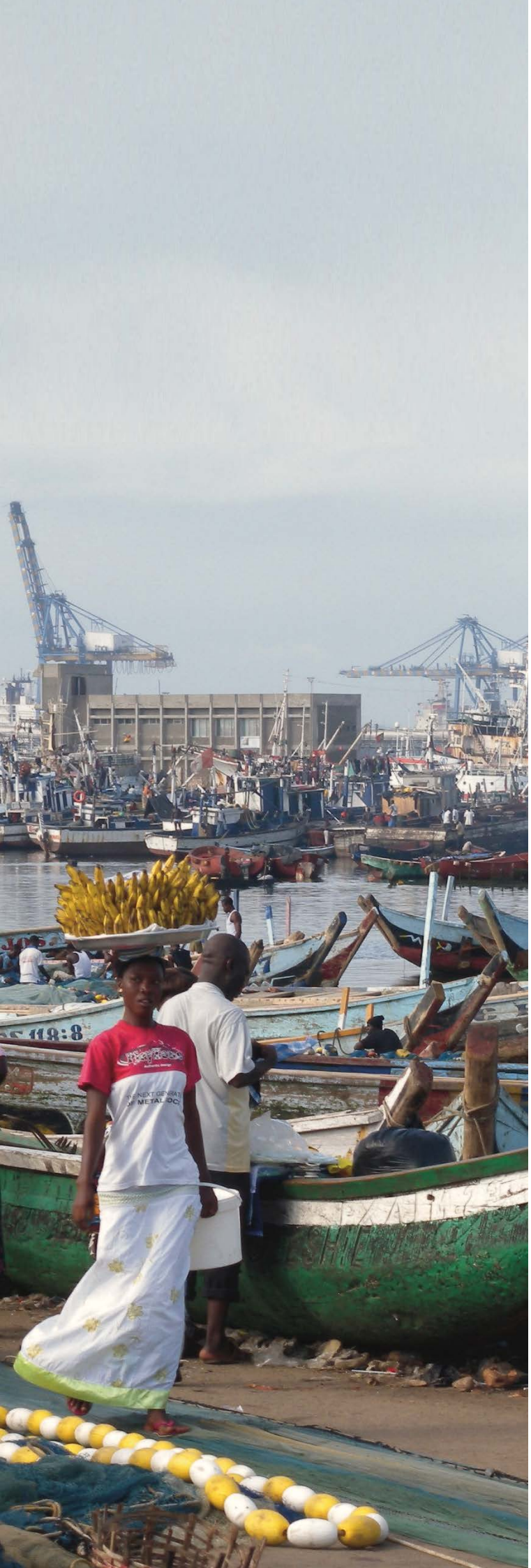

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A Literature Review on Wetlands in Accra

WaterPower Working Paper Volume No. 5

WATERPOWER

WaterPower Working Paper Series

WaterPower Working Paper Series
ISSN (Print) 2510-0521
ISSN (Online) 2510-2222
Governance and Sustainability Lab
Faculty VI - Regional and Environmental Sciences
Trier University

Suggested Citation: Wiegleb, Viviana (2016): A Literature Review on Wetlands in Accra. WaterPower Working Paper, No. 5. Governance and Sustainability Lab. Trier.

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Abstract

This literature review was conducted to identify important wetlands in the Greater Accra Region and to illustrate dominant research trends, prevailing perspectives and corresponding research gaps. Six wetlands systems were identified as most significant lagoon systems, namely the Densu Delta, Sakumo, Muni-Pomadze, Keta, Korle and Songor Lagoons. Research foci for each of the respective wetlands were extrapolated and summarized in a category system. The frequency of different categories illustrates that natural science's perspectives dominate, as most of Accra's lagoons have been studied with regard to their ecological, physical and chemical properties. The development of research interest over time and focus on ecological baseline conditions are related to the designation of Ramsar Sites and orientation of national policies towards environmental protection. A research gap was identified, as studies link their findings to human activities but neglect the connection between governance variables and environmental developments. It is suggested to expand the natural science's perspective on Accra's wetlands to account for social and political aspects in order to develop a holistic and more sustainable management strategy.

A Literature Review on Wetlands in Accra

Viviana Wiegleb

1 Introduction

Natural wetland areas occur all over the world and deliver important functions for hydrological and biogeochemical cycles (Junk et al., 2013). Wetlands are also amongst the world's most productive environments in terms of biodiversity and primary productivity and therefore deliver natural resources that are often directly or indirectly exploited by humans for economic benefit. Important ecosystem services provided by wetlands include storm prevention, flood control, water supply, maintenance of the water table, groundwater recharge as well as nutrient and pollution retention in floodplains (Barbier, 1993). Wetland specific assets also comprise the support of rich wildlife, fisheries, fertile soil for agriculture, timber and energy supply (peat matter) in addition to recreation and tourist opportunities. In the context of climate change, natural wetlands may act as important carbon sink, while the degradation and draining of wetland areas generally increases greenhouse emissions and accelerates global warming further. For local communities, wetland areas may also be of great cultural and religious value (Barbier et al., 1997; Turner, 1991).

Wetlands occupy about 6% of the global land area (Junk et al., 2013) and occur in a great variety of forms, which makes it difficult to provide a generally valid definition. In this study, wetlands will therefore be considered under the broad designation provided in Article 1.1. of the Ramsar Convention on Wetlands of International Importance as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres" (UNESCO, 1994). According to Article 2.1. of the convention, this may also incorporate "riparian and coastal zones adjacent to wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands" (UNESCO, 1994).

Since 1900 and despite our heavy reliance on their ecological functions, over half of the earth's wetland areas have disappeared in response to anthropogenic influences (Barbier, 1993; Barbier et al., 1997; Junk et al., 2013). The remaining areas are often heavily impacted by human activities (LePage, 2011), which is particularly true for temperate wetlands in densely populated areas such as Western Europe (Junk et al., 2013). However, tropical wetlands in less developed countries, and coastal lagoons in particular, are also increasingly threatened by conversion and degradation in response to unsustainable levels of fishing, animal grazing, increasing pollution, conversion to agricultural land, as well as industrial and urban development (Junk et al., 2013; Millennium Ecosystem Assessment, 2005; Ryan & Ntiamoa-Baidu, 2000). The destruction of coastal wetlands often occurs under the presumption that the short-term exploitation of their natural resources yields higher returns than the indirect benefits through ecosystem services provision. This view prevails mainly due to the lack of scientific data regarding ecological functions and services in less developed countries (Barbier, 1994).

In this respect, the study of Ghana's coastal wetlands and their ecosystem functions is of particular interest, as Ghana represents a developing African country with 550 km of coastline harbouring approximately 100 tropical lagoon systems (Gbogbo, 2007; Willoughby et al. 2001). Six of these wetlands are managed under the Ramsar Convention on Wetlands of International Importance, as they support internationally valuable waterbird populations. These protected areas include the Owabi Wetland, Muni-Pomadze Lagoon, Densu Delta, Keta, Songor and Sakumo Lagoons, of which five (Densu Delta, Keta, Sakumo, Muni-Pomadze and Songor Lagoon) are located within the Greater Accra Metropolitan Region (GAMA) or in its vicinity (Ramsar Convention Secretariat, 2014).

The Greater Accra Region represents the case study area of the transdisciplinary research group WaterPower (www.waterpower.science) and is particularly important due to its state as national capital. Although Accra only covers 6.5 % of the country's surface area, it houses 25% of the total population (Amlalo, 2006). In recent decades, Accra experienced rapid urbanisation, which has mostly been unaccompanied by a corresponding expansion of sanitation and infrastructure (Boadi & Kuitunen, 2003). Increasing urbanisation rates and insufficient land use planning have also resulted in urban sprawl. Together with environmentally unsafe industrialisation and encroachment of former wetland areas (Boadi & Kuitunen, 2003; Grant, 2006), Accra's lagoons have been subjected to serious environmental degradation and require urgent attention. As water and security and the effects of urbanisation on Accra's wetlands are amongst the main research objectives of WaterPower, tropical wetlands within and around Greater Accra were investigated to portray ecological functions and main threats (anthropogenic or natural) to their ecosystem services. In this context, this literature review was conducted as a starting point to identify important wetlands and to illustrate dominant research trends and perspectives. Conclusively, gaps in current research approaches are presented.

2 Methodology and Research Design

2.1 Literature Search Strategy

Relevant scientific articles and official reports reflecting the state of the art research on wetlands within the Greater Accra Region were identified from the "Google Scholar" database. For each search term, the first ten results of the online quest were analysed in detail by one author with regard to their content and relevance. In order to assure the quality of this literature review, only peer reviewed articles and official grey literature such as World Bank and government reports were considered. Books were generally excluded and in the case of limited access, only article abstracts were analysed. As a result of the selected search words, this study was restricted to documents

published in the English language. No formal restriction was put on the time of publication.

2.1.1 Part I: General Literature Review

The first phase of the search strategy comprised the identification of pa-pers including the keywords “wetlands Ghana”, “coastal wetlands Ghana”, “wet-lands Accra”, “lagoons Accra” and “ecosystem wetland Accra” in their title, abstract or text body.

In this first and more general search phase, papers were included in this re-view if they contained descriptions of coastal wetlands and lagoons in Ghana. Literature solely analysing terrestrial wetlands in other regions or countries were excluded. Due to some overlap, 23 different articles could be identified in the first phase that fulfilled the selection criteria (see Ap-pendix).

2.1.2 Part II: Wetland Specific Literature Review

The first and more general search phase revealed that the Sakumo lagoon system presents the most research wetland area in Ghana, followed by stud-ies on the Densu Delta/River, Muni-Pomadze Lagoon, Keta Lagoon, Korle La-goon as well as Songor Lagoon in addition to studies investigating Accra’s coastline as a whole (Figure 1). Collectively, these wetlands also represent the six major lagoon systems in the Greater Accra Region.

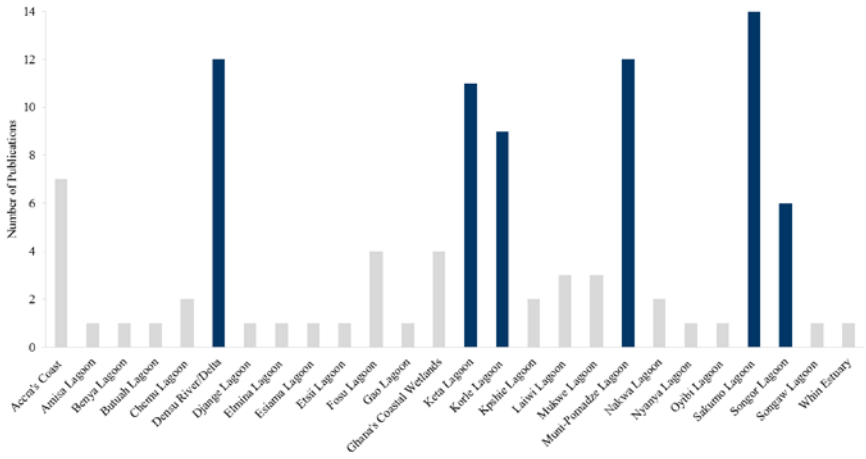

Figure 1: Number of publications analysing wetlands in Ghana and Accra. Most frequent case study areas are highlighted.

Based on these initial results, the most commonly studied wetlands in Ghana and Accra were chosen as case study regions for this literature review and the search process was repeated in Phase II with the search words “Sakumo Lagoon”, “Densu Delta/Lagoon”, “Muni-Pomadze Lagoon”, “Keta Lagoon”, “Korle Lagoon” and “Songor Lagoon”. Although many of the initially reviewed articles also mentioned smaller wetland areas within the capital region, these were not investigated further in lack of additional literature and due to their

limited area extent. While Keta and Muni-Pomadze lagoon systems lie outside the administrative border of GAMA, they were included in this review due to their proximity to the urban area, their status as Ramsar sites and because Keta presents Ghana's largest wetland area (Dankwa et al., 2004).

In addition to the articles found in Part I, the second and more focused phase of the literature search, yielded 36 additional papers meeting the formal conditions (see Appendix).

2.1.3 Analysis and Categorisation of Relevant Articles

As indicated above, the literature search and categorisation of relevant articles occurred according to the procedure shown below in Fig. 2. During the first and second part of this analysis, all articles were read in detail to extract their selected study areas and main research foci. Based on this general overview and to extract prevailing research perspectives from which wetlands had already been analysed, a classification system was produced summarising reoccurring topics.

The established categories were extrapolated from keywords that were repeatedly found in the title and abstract of reviewed publications. Titles and abstracts of all articles were read again and papers assigned categories according to the keywords they contained (see Appendix).

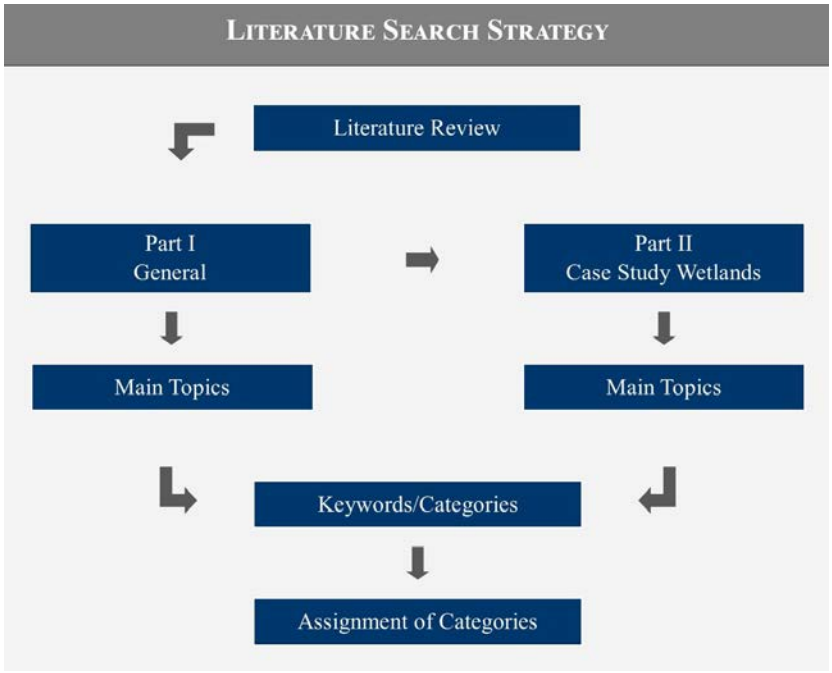

Figure 2: Overview of the literature search strategy and categorisation approach of articles.

3 Results

3.1 Case Study Wetlands

As shown in Fig. 1, most publications focus their attention on the designated Ramsar sites as well as urban wetlands in and around GAMA. With 14 articles focussing on the Sakumo lagoon system, it presents the most researched wetland in Ghana, followed by studies on the Densu Delta/River (12), Muni-Pomadze (11), Keta (11), Korle (9) and finally Songor Lagoon (6) (see Fig. 1). Their respective geographical locations are shown below in Figure 3.

Figure 3: Map of the Greater Accra Region illustrating the location of case study wetlands.

3.1.1 Sakumo Lagoon

The Sakumo Lagoon is the most studied wetland and a designated Ramsar site, which is located on the coastal road between Accra and Tema and covers an area of 1,4 ha comprising an open lagoon and surrounding floodplains, freshwater marsh, coastal savannah grasslands and narrow sand-dune connections to the sea. The total area is covered by brackish-saline water and provides important habitats for resident or migratory bird populations with an estimated 70 waterbird species (Ntiamoa-Baidu, 1991a; Ramsar Convention Secretariat, 2014). As the Sakumo Lagoon also provides a habitat for marine and freshwater fish species, many local communities rely on fishing as their main source of income. Additionally, the area is used for agriculture, industrial development and recreation and is also subjected to rapid population growth, urbanisation and pollution through sewage and domestic waste disposal (Ramsar Convention Secretariat, 2014).

3.1.2 Densu Delta

The Densu Delta is an estuary comprising an open lagoon, salt pans, fresh-water mash, scrubland and sand dunes. The Densu Delta is also a designated Ramsar site and comprises an area of 5,8 ha of which 39% are used for salt production, an important source of income for adjacent communities (Gbogbo, 2007; Ramsar Convention Secretariat, 2014). The Densu Lagoon complex is fed by the Densu River and has been subjected to significant coastal erosion in response to dam construction and the Kokrobite irrigation scheme (Addo, 2011).Several studies confirm the importance of the Densu Delta and the Sakumo Lagoon for waterbird populations (Gbogbo, 2007), as they provide large mudpans, shrub and mash land areas, which act as ideal habitats for feeding, roosting and nesting (Ntiamoa-Baidu, 1991b). Despite presenting an ecologically valuable ecosystem, the Densu Delta is exposed to serious pollution from the municipal and industrial waste deposition in the Oblogbo landfill, which leaches into the wetland area (Osei et al., 2011).

3.1.3 Muni-Pomadze Lagoon

The Muni-Pomadze Ramsar site features sand dunes, degraded forest, scrub, farmland and marsh area with an extent of approximately 9,4 ha. Local communities depend on the wetland in terms of commercial fishing, hunting grazing, farming and fuel wood obtained from the mangrove forest located on the eastern border of the wetland. Due to rapid urbanisation, Muni-Pomadze is also increasingly subjected to encroachment (Ramsar Convention Secretariat, 2014).

3.1.4 Keta and Songor Lagoons

The Keta Lagoon is the largest wetland in Ghana and, together with the Songor wetland, it is associated with the Volta River discharging into the ocean. Collectively, the Songor and Keta wetland systems provide the most valuable wetland habitat for waterbirds along Ghana's coast. The Songor Lagoon covers an area of 51 ha but Keta alone comprises 101 ha and stretches 40 km along the coast (Ntiamoa-Baidu, 1991b; Ntiamoa-Baidu et al., 1998; Ramsar Convention Secretariat, 2014). Both wetlands are characterized by brackish water as well as mud- and saltflats and both are economically exploited for the production of salt (Affam & Asamoah, 2011). Since the construction of the Akosombo dam in 1964, large amounts of water from the Volta River are retained upstream and freshwater as well as sediment inflow into the wetlands have been reduced (Ntiamoa-Baidu et al., 1998). With regard to the literature it becomes clear that the eastern coast of Ghana, and the Songor and Keta Lagoons in particular, are affected by substantial sea level rise, which is anticipated to cause increasing coastal erosion, floods and morphological change in the near future and in response to climate change (Boateng, 2009; Nairn et al., 1998). In the historical and more recent past, violent conflicts and numerous struggles between local communities have taken place

around the Songor Lagoon complex, in order to gain power over its salt production (Harvey & Langdon, 2010).

3.1.5 Korle Lagoon

The Korle Lagoon is not a designated Ramsar site but presents one of the largest and most important wetland areas within Ghana and GAMA (Dankwa et al., 2004). It constitutes the principle outlet to the sea, as most drainage channels in the capital are connected to it (Boadi & Kuitunen, 2002). Due to siltation and deposition of domestic waste, the Korle Lagoon has be-come stagnant and is prone to flooding, which regularly affects large numbers of urban residents (Boadi & Kuitunen, 2002). The former wetland areas and banks of the lagoon are also affected by informal settlement and rapid urban growth, so that they now host poor slum areas such as Korle Gonno, Korle Dundor, Adadinkpo and James Town (Boadi & Kuitunen, 2002; Grant, 2006). Domestic, industrial and medical waste disposal, sewage discharge, poverty as well as lack of infrastructure capacity represent the main cause for Korle's extensive pollution, which also poses a significant health hazards (Boadi & Kuitunen, 2002).

3.2 The Development of Research Interest

Figure 4 portrays the development of research interest in the case study wetlands over time, indicating that research began as early as 1975. Up until the turn of the millennium, only one or two articles were published per year, often with three year gaps in between publications. The year 2000 is marked by a significant increase in the research interest, as from then on and with only few exceptions, several articles have been published per year. A total of seven scientific papers appearing in 2000, currently representing the "publication-peak" concerning Accra's wetlands. However, recently the number of publications seems to have declined.

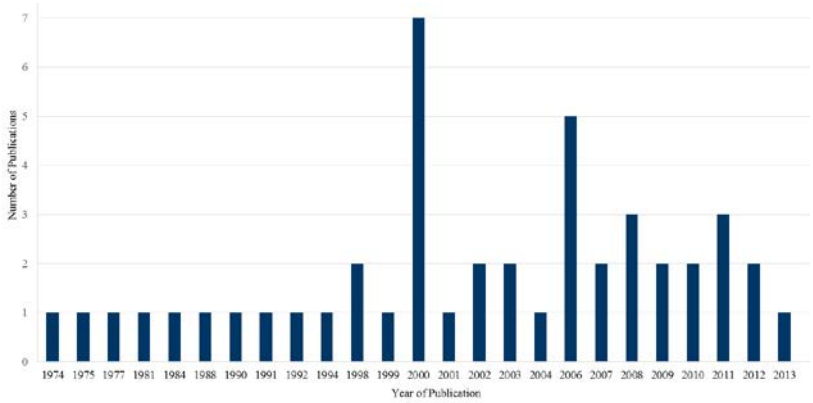

Figure 4: The development of research interest in Accra's case study wetlands over time.

3.3 Categorisation of Reviewed Articles

After the review of all 59 articles, their research perspectives were summarised in 11 categories. The direct human impact on wetlands in the Greater Accra Region is portrayed in more detail by dividing the category 'Human Activities' further divided into five sub-classes (Tab. 1). To illustrate the perspectives from which the six case study wetlands in Accra have previously been studied, Fig. 5 furthermore demonstrates the frequency of different categories for each of the lagoons: Densu Delta, Keta, Korle, Muni-Pomadze, Sakumo and Songor Lagoon. To provide an overview of the different research perspectives for the case study wetlands, Figure 6 also portrays a summary of all extrapolated research foci.

Table 1: The classification system in terms of corresponding keywords found in the abstracts or titles of all reviewed articles.

Categories	Keywords
Sea-Level Rise/Climate Change	Sea-Level Rise; Climate Change
(Coastal) Erosion	Coastal Erosion; Erosion
Flooding/Flood Risk	Flooding; Floods; Flood Risk
Salinization/ Saline Groundwater	Salinization; Saline Groundwater
Ecology/Ecosystems	Fish; Shell Fish; Crabs; Birds; Mammals; Insects; Benthic Fauna; Herpetofauna; Fauna; Feeding Habits; Feeding Styles; Plants; Vegetation; Biodiversity; Species Diversity; Insect Diversity; Coastal Habitat; Habitat; Ecosystems; Freshwater and Coastal Ecosystems; Ecological Conditions; Macro-Invertebrates; Ecological Integrity
Human Activites	
General	Bushment; Hunting; Fishing; Fisheries; Farming; Bushfires; Livestock Rearing; Dam Construction; Sand Winning; Human Intervention; Lumbering; Animal Grazing; Cultural Ceremonies
(Over)Exploitation	Overexploitation; Exploitation; Anthropogenic Threats; Sustainable Exploitation
Salt Production	Salt Production; Salt Mining
Informal Settlement	Informal Settlement
Communities	Communities
Management/Conversation	Conservation; Conservation Areas; Conservation Efforts; Ecosystem Management; Shoreline Management; Management; Sustainable Development; Emergency Planning; Management Units; Management/Protection
Geology/Morphology	Geology; Morphology; Geomorphology; Fluvial Processes
Wetland Degradation	Habitat Degradation; Degradation of Wetland Habitat; Pollution; Waste; Degradation (Hazardous to Humans); Degradation (Environmental Stressor); Degradation (Environmental Pressures); Environmental Degradation; sewage production
Tourism	Eco-Tourism Potential
Physical/Chemical Properties	Pysical/Chemical Properties (pH, Turbidity, Nutrient Concentrations, Transparency of Water; Pesticides, Temperature, Salinity, DO, Productivity, (Biochemical) Oxygen Demand, Heavy Metals, Chlorine, Faecal Coliforms, % Clay, EC, Exchange of Water with the Sea); Water Quality

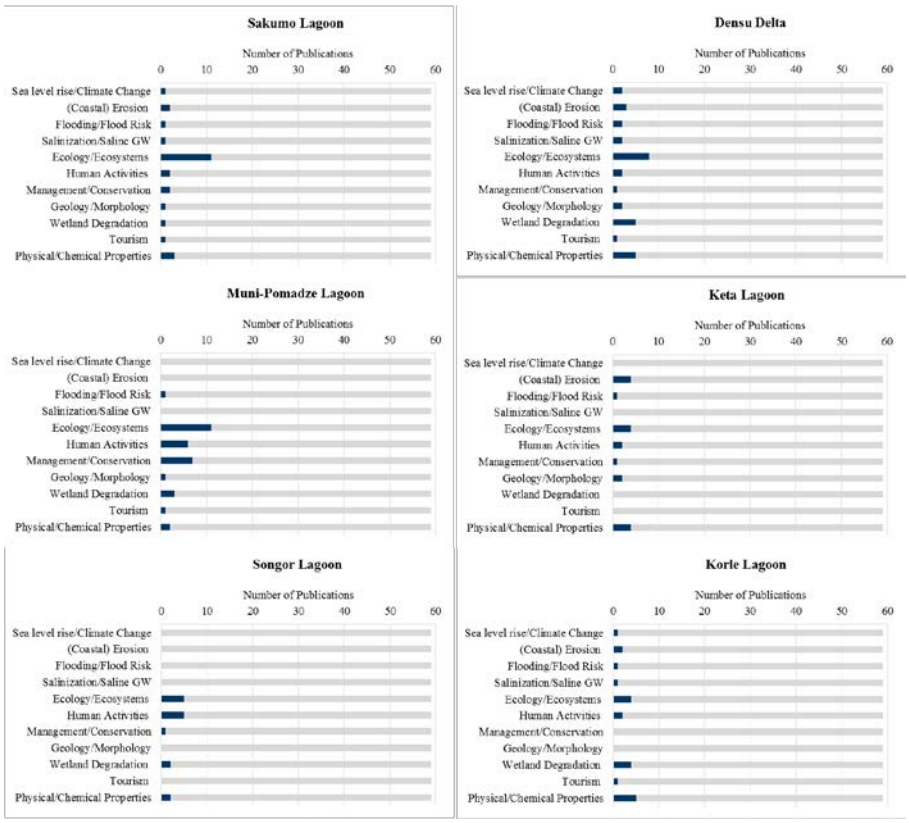

Figure 5: Overview of categories and frequency of occurrence with regard to individual case study wetlands.

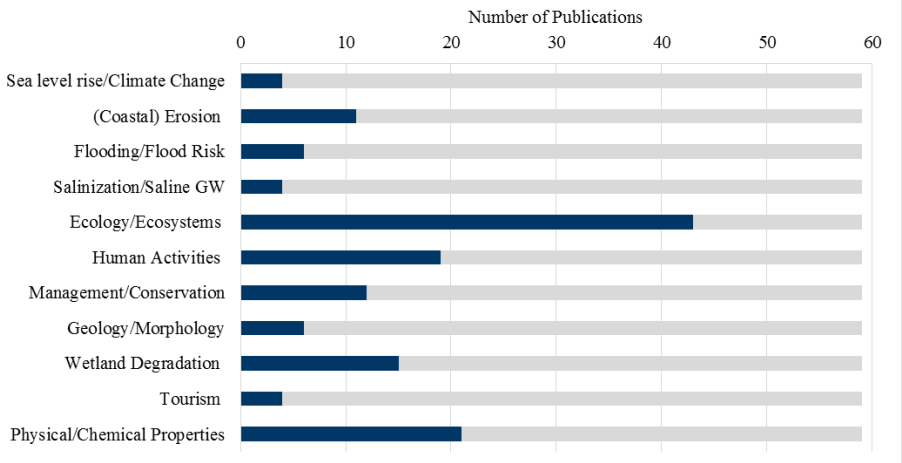

Figure 6: Overview of categories and frequency of occurrence with regard to all case study wetlands combined.

With regard to Tab. 1, Fig. 5 & 6 and the overall impression obtained during this review it becomes clear that the case study wetlands in their entirety have mainly been studied from the perspective of natural sciences. This is supported by the fact that with a total category count of 43, studies on "Ecology/Ecosystems" are most prominent. This category mainly contains research on plant and animal diversity with a heavy focus on the feeding habits of bird and fish populations.

The category “Physical/Chemical Properties” presents the second most frequent classification and many of the associated documents seek to determine the general environmental baseline conditions of Ghana’s and Accra’s wetlands.

Most studies link their findings to humans or human activities in wetland areas, which is why “Human Activities” presents the third most frequent category of all case study wetlands. The frequency of different categories portraying the analysis of human activities in the case study wetlands is shown in Fig. 7 and demonstrates that a variety of human impacts such as grazing and bushfires as well as salt production are studied most commonly.

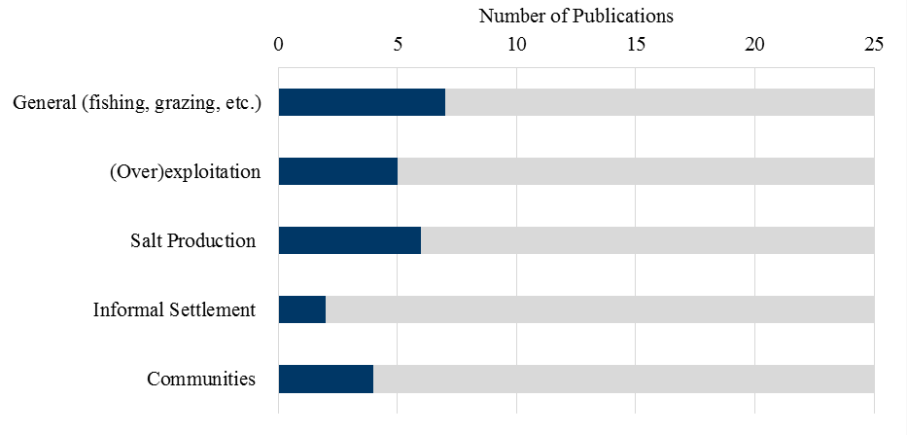

Figure 7: Categories and frequency of occurrence in terms of human activities in the case study wet-lands.

Although most papers mention the connection between anthropogenic activities and wetland degradation, policy and governance arrangements are often not specifically taken into account. In fact, only Grant (2006) and Ntiamoa-Baidu (1991a) focus on the impact of policy settings on the development of urban wetlands and their degradation through humans.

Overall, only eight of the reviewed documents analyse Ghana’s wetlands from a social science’s perspective by also explicitly employing social scientific methods such as interviews with local citizen. These include the two publications by Boadi and Kuitunen (2002, 2003), who investigate the history of pollution in the Korle Lagoon and municipal solid waste management in Accra. Affam and Asamoah (2011) point towards the economic potential of increasing salt production in the areas of the Songor and Keta Lagoons, while Sutton (1981, 1984) studies historical aspects of law and chieftaincy by investigating conflicts over saltpans. Farouk and Owusu (2012) analyse community based enumeration campaigns in the Old Fadama region, near the Korle Lagoon. Grant (2006) studies the impact of land policies on the Korle Lagoon and Ntiamoa-Baidu (1991a) explores the effect of religious taboos on wetland degradation. Wuver and Attuquayefio (2006) conduct interviews to investigate the interconnection between human activities and biodiversity loss in the Muni-Pomadze Lagoon.

“Wetland Degradation” and “Management/Conservation” are also reoccurring categories, although very few of the articles put a major focus on these

aspects or study them as main subject of analysis. While some studies refer to the connection of social developments such as squatter settlement, poverty, development and environmental degradation in the context of conservation and management plans, natural scientific perspectives and methods prevail. Many articles such as Attuquayefio and Gbogbo (2001) seek to eventually propose conservation strategies but primarily focus on quantitatively measuring indicator species and levels of pollution to determine baseline conditions.

"Coastal Erosion" presents a pressing problem for Accra, which is partially mirrored in the results, as receding coastlines were modelled in different studies.

4 Discussion

The overall results of this literature review display the great research interest in Accra, as nearly all articles retrieved in the initial search phase (Part I) include at least one of the urban lagoons in their studies. The Ramsar sites are most extensively investigated and a heavy focus lies on a natural sciences perspective. This observation can be explained by the fact that in 1992, Ghana received financial funds from the Global Environment Facility (GEF) for the protection of its first five Ramsar areas, namely the Densu Delta, Keta, Sakumo, Muni-Pomadze and Songor lagoon systems (Raxworthy & Attuquayefio, 2000). As part of the Coastal Wetlands Management Project (World Bank, 1992), these areas were consequently subjected to several scientific investigations to outline their environmental baseline conditions and environmental monitoring options. This explains the high number of publications investigating "Ecology/Ecosystems" and "Physical/Chemical Parameters" of the GAMA case study wetlands (Koranteng et al., 2000; Ntiamoa-Baidu et al., 1998; Oteng-Yeboah, 1999; Raxworthy & Attuquayefio, 2000; Ryan & Ntiamoa-Baidu, 2000).

Supplementary to the implementation of "The Wetland Management (Ramsar Sites) Regulation" in 1999, the development of research interest in wetland ecosystems is also suggested to result from a general orientation of national politics towards more environmental protection, which occurred during the 1990s (Amlalo, 2006). Amongst others, management strategies and legislations compiled during this period include documents such as the "Coastal Zone Management Indicative Plan" (1990), the "National Environmental Action Plan" (1994), the "Draft Integrated Coastal Zone Plan" (1998), the "Environmental Sensitivity Map of the Coastal Areas of Ghana" (1999 & 2004) and the "Environmental Assessment Regulation" (1999) (Amlalo, 2006). At the same time, several important protection measures were implemented, including the "Ghana Environmental Resource Management Project in Coastal Wetlands Management Component" as well as "Monitoring fish stock levels and associated oceanographic parameters" (Amlalo, 2006).

The number of publications investigating "Ecology/Ecosystems" in terms of bird, fish and shrimp populations are not only linked to the increasing interest in environmental issues and national policies but are also due to the fact that the Ramsar sites were chosen on the basis of their importance for internationally important populations of resident and migratory birds (Willoughby et al., 2001). Furthermore, most of Ghana's wetlands as well as the lagoon systems in Accra have traditionally sustained significant artisanal fisheries, which are now threatened by over-exploitation, which explains the research focus on "Human Activities", "Management/Conservation" and "Wetland Degradation" (Pauly, 1975). Disappearing fish stocks pose a serious threat to the livelihood of people living in the vicinity of the degrading wetlands. In the reviewed literature, over-exploitation of fish populations is partially explained by the suspension of traditional regulations such as religious bans on fishing (Boadi & Kuitunen, 2002).

Next to these internationally important Ramsar wetlands, the Korle Lagoon is of special concern, as it can be counted amongst the most polluted water bodies on earth (Boadi & Kuitunen, 2002). The research interest can further be explained by its location within the economically important and densely populated Greater Accra region. Up until the mid-1950s, the Korle Lagoon for example supported a thriving fishery. However, due to extensive pollution and waste deposition, nearly all animal species within this former wetland area have now gone extinct (Boadi & Kuitunen, 2002).

Other research perspectives extrapolated in this study focus on "(Coastal) Erosion", "Flooding/Flood Risk" and "Sea level rise/Climate Change", as coastal wetlands are usually prone to flooding, which causes significant problems for the densely populated GAMA region. Accra's lagoons are of low elevation and their soil is clayish and impermeable (Twumasi & Asomani-Boateng, 2002). The lack of drainage and increasing siltation in addition to the deposition of domestic waste near lagoon outputs have generated an increasing risk of flooding, especially during the wet season (May-July) (Boadi & Kuitunen, 2002; Boateng, 2012; Twumasi & Asomani-Boateng, 2002). Moreover, sea level is currently rising and is predicted to increase even further in response to progressing climate change (Stocker et al., 2013). Climate change is also expected to result in an intensification of coastal erosion, storm surges and an exacerbated flood risk for Accra and Ghana's coastal areas. Therefore, several studies aim at modelling sea level rise and flood risks for Accra's future (Addo, 2011; Boateng, 2012; Twumasi & Asomani-Boateng, 2002).

With regard to the reviewed articles, it becomes clear that human influence on Accra's wetlands has and is causing serious environmental degradation, which diminishes their ecosystem functions such as floodwater retention and fresh water provision. Local livelihoods are threatened by reduced or over-exploited fisheries and wildlife biodiversity (Boadi & Kuitunen, 2002; Pauly, 1975). Pollution and waste deposition not only cause the extinction of former resident species but also pose a serious threat to human health (Boadi & Kuitunen, 2002; Osei et al., 2011). Waste deposition and upstream dam construction also result in exacerbated flood risk, which is further augmented by

climate change, sea level increase and coastal erosion (Boateng, 2009; Nairn et al., 1998).

With regard to the overall results, a research gap becomes apparent, as coastal wetlands in Ghana and Accra have not yet been investigated in detail with regard to the coupling of political and geo-biophysical processes. It is suggested to extend the prevailing perspective of natural sciences to include social, political and governance dimensions, in order to develop a deeper understanding on the inherent socio-ecological co-evolution of wetland systems. Only if this is achieved, a more holistic, realistic and sustainable management strategy for the development of the lagoons and their ecosystems can be developed. Considering Accra's increasing urban population, over-exploitation of wetland resources and their diminished ecological functions, the association between wetland ecosystem services and society needs to be addressed in an inter- and transdisciplinary approach.

The aim of this literature review was to provide a general outline of the state of the art research on Ghana's wetlands and the six major lagoon systems within or the close proximity of the GAMA region. As a result, the generated category system acts as a simplistic synopsis of dominant research foci but should be dissected and differentiated further for an in depth understanding of prevailing research perspectives. A broader and less biased outline of this topic could be achieved by conducting a literature search with several databases, more search keywords and by including a greater number of scientific articles.

As part of the WaterPower project, a more comprehensive study of the social and political co-production of aquatic ecosystems will be conducted in order to generate a more detailed overview of current dynamics in coastal wetlands in Ghana and Accra.

5 Conclusion

During this literature review it has become clear that of all coastal wetlands in Ghana, lagoons in the Greater Accra Region and the originally designated Ramsar sites have been most extensively studied, as they are often chosen as case study wetlands. Although the Korle Lagoon is not managed under the Ramsar Convention, it is also attracts research interest as one of the most polluted water bodies on earth (Boadi & Kuitunen, 2002). Korle is therefore of great importance with regard to health hazards within Greater Accra.

This study suggests that the development of research interest over time can be related firstly to the designation of Ramsar sites, the Coastal Wetlands Management Project (World Bank, 1992), and the official adaptation of the "Wetland Management (Ramsar Sites) Regulation" in 1999, which were followed by several environmental baseline studies. Secondly, research interest is proposed to be influenced by an increase in environmental awareness on a national level, manifesting itself in several environmental regulations and legislations adopted in the 1990s.

Coastal wetlands in the Greater Accra Region have mainly been studied from the perspective of natural sciences and most wetlands have been analysed with regard to their ecological, physical and chemical properties. The Ramsar sites were selected on the basis of their importance for internationally important waterbird populations (Willoughby et al., 2001), which explains the great number of ornithological studies. The number of articles focussing on "Wetland Degradation" and "Human Activities" in combination with studies on fish, crab or shrimp populations is related to the fact that the livelihoods of local communities are endangered by wetland degradation and the over-exploitation of fish stock. Studies on climate change, (coastal) erosion and flood risk is mirror the regular flooding of Accra's urban wetlands in response to their low-lying nature, domestic waste deposits blocking lagoon inlets and increasing siltation. The construction of several inland dam systems reduced freshwater and sediment flow into Accra's coastal wetland, posing an increasing erosion hazard with regard to progressing sea level rise and climate change. Attempts to quantify and model these effects in the future have been made throughout the literature.

Despite many articles linking their findings to human activities, a research gap becomes apparent, as only two papers (Grant, 2006; Ntiamoa-Baidu, 1991a) analyse the connection between political and governance variables and environmental developments in wetland areas. As Accra experiences increasing urban population and an over-exploitation of natural resources, the association between wetlands, ecosystem services and society needs to be addressed in an inter- and transdisciplinary approach. It is therefore suggested to expand the natural science's perspective on wetlands in Accra to account for social and political aspects in order to develop a holistic and sustainable management strategy.

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7 Appendix

List of all articles obtained during this literature review.

Results of the first search phase with keywords: "wetlands Ghana", "coastal wetlands Ghana", "wetlands Accra", "lagoons Accra" and "ecosystem wetland Accra"	**Assigned Categories**	**Case Study Wetlands**
ADDO, K. A. (2011). Changing morphology of Ghana's Accra coast. *Journal of Coastal Conservation,* 15(4), 433-443.	Morphology, SL-Rise, Flooding, Coastal Erosion, Geology, Human Activities (dam construction)	Accra's coast Densu River
AHETO, D.W., MENSAH, E., AGGREY-FYNN, J., OBODAI, E.A., MENSAH, C.J., OKYERE, I., & AHETO, S.P.K. (2011). Spatio-temporal analysis of two coastal wetland systems in Ghana: Addressing ecosystem vulnerability and implications for fisheries development in the context of climate and land use changes. Archives of Applied Science Research, *3*(3), 499-513.	Habitat, Fish, Ecosystem,Vulnerability, Climate Change, Biodiversity, Ecological condition, Ecosystem management, Sustainable Development, Communities	Whin Estuary, Butuah Lagoon

AHULU, M., NUNOO, F. & OWUSU, E. H. (2006). Food preferences of the common tern, Sterna hirundo (Linnaeus, 1758), at the Densu floodplains, Accra. *West African Journal of Applied Ecology,* 9(1), 141-148.	Birds, Fish, Stresses, Importance of Conservation Efforts	Densu Delta
ATTUQUAYEFIO, D. & GBOGBO, F. (2001). Prospects of conserving wetlands along the Mukwe lagoon at Nungua in the greater Accra region of Ghana. *West African Journal of Applied Ecology,* 2(1), 65-75.	Human Activities (overexploitation through fishing, farming, grazing) Conservation, Pollution, Habitat Degradation, Eco-Tourism Potential, Human Activities (farming, fishing, hunting, livestock rearing), Pysical/Chemical Properties, Fish	Mukwe Lagoon
ATTUQUAYEFIO, D. & WUVER, A. M. (2003). A study of bushfires in a Ghanaian coastal wetland. I. Impact on small mammals. *West African Journal of Applied Ecology,* 4(1), 13-26.	Human Activities (bushfires), Mammals Biodiversity, Degradation of Wetland Habitat, Eco-Tourism Potential	Muni-Pomadze

BINEY, C. A. (1990). A review of some characteristics of freshwater and coastal ecosystems in Ghana. *Hydrobiologia, 208*(1-2)**,** 45-53.	Physical/Chemical Properties (pH, turbidity, nutrient concentrations, transparency of water), Freshwater and Coastal Ecosystems	Laiwi Gao Mukwe Kpshie Fosu Korle Densu Delta Sakumo Nakwa Chemu
BOADI, K. O. & KUITUNEN, M. (2002). Urban waste pollution in the Korle lagoon, Accra, Ghana. *Environmentalist, 22*(4)**,** 301-309.	Pollution/Waste, Floods/Flood Risk	Korle Lagoon
BOADI, K. O. & KUITUNEN, M. (2003). Municipal solid waste management in the Accra Metropolitan Area, Ghana. *Environmentalist, 23*(3)**,** 211-218.	Pollution/Waste, Management	Accra's coast
ESSUMANG, D., TOGOH, G. & CHOKKY, L. (2009). Pesticide residues in the water and fish (lagoon tilapia) samples from lagoons in Ghana. *Bulletin of the Chemical Society of Ethiopia, 23*(1)**,** 19-27.	Physical/Chemical Properties (pesticides), Degradation (hazardous to humans)	Chemu Etsii Korle Fosu

GBOGBO, F. (2007). Impact of commercial salt production on wetland quality and waterbirds on coastal lagoons in Ghana. *Ostrich-Journal of African Ornithology,* 7(1), 81-87.	Benthic Fauna, Birds, Feeding Habits, Physical/Chemical Properties, Human Activites (Salt Production)	Ghana's coastal wetlands
GBOGBO, F. (2007). The importance of unmanaged coastal wetlands to waterbirds at coastal Ghana. *African journal of ecology,* 45(4), 599-606.	Birds, Pollution	Densu Delta Sakumo Laiwi Mukwe
GRANT, R. (2006).Out of place? Global citizens in local spaces: a study of the informal settlements in the Korle Lagoon Environs in Accra, Ghana. *Urban Forum*, 17(1), 1-24.	Human Activities (Informal Settlement)	Korle Lagoon
KWEI, E. A. (1977). Biological, chemical and hydrological characters of coastal lagoons of Ghana, West Africa. *Hydrobiologia,* 56(2), 157-174.	Biodiversity, Physical/Chemical Properties (temperature, salinity, DO, productivity)	Sakumo Densu Delta

NIXON, S. W., BUCKLEY, B. A., GRANGER, S., ENTSUA-MENSAH, M., ANSA-ASARE, O., WHITE, M., MCKINNEY, R. A. & MENSAH, E. (2007). Anthropogenic enrichment and nutrients in some tropical lagoons of Ghana, West Africa. *Ecological Applications,* 17(5), 144-164.	Waste/Pollution (sewage production), Water Qualitiy, Physical/Chemical Properties (nutrients, temperature), Plants, Fish	Amisa Nakwa Oyibi Nayanya Muni-Pomadze Benya Sakumo Korle
NTIAMOA-BAIDU, Y., PIERSMA, T., WIERSMA, P., POOT, M., BATTLEY, P. & GORDON, C. (1998). Water depth selection, daily feeding routines and diets of waterbirds in coastal lagoons in Ghana. *Ibis,* 140(1), 89-103.	Birds, Feeding Styles, Habitat,	Songor Keta Lagoon
NTIAMOA-BAIDU, Y. (1991). Seasonal changes in the importance of coastal wetlands in Ghana for wading birds. *Biological Conservation,* 57(2), 139-158.	Birds, Coastal Erosion (Keta & Korle Lagoon), Conservation areas (proposition of Sakumo & Songor)	Esiama Elmina Densu Delta Laiwi Muni-Pomadze Sakumo Songaw Keta
NTIAMOA-BAIDU, Y. (1991). Conservation of coastal lagoons in Ghana: the traditional approach. *Landscape and Urban Planning*, 20(1), 41-46.	Conservation , Human Activities (communities, overexploitation), Birds, Habitat, Fish/Crabs	Sakumo Lagoon Djange

NYAME, F.K., TIGME, J., KUTU, J.M., & ARMAH, T.K. (2012). Environmental implications of the discharge of municipal landfill leachate into the Densu River and surrounding Ramsar wetland in the Accra Metropolis, Ghana. *Journal of Water Resource and Protection*, 4(8), 622-633.	Waste, Physical/Chemical Properties (oxygen demand, nutrients, heavy metals, chlorine), Ecosystem	Densu Delta
OSEI, J., OSAE, S., FIANKO, J., ADOMAKO, D., LAAR, C., ANIM, A., GANYAGLO, S., NYARKU, M. & NYARKO, E. (2011). The impact of Oblogo landfill site in Accra-Ghana on the surrounding environment. *Research Journal of Environmental and Earth Sciences,* 3(6)**,** 633-636.	Pollution /Waste, Physical/Chemical Properties (nutrients, metals)	Densu Delta
OTENG-YEBOAH, A. (1999). Biodiversity studies in three coastal wetlands in Ghana, West Africa. *Journal of the Ghana Science Association,* 1(3)**,** 147-149.	Plants, Biodiversity	Sakumo Muni-Pomadze Densu Delta

RAXWORTHY, C. J. & ATTUQUAYEFIO, D. K. (2000). Herpetofaunal communities at Muni lagoon in Ghana. *Biodiversity & Conservation,* 9(4), 501-510.	Herpetofauna, Habitats, Degradation (environmental stressor), Conservation	Muni-Pomadze
RYAN, J. M. & NTIAMOA-BAIDU, Y. (2000). Biodiversity and ecology of coastal wetlands in Ghana. *Biodiversity and Conservation,* 9(4), 445-446.	Biodiversity, Ecology, Habitats, Species Diversity	Ghana's coastal wetlands
WUVER, A. & ATTUQUAYEFIO, D.K. (2006). The impact of human activities on biodiversity conservation in a coastal wetland in Ghana. *West African Journal of Applied Ecology,* 9(1).	Human Activities (bushfires, hunting, fishing, farming), Habitat, Biodiversity, Conservation	Muni-Pomadze
Results of the second search phase with keywords: "Songor Lagoon", "Sakumo Lagoon", "Densu Lagoon", "Korle Lagoon", "Muni-Pomadze Lagoon" and "Keta Lagoon"	**Assigned Categories**	**Case Study Wetlands**

ADDO, K.A., WALKDEN, M. & MILLS, J. (2008). Detection, measurement and prediction of shoreline recession in Accra, Ghana. *ISPRS Journal of Photogrammetry and Remote Sensing,* 63**,** 543-558.	Erosion, Sea-level rise	Accra's coast
AFFAM, M. & ASAMOAH, D. (2011). Economic potential of salt mining in Ghana towards the oil find. *Research Journal of Environmental Sciences,* 3(5)**,** 448-456.	Human Activities (salt production)	Songor lagoon
ATTUQUAYEFIO, D. K., GBOGBO, F., SUAPIM, R. H., KROBEA-ASANTE, A., & OWUSU, E. H. (2008). Aspects of the feeding ecology of wintering waterbirds on the Densu Delta site, Greater-Accra Region, Ghana. *Ghana Journal of Science,* 47, 17-34	Feeding Ecology Birds	Densu Delta
BINEY, C. & AMEYIBOR, E. (1992). Trace metal concentrations in the pink shrimp Penaeus notialis from the coast of Ghana. *Water, Air, and Soil Pollution,* 63(3-4)**,** 273-279.	Fish, Physical/Chemical Properties	Korle Lagoon

BLAY, J., & ASABERE-AMEYAW, A. (1993). Assessment of the fishery of a stunted population of the cichlid, Sarotherodon melanotheron (Rüppel), in a "closed" lagoon in Ghana. *Journal of Applied Ichthyology*, *9*(1), 1-11.	Fish, Human Activities (fishery, exploitation	Fosu Lagoon
BOATENG, I. (2009). Development of integrated shoreline management planning: a case study of Keta, Ghana. *Proceedings of the Federation of International Surveyors Working Week 2009-Surveyors Key Role in Accelerated Development, TS 4E, Eilat, Israel, 3-8 May*.	Coastal Erosion, Management (Shoreline Management, Emergency Planning) , Flood/Flood Risk, Geology	Keta Lagoon
BOATENG, I. (2012). An assessment of the physical impacts of sea-level rise and coastal adaptation: a case study of the eastern coast of Ghana. *Climatic change,* 114(2)**,** 273-293.	Sea Leval Rise, Coastal Erosion, Flood, Human Intervention, Coastal Habitat, Management Units	Accra's coast Keta

DANKWA, H., SHENKER, J., LIN, J., OFORI-DANSON, P. & NTIAMOA-BAIDU, Y. 2004. Fisheries of two tropical lagoons in Ghana, West Africa. *Fisheries Management and Ecology,* 11(6)**,** 379-386.	Fish, Water Quality, Physical/Chemical Properties, Sustainable Exploitation	Keta Lagoon Songor Lagoon
FAROUK, B. R. & OWUSU, M. (2012). "If in doubt, count": the role of community-driven enumerations in blocking eviction in Old Fadama, Accra. *Environment and Urbanization,* 24(1)**,** 47-57.	Human Activity (Informal Settlement, Community)	Korle Lagoon
GBOGBO, F., ODURO, W. & OPPONG, S. (2008). Nature and pattern of lagoon fisheries resource utilisation and their implications for waterbird management in coastal Ghana. *African Journal of Aquatic Science,* 33**,** 211-222.	Fish, Crabs, Sustainable Management, Birds, Humans/Human Activity (exploitation, fisheries)	Ghana's Coatal Wetlands
GORDON, C. (2000). Hypersaline lagoons as conservation habitats: macro-invertebrates at Muni Lagoon, Ghana. *Biodiversity & Conservation*, *9*(4), 465-478.	Macro-Invertebrates, Conservation Habitats, Biodiversity, Crabs, Human Activities (Anthropogenic Threats)	Muni Pomadze Lagoon

GORDON, C., NTIAMOA-BAIDU, Y., & RYAN, J. M. (2000). The Muni-Pomadze Ramsar site. *Biodiversity & Conservation*, *9*(4), 447-464.	Geomorphology, Physical/Chemical Properties, Vegetation, Human Activities (bushmeat hunting, agriculture, fishing, communities), Biodiversity, Ecological Integrity Waterbirds, Conservation, Management	Muni-Pomadze
GORDON, I., & COBBLAH, M. (2000). Insects of the Muni-Pomadze Ramsar site. *Biodiversity & Conservation*, *9*(4), 479-486.	Insect Diversity, Habitat Quality	Muni-Pomadze
HARVEY, B. & LANGDON, J. (2010). Re-imagining Capacity and Collective Change: Experiences from Senegal and Ghana. *IDS Bulletin,* 41(3)**,** 79-86.	Human Activities (community), Degradation (environmental pressures)	Songor Lagoon
JØRGENSEN, N. O. & BANOENG-YAKUBO, B. K. (2001). Environmental isotopes (18O, 2H, and 87Sr/86Sr) as a tool in groundwater investigations in the Keta Basin, Ghana. *Hydrogeology Journal,* 9(2)**,** 190-201.	Physical/Chemical Properties, Saline GW	Keta Lagoon

KARIKARI, A., ASANTE, K. & BINEY, C. (2006). Water quality characteristics at the estuary of Korle Lagoon in Ghana. *West African Journal of Applied Ecology,* 10(1).	Water quality, Pollution/Waste, Physical/Chemical Properties (biochemical oxygen demand, faecal coliforms), Environmental Degradation	Korle Lagoon
KORANTENG, K., OFORI-DANSON, P. & ENTSUA-MENSAH, M. (2000). Fish and fisheries of the Muni lagoon in Ghana, West Africa. *Biodiversity & Conservation,* 9(4), 487-499.	Fish/Shell Fish, Human Activities (exploitation), Conservation, Ecology (Physical/Chemical Environment)	Muni-Pomadze
KUSIMI, J. M. (2008). Stream processes and dynamics in the morphology of the Densu River channel in Ghana. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *37*(B8), 1177-1181.	Morphology, Human Activities (farming, lumbering, sand winning, animal grazing, dam construction), Fluvial Processes, Erosion, Flooding, Salt Mining	Densu River Basin Sakumo Lagoon
KWEI, E. A. (1978). Size composition, growth and sexual maturity of Callinectes latimanus (Rath.) in two Ghanaian lagoons. *Zoological journal of the Linnean Society,* 64(2), 151-175.	Fish/Crabs	Ghana's wetlands

LAAR, C., FIANKO, J., AKITI, T., OSAE, S. & BRIMAH, A. (2011). Determination of heavy metals in the black-chin tilapia from the Sakumo Lagoon, Ghana. *Research Journal of Environmental and Earth Sciences,* 3(1), 8-13.	Fish, Physical/Chemical Properties	Fosu Lagoon
LAMPTEY, E. & ARMAH, A. K. (2008). Factors affecting macrobenthic fauna in a tropical hypersaline coastal lagoon in Ghana, West Africa. *Estuaries and Coasts,* 31(5), 1006-1019.	Benthic Fauna, Biodiversity, Physical/Chemical Properties (Salinity, % clay, pH, Turbidity)	Keta Lagoon
NAIRN, R., MACINTOSH, K., HAYES, M., NAI, G., ANTHONIO, S. & VALLEY, W. (1998). Coastal Erosion at Keta Lagoon, Ghana – Large Scale Solution to a Large Scale Problem. *Coastal Engineering Proceedings,* 1(26).	Coastal Erosion	Keta Lagoon
NTIAMOA-BAIDU, Y., NYAME, S. K. & NUOH, A. A. (2000). Trends in the use of a small coastal lagoon by waterbirds: Muni Lagoon (Ghana). *Biodiversity & Conservation,* 9(4), 527-539.	Birds, Floods, Habitats, Management/Protection	Muni Lagoon

OFORI-DANSON, P. K., & KUMI, G. N. (2006). Food and Feeding Habit of Sarotherodon melanotheron, Rüppell, 1852 (Pisces: Cichlidae) in Sakumo Lagoon, Ghana. *West African Journal of Applied Ecology*, *10*(1).	Feeding Habit of Fish, Microhabitats	Sakumo Lagoon
OSEI, J., KWAKYI, F. N., KAKU, T. A., OSAE., S.K., DAMPARE, S.B., RICHMOND, J. F., ADOMAKO, D., & BENTIL, N. (2010). Application of multivariate analysis for identification of pollution sources in the Densu delta wetland in the vicinity of a landfill site in Ghana. *Journal of Water Resource and Protection*, 2(12), 1020-1029.	Pollution, Physical/Chemical Properties (heavy metals, pH, temperature, EC, turbidity)	Densu Delta
PAULY, D. (1975). On the ecology of a small West African lagoon. *Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung,* 24(1), 46-62.	Ecology, Fauna, Fish/Gastropod, Physical/Chemical Properties (Temperature, Salinity, Exchange of water with the sea)	Sakumo Lagoon

PAULY, D., MOREAU, J., PALOMARES, M. & LOURDES, D. (1988). Detritus and energy consumption and conversion efficiency of Sarotherodon melanotheron (Cichlidae) in a West African lagoon. *Journal of Applied Ichthyology,* 4(4), 190-193.	Fish (Feeding Habits)	Sakumo Lagoon
PAULY, D. (2002). 21 Spatial modelling of trophic interactions and fisheries impacts in coastal ecosystems: A case study of Sakumo Lagoon, Ghana. *Large Marine Ecosystems,* 11, 289	Fish, Ecosystem/Ecology	Sakumo Lagoon
ROELVINK, J., WALSTRA, D. & CHEN, Z. (1994). Morphological modelling of Keta lagoon case. *Coastal Engineering Proceedings,* 1(24), 3223-3236.	Morphology, Coastal Erosion (Modelling)	Keta Lagoon
RYAN, J. M., & ATTUQUAYEFIO, D. (2000). Mammal fauna of the Muni-Pomadze Ramsar site, Ghana. *Biodiversity & Conservation*, *9*(4), 541-560.	Terrestrial Mammals, Habitat, Human Activites (hunting bushmeat, cultural ceremonies), Conservation efforts, Management	Muni-Pomadze

SAGOE-ADDY, K. & ADDO, K. A. (2013). Effect of predicted sea level rise on tourism facilities along Ghana's Accra coast. *Journal of Coastal Conservation,* 17(1), 155-166.	Sea-level rise, Tourism, Coastal Erosion, Salinisation	Accras Coast, Densu Delta, Sakumo, Kpeshie, Korle
SØRENSEN, T., VØLUND, G., ARMAH, A., CHRISTIANSEN, C., JENSEN, L. & PEDERSEN, J. (2003). Temporal and spatial varations in concentrations of sediment nutrients and carbon in the Keta lagoon, Ghana. *West African Journal of Applied Ecology,* 4(1), 91-105.	Physical/Chemical Properties (Sediment Characteristics, Marine Conditions, Nutrient Contents)	Keta Lagoon
SUTTON, I. B. (1981). The Volta River salt trade: The survival of an indigenous industry. *The Journal of African History,* 22(1), 43-61.	Salt Production	Songor Lagoon Keta Lagoon
SUTTON, I. (1984). Law, chieftaincy and conflict in colonial Ghana: The Ada case. *African Affairs*, 83(330),41-62.	Salt Production	Songor Lagoon

TWUMASI, Y. & ASOMANI-BOATENG, R. (2002). *Mapping seasonal hazards for flood management in Accra, Ghana using GIS. Geoscience and Remote Sensing Symposium, 2002.* IEEE. 2874-2876.	Floods	Accra's coast
VAN BANNING, P. (1974). A new species of Paeonodes (Therodamasidae, Cyclopoida), a parasitic copepod of the fish Tilapia melanotheron from the Sakumo-lagoon, Ghana, Africa. *Beaufortia*, *22* (286), 1-7.	Fish	Sakumo Lagoon

WaterPower is a laboratory for experimenting with novel ways of doing research based on the integration of multiple disciplines, approaches, methods and non-academic knowledge through dialogue and collaboration.

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WaterPower is funded by

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Federal Ministry of Education and Research

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