INTEGRATED ASSESSMENT OF CHANGES IN WETLAND TYPES IN THE SONGOR BIOSPHERE RESERVE, GHANA

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Abstract

The Songor wetlands form an ecologically valuable resource in Ghana, providing numerous support for biological diversity. Despite its relevance, studies have shown that overexploitation due to developmental activities and overdependence on their values for livelihood pose a threat to the existence of the wetlands. This study investigated long-term changes that have occurred as a result of human activities in the area over a 25 year period (1990-2015). Landsat TM and ETM+ and OLI/TIRS images were used to categorize and quantify the changes in the various wetland types. Local perceptions of the riparian population on the historical changes and drivers for the changes were also sought to complement the assessment. The study revealed that, lagoon/lake and inter-tidal forested wetland experienced increase in spatial extent while seasonal/intermittent and permanent marshes experienced a decrease over the 25 year period. Among the various land use activities undertaken in the Ramsar site agriculture was seen to have greatest impact on biodiversity conservation through truncation of streams in upland areas for fish and crop production. The study strongly recommends that various stakeholders should be involved in the management of the Songor Ramsar site and the regulator should institute stringent monitoring of the wetland due to the constant anthropogenic pressure.

Keywords: Songor wetland, Remote sensing, Perceptions, Human disturbances, Biodiversity conservation

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1.0 Introduction

Wetlands are one of the most important ecosystems in the world. They occupy about 6 percent of the earth's surface and vary according to origin, geographical location, hydro-period, chemistry, and plant species (Nyarko, 2007). They play an immense role in the survival of man by providing services such as water quality maintenance, agricultural production, and habitat for fish and wildlife species (Tijani et al., 2011). Communities that live around wetlands in many parts of the world depend directly and indirectly on them for their livelihoods (Aheto, et al., 2011). Despite these advantages, wetlands have been considered "wastelands" (Williams, 1993) and, therefore, subjected to degradation through dredging, flooding, filling and excavation for various land use activities. In most places, increasing population and subsequent demand for more wetland resources to sustain livelihoods have resulted in conversion of wetland types to different land uses, thus accelerating their degradation and threatening biodiversity conservation and sustainable development of wetland areas.

The Songor wetland serves as a feeding, nesting and roosting site for water birds, while the coastal stretch serves as nesting sites for marine turtles and fish species. The mangroves serve as habitat for diverse wildlife species. To ensure sustainable use of the site resources and to enhance the benefits derived from the wetlands by the local communities, it was designated as Songor Biosphere Reserve as part of the World Network of Biosphere Reserves in 2011 by the United Nations Educational, Scientific and Cultural Organization (UNESCO), based on ecological communities including water bird populations whose presence relate to the international importance of the site (UNESCO, 2011). Despite its relevance, the Songor wetlands are under increasing threat from over-exploitation and degradation. According to Yeboah, Nii-Moe and Nani (2013), there is a perceived loss of the ecosystem services. A study by the Centre for African Wetlands in 2014 on land use and land cover indicated that between 1990 and 2007, there has been an estimated loss of 57.6% of healthy vegetation cover from 3,087 hectares to 1,308 hectares at the site. Field observations and satellites images analysis of the Songor biosphere reserve depicts that the wetland landscape show spatially fragmented patches with decreasing configuration and composition (Adade et al., 2017). The current situation, if allowed to continue, is likely to result in biodiversity loss from the wetland, consequently diminishing both the local and international significance of the wetland. Therefore, this study investigated long-term wetland changes that have occurred as a result of human and developmental activities in the area for the periods between 1990 and 2015. This is to improve understanding of wetland functions and help decision makers implement

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policies and adopt management approaches for the protection and conservation of wetlands.

2.0 Study Area

The study area is the Songor Ramsar Site (5° 45′0″N 0° 30′0″E) located in the Damgbe East District in Ghana, as shown in Fig. 1. It is about 79 km from the national capital, Accra, and is the second largest Ramsar site along the coast of Ghana. The Songor wetland covers an estimated area of 51,133.3 ha and is the only natural point where the Volta River enters the sea. The boundaries of the site include the West Bank of the Lower Volta River estuary and the Songor lagoon. It was designated a Ramsar wetland site of international importance number 14 in August 1992. In 2011, UNESCO approved the Songor Biosphere Reserve as part of the World Network of Biosphere Reserves (UNESCO, 2011). Among several other important functions, the Songor Ramsar Site acts as a habitat and breeding ground for several notable species of water birds such as black winged stilt. Major land use activities in the Songor area include farming, livestock grazing, fishing, salt production, recreation and settlement.

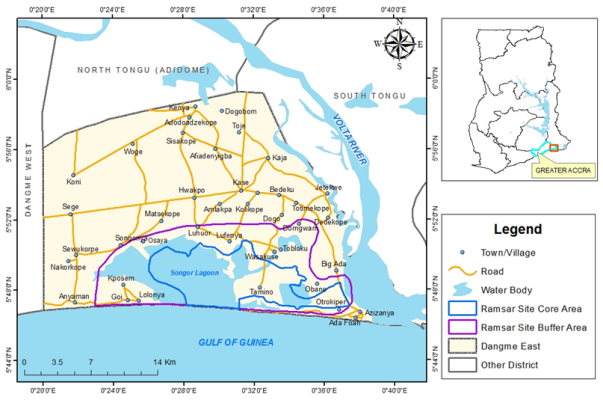

Figure. 1. Map showing the core and buffer areas of the Songor Biosphere Reserve in Dangme East District of Ghana.

3.0 Materials and Methods

3.1 Field data collection and analysis

Both primary and secondary data were used for the study. Data from the field was based on field observation, informal interviews and field measurements. The field observations were undertaken to identify physical features such as vegetation types and other land use activities. Interviews were conducted in communities and the number of respondents were Obane (7), Osaya (10), Otrokper (18) and Pute (25). The survey targeted residents in the communities who have lived in the site for at least 25 years. The number of selected respondents varied between communities because of differences in populations. Descriptive statistics was employed in analyzing the close-ended questions in the schedule with the help of Statistical Product for Service Solution (SPSS) version 21. The open questions were categorized under common

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themes. Photographs were taken as part of the observation to back data collected with the other tools. The interview data are presented primarily using tables, graph, pictures and narrations.

3.2 Secondary data collection and analysis

In addition to the field data, secondary data such as satellite images, aerial photograph and topographic maps of the study area were also used. Three Landsat imageries of the years 1990 (TM), 2003 (ETM+) and 2015 (OLI/TIRS) were freely downloaded from the United States Geological Survey (USGS) website. Acquisition dates of the multi- temporal satellite data fell within an equivalent season. Ortho-photos and topographic maps of the study area were also obtained from the Department of Geography and Regional Planning (DGRP) of the University of Cape Coast.

The satellite images were subjected to processing operations such as stacking single bands, radiometric and geometric corrections in ERDAS 2013 software and subsetted using the boundary polygon of the core and buffer areas of the reserve. The subset images were then geometrically registered to each other before all other image processing and analyses were performed. In the wetland classification process, bands 1,2,3,4 and 5 of Landsat TM, EMT+ and bands 2,3,4,5,6 and 7 of Landsat OLI/TIRS were used. The study employed both unsupervised and supervised classification algorithms. Unsupervised classification was done to aid in the exploration of the wetland types. Normalized Vegetation Index (NDVI) were generated for 1990 Landsat TM, 2003 Landsat ETM+ and 2015 Landsat OLI/TIR to help in the categorization of the wetlands. Thereafter, four wetland classes were identified on the three images based on the Ramsar classification of wetland type (Table 1). The wetland classes include: lagoon/lake, inter-tidal forested wetland, seasonal marshes, permanent marshes and non-wetland.

Table 1: Description of wetland categories based on Ramsar classification system for wetland type

Wetland class	Description
Inter-tidal forested wetlands	It includes mangrove swamps and tidal freshwater swamp forests.
Permanent marshes	It comprises marshes and swamps with emergent vegetation waterlogged for at least most of the growing season.
Seasonal/intermittent Marshes	Its include sloughs, potholes, seasonally flooded meadows, sedge marshes.
Lagoon/lake	This constitute brackish/saline/fresh water lagoons and lakes

4.0 Results

4.1 Wetland types and distribution in the Core and Buffer areas

The core area is designated to protect rare and sensitive plants and animal species with land use

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activities mostly restricted in the area. As shown in Table 3 and Figure 2, Lagoon/lake was the dominating wetland type in this area. It occupied 4130.28 ha, 5281.21ha and 5647.23h ha in 1990, 2003 and 2015 respectively. Intertidal forested wetland also increased steadily within the core area. From 1990 to 2003 it increased from 343.71 ha to 569.07 ha and then increased to 574.83 ha in 2015. The seasonal/intermittent and permanent marshes occurring at the eastern and south-eastern portions of the core area, however, continue to decrease significantly. From 1990 to 2003, seasonal/intermittent and permanent marshes reduced significantly by 221.85 ha and 141.48 ha respectively. More so, from 2003 to 2015 they further reduced by 440.46 ha and 259.29 ha respectively.

Similarly, considering the Buffer Area (Table 3 and Figure 2), Lagoon/lake was the most prevalent wetland type in the area which permeated the middle sectors of the study area with small isolated patches occurring in the eastern fringes. It covered 2886.48 ha, 4281.21 ha and 4625.19 ha in 1990, 2003 and 2015 respectively. The area under Inter-tidal forested wetland increased from 749.07 ha in 1990 to 1328.94 ha in 2003 and 1491.66 ha in 2015. Seasonal/intermittent marshes reduced significantly in area from 1735.83 ha in 1990 to 1498.05 ha in 2003 and 910.53 ha in 2015. Similarly, permanent marshes which formed the third most predominant wetland class in 1990, reduced from 1739.07 ha in 1990 1402.29 ha in 2003 and 646.29 ha in 2015. These wetland types remained consistent in the south-eastern part of the buffer area giving way to other land use/cover types.

Table 2: Buffer and Core Area statistics for 1990, 2003 and 2015 (Hectares)

	1990		2003		2015	
Wetland Type	Core area	Buffer area	Core area	Buffe r area	Core area	Buffe r area
Lagoon/lake	4130.3	2886.5	5259.6	4281. 2	5647. 2	4625. 2
Inter-tidal forested wetland	343.7	749.1	569.1	1329. 0	574.8	1491. 7
Seasonal/int ermittent marshes	1218.6	1735.8	996.8	1498. 1	556.3	910.5
Permanent marshes	740.1	1739.1	598.6	1402. 3	339.3	646.3

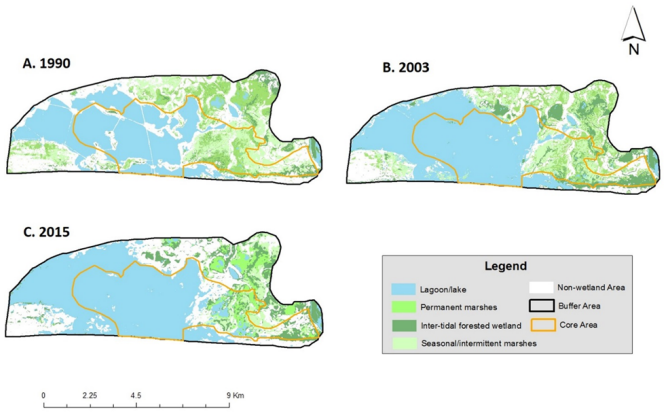

Figure 2: Wetland types distribution in 1990, 2003 and 2015

4.2 Total Changes in Wetland types and Trend

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The trend analysis of the Songor wetlands revealed some changes in the spatial extent of the four wetland types over the 25 year period of the study (Figure 3). Lagoon/lake experienced the larger increase while permanent marshes experienced the large reduction. From 1990 to 2003, lagoon/lake and inter-tidal forested wetland experienced an increment in area while seasonal/intermittent marshes and permanent marshes experienced a reduction in area. From 2003 to 2015, the same trend continued with lagoon/lake and inter-tidal forested wetland experienced an increment in wetland area while seasonal/intermittent marshes and permanent marshes experienced a reduction in area.

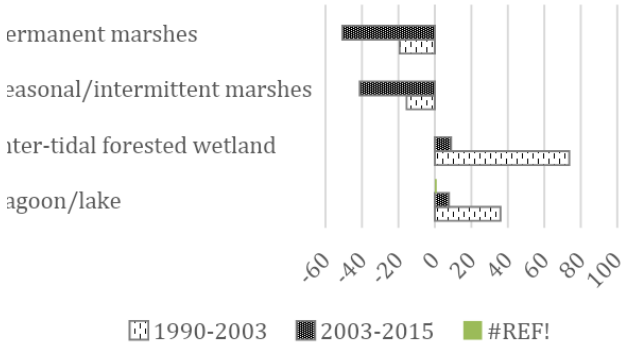

Figure 3: Percentage change in wetland types from 1990-2003 and 2003-2015

4.3 Land Use Activities in Songor Biosphere Reserve

Human activities have shown to have a significant influence on all aspects of wetland ecosystems. Thus it is essential to understand how humans interfere with the landscape systems. All the respondents indicated that the reserve was important for their livelihood and supported a vast number of residents within the catchment areas. Figures 4 shows the major land use activities and their seasonal calendar in the Songor wetland site respectively. The respondents were engaged in seven main socio-economic activities: These were fishing (26.0%), crop production (21.9%), salt production (19.2%), harvesting natural herbaceous vegetation (16.4%), building and construction (6.8%), tourism (5.5%) and livestock grazing (4.1%). The results indicate a high demand for wetlands goods and services by the residents within the site. The least of the respondents (4.1%) used the site as pasture for small-scale free range livestock production.

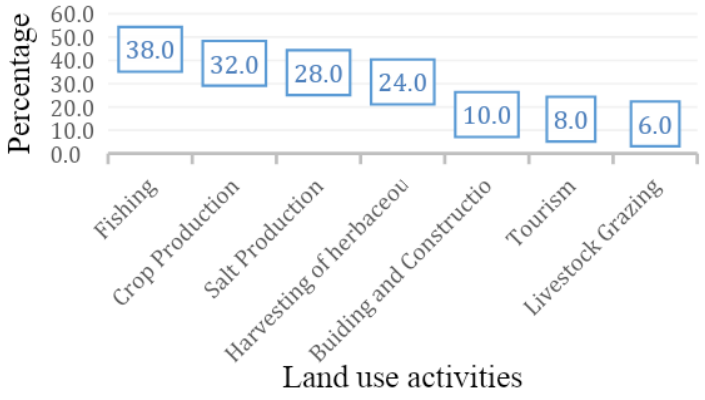

Figure 4: Land use activities in Songor Biosphere Reserve

4.4 Perceived Causes of Wetland Degradation and Loss

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There are both natural and human causes of degradation in wetland ecosystems. However, the Ramsar Convention Secretariat (2007) suggested that the Ramsar site wetland degradation is mostly as a result of human activities rather than natural events. The above assertion was in tandem with respondent's views as they identified a total of seven human causes of wetland degradation and loss shown in Table 3. The results presented in Table 3 indicates that wetland degradation in the site is largely caused by agricultural activities (36.1%), followed by road construction (26.9%), saltpan construction (15.4%), changing weather pattern (11.5%), solid/liquid waste disposal (6.7%), and landfilling (3.4%).

Table 3: Perceived causes of wetland degradation and loss

Perception	Frequency	Percentage
Agriculture	75	36.1
Road construction	56	26.9
Saltpan construction	32	15.4
Landfilling	31	14.9
Solid/liquid waste disposal	14	6.7
Total	208*	100

**Frequency is more than 60 because of multiple responses*

5.0 Discussion

5.1 Driving factors for the observed changes in Wetland types

The analysis from the satellite images of the Songor wetlands over the 25-year period, revealed some changes in the spatial extent of the four wetland types in both the buffer and core area. From 1990 to 2003 lagoon/lake and inter-tidal forested wetland experienced an increase in area while seasonal/intermittent marshes and permanent marshes experienced a reduction. From 2003 to 2015 the same trend continued, with lagoon/lake and intertidal forested wetland experiencing an increase in wetland area while seasonal/intermittent marshes and permanent marshes experienced a reduction in area. The significant increase in the physical extent of Songor lagoon from 1990 to 2015 as result of the increase in the level of unsustainable salt mining by small-scale artisanal salt miners around the lagoon. Salt extraction was also identified as a cause of degradation in the site (Table 3). The construction of evaporating ponds and crystallising pans in the flatlands lead to biodiversity losses. This arises from destruction of mangroves and benthic communities as a result of scraping material from the bottom of the lagoon during pan construction (Ntiamoa-Baidu, 1992). The embankment constructed in the lagoon during salt production act as barriers, preventing free movement of fish within the habitat. This practice according to Hanski and Gagiotti (2004) may isolate the fish species population into sub-populations. It may also lead to the displacement of some wetland resources and introduce some invasive species into the system. Salt production occurs during the dry season from November to

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April, which overlaps with the non-breeding season of migrating shorebirds.

Similarly, the extent of inter-tidal forested wetlands also increased throughout the period of 25 years. This increase might be attributed to the awareness of the importance of these forested wetlands and management practices instituted by government agencies, particularly the Wildlife Division of the Forestry Commission of Ghana, traditional authorities and environmental NGOs. From the interviews some respondents indicated that various environmental NGO's such as the Ruddorf organization have supported initiatives such as planting mangrove and acacia tree as well as provision of alternative livelihoods for surrounding communities.

This reduction in both seasonal and permanent marshes could be attributed to the truncation of the streams upland and increase in anthropogenic activities such as the construction of irrigation facilities, urban expansion and increased livestock rearing. Observations made indicated that large tracts of these wetland types have been converted to settlements, farmlands and rangeland. Leachate from solid waste landfills often has high biological oxygen demand (BOD), ammonium, iron, and manganese in concentrations and can be potential threat to aquatic ecosystems and public health (Eggen, Moeder & Arukwe, 2010). A study by Yeboah et al. (2013) revealed that the Azizanya community used to be a wetland area, but it was totally reclaimed with red sand (laterite) for settlement development. Pute, Totope, Anyamam, Goi, Loloyna and other coastal communities are reclaiming wetland areas with solid waste for construction of houses after being displaced by tidal waves.

Majority of the respondents indicated that agriculture is the major cause of wetland degradation within the site. This finding clearly affirms USEPA (1994) cited in Aragaw (2013) assertion that agriculture is the major factor in freshwater and estuarine wetland loss and degradation. This does not only relate to agricultural land expansion, but also other agricultural activities such as harvesting food and construction of irrigation ditches break the wetlands into smaller fragments. Furthermore, livestock grazing also lead to degradation of wetlands which would otherwise have been reserved. In recent years, animal husbandry in the Songor wetland area has developed greatly to meet the needs of population growth and economic development, causing conflicts between wetland conservation and sustainable use of natural resources. Mostly, these marshes are overgrazed and over-trampled by domesticated animals that resulting in the disappearance of primary plant species, hardening of soils and increased surface runoff. These activities according to Tian, Lu and Chang (2004) results in increased soil erosion, changes in plant species composition and spatial

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patterns, eventually altering the entire landscape pattern of the nature reserve.

The residents pointed out that road construction can disrupt habitat continuity and drive out more sensitive species. Observation from the site suggests that roads have been constructed throughout the wetland connecting various towns and villages and industrial development. These roads impede movement of certain species or result in increased mortality for animals crossing them. According to Wilson (1998), wetland biodiversity is being threatened while many others are at the verge of extinction due to human activities. Thus, wetland degradation at the site is largely due to these economic activities as these are the main occupation of the communities around the site.

6.0 Conclusion and Recommendations

The study indicated that the open access to the Songor Biosphere Reserve has made it difficult for the authorities in charge to protect the site from over-exploitation and degradation. This has resulted in the transformation of wetland ecosystem to other land use activities. Most respondents depend solely on the wetland resources for their livelihood. They also undertake activities such as crop production, fishing, salt production, and housing construction in the wetland. The intensity of these activities if not controlled could affect broader ecosystem functioning and biodiversity assemblages. The study strongly recommend that various stakeholders should be involved in the management of the reserve to continue monitoring the wetland due to the constant anthropogenic pressure. Secondly, we also propose that further studies should be conducted, combining geographic, socioeconomic and ecological information to identify and delineate specific areas of risk. Lastly, sensitization and education to create awareness among civil society and policy-makers of the ecological and socioeconomic services of wetlands and the need for their conservation. Sustainable financing mechanism need to be explored and developed for effective national wetlands conservation programs.

Author Contributions

RA‡ took part in the field data collection, analysis and writ-ing the manuscript. DWA ‡ Supervised the work, developed the layout of the paper, contributed in writing the manu-script. DYA‡ took part in the field data collection and con-tributed to the writing the manuscript. All authors read and approved the final manuscript.

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REFERENCES

Adade R., Nyarko B.K., Aheto W.D., & Osei N.K (2017) Fragmentation of wetlands in the south eastern coastal savanna of Ghana Regional Studies in Marine Science 12 (2017) 40–48

Aragaw, K.H. (2013). Assessment of spatio-temporal changes of wetlands using GIS and RS techniques in Dawa Chefa Area in the Northern Central Ethiopian Highlands (Master thesis), Department of Geography and Environmental Studies, Mekelle University.

Eggen T, Moeder M. & Arukwe A. (2010). Municipal Landfill Leachates: A Significant Source for New and Emerging Pollutants. Science of the Total Environ. 408 (21), 5147-5157.

Falkenmark, M., Andersson, L., Castensson, R., Sundblad, K., Batchelor, C., Gardiner, J., Lyle, C., Peter, N., Pettersen, B., Quinn, P,

Rockstrom, J. & Yapijakis, C. (1999). Water as a reflection of land use: Options for counteracting land and water mismanagement. Sweden: Stockholm Ltd.

Hanski I., & Gaggiotti, O. E. (2004). Ecology, genetics and evolution of metapopulations, London: Elsevier Academic Press, UK.

Middleton, B. (2002). Non –equilibrium dynamics of sedge meadows grazed by cattle in southern Wisconsin. Plant Ecology 151(1):89-110

Ntiamoa-Baidu, Y. (1992). A Review Of Environmental Impacts Of The Salt Mining Industry In The Coastal And Riverine Lagoons In Ghana, Department of Zoology, University of Ghana, PBAAB246.

Nyarko, B. K. (2007). Floodplain wetland-river flow synergy in the White Volta basin, Ghana, Bonn: Centre for Development Research.

Ramsar Convention Secretariat (2007). Participatory skills: Establishing and strengthening local communities' and indigenous people's participation in the management of wetlands. Ramsar handbooks for the wise use of wetlands (3rd Ed), 5.

Tijani, M.N., Olaleye, A.O. & Olubanjo, O. O. (2011). Proceedings of the environmental management conference, Federal University of Agriculture, Abeokuta, Nigeria.

Wang, Z.M., Huang, N., Luo, L., Li, X.Y., Ren, C.Y., Song, K.S., & Chen, J.M., (2011). Shrinkage and fragmentation of marshes in the West Songnen Plain, China, from 1954 to and its possible causes, Int. J. Appl. Earth Obs. Geoinf. 13, 477–486

Williams M. (1993). Wetlands: A threatened landscape. Blackball Publishers, Oxford.

Wilson, D. E. (1998). The Diversity of Life. Massachusetts: Belkanp, Cambridge.

Yeboah, S. A., Nii-Moe, A. A., & Nani, E. (2013) Environmental effects of socio-economic activities on Songor Ramsar Site in Ada, Ghana. Journal of Environmental Issues and Agriculture in Developing Countries, 5 (2), 13-15.

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