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FACTORS, IMPACTS OF DEGRADATION AND SOLUTION APPROACHES FOR THE OUIDAH COASTAL LAGOON IN SOUTHERN BENIN

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ABSTRACT

The degradation of the coastal lagoon over the past two decades is linked to both natural and human-induced factors. The objective of this study is to identify the factors contributing to the degradation of the coastal lagoon and to propose solutions for its regeneration. The methodology combined a literature review, field observations, and questionnaire surveys of 100 individuals, yielding socioeconomic data as well as information on the lagoon's condition. The results show that high salinity (30 g/L) at Djondji and Djègbadji, a marked drop in pH (0.52) in December followed by a rise to 7.81 in January, high temperatures (37.2°C) in February, together with the expansion of settlements (+0.879%), of cropland–fallow mosaics (+8.474%), and the decline of mangrove cover (-7.213%) over the period 2005-2022, have driven the degradation of the coastal lagoon. This is reflected in the disappearance of fish and bird species, together with sedimentation, bank erosion and siltation of the lagoon. According to 100% of the population surveyed, these causes are compounded by socioeconomic activities linked to the various techniques used for fishing and salt production. All these factors have depleted the lagoon's resources and are responsible for the decline in the population's standard of living and income, with migration as a consequence. In response, both locally-rooted solutions and recommendations are proposed to support the restoration of the coastal lagoon's natural resources.

Keywords: Southern Benin; Ouidah Coastal Lagoon; Degradation Factors; Degradation Impacts; Solutions

1 INTRODUCTION

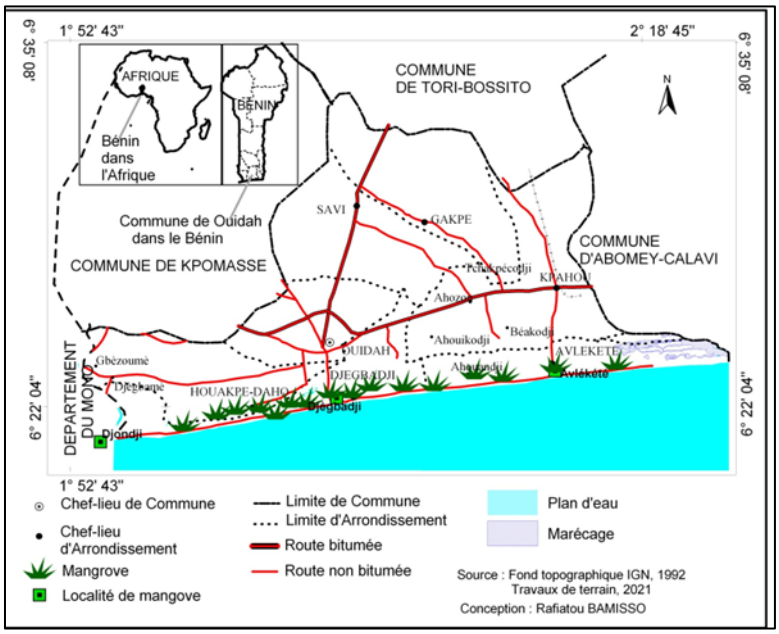
Natural ecosystems worldwide are undergoing serious disruption as a result of the interaction between natural and anthropogenic factors. Over recent decades, the condition of the world's natural resources has become a growing concern for the scientific community. Water bodies lagoons and their banks in particular ? lie at the centre of this concern, as they represent both resources to be exploited and areas requiring strict protection because of the fragility of their ecosystems. Indeed, the formation and evolution of lagoons and their associated ecosystems are closely linked to sea-level variation, coastal dynamics and sediment inputs [1]. Coastal lagoons are consequently recognised as nurseries and highly productive environments, owing to highly variable physical factors and the spatial heterogeneity of community structure, which is strongly related to the availability of food resources (Villanueva, 2004, as cited in [2]). Nevertheless, coastal lagoons remain heavily exposed to pressures linked to pollution, urbanisation and human-induced

changes in hydrological functioning, compounded by the growing effects of climate change [3]. In Benin, siltation and infilling of the coastal lagoon caused by human activities, combined with the construction of the Nangbéto dam, have altered the water and sediment regimes of the Mono River, further accentuating the degradation of this lagoon ecosystem. Environments whose morphology has been degraded may require ecological restoration works [4]. For the population living along the lagoon ecosystem, the drivers of ecological degradation are largely embedded in a cultural context [5]. Given this imbalance in the lagoon ecosystem, it is important to identify solutions capable of restoring its natural functions and to raise awareness among the riparian population of better management practices.

2 MATERIALS AND METHODS

2.1 Study area

This study focuses on the coastal lagoon located in the municipality of Ouidah, in southern Benin, which extends over approximately 40 km along the coast. This lagoon ecosystem lies between latitudes 6°22'04" and 6°35'08" North and longitudes 1°52'43" and 2°18'45" East (Figure 1).



Source: Topographic base map, 1:600,000, IGN 1992

Figure 1: Location of the study area

This coastal lagoon supports several activities for the riparian population, including salt production, traditional fishing , practised with techniques that vary from one fisherman to another , tourism and trade. Mangrove vegetation develops along the banks of this lagoon ecosystem.

2.2 Data collection and materials

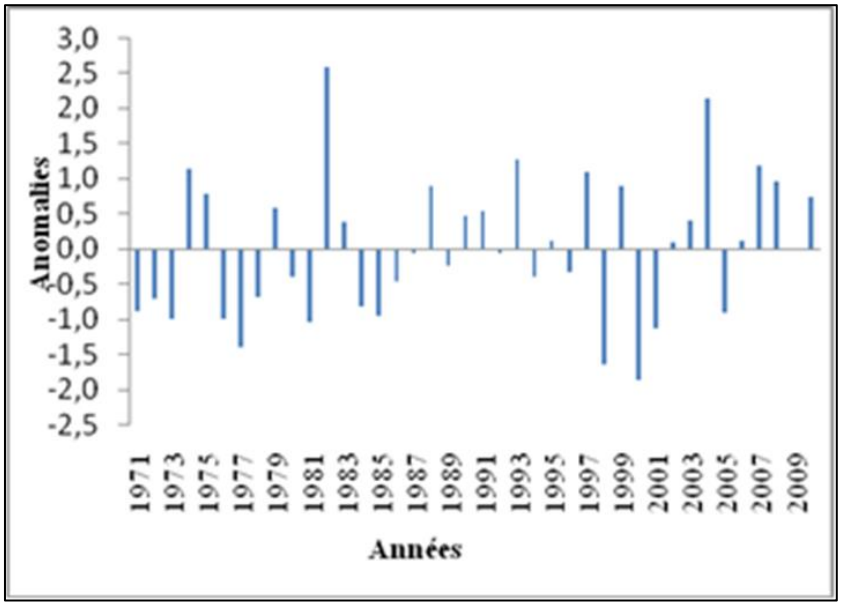
Several documents were consulted at documentation centres and institutions relevant to the subject, in particular BIDOC/FSA, LACEEDE, MCVD, and the Ouidah town hall. This literature review was complemented by field surveys and direct observations. Field surveys made it possible to gather information from 100 individuals (fishermen, salt producers, women processing fishery products, village chiefs, the mayor of the municipality, traditional notables, market gardeners, traditional chiefs, and various associations involved in the sustainable management of the lagoon) in order to identify the factors contributing to the degradation of the lagoon. Various tools, equipment and data-collection techniques were used for the fieldwork: a GPS unit was used to record geographic coordinates; a digital camera was used to photograph phenomena related to the degradation of the lagoon ecosystem; a topographic map was used to define field investigation routes; and aerial photographs were used to analyse and illustrate the dynamics of the landscape units of the Ouidah lagoon.

3 RESULTS

3.1 Natural factors of degradation of the Ouidah coastal lagoon

3.1.1 Rainfall variability

The coastal lagoon lies within the sub-equatorial climatic domain, whose rainfall has shown a declining trend since the 1970s, with values almost consistently below the long-term average (Figure 2).



Source: Météo-Bénin, July 2025

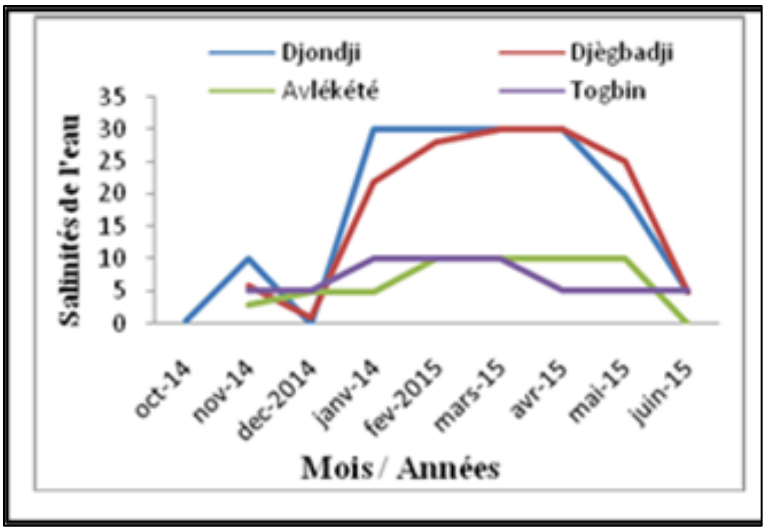
Figure 2: Interannual rainfall variability (1971–2010)

Analysis of Figure 2 shows that, of the forty years considered in this study, twenty-one were rainfall-deficit years, including 1971 (822.60 mm), 1973 (789.50 mm), 1977 (688.10 mm), 1998 (620.70 mm), 2000 (562.10 mm), 2001 (754.70 mm) and 2005 (815.60 mm). The wet periods (June–July and September–October) coincide with lagoon water levels overflowing as a result of rainfall runoff and flooding of the Mono and Couffo rivers. During these overflow episodes, activities such as fishing and salt production are seasonally suspended by local residents. During the dry season, water flow is dominated by marine currents, resulting in an intrusion of seawater followed by a marked rise in salinity within the coastal lagoon; this, combined with elevated temperatures, sometimes causes the death of certain species, particularly tilapia, according to 80% of the fishermen surveyed.

3.1.2 Salinity, pH and temperature of the coastal lagoon

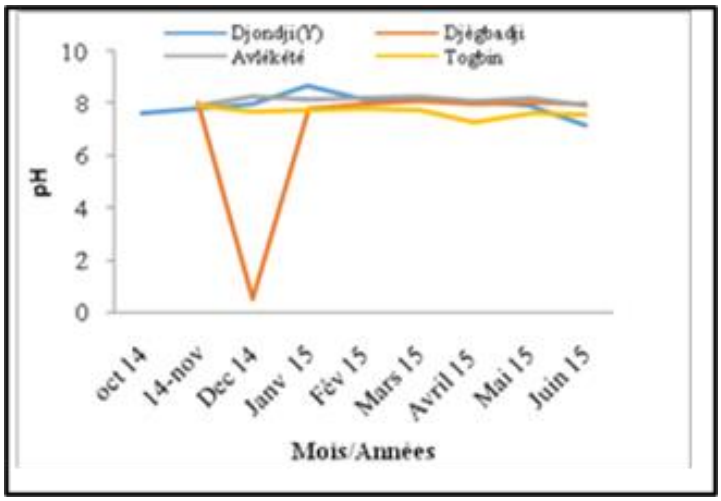
Salinity and pH depend on the season and on the water balance (Figures 3 and 4).

The salinity values recorded (Figure 3) in the lagoon are low 6 g/L at Avlékété and Togbin, and 10 g/L at Djondji and Djègbadji , during the short rainy season and the start of the dry season (October to December). They become high (30 g/L at Djondji and Djègbadji, and 10 g/L at Avlékété and Togbin) during the dry season (January to May). The high salinity recorded at Djondji and Djègbadji can be explained by their proximity to the river mouth. The pH values recorded (Figure 4) range from 7.27 to 8.70 in the lagoon. At the Djègbadji station, a marked drop in pH to 0.52 was recorded in December before rising again to 7.81 in January; this value represents a pronounced anomaly relative to the range observed at the other stations and periods and warrants verification against the raw field data. Temperatures at the various sampling points (Figure 5) range from 26.6°C (November) to 37.2°C (February) and are higher during the dry season than during the rainy season. According to 92% of the population surveyed, the variation in these parameters in the coastal lagoon is linked to climate variability, bank erosion, mangrove cutting, hydrological change and local pollution.



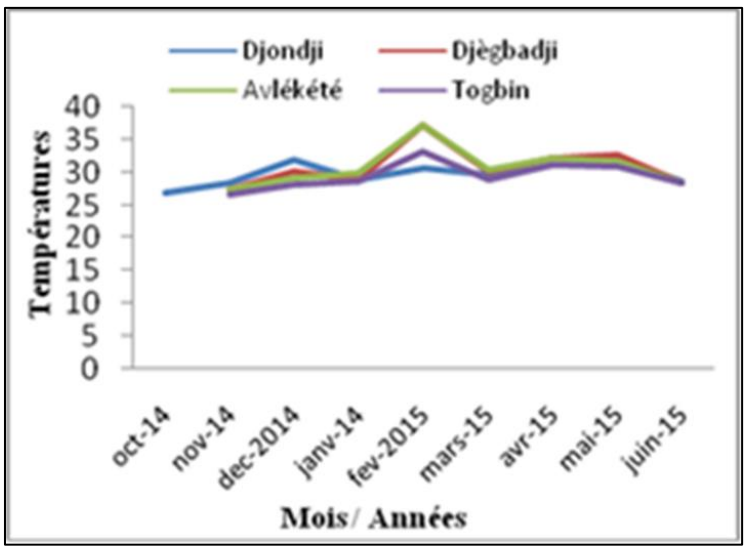
Source: Directorate of Fisheries, July 2025

Figure 3: Salinity of the coastal lagoon



Source: Directorate of Fisheries, July 2025

Figure 4: pH of the coastal lagoon

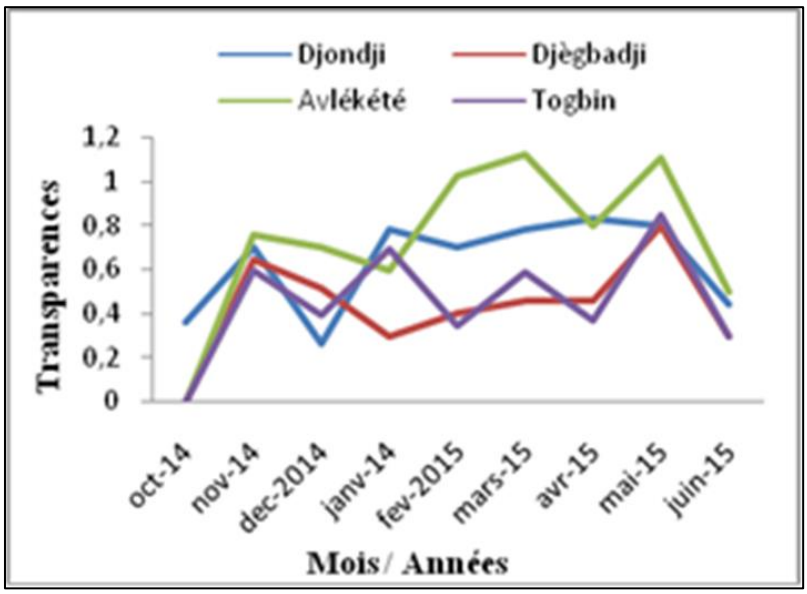


Source: Directorate of Fisheries, July 2025

Figure 5: Temperature of the coastal lagoon

3.1.3 Transparency of the coastal lagoon

Water transparency results from several factors, including substances dissolved and suspended in the water, such as clay, humic substances, silt, plankton and colouring compounds (Figure 6).



Source: Météo-Bénin, July 2025

Figure 6: Transparency of the coastal lagoon

Figure 6 shows the transparency values measured in the coastal lagoon, ranging from 0 m (Togbin, October) to 1.12 m (Avlékété, March). According to 100% of the population surveyed, the low transparency of the lagoon reflects high turbidity and is harmful to fish species, as it contributes to the clogging of spawning grounds and the asphyxiation of eggs, and can cause gill lesions. It also reduces the abundance and growth of aquatic invertebrates, which serve as a food source for fish.

3.1.4 Land-use dynamics around the coastal lagoon between 2005 and 2022

Land-use dynamics were assessed by comparing the areas of each land-cover unit in 2005 and 2022 (Table 1).

Table 1: Summary of land-use/land-cover status in 2005 and 2022 around the coastal lagoon

Land-use / land-cover unit	Share of area 2005 (%)	Share of area 2022 (%)	Change 2005–2022 (%)
Settlements (agglomerations)	1.733	2.612	+0.879
Mangrove	9.719	2.506	-7.213
Marshland	0.003	25.105	+25.102
Cropland–fallow mosaic	24.256	6.921	-17.335
Cropland–fallow mosaic under oil-palm	2.340	10.814	+8.474
Sandy beach	0.925	1.972	+1.048
Water bodies	49.515	49.897	+0.382
Plantation	11.510	0.174	-11.336
Total	100	100	100

Source: Results of 2022 cartographic data processing

Table 1 shows that mangrove cover , one of the vegetation formations that limits infilling and siltation of the lagoon declined by 7.21% despite various reforestation efforts. This decline is attributable to the use of mangrove wood as fuel

for salt production and for the construction of acadja fish enclosures. Marshland and cropland–fallow mosaics under oil-palm groves increased by 25.10% and 8.47% respectively, reflecting an intensifying human footprint on the lagoon's resources; plantation cover, meanwhile, declined sharply, by 11.34%, over the same period. Overall, the net regression of vegetation cover is intensifying the pace of lagoon degradation through siltation, infilling and sedimentation.

3.2 Socioeconomic activities as factors of degradation of the Ouidah lagoon

The degradation of the lagoon is driven by several human activities, notably fishing, salt production and market gardening.

3.2.1 Fishing

Fishing is the primary activity practised by many riparian residents, both men and women. It involves capturing and collecting fish, crabs, shrimp and other organisms using a variety of techniques, practised year-round according to season. The fishing techniques used in this lagoon ecosystem include line fishing, the xa barrage and the acadja brush park, among others (Plate 1).



Photographs: Bamisso, January 2026

Figure 7: The xa technique (Photo 1) and an acadja brush park (Photo 2) in the coastal lagoon

The xa (barrage) is a device developed in the eastern part of the lagoon (specifically at Kouvenanfidé, Djègbadji, Dégouè and Houakpè). Field investigations recorded around twenty Gbéto Kouvènafidé structures in the village of Djègbadji. According to 98% of the population surveyed, this technique is a source of conflict between local authorities and fishermen, since it slows water flow and accelerates sedimentation in the lagoon. Regarding the acadja technique, 80% of respondents consider it a contributor to infilling, since the quantity of brushwood installed always exceeds what is later removed after exploitation; the prolonged immersion of this brushwood promotes muddy sedimentation on the lagoon bed. It should also be noted that oyster farming, practised mainly in the localities of Djègbadji, Dégouè and Houakpè, relies on enclosures built from mangrove branches; once worn out, these enclosures together with dead oysters are abandoned in the lagoon, further contributing to its siltation.

3.2.2 Household solid waste management

Household waste management is a major environmental problem in the localities along the coastal lagoon (Photo 1).



Photograph: Bamisso, January 2026

Figure 8: Household waste dump along the coastal lagoon

According to 100% of the population surveyed, household waste is dumped along the lagoon banks to gain habitable space, to fill in low-lying land, and to guard against flooding. Directly or indirectly, this waste contributes to the siltation of the lagoon, since strong winds, runoff, waves and periods of high water carry it away, deposit it, and cause it to decompose on the lagoon bed, forming layers of mud.

3.2.3 Salt production

Salt production is carried out mainly by women and remains the second most important activity after fishing. It is practised along the banks of the coastal lagoon during the dry season (November to April). The process involves site selection, site preparation by burning and weeding, scraping of the salt crust and heaping it into mounds, transferring the mounds into a leaching basket, and finally boiling (Plate 2).



Photographs: Bamisso, January 2026

Figure 9: Brine-extraction basket (Photo 1) and mangrove wood at Djègbadji village (Photo 2)

According to 100% of the population surveyed, boiling is carried out using mangrove wood, recognised for its high calorific value. This activity has considerable consequences for the coastal lagoon, including mangrove degradation which in turn drives the disappearance of fish and bird species bank erosion and denudation, and siltation of the lagoon. This explains the near-total destruction of mangrove cover at Dégouè, Mèko and other localities.

3.2.4 Agriculture

Lagoon-side villages with arable land are farmed by 75% of the population surveyed, for whom agriculture is not only a supplementary activity but also an essential substitute for fishing and salt production, particularly during flood periods. Two types of production can be distinguished:

Market gardening is practised in certain localities such as Djègbadji village, Dégouè and Gbèto Kouvènafidé. Produce is sold on-site and in surrounding markets of the Ouidah municipality, such as Pahou, Cocotomey, Atrokpocodji and even Comè. Market-garden crops include tomato (Solanum lycopersicum), chili pepper (Capsicum frutescens), carrot

(Daucus carota) and watermelon (Citrullus lanatus), in addition to maize (Zea mays), cassava (Manihot esculenta) and cowpea (Vigna unguiculata).

These operations are generally family-run. Processing of agricultural products constitutes another income-generating activity, and the waste generated by this processing is also a source of pollution that is difficult to manage. It should be noted that fields located very close to the lagoon, combined with pesticide use and ridge-tillage techniques, degrade the lagoon banks particularly when crops fail to absorb the full quantity of nutrients applied (notably nitrates and phosphates); the resulting surplus infiltrates the soil or is carried by rainfall into the lagoon (Photo 2).



Photograph: Bamisso, January 2026

Figure 10: Tomato field at the edge of the coastal lagoon at Houakpè

This contamination produces two major effects: eutrophication and the degradation of water quality.

3.3 Impacts of degradation of the Ouidah lagoon

3.3.1 Infilling and sedimentation of the coastal lagoon

This phenomenon leads to a reduction in water depth and the drying-up of floodable plains, which shortens and compromises the developmental cycle of fish species. In addition, fish traps installed in migration corridors trap muddy sediments, as observed in Djègbadji village according to 85% of the population surveyed. Lagoon depth is also unevenly distributed, varying from one locality to another: in Méko and Houkonnou, depth reaches a maximum of 2.5 m, whereas in Djondji water depths range from 3 to as much as 6 m. Acadja enclosures and xa barrages both contribute to siltation by slowing the rate of water flow. In addition, houses roofed with corrugated iron sheets concentrate rainwater droplets and increase their kinetic energy, producing small, deep gullies observed in most villages. The use of chemical fertilisers and pesticides, together with their runoff, constitutes a significant source of pollution within this lagoon ecosystem.

3.3.2 Depletion of fisheries resources in the coastal lagoon

Since the construction of the Nangbéto dam, overflow of lagoon waters resulting from flooding of the Mono River has been reduced. This hydrological regulation has led to siltation of the lagoon, a progressive reduction in its surface area and, above all, an impoverishment of fish diversity. Over the past two decades, several species have disappeared from the ecosystem. The essential goods and services provided by nature depend on species and genetic diversity; biological resources are interdependent, and a break in the food chain can have unforeseen repercussions for the ecosystem, according to 55% of the population surveyed. For example, Penaeus notialis (shrimp) is a food source for fish such as Caranx hippos (crevalle jack) and Epinephelus aeneus (white grouper); the disappearance of shrimp would therefore lead to the disappearance of species dependent on them. The year-round presence of freshwater in certain villages of the Djègbadji district (Houakpè, Dégouè, Djègbadji) has resulted in the disappearance of brackish-water species and their replacement by freshwater species. This phenomenon, which threatens the maintenance of biodiversity, severely jeopardises human development.

Table 2 lists fish species that now appear only sporadically or have disappeared from the lagoon ecosystem.

Table 2: Fish species that have become sporadic or have disappeared from the Ouidah lagoon

Scientific name	Family	Local name (Xwla / Xwela)
Parachanna obscura	Channidae	Hotrou
Heterotis niloticus	Osteoglossidae	Houâ
Pseudotolithus senegalensis	Sciaenidae	Djoké
Galeoides decadactylus	Polynemidae	Tchicoué
Caranx senegalensis	Carangidae	Pampanvi
Dasyatis margarita	Dasyatidae	Ozouin
Pomadasys jubelini	Haemulidae	Kokouin
Epinephelus aeneus	Serranidae	Toboko

Source: Field data, July 2026

3.3.3 Socioeconomic impacts of coastal lagoon degradation

3.3.3.1 Decline in the purchasing power of riparian populations

The situation of fishermen in the study area is highly precarious. The decline in fisheries productivity has reduced the purchasing power of local populations. In the past, populations of the river–lagoon complex supplied the markets of Djoda and Vogan in Togo, and Comè, with fishery products, receiving cereals (maize, gari) and other manufactured goods in return; until recently, these exchanges took the form of barter. Today, these populations have become importers of frozen fish. Since fishing is the primary activity in the area, the population has fallen into advanced impoverishment. In addition, the decline of secondary activities, particularly salt production and mangrove oyster (Crassostrea tulipa) harvesting, has worsened the situation.

3.3.3.2 Tourism and attractiveness

The degradation of the coastal lagoon causes major economic losses in the tourism sector through increased public costs, while reducing the ecosystem's protective and food-production services. The presence of waste and the degradation of the landscape directly reduce the lagoon's recreational value, leading to a decline in tourist visits, shorter stays and reduced tourist spending. Declining visitor numbers are forcing hotels to cut staff or close altogether. Tour guides, artisans and lagoon boat operators are losing their main source of income, according to 90% of the population surveyed. The lagoon is thus shifting from a natural asset to a health and environmental hazard. According to 100% of the population surveyed, eutrophication and anoxia in the lagoon produce foul-smelling putrid sludge, resulting in swimming bans and constraints on water sports popular with tourists such as kayaking and jet-skiing at Djègbadji and Djondji. Siltation and sediment accumulation block channels and complicate the passage of pleasure boats. Furthermore, the disappearance of fish and bird species has eliminated the appeal of nature-observation tours, while mangrove degradation along the lagoon banks has removed key ecological barriers and popular hiking sites.

3.3.3.3 Migration

A defining characteristic of the population in the study area is emigration and rural exodus. Traditionally, the Xwla and Pédah populations migrate to coastal countries with more fish-rich coasts and water bodies, notably Côte d'Ivoire, Gabon, Cameroon and the Republic of Congo. Today, this phenomenon has intensified alongside the breakdown of the area's environmental functions. Rural exodus manifests as the movement of young people toward Benin's major cities, with Cotonou being the most sought-after destination, where they find work at the Cotonou fishing port, as “Zémidjans” (motorcycle-taxi drivers) and in other activities. The consequence of this phenomenon is the depopulation of villages; several villages, notably Djègbadji, Aîdo, Dégouè and Djondji, have lost much of their able-bodied population, leaving houses to the elderly and children.

3.4 Solution approaches for efficient management of the coastal lagoon

Several locally-rooted (endogenous) solutions have been developed by the population in response to the degradation of the coastal lagoon. Ninety percent of the population proposes dredging the coastal lagoon, with priority sectors identified as the area from the river mouth to Djondji, the entire Ahô channel up to Djègbadji, “Toffadji”, and the northern bank up to the bridge. Forty-five percent prefer the establishment of fish refuges in certain sectors of the lagoon where fishing would be prohibited. The population also favours installing the Avlékété shrine in all villages bordering the lagoon, a practice already considered beneficial, particularly at Avlékété and Hounkounnou. To prevent

further decline in fisheries production, the population, supported by traditional religious leaders, has sanctified a small portion of the lagoon; this practice involves conserving fishery resources for sustainable fishing and has led to the creation of an "aquatic sanctuary" at Avlékété, and another at Mèko, where the Kokougba shrine has been installed since the 1990s. The use of fine-mesh nets ("mèdokpokonou" and "Gbagba-Loulou") has also been banned. In addition, 100% of the population surveyed proposes restoring mangrove cover along the lagoon banks and monitoring it, which would contribute to higher fisheries productivity and to the development of bird-watching tourism. Other solutions proposed by the population include installing wells in all riverside villages, resolving conflicts between animists and Christians whose behaviours sometimes run counter to the traditional rules governing lagoon management, state subsidies for the installation of Avlékété-tins (enclosures surrounding the Avlékété shrine), the construction of hospitals and schools, the electrification of villages, and subsidies to support the economic reconversion of populations exploiting the coastal lagoon.

For more rational management of the coastal lagoon, the following measures are recommended:

- Sanitation of the coastal lagoon requires complete dredging of the lagoon to allow the recovery of both fish and bird species, as well as of fish-farming activities, as emphasised by 97% of the population surveyed rather than the partial dredging of only a few villages, such as Djondji and Houncloun, up to Docloboé in Grand-Popo, as currently initiated by the government. Fishermen's committees encountered in the field, with the support of the town hall and certain NGOs involved in ecosystem protection, could carry out seasonal, localised and sector-specific dredging of the lagoon, removing sediment and plastic waste to allow fish populations to grow and reproduce; prohibiting destructive or illegal fishing techniques such as acadja and xa, as well as fine-mesh nets; and banning the disposal of waste along the lagoon banks.
- Restoration of mangrove ecosystems through reforestation in the most degraded areas, in order to stabilise soils and prevent erosion and sedimentation, together with awareness-raising sessions for the riparian population, conducted in partnership with fishermen's and women's groups active around the lagoon as well as with national and international organisations involved in mangrove conservation.
- Participatory governance of lagoon management, involving all stakeholders (fishermen, market gardeners, salt producers, local tour guides, fish processors, etc.) in decision-making, to reconcile biodiversity conservation with socioeconomic activities.

Effective and regulatory reorganisation of fishing activities, requiring the restriction of certain active gear to deeper zones and the regulation of net mesh sizes; a ban on the capture of fry while avoiding the obstruction of passageways between the lagoon and the sea; the establishment of closed zones or seasons to allow migratory fish to complete their biological cycle; the use of shallow areas for aquaculture, restocked with artificially reared fry; local awareness campaigns, such as those conducted by the NGOs CREDEL and Eco-Bénin and by certain international and state bodies, to inform stakeholders about lagoon ecosystem protection; financial support for the professional reconversion of populations toward other income-generating activities such as livestock rearing, market gardening and agriculture in areas somewhat removed from the lagoon; and, finally, planting fast-growing, semi-hydromorphic species along the lagoon banks.

4 DISCUSSION

This study has shown that human activities have contributed to the degradation of lagoons through various forms of pollution, urbanisation and the exploitation of different vegetation formations. In Benin's coastal zone, it is primarily fishing techniques, agricultural activities and mangrove cutting that have accentuated the degradation of this lagoon ecosystem. A similar observation was made by Toffi [6], who showed that it is the pursuit of basic livelihood needs that drives riparian populations toward the unregulated use of natural resources in lagoon environments. The degradation of the lagoon has also led to a decline in income linked to the reduction of fishery products, an essential source of protein for human health. This degradation has likewise had consequences for the tourism sector: whereas the coastal lagoon once attracted a substantial number of tourists, visitor numbers have declined and in some cases disappeared entirely owing to its current condition. This is consistent with the findings of Adingra and Kouassi [7], who showed that pollution renders the lagoon unsuitable and disqualified for sporting, tourism and cultural activities, that the social capital derived from these activities no longer exists, and that children who continue to bathe in the lagoon are exposed to the risk of diarrhoeal and other water-borne diseases. Various strategies have been proposed for better management of this lagoon ecosystem, though they remain focused on the professional reconversion of resource users on the one hand, and on the sanctification of certain sectors of the lagoon on the other. The work of Amoussou [5] showed that strengthening and rigorously monitoring positive endogenous strategies, combined with fisheries production technologies, constitute promising approaches for the integrated and sustainable management of Benin's lagoon ecosystems.

5 CONCLUSION

Natural and anthropogenic factors are driving the ongoing degradation of the coastal lagoon, with substantial impacts on the socioeconomic development of this environment. The irrational use of the lagoon could be regulated through awareness-raising campaigns, the regulation of fishing days, and restoration through the protection and planting of mangrove and other fast-growing species. Achieving this will require the involvement of institutions and the town hall, through strengthened technical and financial resources and the sanitation of the entire lagoon, so that the population can adequately meet its basic needs and properly benefit from the lagoon's resources. Success in this endeavour will not be possible without the involvement of fishermen's committees, religious leaders, and the economic reconversion of the populations exploiting this ecosystem.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The author declares that there is no conflict of interest regarding the publication of this paper.

Statement of informed consent

Participation in the survey was voluntary. All respondents were informed of the purpose of the study and provided their informed consent before participating in the interviews. Confidentiality was maintained, and responses were anonymised to protect participants' identities. No formal ethical approval was obtained for this study.

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