



Resilient lagoons? Climate change, sustainability and adaptation

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with Funmilayo Doherty, Andrews Agyekumhene, Idowu Aneyo, Kwasi Appeaning Addo, Isaac Boateng, Anne Danby, Esther Danso-Wiredu, Georges Degbe, Sarah Hemstock, Steve Mitchell, Debadayita Raha and Zacharie Sohou

Introduction

Lagoons are found at low-lying coastlines around the globe (Figure 1) and their associated wetlands are important dynamic environments. Ensuring the sustainability of the world's lagoons is vital for communities, ecosystems and economies. Lagoons support highly productive ecosystems and provide critical ecosystem services, societal benefits and myriad fundamental and valuable resources that are vital for the wellbeing and livelihoods of coastal communities. Yet, the sustainability of lagoons and the communities who rely on them are under increasing pressure from a complex set of interconnected issues, including climate change, sea-level rise, pollution, poor waste management, population growth and policy approaches that favour top-down governance to the exclusion of local knowledges and priorities (Convention on Wetlands, 2021). This article summarises the latest research on lagoons using the examples of Muni Lagoon in Ghana and Lagos Lagoon in Nigeria (Figure 1). It also draws from the interdisciplinary dialogues emerging through the Global Challenges Research Fund (GCRF)-funded Resilient Lagoon Network (see website), which seeks to challenge top-down management approaches and instead prioritise participatory approaches that value local knowledges and in which coastal communities are central to resilient lagoon governance.

This article has been corrected with minor changes. These changes do not impact the academic content of the article.



Figure 1: The distribution of coastal lagoons noted in the academic literature published from 2020 onwards. The location of Lagos and Muni lagoons discussed in the text is also shown.

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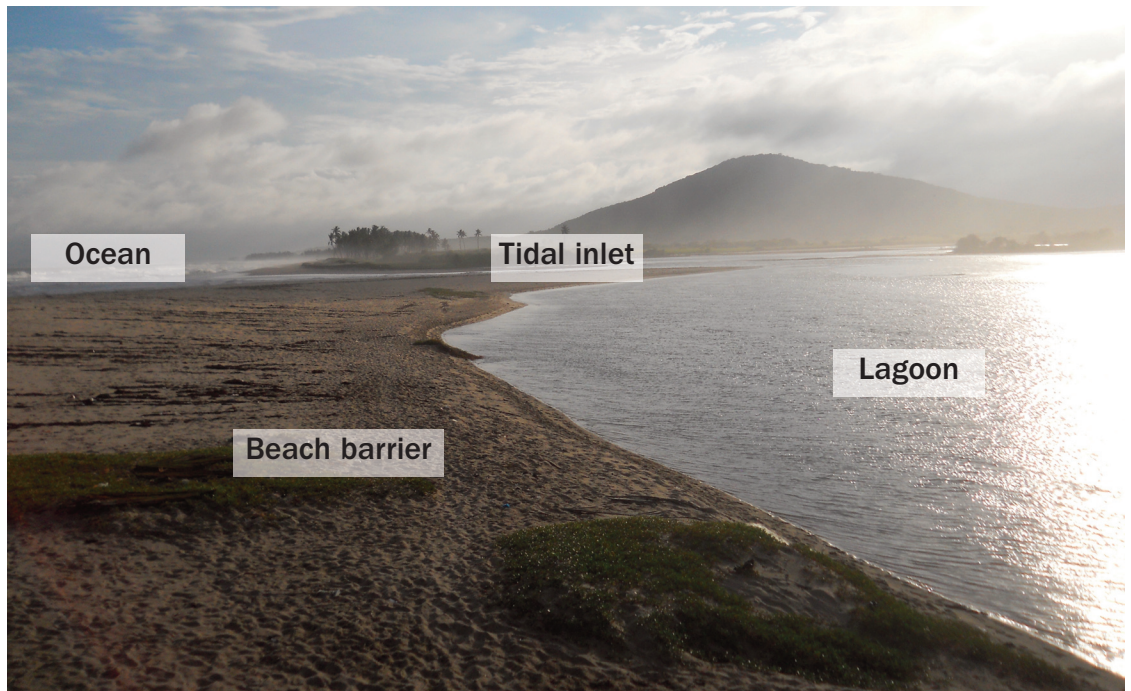


Figure 2: Here, Muni Lagoon in Ghana is used to illustrate the main physical features of a lagoon. Photo: © K. Siân Davies-Vollum.

Lagoon processes

Lagoons are shallow coastal lakes found at the nexus of land and sea. Here, biota and water from ocean and rivers mix to create a distinctive coastal environment. Lagoons formed as sea levels rose at the start of the Holocene, transporting sand onshore that was deposited at the mouth of estuaries. The sand formed beach barriers, which impounded estuaries to form lagoons on their landward side (Figure 2). Beach barriers are the key physical feature of a lagoon. They are transient, responding to variations in sea level and coastal sediment budget as well as local weather, and oceanic and hydrological conditions (Kjerfve, 1994). When a barrier is breached, a tidal-inlet

forms, allowing the mixing of lagoon and ocean waters. Breaching can occur randomly or on a regular cycle aligned to rainfall and storm patterns (Davies-Vollum *et al.*, 2019).

Lagoon case studies from West Africa

The Muni Lagoon (Figure 3) is a small, peri-urban lagoon on Ghana's central coastline, adjacent to the town of Winneba (population approximately 60,000). The lagoon is intermittently a 'closed lagoon', i.e. it is fed by rivers whose discharge fluctuates greatly between wet and dry seasons, resulting in significant hydrological, physicochemical and ecological variation. At the end of the wet season, Muni Lagoon covers approximately 1000 ha, but by the end of the dry season it shrinks to about 100 ha, with salinity higher than the adjacent ocean. Breaching of the barrier releases lagoon freshwater to the ocean while allowing ocean water to enter the lagoon. Breaching commonly takes place at the end of the heaviest rainy seasons, when water levels in the lagoon are at maximum. The breach is closed during the dry season by the deposition of sand transported by longshore ocean currents. Muni Lagoon has high habitat diversity and is globally important as a staging post for migrating water birds (Ntiamo-Baidu *et al.*, 2000). Because of this, in 1992, Muni Lagoon was designated as a 'Ramsar' site – a wetland site of international importance. The lagoon and barrier provide a number of socio-economic benefits and resources to the local community including fish, mangroves, salt production and sand for construction.

Figure 3: Muni Lagoon in Ghana is a wetland site of international importance. Photo: © K. Siân Davies-Vollum.





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Figure 4: Lagos Lagoon in Nigeria is an important resource for the city's inhabitants. Photo: © Kehinde Temitope Odutayo/Shutterstock.com.

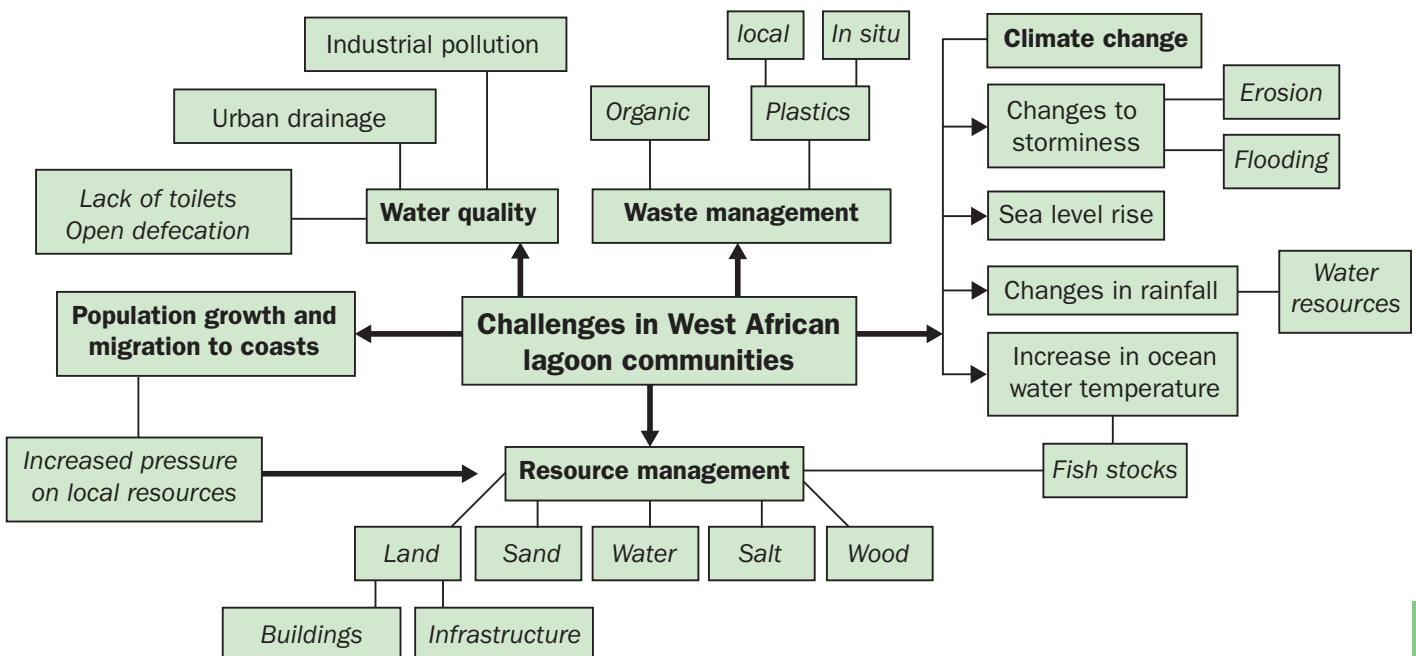
The Lagos Lagoon is an urban lagoon around which the city of Lagos was built (Figure 4). Lagos is the most populous city in Nigeria and one of the fastest-growing cities in Africa, with estimates of between 17.5 and 21 million inhabitants. Lagos Lagoon is part of the most extensive coastal lagoon complex in West Africa that stretches 257km from Cotonou (Benin) to the Niger Delta (Nigeria). An inlet connects Lagos Lagoon to the sea, which enables the lagoon to be used as the city's harbour. The open inlet keeps the water brackish in the lagoon's tidal reaches, and the shallow, inter-connected creeks supply fresh water. Lagos Lagoon is bounded by low-lying marshy areas to the north and south that include mangrove swamps. The principal ocean port of Lagos is

located at Apapa, which is the busiest port in Nigeria and possibly one of the busiest in sub-Saharan Africa. The population of Lagos depend on the lagoon for potable and recreational water, and fish for affordable protein. The lagoon is also a major source of livelihood, and parts of two neighbourhoods – Makoko and Ilaje – include stilt settlements built directly on the lagoon.

Challenges facing lagoons

The challenges facing lagoons and the communities who live on and around them are complex and interconnected (Figure 5). This is particularly true of lagoons in the Global South, as illustrated by the Muni and Lagos lagoons, where communities rely on them for resources and livelihood.

Figure 5: The interconnected challenges facing lagoons in the Global South. Note: emboldened labels relate to the issues discussed in the text, with reference to Muni and Lagos lagoons.



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Climate related challenges

Coastal lagoons are highly vulnerable to sea-level rise and climate change because of their low elevation and their dependence on the dynamic coastal physico-chemical regime for their unique habitats. At Muni Lagoon (Ghana), shoreline retreat and erosion have been observed and attributed to sea-level rise, and projections of sea levels have confirmed the vulnerability and continued loss of the barrier (Davies-Vollum and West, 2015). Changes to the timing and extent of the rainy season have been recorded (Koomson *et al.*, 2020); this not only affects lagoon opening, but also increases the potential for flooding. In addition, increased storminess and irregularity of the onset of the rainy season negatively affects when fishing is possible and thus impacts on people's livelihoods (Koomson *et al.*, 2022). At Lagos Lagoon (Nigeria), changes in sea level and rainfall patterns have resulted in more frequent flooding of the city. This has led to economic losses estimated at US\$4 million annually across Lagos state (Lucas, 2021).

Resource management and population growth

Communities that live around lagoons are dependent on them for basic resources such as water, food, fuel and construction materials. With growing populations around coastal lagoons comes increasing resource use. As with many coastal towns in Ghana, Winneba's population is growing and the town is encroaching on the shores of Muni Lagoon. This has resulted in unmanaged resource use and subsequent depletion. Until the 1990s, mangroves proliferated in the lagoon; today they are virtually non-existent due to overharvesting of the wood for cooking fuel and for smoking fish in preparation for selling. Attempts at re-planting mangroves have had limited success. This is particularly problematic because mangroves act a natural protection from coastal erosion. Removal of barrier sand (known in the region as 'sand winning') for use in the construction of new houses around Muni Lagoon has also taken place despite laws designed to prevent this activity.

Waste, sanitation and water quality

The water quality of Lagos Lagoon has been impacted by urbanisation and industrialisation. Studies show the pollution level of the lagoon is greatest in the Lagos harbour area, due to port and oil industry activities. Hydrocarbons are a particular problem, especially when they enter the lagoon

ecosystem from urban run-off, spillages related to the petroleum industry, outboard motors on boats and waste oil disposal (Doherty *et al.*, 2019). At Muni Lagoon, urban run-off and lack of sanitation (toilets) are the main causes of pollution; the pollution becomes more concentrated when the lagoon is closed and there is no flushing from the ocean (Mitchell *et al.*, 2017). At both Muni and Lagos lagoons, waste management and disposal is limited and has resulted in the dumping of waste in and around the lagoons. The proliferation of plastic waste is particularly problematic.

Policy responses

Policy and frameworks influencing the governance of lagoons and wetlands exist at a range of scales. At the international scale, the Intergovernmental Panel on Climate Change (IPCC) provides scientific assessment on climate change and its potential risks, possible adaptation and mitigation and is a key source for informing coastal governance and policy. National Adaptation Programmes of Action (NAPAs) – under the auspices of United Nations Framework Convention on Climate Change (UNFCCC) – outline priority adaptations and interventions for climate change. The Ramsar Convention on Wetlands (2021) goes beyond climate change; it is an intergovernmental treaty that provides a framework for the conservation and sustainable use of wetlands. A Ramsar designation for a specific coastal site provides a structure and resources for its governance. At the regional scale, collaborative initiatives and frameworks have been developed to support coastal management and governance. Of relevance to the Muni and Lagos lagoons discussed here are the West Africa Coastal Areas Resilience Investment Project (WACA ResIP), the Guinea Current Large Marine Ecosystem (GCLME) programme (GCLME, 2006), and the West Africa Coastal Areas Management Program (WACA). Despite these international and regional conventions, national planning and regional initiatives designed to secure the future of lagoons and their associated wetlands, success has been limited (Tooth and van der Waal, 2019; Convention on Wetlands, 2021). These formal, top-down approaches have largely proved unsuccessful because of a 'policy gap': a failure to connect international and regional policy to stakeholders in ways that might be successfully enacted at the local level (Davies-Vollum *et al.*, 2021). The key to a more effective method of creating coastal policy is a 'bottom-up meets top-down approach' in which the lived experiences of coastal stakeholders are included in policy development and with coastal communities playing a central role in the design, direction and priorities for lagoon governance.

Resilient futures for lagoons?

Coastal lagoons face a multitude of interconnected challenges (Figure 5), as briefly illustrated here through the cases of the Muni and Lagos lagoons. Addressing these challenges requires multi-faceted approaches that draw on a range of expertise, experiences and knowledges, linking stakeholders, policy makers, practitioners and researchers. The Resilient Lagoon Network (see website) comprises an international interdisciplinary team that aims to facilitate dialogue and knowledge transfer in ways that foreground local communities' knowledge and expertise to inform the ways in which policymakers conceptualise and respond to the challenges facing lagoons. The Network is an example of how the 'bottom-up meets top-down approach' to lagoon policy and governance can be facilitated. It emphasises participatory approaches with coastal communities playing a central role in the design, direction and priorities for lagoon governance. It also acts as a platform to connect stakeholders and share practice, provide information and raise awareness of coastal lagoons.

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