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Regulatory framework for environmental protection and analysis of the perception of coastal waste management practices in Libreville conurbation, Gabon

Leslie Bertha Mouloungui Kussu^{1,*}, Corine Ada Nzoughé épouse Obounou², Agogno Agbogon³,
Nagbandjoa Dounwourgue¹, René Casimir Zoo Eyindanga², Annie Beka Beka², Messan Vimeny³

¹ Regional Center of Excellence on Sustainable Cities in Africa (Cervida Dounedon), University of Lomé, Lomé 01 BP 1515, Togo

² History and Geography Department, Geography and Environment Laboratory, Higher Teacher's Training College, Libreville B.P. 17009, Gabon

³ Geography Department, Research Laboratory on the Dynamics of Environments and Societies, University of Lomé, Lomé 01 BP 1515, Togo

* **Corresponding author:** Mouloungui Kussu Leslie Bertha, moulounguiliebertha@gmail.com, leslie.mouloungukussu@cervida-togo.org

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Abstract: Over the last few decades, demographic growth combined with poorly controlled urbanization has confronted African cities with a variety of environmental protection challenges. As part of a gradual awareness-raising process, African countries have ratified conventions and adopted a series of laws to protect the environment. Since independence (1960), Gabon has adopted legal instruments to provide a better framework for environmental protection. Despite the existence of well-developed legislation, the Libreville conurbation faces difficulties in waste management. This situation contributes to the degradation of the coastal zone. This study aims to analyse stakeholders' perceptions of environmental protection regulations in solid waste management practices along the coastline of the Libreville metropolitan area in Gabon. The methodology includes documentary research, field observations, and surveys of 300 study area participants. The results show that the degradation of the coastline is due to a lack of awareness and compliance with the laws governing environmental protection and waste management. As a result, waste disposal practices such as dumping in nature, waterways, illegal dumps, and gutters are commonplace among the population. To achieve sustainable coastal zone management, it is essential to apply regulatory texts and involve stakeholders in improving planning and the quality of the coastal environment.

Keywords: regulations; management; waste; coastline; Libreville; Gabon

1. Introduction

The world's coastal zones are high human density territories with very important socio-economic and environmental stakes activities. Over 60% of the world's population lives on coasts, along large lakes, and in major cities (Pottier et al., 2016). They are highly sensitive and fragile due to their location at the interface of continental and marine environments, in addition to the demographic pressure they face (Van Lang, 2012). In addition, human activities along the coastline produce a significant amount of waste, which is growing in most of the world's cities, and volumes could reach over 70% by 2050. (Kaza et al., 2018; Yousefloo and Babazadeh, 2020). Due to demographic growth and urbanization, this waste is often managed irrationally, due to a lack of adequate collection systems. It ends up in sewer systems or directly in nature, affecting the environmental quality of the coastline (Mansui, 2017). To this end, various tools have been developed on the international scene, including conventions and a regulatory framework to protect the environment in each country. Indeed, since

the adoption in Stockholm in 1972 of the preambles to the United Nations Declaration on the Human Environment, environmental protection has become a major issue in a context where the process of environmental degradation is caused by the increase in human activities (Cadoret, 2007; Herdiansyah et al., 2021; Konecny et al., 2018). Consequently, it is crucial to preserve the environment about the three pillars of sustainable development. It is also the 7th of the eight Millennium Development Goals, considered by the UN as “crucial to the success of the other goals set out in the Millennium Summit Declaration” (Kianguebeni, 2021; Wandan Eboua et al., 2014;). As a result, urban areas and cities in developing countries continue to experience difficulties in managing their solid waste. The waste to be disposed of in these countries is often not regulated and controlled (Germain, 2022). It is with this in mind that, since independence, regulatory texts have been adopted. We are witnessing the emergence of several draft laws for environmental protection and integrated coastal zone management (Cadoret, 2007). Despite this vast movement, many countries that have adopted regulations are still unable to clean up their environment, as most of the waste collected remains scattered. Coastal cities in Africa in particular are no exception to this rule, as there are few cities where legislation on environmental protection and solid waste management is scrupulously applied (Koledzi, 2011). Faced with the persistence of conditions that encourage poor management of coastal areas, coastal cities have become a major source of waste (Ourega and Gbocho, 2021), the coastlines of African cities languish under garbage, making for an unhealthy living environment (Bangoura, 2017; Ngnikam and Tanawa, 2006). Like other coastal cities in Central Africa, Gabon’s coastal cities are not exempt. With an estimated population of 2.2 million and a surface area of 276,677 km², Gabon is a relatively sparsely populated country by (Leboulanger et al., 2021; Makanga, 2012), with a population growth rate of 2.5%. It has one of the highest urbanization rates in Africa (89.7%), and this rate is set to rise to 92% and 95% by 2030 and 2050 respectively. The country’s population is expected to reach 2.7 million in 2030 and 3.8 million in 2050 according to Leboulanger et al. (2021), World Bank Group (2020) and World Bank Group (2021). In addition, Gabon’s coastline, which is almost 800 km long, includes several towns under demographic pressure (Pottier et al., 2016). Two cities, Port-Gentil and especially Libreville, alone account for over 70% of the population. According to the Direction Generale de la Statistique DGS Libreville (2015), the Libreville conurbation comprises three communes: Libreville (Gabon’s administrative capital), Owendo (port and industrial zone), and Akanda (booming town). Due to its exponential growth over the last few decades, it is experiencing problems of public sanitation and waste management that no longer correspond to the city’s expansion and growing population (Beka Beka, 2020; Moubélé and Mbonda, 2017). According to Gerep-environnement quoted by Nfono Obame (2021), waste generated in the city was 224,768 tonnes/year in 2011. However, according to projections, this figure is set to rise from 441,588 tonnes/year in 2021 to 906,800 tonnes/year by 2035. This represents a daily production of 616 tonnes in 2011, possibly rising to 2484 tonnes by 2035. With collection services inadequate to protect the environment, and people resorting to unsuitable practices to dispose of their waste, the estuary coastline is not immune to problems of insalubrity and pollution. Indeed, after several initiatives, the collection service is still the cause of insalubrity problems in the Libreville urban area. Since the 1970s, responsibility for

waste management has been entrusted to Société Gabonaise d'Assainissement (SGA). In contrast, at the beginning of the 2000s, the waste management service was privatized and entrusted to the Société de valorization des ordures du Gabon (SOVOG) (Mombo and Edou, 2007; Mvele-n'dango'o, 2007). Today, in the process of making waste collection efficient, since 2013, the collection initially the responsibility of the SOVOG structure has been renamed Clean' Africa. This company is responsible for waste collection in the Libreville area. As a result, the legal and institutional framework for urban waste is increasingly inadequate. Since January 3, 2022, nine public bodies have sat on Clean' Africa's Board of Directors (Milla et al., 2022). In addition, despite the adoption of such measures and the existence of several regulatory texts, the major challenge of improving environmental protection through solid waste management practices is still in force to alleviate insalubrity along the coastline of Greater Libreville. This study aims to analyse stakeholders' perceptions of environmental protection regulations and solid waste management practices along the coastline of the Libreville metropolitan area in Gabon. The aim is: to analyze the evolution of regulatory materials adopted since independence (1960) up to the present day relating to environmental protection and waste management; to assess the contrast between the population's perception of the regulatory provisions and the management practices adopted on the coastline of the Libreville conurbation. Finally, to suggest ways of improving planning and the quality of the coastal environment

2. Materials and methods

2.1. The study site

Gabon is a country (**Figure 1**) Central Africa, straddling the Equator. It lies at the center of the Gulf of Guinea, bordered to the west by the Atlantic Ocean. It lies adjacent to the Atlantic Ocean to the west. Gabon shares borders with Cameroon and Equatorial Guinea to the north and the Republic of Congo to the south. It is subdivided into 9 provinces. The city of Libreville is located in Gabon's Estuaire province, and is the political and administrative capital of the country. It stretches along the banks of the Komo Estuary, with over 30 km of coastline (Pottier et al., 2016). Its population was estimated at 703,940 in 2013, according to the latest census, i.e., 3700 inhabitants per km². Nearly 87% of this population is essentially urban and is concentrated on just 1.1% of the national territory. According to the Direction Generale de la Statistique (DGS) Libreville, (2015). The population has tripled from 1960 to 2013 and has grown by 78% in the last 20 years (Beka Beka and Ada Nzoughe épouse Obounou, 2021; Moughola Leyoubou, 2020). It is Gabon's most populous city, accounting for half of the country's population, rising from 447,864 in 1960 to 1,014,976 in 1993, then to 1,811,079 in 2013 (Direction General de la Statistique (DGS) Libreville, 2015). The whole city lies on a coastal plain belonging to the low plains and hills of the coastal sedimentary basin. This region is drained by a hierarchical hydrographic network. It is traversed by twenty-one (21) watersheds of irregular size and morphology (Mombo and Itongo, 2011).

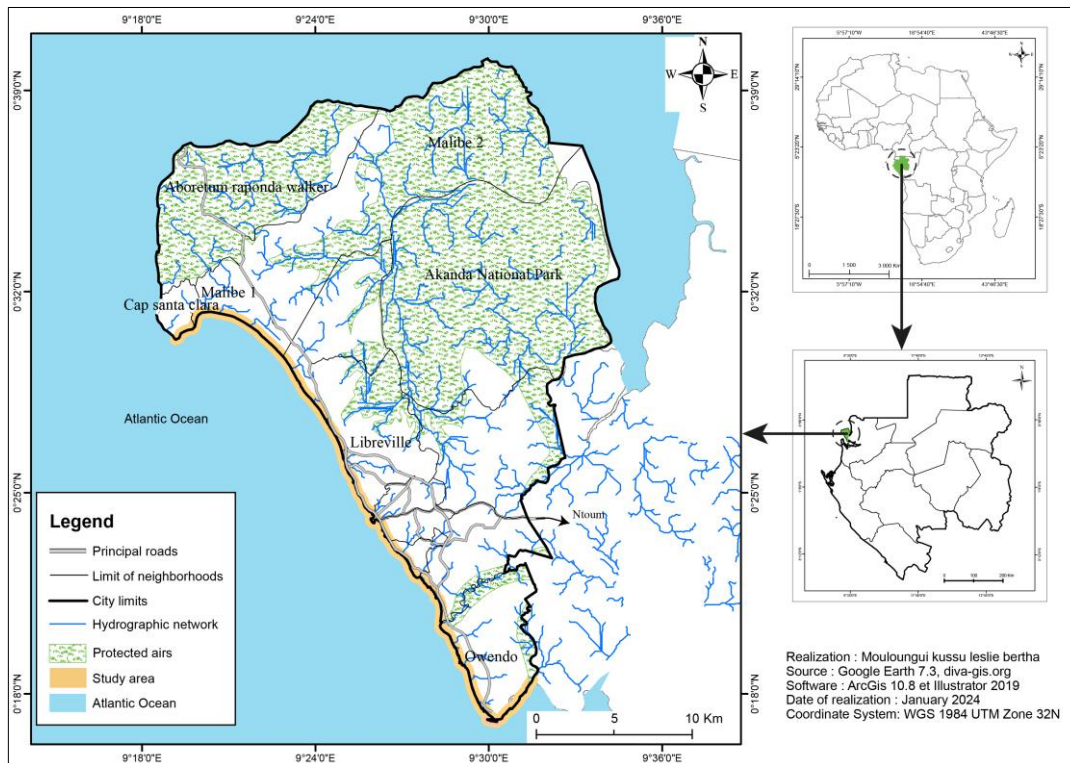


Figure 1. Location of study area.

The city's best-known rivers include the Arambo, Nomba and Batavéa. The city is also surrounded by a deep forest, the extension of which is sometimes visible in certain areas of the capital, such as Sibang, Ondôk, and Mindoubé, as is the classified forest to the north (the Mondah), which extends beyond the northern periphery, on the Cap Estérias road, into the mangrove domain. From the Atlantic coast, which stretches from north to south of the capital. It is set on a coastal edge that stretches more than 13 km inland, dotted with fine white sandy beaches and socio-economic activities.

2.2. Documentary research, field observation, and questionnaire surveys

The documentary research consisted in exploiting the literature review relating to waste management, coastal preservation and environmental protection and various materials (laws, decrees and orders, etc.) in the Gabonese Republic from independence to the present day.

The field survey was carried out using a questionnaire sent to the target players, i.e. socio-economic players carrying out an activity (formal or informal), residents living close to the coast, and temporary users such as picnickers. The method used was a purposive survey. Using the KoboCollect digital application embedded in our smartphone, 300 people were questioned. This study focused on the following questions: "Are you aware of the regulations relating to environmental protection and waste management on the coast?" and "What method of waste disposal do you opt for?". In addition, observations and photographs were taken to analyse the realities on the ground.

Based on data collected from 300 surveys, with a quota of 100 individuals per target group (socio-economic players, local residents and temporary users), data processing was carried out using SPSS version 25, and tables were produced using an

Excel spreadsheet. The result of the data analysis is presented in the form of a cross-tabulation. The relationship between knowledge of the regulatory framework appears in the columns and coastal waste management practices in the rows. The Pearson chi-square test is applied to investigate the existence or otherwise of a dependency relationship between these two qualitative variables (Wandan Eboua et al., 2014). For this purpose, there is dependence between the two qualitative variables if the coefficient of asymptotic significance of the chi-square is less than 0.05, whereas with an asymptotic significance of the chi-square greater than 0.05, there is no dependence between the two variables.

3. Results and discussion

3.1. Diachronic analysis of environmental protection and waste management legislation in the Gabonese Republic

Gabon’s national environmental policy is strongly inspired by international resolutions. The Stockholm Conference, the first United Nations Earth Summit, held in Sweden in 1972, marked the beginning of awareness of environmental problems and the birth of a collective consciousness of the need for better resource management. This has had an impact on national environmental awareness in Gabon. Gabon has also ratified several conventions concerning the prevention and control of marine pollution from ships, notably the 1973 MARPOL Convention and the Abidjan International Convention on Cooperation in the Protection and Development of Coastal Areas. In 1981, the first National Seminar on the Environment was held in Makokou, Gabon. Following the third United Nations Earth Summit in Rio in 1992, Gabon implemented Law 16/93 of 26 August 1993, on the protection and improvement of the environment, also known as the Environmental Code. It was repealed by Law N°007/2014 of 1^{er} August 2014 on environmental protection representing the main source in national law for environmental protection (**Figure 2**).

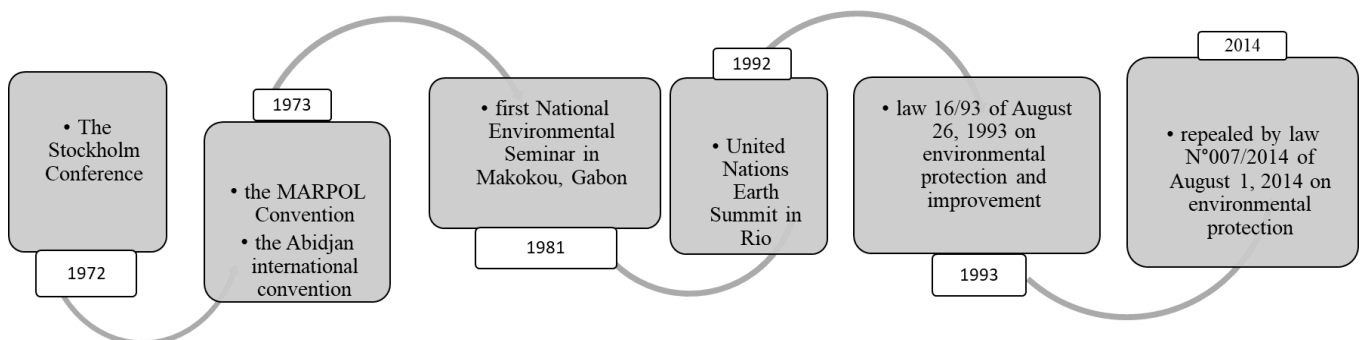


Figure 2. Chronology of events related to environmental protection regulations in the Gabonese Republic. source: Authors’ construction.

At the national level, this environmental code has led to the implementation of regulations on waste disposal and the reduction of nuisances in general. Furthermore, the management of coastal zones, as defined in Chapter 2, remains a key option in Gabon’s environmental policy in terms of organization, preservation, and control of space. It is part of an overall development framework that takes into account the natural aspects, economic interests, and ecological challenges of the coastal environment.

3.2. A legal and regulatory framework dedicated to coastal environmental protection and waste management

Gabon has six laws governing environmental protection in coastal areas. These include legal texts based entirely on environmental protection, decrees and orders. Indeed, it is presented through Law N°16/93 of 26 August 1993 relating to the protection and improvement of the environment, which has been amended and replaced by Law N°007/2014 relating to Environmental Protection in the Gabonese Republic. This law determines the general principles of the national environmental protection policy, which promotes sustainable development and aims in particular at the preservation and sustainable use of natural resources; the fight against pollution and nuisances; the improvement and protection of the living environment; the promotion of new values and income-generating activities linked to environmental protection; and the harmonization of development and the protection of the natural environment. Some of the articles of this law set out guidelines for the management and elimination of waste and the preservation of the coastline.

Article 6 of the law defines waste as: “Any residue of a production, transformation or use process, any substance, material, product or, more generally, any movable property abandoned or intended for abandonment by its holder “. The wastes considered are defined in Article 92 as effluents, household waste, industrial offcuts, and residues. Article 95 of Gabon’s Environment Act prohibits the discharge into the natural environment of any effluent likely to harm health or the quality of the environment. In addition, this law includes provisions to contribute to the reduction of sources and collection of waste. Articles 97, 98, and 99 focus on operations that promote waste reduction at source. Finally, article 100, highlights the waste management process through collection, sorting, storage, transport, recovery, reuse, recycling, and disposal.

Since the adoption of the law establishing the Environment Code, we have noted that waste management issues are general. To date, there is no specific legislation or regulation on waste management in the Gabonese Republic, even though the code gives the Ministry of the Environment responsibility for designing public policy and policing waste management. The legislation only covers general aspects.

Gabonese law contains provisions designed to prevent or reduce the production or harmfulness of waste. Waste recovery, on the other hand, is a crucial stage in the waste life cycle in Gabon, and is explicitly addressed in the waste management policy set out in the aforementioned law on environmental protection in the Gabonese Republic. Yet, despite all these provisions, they remain less and less observable in the field due to a lack of application.

Chapter 2 deals with the coastal zone, the sea and the ocean. Section 3 is devoted to the coastline. In article 63, the State must ensure the protection of the coastline, both on land and at sea. It shall draw up public policies for: erosion control and the preservation of sites, landscapes and heritage; the protection of biological and ecological balances and the preservation and development of economic activities linked to the proximity of water, in particular fishing, marine farming, port activities, shipbuilding and ship repair; the maintenance and development of economic, agricultural, forestry, industrial, craft and tourism activities in the coastal zone. Article

64 stipulates that the extraction of materials that may directly or indirectly compromise the integrity of beaches, natural areas, fauna, and flora is prohibited. Finally, article 65 deals with measures taken to reduce, mitigate, or eliminate serious or imminent dangers to the coast from any form of pollution, as well as monitoring and control procedures.

The law on environmental protection is governed by very few articles reserved for the coastal zone. This is because there is only one mention of the protection of the coastline in its terrestrial and marine parts, and a few provisions concerning pollution on the coasts. Nevertheless, this law has led to the publication of decrees on waste disposal, the discharge of certain products into surface, ground, and marine waters, the legal status of classified installations, the recovery of used oils, and the preparation and combating of pollution by hydrocarbons and other harmful substances. It also covers environmental impact assessment issues (Food and Agriculture Origination, 2005). And the following orders:

- Decree N°00405/pr/MEFEPEPN (Ministry of Forestry, Water and Fisheries, in charge of the environment and nature protection) of 15 May 2002, regulating environmental impact studies. This decree requires any developer of a development project likely to harm the environment or alter its natural qualities and aesthetics to carry out an impact study beforehand, and to envisage accompanying measures to rehabilitate degraded sites. In the marine and coastal fields more than anywhere else, the application of the regulatory provisions of this text is essential.
- Decree N°00653/pr/MTEPN (Ministry of Tourism, Environment and Nature Protection) of 21 May 2003, relating to the preparation and fight against pollution by hydrocarbons. This decree lays down the procedures for preparing for and combating pollution by hydrocarbons and other harmful substances and identifies the bodies responsible for preparing for and combating such pollution, as well as those who organize the operations themselves. To this end, it incorporates the National Emergency Plan, which unfortunately is not yet operational.
- Article 3 of Decree N°00539 PR/MEFEPEPN of 15 July 2005, stipulates that all waste treatment and sanitation facilities are subject to an environmental impact assessment by the provisions of Article 67 of the Environmental Code. This decree has the merit of applying to all environments, in that it responds to the likelihood of environmental degradation caused by projects. This legal instrument provides answers to the problems likely to be posed by projects. It sets out the list of projects requiring an EIA (Environmental Impact Assessment) and a procedural manual for carrying out EIAs.
- Decree N°00541 PR/MEFEPEPN of 15 July 2005, regulating waste disposal, defines the different types of waste and sets out the methods of disposal. Article 19 of Decree 541 stipulates that this decree is the basis for waste management at the national level, and its purpose is to guide and coordinate all actions carried out by both public authorities and private bodies while defining the regulatory requirements for treatment and landfills. It helps improve waste management by regulating collection and disposal conditions to ensure that certain fragile environments are not adversely affected.

- Decree N°00542/PR/MEFEPEPN of 15 July 2005, regulates the discharge of certain products into surface, ground, and marine waters.
- Decree N°00543 of 15 July 2005, setting out the legal regime for classified installations and the decree on environmental impact studies. These provide a framework for the operation of these facilities, which are present both in the marine environment, where oil production takes place and, on the mainland, where they have a direct impact on marine waters. Applications for authorization should contain documents providing the authorities with information on the type of activity, the area of influence of the activity, the type of discharges caused by the activity, the impact of said discharges on the environment, the measures taken to correct the impacts (EIA), and so on.
- Decree N°00545/PR/MEFEPEPN of July 15, 2005, regulating the recovery of used oils.
- Arrêté N°0003/PM/MEPNRT (Ministry of the Environment, Nature Conservation, Research and Research and Technology) du 14 avril 2006 setting out the procedures for monitoring classified facilities
- Arrêté N°0002/PM/MEPNRT du 14 avril 2006 laying down the procedures for issuing approval to carry out Environmental Impact Assessments

Gabon's waste management decrees stipulate that the production and harmfulness of waste must be prevented or reduced, in particular by regulating the conditions under which waste is collected, treated and disposed of. However, they are still generic in this respect. Over the years, the delay between the drafting of the law and the application decrees has been close to a decade. Most of the implementing decrees date from the 2000s, and more precisely from 2005, whereas the law was established in 1993 and repealed in 2014. This demonstrates the slowness and cumbersomeness of the enactment of implementing legislation, but also a handicap in the operation of environmental management policies in Gabon. Despite the existence of several decrees and orders, these remain insufficient and unspecific for rigorous enforcement. And yet, the objective driving decision-makers is to apply this legal arsenal to all forms of coastal degradation resulting from human activities. An analysis of environmental regulations in the Gabonese Republic reveals that very few decrees and orders have been issued on coastal protection. To this end, knowledge of regulatory texts and waste management practices on the coast presents a contrast that is visible on the coast of the Libreville conurbation

3.3. The contrast between regulatory provisions and solid waste management practices in the Libreville coastal area

The socio-economic players surveyed who use different methods of waste disposal have varying levels of knowledge of the regulations governing coastal environmental protection (**Table 1**).

Table 1. Opinions of socio-economic players on knowledge of the law governing environmental protection (waste management) and waste disposal practices on the coast (source: Processed by authors).

Are you aware of the regulations governing environmental protection and waste management on the coast?				
	No	Yes	Total	
How do you dispose of waste?	In nature (environment)	17	8	25
	In nearby dumps	5	8	13
	In watercourses	6	6	12
	In garbage bins (container)	13	25	38
	In the gutters	10	2	12
Total	51	49	100	
Asymptotic significance (two-tailed) of Pearson's chi-square		0.011		

Table 1 shows that 49% of socio-economic players are aware of compared with 51% who are unaware of the law. The most common ways of disposing of waste are in garbage bins (38%), in nature (25%), in nearby dumps (13%), in waterways and gutters (12%). The chi-square test indicates an asymptotic significance equal to $0.011 < 0.05$. This result shows that knowledge of regulations influences waste disposal practices, as socio-economic players are more inclined to use garbage bins and ensure compliance with environmental standards. This can be explained by the fact that people involved in socio-economic activities are required to comply with hygiene regulations, and are subject to regular or unannounced inspections by municipal and sanitation officials. In addition, these players are subject to penalties in the form of fines or sanctions, if their activities compromise good housekeeping and compliance with environmental standards. For example, they must be careful not to dump waste in the wild, at the risk of being fined or penalized for deviant behavior.

Table 2 also shows that residents are less familiar with the law than socio-economic players.

Table 2. Residents' opinions on knowledge of the law governing environmental protection (waste management) and waste disposal practices on the coast (source: Processed by authors).

In your opinion, are you aware of the regulations governing environmental protection and waste management on the coast?				
	No	Yes	Total	
Where do you dump waste?	Channels	8	2	10
	In garbage bins	15	8	23
	In the watercourse	16	10	26
	In the wild	22	10	32
	In the dumps	4	5	9
Total	65	35	100	
Asymptotic significance (two-sided) of Pearson's chi-square		0.559		

Table 2 shows that 35% of local residents surveyed claim to be aware, compared with 65% who claim to be unaware of the regulations governing environmental protection (waste management). The methods used by residents to dispose of waste are: in nature 32%, in waterways 26%, in garbage bins 23%, in gutters 10% and in

local dumps 9%. The chi-square test indicates an asymptotic significance equal to $0.559 > 0.05$. This shows that there is no dependence between knowledge of the law and practices. These results clearly illustrate local residents' lack of knowledge or ignorance of environmental protection regulations. This tendency leads to less-than-honorable waste disposal practices, which are often found in the natural environment. They rightly tend to dispose of waste wherever they see fit. Some dump it in nature, in garbage bins, while others dump it in waterways, dumps and gutters. The main thing for them is to get rid of it, without taking any precautions or respecting the rules of hygiene. So, it's not unusual to see local residents living side by side with the heaps of garbage that litter the area around their coastal concessions.

The situation is similar for temporary users, with **Table 3** showing a low level of awareness of the regulations.

Table 3. Users' opinions on knowledge of the law governing environmental protection (waste management) and waste disposal practices on the coastline (source: Processed by authors).

Are you aware of the regulations governing environmental protection and waste management on the coast?				
	No	Yes	Total	
How do you dispose of your garbage on the beach?	In the wild	31	9	40
	In garbage bins	23	10	33
	In watercourses	3	1	4
	Channels	0	0	0
	In the dumps	18	5	23
Total	75	25	100	
Asymptotic significance (two-sided) of Pearson's chi-square			0.859	

Table 3 shows that 25% of temporary users claim to have some knowledge, compared with 75% who are unaware of waste management regulations. Temporary users dispose of waste in nature (40%), in garbage bins (33%), in dumps (23%) and in waterways (4%). The Chi-square test indicates an asymptotic significance equal to $0.859 > 0.05$. This shows that unfamiliarity with the regulations contributes to the trend towards uncivil behavior among beach lovers. The reasons for these opinions lie in the lack of respect for hygiene rules in places of public recreation. For them, the main concern is to relax, to recreate, to have fun and to have a good time. Also, the lack of garbage cans close to the site increases the tendency to dump waste from leftover picnics left abandoned on the beach, together with waste from overflowing garbage bins and rubbish dumps.

On the whole, the people surveyed had little knowledge of the laws governing environmental protection and particularly waste management on the coast. The general public knows very little about them. This finding is justified by the results of this study, which indicate that 53.67% of people are unaware of the existence of such laws, and only 46.33% claim to be familiar with them. On the other hand, this limited knowledge and the lack of enforcement lead people to resort to waste disposal practices that degrade the coastal environment. The main ones are dumping waste in the natural environment (32.33%) and in garbage bins (31.33%), which are usually faulty. In

addition, waste is dumped in dumps (15%), watercourses (14%) and gutters (7.34%), thus denaturing the coastline of Greater Libreville.

3.4. A coastal landscape victim of poor waste management practices despite the presence of a few regulations' initiatives

Limited knowledge of regulations and different waste disposal practices contribute to the degradation of the coastal environment as seen in the field. Observations show that garbage storage facilities are generally defective or overflowing with open-air garbage, to the point where waste ends up on the ground. Beaches often frequented by local residents are unhealthy, littered with piles of buried garbage - in other words, garbage cemeteries. The cohabitation of people and garbage is usually permanent during moments of relaxation. These observations are the result of irregular clean-up operations, clearly due to insufficient resources (material, human and financial) for the proper management of waste in the coastal zone. In addition, the coastline suffers from the absence and non-application of regulations governing urban waste management. It goes without saying that the actors involved in waste management are slack, lax or uncoordinated in their tasks. The result is repulsive, disgusting spaces where waste of all kinds reigns supreme. **(Figure 3)**.



Figure 3. A full Clean Africa garbage bin in front of the Radisson Blue hotel at Léon Mba beach. **(A)** the proliferation of garbage along the coast at the Glass District; **(B)** cohabitation of garbage and picnickers at Acaé beach; **(C)** and the proliferation of miscellaneous garbage along the beach at the sandpit; **(D)** source: the authors.

However, there is still a lot to be done in terms of coastal development in Gabon, and particularly in the capital, to help maintain cleanliness. It's clear that there are a number of initiatives sprouting up along the coastline, despite the delay in enforcing coastal development regulations. For example, there are billboards to raise public awareness, beach clean-up days organized by Clean Africa's waste collection and sanitation agents, and many others. In addition, the presence of towers erected by police officers to monitor the beaches. The presence of a number of garbage cans to encourage the sorting and recycling of plastic waste. The resplendent facilities recently

installed on the coast, such as the Baie des rois project. This is a leisure facility where you can spend some quality time with family and friends. It is being built by the Façade Maritime du Champ Triomphal (FMCT) company, which has taken steps to ensure compliance with environmental standards. But these remain insignificant or insufficient to dissuade, sensitize and reprimand the in civism that undermines the environment along the coastline (**Figure 4**).



Figure 4. Location of a tower erected for police surveillance. (A) An awareness-raising advert on the shores of Léon Mba beach; (B) the urban development of Baie de Rois; (C) and the cleaning of the beach by the city’s waste collection and sanitation agents; (D) source: the authors.

Given the limitations resulting from environmental protection and the initiatives observed to preserve the coastline of the Libreville conurbation. There is a need for planning that meets the requirements of integrated coastal zone management. To this end, it would be beneficial to reinforce existing regulatory texts by focusing specifically on coastal and maritime waste management, as the only document that describes, analyzes and frames the environmental risks of the coastal zone in Gabon. In addition, the creation of an agency in collaboration with the ministries involved in coastal and maritime activities. This agency will coordinate the various players involved to avoid overlapping competencies within the regulatory and institutional framework specific to the coast. Its mission will be to oversee coastal protection, promote ecotourism and rehabilitate sites associated with coastal and marine activities. In addition, a coastal observatory committee is to be set up to ensure permanent surveillance of bathing sites, monitor waste collection and organize installed and planned developments on the coast to create synergy in the integrated management of coastal zones for the benefit of future generations.

4. Discussion

With environmental concerns on the rise at both global and local levels, policies aimed at protecting the environment and reducing the amount of waste produced remain a major challenge for countries. The regulatory texts guiding environmental protection and waste management policies, although existing and well-developed, face shortcomings due to their limited application and lack of awareness. This study reveals that 53.67% of the 300 people questioned were unaware of the relevant legislation, while only 46.33% claimed to be familiar with it. This limited knowledge is because the legal aspect is at an embryonic stage in the study area and the law aimed at specific coastal problems such as uses, exploitation, and protection is insufficient, obsolete, and generic, even if, a few aspects of the coastal domain are mentioned therein (Pnud, 2011). To this end, the coastal law or the law relating to the development, protection, and enhancement of the coastline in the Gabonese Republic is absent despite the role played by the few conventions that regulate and provide a framework for coastal zone protection in Gabon (Unesco/COI/MSProadmap, 2020). This situation is not unique to Gabon or its coastal towns. Limited knowledge of regulatory texts and the absence of a coastal law are a reality for many coastal countries. In the same vein, Algerian policy on waste management and environmental protection, especially in coastal areas, has not been clearly defined, and implementing decrees have been slow to be promulgated, which has delayed its application in the field (Kacemi, 2008). Studies carried out on the Tizirt beach revealed that 70% of summer holidaymakers were unaware of the laws governing waste management, and only 30% claimed to be familiar with the legislation on environmental protection and waste management (Ait aider and Kadi, 2015). However, although the law on coastal protection and development was published in the Official Gazette on 5 February 2002, the country does not have a long history of effective environmental legislation and, as a result, its application remains limited (Boutarcha, 2022). The same is true of the Moroccan coastline, which is not covered by any specific law on coastal protection, (Nakhli-ghazi and Ghazi, 2008). This is also the case in Côte d'Ivoire, where the regulatory and legal approach to environmental problems linked to waste management remains difficult to apply to coastal management, even though it resorts to the provisions of international conventions (Bayeba, 2019; Dje, 2012). Furthermore, in Togo, a framework law on environmental protection was drawn up late (law n°2008-005 of 30 May 2008), and was only recently adopted in 2021 with the draft law on coastal development, protection, and enhancement. To this end, despite several initiatives, its application in the field still fails to resolve waste management problems in Togo, particularly on the coastline (Koledzi, 2011). This was also noted by Herdiansyah et al. (2021), as the lack of knowledge of laws to raise public awareness would be an obstacle to effective waste management in coastal areas. In fact, the application of regulatory texts lacks rigor in the field, particularly in developing countries, according to Carlos-Alberola et al. (2021). As in most of these countries, there is lax legislation, which leads inexorably to poor waste management practices and, by extension, to coastal erosion (Aina, 2006; Doron, 2021). This is demonstrated by the way waste is disposed of along the coastline. This study reveals that limited knowledge and shortcomings in the application of regulatory texts have led to waste disposal methods

that degrade the coastal environment. This study reveals that the main methods used to dispose of waste along the coastline of the Libreville conurbation are in the natural environment (32.33%), in refuse bins (31.33%, which are most often defective), in dumps (15%), in waterways (14%) and in gutters (7.34%). The chi-square test indicates an asymptotic significance equal to $0.011 < 0.05$. This shows a dependence of laws on waste management practices for socio-economic actors. Next, the Chi-square test indicates an asymptotic significance equal to $0.559 > 0.05$. This shows that there is no dependency, or that knowledge of the laws has no influence on waste management practices among residents. Finally, the Chi-square test indicates an asymptotic significance equal to $0.859 > 0.05$, which means that there is no dependence on laws and waste management practices for temporary users.

Given the above, the absence and weakness of environmental protection legislation would explain the inefficiency of the waste management system on the coast. This is a similar finding of the study carried out in Indonesia by Herdiansyah et al. (2021) who explain that inadequate infrastructure, economic conditions, and lack of knowledge of the laws make efforts to solve the problem of waste in coastal areas ineffective. In the same vein, Bangoura (2017) points out that it is essential to mobilize sufficient resources, strategies, and above all legal tools to achieve better waste management in the city of Conakry. Indeed, the author's study (Mvele-n'dango'o, 2007) had already underlined this in his comparative study in Libreville and Abidjan, which states that the shortcomings observed in waste management in these two cities are due to a lack of organization, overlapping responsibilities, non-application of regulatory texts and logistical shortcomings relating to environmental protection and waste management. The general public's lack of knowledge of regulations is an obstacle to their application. This leads to incivism, negligence, and non-compliance with hygiene and sanitation rules along the coast. This can be explained by the fact that in developing countries, environmental protection regulations are limited and lack application in the field (Carlos-Alberola et al., 2021; Doron, 2021). Consequently, adopting a legislative framework to waste management practices would be an essential element in coastal governance. This is also emphasized by (Ivanova and Lisina, 2023) that laws play a key role in effective waste management in the field of environmental protection. However, without the application of regulations, it is difficult to provide for planning (Mounganga, 2013). To achieve this, it is essential to harmonize precise regulations, planning tools, and the creation of a monitoring body to promote waste management on the coast. This management will aim to minimize production, reduce the volume of waste to be landfilled, and increase the rate of waste recovery. It is also essential to implement information, awareness, and education campaigns among the city's inhabitants to develop an understanding of the regulations and best practices on coastal waste disposal. On the strength of these initiatives, this study suggests the creation of a coastal observatory specific to the realities of the Gabonese Republic. This observatory will ensure permanent surveillance of bathing areas, monitor waste collection, and organize installed and planned facilities on the coast, as there are currently no precise regulations on coastal waste management. As was the case in France in 1975, when the Conservatoire of coastal areas and lakeshores was created, and in 1986 the French parliament passed the Littoral law, which would accompany a set of measures relating to coastal protection and development (Légifrance, 1975).

Thus, under the dual impetus of European Union law and the Grenelle de lamer, the legislator introduced integrated management of the sea and coastline by instituting an innovative framework described as governance (Boillet, 2012). This new framework makes it possible to act collectively on anthropogenic and natural processes that threaten the sustainable quality and planning of the coastal environment. To this end, as emphasized by Desse (2010) taking into account all stakeholders, coastal zone territories, scientific approaches, and vernacular knowledge could then be effective, over the long term, in a perspective of sustainability in the coastlines of sub-Saharan Africa. This study constitutes an opening for studies in the field of waste management in coastal zones in Gabon and countries of the South.

5. Conclusion

Coastal zone management in Gabon, and particularly in the Libreville metropolitan area, remains a priority insofar as it is of economic, social and environmental interest. However, despite the existence of these various regulatory texts, coastal zone management has many shortcomings in the fields of waste management, planning and coastal preservation. To this end, this study contributes to the analysis of environmental protection regulations, focusing on coastal waste management, for which a specific law and its application are necessary to achieve sustainable coastal zone management. Hence the need to set up a coastal management agency and an observatory committee to oversee missions linked to waste collection monitoring, coastal protection, ecotourism and the development of infrastructures linked to coastal activities and the sea along the coast.

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References

- Aina, M. P. (2006). Assessments of municipal waste landfills in developing countries: contributions to the drafting of a methodological guide and its experimental validation on sites (French) [PhD thesis]. Université De Limoges.

- AIT aider, F., & Kadi, A. (2015). Contributions to the characterization of solid waste generated by summer visitors to beaches: Case study of Tizirt (Wilaya de Tizi ousou, Algeria), socio-economic and ecological approach (French). *Memoire de Master*.
- Bangoura, M. R. (2017). Household solid waste management and socio-spatial segregation in the city of Conakry (French) [PhD thesis]. Université de Toulouse.
- Bayeba, M. C. (2019). Integrated coastal zone management in West Africa: the case of Côte d'Ivoire (French). Available online: <https://theses.hal.science/tel-02895725> (accessed on 2 June 2023).
- Beka Beka A., & Ada Nzoughe épouse Obounou, C. (2021). Urbanisation processes and housing in Gabon: diagnosis and resilience of the populations of "Greater Libreville" (French). Available online: <https://regardsuds.org/processus-durbanisation-et-habitat-au-gabon-diagnostic-et-resilience-des-populations-du-grand-libreville-2/> (accessed on 2 June 2023).
- Beka Beka, A. (2020). Autonomous wastewater and household waste disposal practices in urban areas of Gabon (French). *GéoVision*, 1(003), 133–146.
- Boillet, N. (2012). Coastal governance. *Revue Juridique de l'Environnement* (French), 37(1), 33–55. <https://doi.org/10.3406/rjenv.2012.5759>
- Boutarcha, F. (2022). The Algerian coastline between environmental protection and the imperatives of tourism development: Challenges and prospects (French). *Revue de droit des transports et des activités portuaires*, 10(03), 661–674.
- Cadore, A. (2007). Environmental conflicts and social networks: the challenges of integrated management? The case of the Languedoc-Roussillon coastline (French) [PhD thesis]. Université de Montpellier III-Paul6 valery.
- Carlos-Alberola, M., Gallardo Izquierdo, A., Colomer-Mendoza, F. J., et al. (2021). Design of a Municipal Solid Waste Collection System in Situations with a Lack of Resources: Nikki (Benin), a Case in Africa. *Sustainability*, 13(4), 1785. <https://doi.org/10.3390/su13041785>
- Desse, M. (2010). Between development and Integrated Coastal Zone Management: what prospects for the coastlines of sub-Saharan Africa (French)? Available online: <https://hal.science/hal-01172213/document> (accessed on 2 June 2023).
- Direction generale de la statistique DGS Libreville. (2015). Overall results of the 2013 GABON general population and housing census (RGPL2013) (French). DGS.
- DJE Aya Georgette. (2012). Governance And Management of Urban Household Waste in Abidjan Case of The Communes of Cocody, Yopougon and Abobo (French) [PhD thesis]. Université Laval Quebec.
- Doron, A. (2020). Stench and sensibilities: On living with waste, animals and microbes in India. *The Australian Journal of Anthropology*, 32(S1), 23–41. <https://doi.org/10.1111/taja.12380>
- Food and Agriculture Origination. (2005). Official Gazette of The Gabonese Republic (French). Available online: <https://faolex.fao.org/docs/pdf/gab79519.pdf> (accessed on 2 June 2023).
- Germain, R. (2022). Municipal solid waste management in Haiti the case of the Port-au-Prince metropolitan area (French) [Master's thesis]. University of Ottawa.
- Herdiansyah, H., Saiya, H. G., Afkarina, K. I. I., et al. (2021). Coastal Community Perspective, Waste Density, and Spatial Area toward Sustainable Waste Management (Case Study: Ambon Bay, Indonesia). *Sustainability*, 13(19), 10947. <https://doi.org/10.3390/su131910947>
- Ivanova, S., & Lisina, N. (2023). Municipal and Industrial Urban Waste: Legal Aspects of Safe Management. *Laws*, 12(3), 48. <https://doi.org/10.3390/laws12030048>
- Kacemi, M. (2008). Algeria's Law for The Protection and Development of The Coastal Area: An Ambitious Legal Framework Still Being Developed—The Case of The Arzew Industrial Pole (Oran-Algeria) (French). Available online: [https://www.deepl.com/zh/translator#fr/en-us/la%20loi%20de%20protection%20et%20de%20valorisation%20du%20littoral%20en%20ALGERIE%E2%80%AF%3A%20un%20cadre%20juridique%20ambitieux%20toujours%20en%20attente%20le%20cas%20du%20pole%20industriel%20D%E2%80%99ARZEW%20\(ORAN%20%E2%80%93%20ALGERIE\)](https://www.deepl.com/zh/translator#fr/en-us/la%20loi%20de%20protection%20et%20de%20valorisation%20du%20littoral%20en%20ALGERIE%E2%80%AF%3A%20un%20cadre%20juridique%20ambitieux%20toujours%20en%20attente%20le%20cas%20du%20pole%20industriel%20D%E2%80%99ARZEW%20(ORAN%20%E2%80%93%20ALGERIE)) (accessed on 2 June 2023).
- Kaza, S., Yao, L. C., Bhada-Tata, P., et al. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Washington, DC: World Bank. <https://doi.org/10.1596/978-1-4648-1329-0>
- Kianguebeni, U. K. (2021). Environmental protection and sustainable development: normative and institutional limits (French). *développement durable*, 34–64.
- Koledzi, K. E. (2011). Valorization of urban solid waste in the neighborhoods of Lomé (Togo): Methodological approach to sustainable compost production (French). Université De Lome /Université De Limoges.

- Konecny, C., Fladmark, V., & De la Puente, S. (2018). Towards cleaner shores: Assessing the Great Canadian Shoreline Cleanup's most recent data on volunteer engagement and litter removal along the coast of British Columbia, Canada. *Marine Pollution Bulletin*, 135, 411–417. <https://doi.org/10.1016/j.marpolbul.2018.07.036>
- Leboulanger, C., Kolanou Biluka, L., Nzigou, A. R., et al. (2021). Urban inputs of fecal bacteria to the coastal zone of Libreville, Gabon, Central Western Africa. *Marine Pollution Bulletin*, 168, 112478. <https://doi.org/10.1016/j.marpolbul.2021.112478>
- Makanga, J. D. M. (2012). Pernicious degradation of coastal environment of Gabon: example of the north coast of Libreville. 402-407. Available online: https://d1wqtxts1xzle7.cloudfront.net/72895434/061-libre.pdf?1634458520=&response-content-disposition=inline%3B+filename%3DPernicious_Degradation_of_Coastal_Enviro.pdf&Expires=1723543276&Signature=HCakoQRwaZd1qNxSVbyoVBrdHrPsEPFpcQvkt5RSXqW0juubwvImdeRrgJMfU4~Qf1prl21a63JjKhQXSDjwyFGjPt1KnlgCFBY7JFQ0ACBd-h7~YVbprUyuwVwRxcqumWLqIZ2-PoX1x9MEXKHEitiA231qZWV-jgyG0eJC9LlhEZeEjWZkrK~huTIqnOok1DQxITQq3LsH5y19Rgov99weVxGf1HAhEQfsPW36vh2Yr1Ac2V1X5ZVIKIJr35hyxzOUqYwqOVhWRXOLjOfWjEdNVimSVk78uKOoGEdXHJQdSO7KdE6KVFwSKNbQaHWXu5MJBZG1CyMef4zc0tQ__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA (accessed on 2 June 2023).
- Mansui, J. (2017). Observation and modelling of macro-waste in the Mediterranean Sea, from the large scale to the coastal and littoral scales (French). Available online: https://theses.hal.science/tel-01410279v1/file/These_Mansui.pdf (accessed on 2 June 2023).
- Milla, D. E., Demaze, M. T., & Mba, J. C. N. (2022). Quarries Exploitation and Spatial Dynamics: Case of Akanda in The North of Libreville (Gabon). *Bulletin de La Société Géographique de Liège*, 63–77. <https://doi.org/10.25518/0770-7576.6797>
- Mombo, J. B. & Itongo, M. T. (2011). Site Management and Natural Hazards in Libreville (French). *Gabonica revue du CERGEP*, 5(5), 103–123.
- Mombo, J. B., & Edou, M. (2007). Assainissement et explosion urbaine au Gabon. *Villes En Parallèle*, 40(1), 196–225. <https://doi.org/10.3406/vilpa.2007.1443>
- Moubélé, Anicet., & Mbonda, A. P. (2017). The environmental impact of urban development in Libreville (French). *Les régions littorales du Gabon*, Pottier P, Menie Ovono Z, 257–288.
- Moughola Leyoubou, L. (2020). Urban sprawl in Libreville, socio-economic issues between 1993 and 2013: The example of the eastern suburbs (French) [Master's thesis]. University LAVAL.
- Mounganga, M. D. (2023). Strategic Environmental Assessment for Better Coastal Risk Management in Gabon Magloir-Désiré Mounganga (French). SCRIBD.
- Mvele-n'dango'o, P. (2007). Household waste management in Libreville and Abidjan (French). *Villes En Parallèle*, 40(1), 226–241. <https://doi.org/10.3406/vilpa.2007.1444>
- Nakhli-ghazi, & Ghazi, A. (2008). What Tools for A Sustainable Development of Moroccan Coastal Zones (French). Available online: http://www.meshs.fr/documents/pdf/publications/actes/colloque_littoral/Nakhli-Ghazi.pdf (accessed on 2 June 2023).
- Nfono Obame, C. (2021). Recommendations for Optimising Household Waste Management in Gabon's Capital, Libreville (French) [Master's thesis]. Université De Sherbrooke.
- Ngnikam, E., & Tanawa, E. (2006). African cities face up to their waste (French). Université de technologie de Belfort-Montbéliard.
- Ourega, D. D., & Gbocho, O. D. (2021). Resilience of households in the town of DIVO (southwestern forest, COTE D'IVOIRE) to the increase in household waste (French). *Espace Géographique et Société Marocaine*, 1(54). <https://doi.org/10.34874/IMIST.PRSM/EGSM/28884>
- Pnud. (2011). National strategy for adapting Gabon's coastline to the effects of climate change (French). Available online: <https://www.undp.org/sites/g/files/zskgke326/files/migration/ga/UNDP-GA-EnvChangeClimat-Diffusion-et-Vulgarisation.pdf> (accessed on 2 June 2023).
- Pottier, P., Menie, O. Z., Faure, F. E., et al. (2016). Gabon's coastal regions: an element of reflection for strategic territorial planning (French). Available online: https://www.researchgate.net/publication/313853150_Les_regions_littorales_du_Gabon_elements_de_reflexion_pour_une_planification_strategique_du_territoire (accessed on 2 June 2023).
- Republique Francaise. (1975). Law n°75–602 of July 10, 1975 creating the Conservatoire de l'espace littoral et des rivages lacustres (coastal and lakeshore protection agency) (French). Available online: <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000700418/> (accessed on 2 June 2023).

- Unesco/COI/MSProadmap. (2020). Technical workshop for national consultation on coastal and marine environmental pressures (French). Available online: https://www.mspglobal2030.org/wp-content/uploads/2020/11/MSProadmap_Presentation_Cameroon_20201021.pdf (accessed on 2 June 2023).
- Van Lang, A. (2012). The Coastal Act and the protection of natural areas (French). *Revue Juridique de l'Environnement*, 37(1), 105–116. <https://doi.org/10.3406/rjenv.2012.5764>
- Wandan Eboua, N., Ngoran, N. J., Kouadio, K. B., et al.. (2014). Perceptions of environmental problems in the commune of Yamoussoukro in Côte D'Ivoire (French). *European Scientific Journal*, 10(8), 461–490.
- World Bank Group. (2020). Gabon Increasing Economic Diversification & Equalizing Opportunity to Accelerate Poverty Reduction. Available online: https://files.worldwildlife.org/wwfcmprod/files/Publication/file/7n7f123qkv_FV_ESMF_Gabon.pdf (accessed on 2 June 2023).
- World Bank Group. (2021). Climate Risk Country Profile: Gabon. Available online: https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15858-WB_Gabon%20Country%20Profile-WEB_0.pdf (accessed on 2 June 2023).
- Yousefloo, A., & Babazadeh, R. (2020). Designing an integrated municipal solid waste management network: A case study. *Journal of Cleaner Production*, 244, 118824. <https://doi.org/10.1016/j.jclepro.2019.118824>