Prospects of Conserving Wetlands Along the Mukwe Lagoon at Nungua in the Greater Accra Region of Ghana

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Abstract

The Mukwe lagoon and adjoining wetlands near Nungua in the Greater Accra Region of Ghana is one of the many coastal wetlands in Ghana which are not internationally recognised because of their relatively small sizes and insignificant contribution to the support of migratory birds and biodiversity in general. This study was undertaken in recognition of the current rapid degradation and pollution of the lagoon and wetland, which posed a serious threat to the health of the local community, as well as the ecological integrity and eco-tourist potential of the area. The study, therefore, aimed at assessing the current ecological status of the wetland in relation to human activities, the prospects of any future initiatives, and providing appropriate recommendations. The methodology involved measuring the aquatic production, an investigation of the distribution and population density of a key indicator species (*Uca tangeri*) inhebiting the site, in relation to soil *p*H differences, a faunal survey of the site and interviews with a cross-section of the local community. The results indicate that various human activities, notably farming, fishing, hunting and livestock rearing impinge directly on the ecological integrity of the wetland in terms of over-exploitation of natural resources (fish, mangrove, wildlife, etc.), pollution (due to inappropriate waste disposal practices), and habitat degradation (setting of bushfires, etc.). It is recommended that steps are taken in the immediate future to stem the tide of siltation, which is gradually threatening the lagoon, through education and conservation awareness campaigns, legislation, provision of appropriate waste disposal facilities, stiffer punishments for law-breakers and ecological research.

Introduction

The Ramsar Convention (Ramsar, Iran, 1971) defines wetlands as "*......areas of marsh, fen, peatland or water, whether natural, artificial, permanent or temporal, 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*". In recent times, the importance of wetlands to human communities has been increasingly recognised. Apart from their ecological functions and products derived from them worldwide, they are also of great economic importance to the local communities because of their high biological diversity and cultural value (Gordon *et al.*, 1998).

Among the various uses of coastal wetlands to human communities are the provision of nutrient-rich habitats for fish breeding, food/commercial products such as shells, salt, thatch, and wood that constitute the major sources of livelihood and socio-economic well-being of the local inhabitants (Ntiamoa-Baidu & Gordon, 1991), and the provision of stratified records of past succession and archaeological artifacts buried beneath the surface as a result of slow decomposition in waterlogged soils (Etherington, 1983).

Worldwide, wetlands are threatened by pollution from domestic and industrial solid/liquid waste, over-exploitation and urbanization due to burgeoning human populations. Etherington (1983) and Simpkins & Williams (1989) observed that the pressure on these wetlands has led to concerns being currently expressed by both local and international governmental and non-governmental organisations regarding the manipulation of the population dynamics and relationships among the wild populations inhabiting wetland ecosystems, since most of such wild fauna are of both local and global conservation concern.

The West African coast from Mauritania to Angola, has long been known as a very important wintering area for wader bird species which breed in Europe and Russia (Ntiamoa-Baidu & Hepburn, 1988). In 1985 and 1986, the *Save the Seashore Birds Project- Ghana (SSBP-G)* initiated surveys of wader and seabird populations at 13 coastal wetland sites in Ghana, stretching from Esiama in the Western Region eastwards to the Keta Lagoon Complex in the Volta Region. These wetlands together hold approximately 80% of the recorded Ghana coastal tern populations, 85% of the waders and 95% of herons (Ntiamoa-Baidu, 1991). Their importance to migratory birds was one of the key criteria for their selection by the *SSBP-G* (Ntiamoa-Baidu & Hepburn, 1988) for the surveys. Eight of these wetlands (Keta, Songor, Sakumo, Densu, Muni-Pomadze, Elmina Salt Pans, Korle Lagoon, and Esiama Beach) have been designated as internationally-important wetlands, and to date, the first five (i.e., Keta, Songor, Sakumo, Densu and Muni-Pomadze) have been designated as coastal Ramsar sites.

The Ramsar criteria precluded the selection of one of Ghana's popular coastal wetlands, the relatively small Mukwe Lagoon and its catchment area at Nungua in the Greater Accra Region of Ghana, as an internationally-important wetland. Despite its small size, the Mukwe Lagoon is one of the many publicly-used coastal wetlands in Ghana, with very minimal restriction of human activities and use of resources on the wetland. Even though there has been increasing evidence in recent times that the lagoon is being subjected to a lot of degradation (overgrazing, soil compaction, drainage for agricultural purposes, pollution from industrial and domestic sewage, eutrophication, acidification, etc.), there does not appear to be any efforts to ensure the maintenance of the ecological integrity of the wetland, especially with regard to its biodiversity.

The purpose of this study was, therefore, to investigate the current status of the lagoon in terms of its biodiversity and ecological integrity as compared to what pertained in the past. This is to determine the necessity or otherwise, for the initiation of conservation measures to help improve the environment as a whole, as well as the socio-economic status of the indigenous people. The study specifically investigated the impact of human activities on the ecology of the lagoon and the wetland ecosystem in general, as well as the current and previous faunal diversity of the area to determine whether some form of intervention (conservation initiatives) would be required. It provides recommendations for future management of the wetland, based on the principle of sustainable use, as enjoined by the Ramsar Convention.

Study area

The Mukwe Lagoon (5.36.15°N 0.03.20° W), covering an area of 0.043 km^2, is located at the southern part of Nungua, about 12 km east of Accra, in the Greater Accra Region. The lagoon is linked to the sea by a sluice which allows exchange of water with the sea depending on the tides and rains. The main stream discharging into the lagoon passes through Nungua town and discharges a dark, obviously-polluted water that grades down to greenish colour in the lagoon due to algal growth as a result of sedimentation and dilution of the pollutants. Most of the stream bed has been invaded by aquatic plants, causing the river bed narrowing in areas near the town, with the emergent aquatic vegetation dominated by *Typha domingensis* (cat-tail). Near the mouth of the stream where it enters the lagoon, free-floating species dominated by *Pistia stratiotes* (water lettuce) reduce the current speed, and facilitate sedimentation and silt-up by obstruction.

Although the study area falls within the Coastal Scrub and Grassland vegetation zone of Ghana, its vegetation is distinct from the surrounding areas because of the high soil water content. A mixture of isolated shrubs, tree saplings (e.g. *Azadirachta indica*) and tall grasses near the town changes into clusters of *Avicennia* sp. (white mangrove) and low-lying grass (e.g. *Cyperus* sp., *Paspalum* sp.) around the mouth of the stream. The vegetation on the eastern bank of the lagoon (luxuriantly-growing mangrove forest and herbaceous plants) is different from that of the western bank (stunted mangrove trees and herbaceous ground cover).

Materials and methods

Field studies

The wetland was divided into three zones on both east and west banks of the lagoon, perpendicular to the long axis of the lagoon, and based on the distance from the community and vegetation changes. There were thus a total of six study sites, and the study was conducted over a 6-month period from October 1998 to April 1999. The upper reaches of the stream nearest the town constituted the upper zone. The middle zone was adjacent to the upper zone and encompassed the mouth of the stream, whilst the lower zone farthest from the town, constituted the lagoon and its surroundings.

Crab population density/distribution and soil pH

To investigate whether the various human activities have any direct effect on the populations of the inhabiting organisms, the population density and distribution of crabs *(Uca tangeri)* were determined in each zone of each bank. Crabs were used as the indicator species because (i) they were readily available, (ii) their holes could be used as an index of their presence, and (iii) they were more likely to be affected by any deleterious changes in environmental health because of their relatively high abundance in the area. Quadrats (1.5 m × 1.5 m) were randomly thrown on the six study sites with 18 quadrat samples being obtained for each zone (nine samples per bank per zone).

Corresponding *p*H values in each quadrat were obtained using a soil *p*H meter, and the product-moment correlation co-efficient (r) of mean *p*H and number of crabs per quadrat (crab density) was calculated (Snedecor & Cochran, 1980). This was done to determine whether changes in crab population densities were solely related to the changes in the chemical properties of the soil, which are in turn influenced by the level of pollution or the physical environmental properties of the soil (e.g. compaction, vegetation, etc.).

Effects of pollutants on the production of the lagoon water

To determine the effects of pollutants on lagoon water production, 10 ml samples of lagoon and stream water were taken at random at four different points in each zone using a syringe. Out of the 10 ml samples, 5 ml was taken at a depth of about 15 cm below the water surface to ensure that samples did not contain low-density suspended plankton only, since the primary production takes place far below the immediate water surface. The 40 ml samples for each zone were centrifuged until all suspended particles, mainly plankton, settled at the bottom of the centrifuge tube. This was then separated from the supernatant and oven-dried to constant weight (using an electronic balance) at 55 °C. The experiment was repeated three times to obtain a mean value. Significant differences in the means were expected to be linked with the concentration of the pollutants, since they are discharged from the town and upper reaches, and diluted at the lower reaches.

Direct opportunistic observation of fauna through transect walks.

Any animal sightings or sounds in the study area were recorded opportunistically either by walking along main access roads or paths. Walks were also taken along transects on the wetland on Tuesdays, which are taboo days for the local inhabitants to fish in the lagoon, and, therefore, disturbance or activity on the wetland was at a minimum. All animals observed during such walks, as well as walks on other days, were identified and recorded. Photographs were taken of unidentified species for later identification using Newton (1896), Oliver *et al.* (1983), Serle, Morel & Hartwig (1992), Kingdon (1997), and voucher specimens in the Zoology Museum, University of Ghana, Legon.

Human activities in the wetland

A random sample of 40 individuals patronizing or inhabiting the wetland was interviewed using a structured questionnaire. The questions focussed on investigating the human activities on the wetland, as well as the previous and current ecological status of the wetland environment.

Results and discussions

Crab population density and distribution in relation to soil pH

Table 1 indicates that the eastern banks of all the three zones had higher population densities than the western banks. However, only the difference between the eastern and western banks of the lower zone was significant (t = 4.0649; $P < 0.05$). The highest production was recorded on the eastern bank of the lower zone, while the lowest was recorded on the western bank of the upper zone (Table 1). The results also indicated that an inverse relationship existed between crab population density and soil *p*H (i.e., crab population density tended to be higher where soil acidity level was higher) ($r = -0.51$; $0.10 \leq P \leq 0.05$) (Table 2).

TABLE 1

Distribution of crabs (Uca tangeri) *in the Mukwe wetland*

Zone	*Mean number of crabs per 1.5 m quadrat ± SE*	
	Eastern bank	*Western bank*
Upper	2.0 ± 1.0	1.0 ± 1.0
Middle	3.0 ± 2.0	2.0 ± 2.0
Lower	11.0 ± 7.0	2.0 ± 2.0

The results suggest that *p*H and its determinants may not be the only factor affecting crab distribution in the wetland, and that other physical environmental factors, engendered by various human activities on the wetland, act together to control the

TABLE 2

Relationship between crab population density and soil pH

Number of crabs (Uca tangeri)/1.5 m²	*Mean soil pH*
0	5.7
1	6.6
2	6.3
3	6.1
4	6.6
6	6.8
7	5.8
9	5.6
11	5.8
12	5.8
17	5.5
24	5.8

distribution of the crabs. This, however, needs further investigation. The low *p*H of the lower zone compared to the higher zone of the wetland (an acidity trend from lower to upper reaches) could be explained on the basis of the cation exchange capacity of humus, respiratory production of carbon dioxide (CO_2) by soil organisms, and leaching.

Humus accumulates in the lower zone from decomposition of organic substances deposited by the stream. Since humus is generally rich in organic acids, and has negative charges as a result of which its cations (e.g. Ca^{2+}) are exchanged for hydrogen ions (H^+) in the soil due to tenacity differences, this renders the lower zone acidic. The continuous draining of humus from the upper zone prevented a build-up of H^+ ions that would have made the zone acidic.

Primary production of the lagoon water

Table 3 indicates that the highest primary production was associated with the middle zone (14.5 g/L), while the lowest was recorded in the upper reaches (0.50 g/L) [ANOVA, $F(2, 4) = 48.71, P < 0.05$]. The numerically higher production of the lower and middle reaches relative to the upper reaches indicated a gradual reduction in the severity of pollution with respect to increasing distance from the town.

TABLE 3

Primary production of the stream and lagoon water

Zone	*Mean weight (g/40 ml) ± SE*	*Equivalent weight (g/L) ± SE*
Upper	0.02 ± 0.01	0.50 ± 0.25
Middle	0.58 ± 0.03	14.5 ± 0.75
Lower	0.21 ± 0.01	5.33 ± 0.25

The results provide evidence suggesting a high impact of human activities on the lagoon and surrounding wetland. Sewage in aquatic bodies stimulates decomposer organisms to break down the suspended solids, resulting in a high biochemical oxygen demand (BOD). In the upper reaches, the high sewage input and its attendant high BOD resulted in anaerobic conditions and fish-kill or non-migration of fishes to the upper reaches. Such anaerobic conditions also prevent the growth of most aquatic plants, except for some highly adapted ones like cat-tail *(Typha domingensis)*. Because of poor aeration due to free-floating aquatic plants, the middle reaches of the lagoon had similar conditions of low productivity as pertained in the upper reaches, even though there was sedimentation and aeration. The lower reaches had higher productivity, because in addition to dilution and sedimentation with the flow of the stream, aquatic macrophytes were largely absent.

Faunal diversity of the wetland

Most of the resident fauna of the wetland were observed in isolated clusters of mangrove forests which were limited to the immediate banks of the lagoon. A hare was seen dead, having been killed by a hunter who was followed by two dogs. Most of the birds were seen in the lower zone, except the African jacana *(Actophilornis africana)* which was associated with the middle zone. The type of birds seen and their numbers varied from time to time, but the black-winged stilt *(Himantopus himantopus)* and pied kingfisher *(Ceryle rudis)* were present throughout the study period, although their numbers varied throughout the study.

Marine turtles *(Chelonia mydas)* were reportedly captured when they came ashore in the area to lay eggs, but none had been seen for 4 years prior to this study. The last crocodile *(Crocodylus niloticus)* known to inhabit the area was reported to have been killed about 7 years ago, when it ventured into the town. Except for the turtle and crocodile, which are of conservation concern both locally and internationally, most of the other species were fairly common in the area. The other species of conservation concern were the Nile monitor *(Varanus niloticus)* and the cattle egret *(Bubulcus ibis)*. Table 4 shows the various fauna recorded on the wetland during the study period, and their conservation status.

Human interaction with the environment

The interviews revealed that a variety of economic activities were undertaken in the wetland, with majority of the respondents being involved in more than one activity. For example, most of the fishermen were also farmers and hunters, while some hunters also double as nomadic herdsmen. Fishing, hunting and nomadic herding were male-dominated activities, and only females were fishmongers. Farming was undertaken by both sexes, but males were generally in the majority. It, therefore, appears that the majority of females in the area do not interact with the wetland environment, suggesting that any conservation initiatives undertaken should focus largely on the male population, particularly the youth.

None of the farmers used organic fertilizers, but about two-thirds claimed to have used inorganic fertilizers. Almost half of the respondents admitted that they dumped waste materials on the wetland, but none admitted setting fire to vegetation, and only about 10% claimed to have cut the mangrove vegetation at one time or the other. Most of the respondents claimed to have nothing to do with the lagoon, but the colour of the lagoon water indicated some level of pollution that posed a threat to the eco-tourist potential of the wetland, especially since the "Mighty Beach", a popular tourist beach in Accra, is located only a few metres away.

Farming

Most parts of the wetland had been cleared for cultivation, with vegetables (notably pepper, okro and tomatoes) and food crops (notably maize, cowpea) being the common crops cultivated. Farm sizes were small, and much of the agricultural produce is consumed locally. The crops are grown on manually-constructed raised beds or ploughed fields to prevent flooding. The process of land clearing for cultivation destroys the vegetation, leading to dessication of the wetland, soil loosening (due to ploughing), and destruction of the habitats of some organisms inhabiting the wetland. The animals are, therefore, forced to migrate to localised uncleared vegetation (e.g. mangrove forests), resulting in

TABLE 4

Checklist of animal species recorded at the Mukwe wetland and their conservation status

Taxa/Species	Common name	Conservation status		
		IUCN	CITES	National
INSECTA (Insects)				
Coleoptera	Beetles			
Diptera	Flies			
Lepidoptera	Butterflies/Moths			
Hymenoptera	Wasps			
CRUSTACEA (Crustaceans)				
Callinectes spp.	Crab			
Uca tangeri	Crab			
PISCES (Fishes)				
Tilapia sp.	Tilapia			
REPTILIA (Reptiles)				
Lacertilia (Lizards)				
Agama agama	Agama Lizard			
Varanus niloticus	Nile Monitor		A.II	S.II
Mabuya perottettii	Orange-flanked Skink			
Serpentes (Snakes)				
Lamprophis fuliginosus	House Snake			
Bitis arietans	Puff Adder			
Chelonia (Turtles)				
Chelonia mydas	Green Turtle	E	A.I	S.I
Crocodylia (Crocodiles)				
Crocodylus niloticus	Nile Crocodile	V	A.I	S.I
AVES (Birds)				
Ciconiiformes (Egrets)				
Bubulcus ibis	Cattle Egret			S.I
Charadriiformes (Jacanas)				
Actophilornis africana	African Jacana			
Himantopus himantopus	Black-winged Stilt			
Haematopus ostralegus	Eurasian Oystercatcher			
Charadrius hiaticula	Ringed Plover			
Burhinus senegalensis	Senegal Thick-knee			
Coraciiformes (Kingfishers)				
Ceryle rudis	Pied Kingfisher			
Passeriformes (Songbirds)				
Corvus albus	Pied Crow			
MAMMALIA (Mammals)				
Lagomorpha (Hares)				
Lepus zechi	Togo Hare			
Rodentia (Rodents)				
Rattus rattus	Common Rat			

Legend: Conservation Significance
IUCN (International Union for the Conservation of Nature)

- ***Endangered (E):*** Species in danger of extinction, because both numbers and habitats have been reduced to a critical level, with survival, therefore, unlikely if the causal factors continue operating
- ***Vulnerable (V):*** Species believed likely to move to the *EN (Endangered)* category, if the causal factors continue operating because of rapidly decreasing populations and extensive habitat destruction.
  Indeterminate (I): Species known to belong to categories E, V, above, but current in formation is not enough to put them in either category.

CITES

- *Appendix I (A.I)* threatened species which cannot be traded in.
  Appendix II (A.II) species for which levels of trade are limited.
  Schedule I (S.I) species are completely protected (i.e. their hunting, capture or destruction is prohibited at all times).
  Schedule II (S.II) species are partially protected (i.e. their hunting, capture or destruction is absolutely prohibited between 1st August and 1st December of any season, and the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times).

overpopulation, competition, and exposure to predation or disease.

The loose exposed soil is also prone to being washed into the lagoon to facilitate siltation. As Etherington (1983) pointed out, change in soil structure due to cultivation may alter the plant community that would predominate on the wetland after the cultivation period, posing a potential problem for the fauna inhabiting such vegetation. Also, the use of inorganic (N-P-K) fertilizers, even though resulting in higher yields, could increase the production of the lagoon water when the elements finally get washed into the lagoon. The resultant oxygen depletion could cause fish kill and other unpleasant environmental conditions.

Disposal of domestic waste

Parts of the wetland nearer the town suffered from severe littering and pollution from both solid and liquid domestic waste. Most of the drains from the town discharge sediment-laden water into the stream, and solid waste is dumped directly into or on the banks of the stream, finally entering the lagoon. The most common wastes recorded were poultry farm litter, plastic and metal containers, and cattle and human excreta. In the process of being washed down by the stream, some of the garbage gets entangled in aquatic weeds and mangrove roots, while others float on the water obstructing the free flow of the stream water, and, thereby, reducing its current. Siltation ultimately sets in, causing the narrowing of the stream bed as observed at the upper zone. If such conditions persist, the upper reaches become liable to complete siltation into a marshy swamp, with possibly a similar situation affecting the middle and even the lower zones with time. The long-term effect of this situation on the water content, vegetation, and faunal composition of the wetland could not be over-emphasized, since the nature of the lagoon has a direct effect on the surrounding wetland.

Activities of farm animals

There was evidence of extensive grazing of the wetland vegetation by cattle, the western bank being the more affected. This was evident from the severity of soil compaction and the numerous footprints of the grazing animals on the western bank.

Pigs and ducks also fed on the invertebrates, particularly earthworms *(Lumbricus terrestris)*, in the upper reaches.

The intensity of these activities suggests that the populations of soil invertebrates would be severely affected at the upper reaches, as demonstrated by the very low crab population densities at the western bank of the upper zone. With the low number of invertebrates, only a few carnivorous birds would be expected to visit this area. Indeed, only the African jacana *(A. africana)*, an insectivorous trotter on water lettuce, was associated with the upper and middle zones.

Fishing

The major fin fish species present in the lagoon were *Tilapia* sp. The dominant shell fish species, crabs, *(Callinectes* sp.*)*, were temporary residents in the lagoon, being transported to the lagoon by the high tides. The fishes caught were usually of very small sizes, due probably to overfishing or continuous fishing. The very small fishes which were unwanted, were sorted out and discarded on the banks of the lagoon. Mesh sizes of the nets ranged from about 0.5 cm^2 to 1.5 cm^2. The lack of bigger fishes was obviously an indication of overfishing, especially during the breeding season of the fish. The fishermen appeared not to realise this, but rather complained of low yields. A few of the fishermen were educated about the negative impacts of their activities on fish stocks, but such fishermen admitted that they could not trust their other colleagues to stop the practice even if they themselves put a stop to it. It appears that a much better way to prevent overfishing, especially of fingerlings, is to legislate on the appropriate mesh sizes suitable for use on the lagoon. This, however, needs a lot of intensive education of the local fishermen.

Bushfires

Even though patches of bare land obviously created by bushfires were in evidence all over the wetland, the culprits could not be identified. On close examination it appeared that most of such patches were created by the spread of fire from the burning of waste substances at a nearby refuse dump. The local inhabitants were largely unwilling to volunteer information about such fires for fear of prosecution or other trouble, but it was likely that most of the fires could have been caused by farmers clearing the land for cultivation, nomadic herdsmen in search of greener pastures during the dry season, or the throwing of unquenched cigarette butts by careless smokers. Whatever the cause, the deleterious effects of such human-induced bushfires on the distribution and abundance of the biodiversity on the wetland cannot be underestimated.

Hunting

Hunting was probably the least patronized activity on the wetland. There was no full-time hunter among the respondents, largely because larger wild animals that could be hunted for bushmeat were not abundant in the area. It also appeared that most of the inhabitants were subsistence hunters, who occasionally sold surplus meat. Some respondents reported that they frequently encountered snakes when digging for crabs, and this served as a deterrent for crab hunting. The hunters also claimed that their traps were often destroyed through trampling by heavy animals, especially cattle. The disturbing situation, however, appeared to be that some of the animals (e.g. snakes) were killed just because they were considered a nuisance, while others (e.g.

crabs, birds) were killed for sport mainly by younger folk.

Exploitation of mangrove forests

Even though stumps and twigs of cut mangrove were in evidence all over the wetland, the respondents claimed to have stopped exploiting the mangroves after several warnings from the owners and managers of the land. Since for obvious reasons, the local people could not readily own up as mangrove cutters, the purposes of cutting the mangrove could not be ascertained. There were, however, clear indications that the activity was still going on, probably at odd times of the day when the area became deserted.

Conclusion

Mukwe Lagoon and its associated wetland have, over the years, been subjected to minimal restriction to the use of its natural resources. This has resulted in some degradation of the wetland and pollution of the lagoon, specifically fish-kill, invasion of aquatic plants, silting of the lagoon, reduction in the population density of the inhabiting fauna, soil compaction, degradation of vegetation, and disappearance of previously inhabiting organisms. The range of human activities that has contributed to this state of affairs includes fishing, farming, hunting, livestock grazing, mangrove exploitation, and bush fires. It is recommended that conservation initiatives should focus on the young and middle-aged male inhabitants of the area (aged between 20-45 years), since such activities are largely undertaken by that target group. The single most serious threat to the wetland is siltation of the lagoon over the course of time, and there is, therefore, the need for some form of intervention in the immediate future to forestall this.

A priority for conservation initiatives undertaken for the Mukwe wetland should be to ensure the prevalence of law and order in the use of the resources in order to maintain the ecological integrity, natural beauty and the rich biodiversity of the area. This could be achieved through the education of, and awareness creation among, the inhabitants of the local community of Nungua about the importance of conservation to the wetland ecosystem and their own socio-economic well-being.

Both governmental agencies and organizations (e.g. Fisheries, Wildlife and Forestry Departments, Environmental Protection Agency, Water Resource Commission, etc.) and environmental NGOs (e.g. Ghana Wildlife Society, Friends of the Earth, Green Earth, Conservation International, etc.), should be involved in such education and awareness programmes. The provision of proper sewage disposal facilities and treatment plants for the communities inhabiting the areas around the lagoon and the stream, as well as the enforcement of the legislation by the Fisheries Department regarding the mesh sizes acceptable for fishing nets used on the lagoon should also be given some priority. The activities of herdsmen (both nomadic and local) also need to be monitored, and law enforcement agencies should be encouraged to dispense stiffer punishments to inhabitants whose activities are found to be detrimental to the overall well-being of the wetland ecosystem and the inhabitants. Finally, there is the need to initiate further research on the epidemiology and pathogenicity of the lagoon water in relation to pollutant sources and uses of the lagoon.

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