described in Cintrón and Nonelli (1984). The density of each tree species was calculated by multiplying the number of times the species occurred per quarter by the total stem density per hectare (previously computed as the reciprocal of the square of the mean distance times 10,000). Basal area was calculated by converting diameter data to basal area (using the relationship  $A = \pi D^2/4$ , where  $A$  is basal area of tree stem,  $D$  is stem diameter and  $\pi = 3.14$ ) and then calculating mean basal area, individually for each species. Mean basal area for a species multiplied by the absolute species density yielded the basal area contribution by that species. The total stand basal area was computed as the sum of individual species' contributions. This was computed separately for the backswamp as well as the *Rhizophora* belt. The densities of living and dead seedlings/saplings of the various mangrove species were each compared statistically by *t*-test.

## RESULTS

### Flora and Vegetation

The floristic composition and the reproduction phenology of the vegetation are summarized in Table 1. The mangrove vegetation consisted of five mangrove tree species belonging to three genera and eight mangrove associates. *Rhizophora*, which was represented by three species (Plate 1), occurred mainly along the banks of the creeks and river channels where there was regular inundation, while *Avicennia* occurred at the backswamps. *Laguncularia* was limited in distribution but occurred mainly in topographic depressions behind the *Rhizophora* belt.

**Table 1: Floristic composition and reproduction phenology of Iture estuary flora**

Plant species	Reproduction phenology
<i>Avicennia africana</i>	Flowering; fruiting; fruit fall
<i>Laguncularia racemosa</i>	Flowering; fruiting; fruit fall
<i>Rhizophora racemosa</i>	Flowering; fruiting; fruit fall
<i>Rhizophora x harrisonii</i>	Flowering; fruiting; fruit fall
<i>Rhizophora mangle</i>	Flowering; fruiting; fruit fall
<i>Thespesia populnea</i> *	Flowering; fruiting
<i>Phoenix reclinata</i> *	
<i>Acrostichum aureum</i> *	
<i>Paspalum vaginatum</i> *	
<i>Sesuvium portulacastrum</i> *	
<i>Cyperus</i> spp.*	
<i>Typha</i> sp.*	
<i>Tapinanthus</i> sp.*	Flowering; fruiting

\* Mangrove associates



(a)



(b)

The site had a rating of 56, indicating that it was heavily polluted and/or under severe stress. The vegetation was of secondary or tertiary growth with trees regenerating from stumps.

**Tree Density and Basal Area**

The density of *Avicennia africana* and *Laguncularia racemosa* trees of diameter  $\geq 2.5$  cm at the backswamp was 1433.1 stems ha<sup>-1</sup> and 36.7



(c)

**Plate 1: Inflorescence of *Rhizophora* species present at Iture estuary.**

- a) *Rhizophora racemosa*,
- b) *R. mangle* and
- c) *R. x harrisonii*.

stems  $\text{ha}^{-1}$ , respectively, giving a total stem density of 1469.8 stems  $\text{ha}^{-1}$ . The total basal area was 3.54  $\text{m}^2 \text{ha}^{-1}$ , with *Avicennia* contributing 3.52  $\text{m}^2 \text{ha}^{-1}$ , while *Laguncularia* contributed a mere 0.025  $\text{m}^2 \text{ha}^{-1}$ . The total stem density of mangrove trees with diameter  $\geq 2.5$  cm in the *Rhizophora* belt along the banks of creeks and river channels was 1860.4 stems  $\text{ha}^{-1}$ . The corresponding total basal area was 2.62  $\text{m}^2 \text{ha}^{-1}$ . The stem densities of *Rhizophora*, *Avicennia* and *Laguncularia* were 894.4, 322.1 and 644.0 stems  $\text{ha}^{-1}$ , with corresponding basal area contribution of 1.02, 1.08 and 0.52  $\text{m}^2 \text{ha}^{-1}$ , respectively.

#### Seedling/Sapling Density

The density of dead seedlings/saplings (mainly *Avicennia*) recorded for the backswamp was  $698.67 \pm 78.8$  stems/0.1 ha. This was significantly higher than the density of living seedlings ( $41.2 \pm 7.0$  stems/0.1 ha) recorded for the same area ( $t = 8.32$ ; d.f. = 58;  $P < 0.001$ ). All the living seedlings were young and had most probably germinated after the recent flooding of the area. At the *Rhizophora* belt along the banks of the creeks and river channels, the densities of living and dead seedlings/saplings recorded were  $296.7 \pm 67.6$  stems/0.1 ha and  $40.0 \pm 17.8$  stems/0.1 ha, respectively. The density of living seedlings and saplings, which belonged to *Rhizophora*, *Avicennia* and *Laguncularia*, were significantly higher than the density of dead seedlings/saplings for the same area ( $t = 3.67$ ; d.f. = 58;  $P < 0.002$ ).

#### Mangrove land-use of the area

The most recent and the most significant land-use in the area was salt production and this had entailed a complete destruction of patches of the mangrove vegetation at the western section of the estuary (Plate 2). The mangrove vegetation within the concession area of the salt production company had been clear-felled to make way for the laying of sea water pipelines. Other significant land-use in the area were sand winning (Plate 3), wood harvesting, fishing, garbage dumping, as well as human defaecation.



**Plate 2: Mangrove vegetation clear-felled in the salt concession area. Note the salt water pipe-line under construction**



**Plate 3: Sand-winning activity in the Iture estuary.**

## DISCUSSION

### Mangrove floristic composition and structure

Generally, the mangrove vegetation of Ghana is poor in genera and species (Sackey, 1994). The main mangrove genera are *Rhizophora*, *Avicennia* and *Laguncularia*. However, not all the three genera are present at all the mangrove areas. *Laguncularia* is limited in occurrence (Sackey et al., 1993; Sackey, 1994). Iture estuary is among the few areas in Ghana where all the three genera are present. Furthermore, Iture estuary is one of the mangrove areas in the country where *Rhizophora* is represented by three species.

The densities of *Rhizophora*, *Avicennia* and *Laguncularia* recorded in this study were all considerably lower than the values obtained by Sackey (1994) for the same area. Similarly, the densities of living seedlings/saplings of the various mangrove species were considerably lower than those recorded by Sackey (1994). This may be attributed to human disturbances at the area. This is further evidenced by the high density of dead seedlings/saplings, especially those of *Avicennia*, although the recent flooding of the area is partly responsible. It appears that *Avicennia* seedlings are less tolerant of prolonged inundation than those of *Rhizophora*. These findings are indicative of marked structural changes taking place in the mangrove woody vegetation of the estuary. Questions such as ‘what is the minimum seedling or sapling density needed for satisfactory regeneration?’ or ‘what is the optimum density for regeneration?’ have not been resolved. However, empirical wisdom derived from the Matang mangrove forest in Malaysia suggests that a seedling density of 5000 – 10000 stems ha<sup>-1</sup> should be sufficient to ensure good regeneration (Anon., 1991). On that basis, it can be said that the Iture estuary has a poor regeneration potential. This will likely lead to poor tree recruitment and, consequently, a further decrease in the density of the woody elements as the old coppice re-growths die off.

Over-cutting of mangroves, garbage dumping, human defaecation, as well as widespread seedling mortality accounted for the poor rating of the area. Indiscriminate wood harvesting for fuel and wood cutting for the purposes of creating footpaths is widespread in the estuary. *Rhizophora* trees, which have their basal stems cut leaving the upper part supported on stilt roots are especially common along the river channels and creeks. Consequently, the vegetation is short and open, and generally of secondary or tertiary development, with trees regenerating from stumps.

#### **Impact of mangrove land-use**

Until recently, the mangrove land-use of significance in the estuary has mainly been wood

and crab harvesting (Sackey, 1994). Currently, salt winning at portions of the mangrove area is obviously the most significant land-use. The immediate impact of this enterprise on the mangrove ecosystem has been the clear-felling of portions of the vegetation. This clearly underscores the general perception of developers of the mangrove ecosystem as a wasteland that should be converted into other land-uses. Given this perception, it is envisaged that, more and more land potentially occupied by mangroves will be dedicated to salt production as the industry expands, and this may lead to further degradation of the mangrove ecosystem. Indiscriminate extraction of mangrove wood by the local people has created a more open vegetation, especially along the banks of the creeks and river channels. Canopy opening due to logging generally allows light to reach seedlings and saplings, resulting in enhanced seedling development and seedling density. However, in the Iture estuary, seedling densities were low probably due to over-cutting of propagule-bearing trees and high seedling mortality resulting from seasonal flooding of the area. The effects on the natural regeneration potential of the mangrove vegetation have already been noted in the previous section.

#### **CONCLUSION**

The Iture estuary is one of the mangrove areas in Ghana with five species of mangrove trees, including three species of *Rhizophora*. The densities of trees and seedlings/saplings of the mangrove species were considerably lower than density values found in a similar study about 15 years ago. The density of dead seedlings/saplings was significantly higher than the density of living seedlings/saplings, and this situation was partly attributable to the recent flooding of the area. The estuary had a poor site rating, suggesting that it was under severe stress. The main stress factors were over-cutting of mangrove wood and garbage dumping. The vegetation was consequently short and open, and generally of secondary or tertiary development. The current land-use of ecological significance in the estuary was salt mining, and

this had entailed clear-felling of portions of the mangrove vegetation. As the salt industry expands, human activities in the estuary are likely to increase and this may lead to further destruction of the mangrove ecosystem. It is important that the mangrove vegetation of the estuary is preserved, as it is one of the mangrove areas in the country where *Rhizophora* is represented by three species.

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