

Delta Alliance

Deltares



Report of the
Ouémé Delta
Status and trends

Table of Contents

Boxes, figures and tables	4
List of Abbreviations	4
Current and future state of the Ouémé Delta	5
1.1 Drivers of change	6
1.1.1 Socio-economics (population growth- migration, economic development + most relevant sectoral developments, e.g. for agriculture, fisheries, industry)	6
1.1.2 Evolution of key climate elements	7
1.1.2.1 <i>Climate features</i>	7
1.1.2.2 <i>Average rainfall and thermometric features</i>	7
1.1.2.3 <i>Realities of Climate Change</i>	8
1.1.2.4 <i>Delta Water Resources and Hydrological Movement</i>	9
1.2 Pressures – potential problems / Challenges – opportunities	10
1.2.1 Threats related to interferences in the delta	11
1.2.1.1 <i>Hydrological disturbances</i>	11
1.2.1.2 <i>Overflowing flood</i>	12
1.2.1.3 <i>Salinization of the delta waters</i>	12
1.3 Natural resources	13
1.3.1 Summary of pressures of natural resource layer	13
1.3.1.1 <i>Major socio-economic activities</i>	13
1.3.1.2 <i>Attributes of natural resources</i>	12
1.4 Governance (institutional/organizational aspects of delta management)	16
1.4.1 Major undergoing projects	18
1.4.2 Planned institutional interventions	19
1.4.3 Actions by civil society organizations	20
Sustainable management of the Ouémé Delta: Guiding principles and practical approaches	21
2.1 Levers for sustainable management	22
2.2 Impacts of sustainable management	22
2.2.1 Guiding Principles	22
2.2.2 Analysis restricted to the SWOT model	23
2.2.2.1 <i>The Ouémé delta: Opportunities and Threats</i>	23
2.3 Opportunities / Assets	23
2.4 Threats / Constraints	24
2.5 Prospects	24
Summary of the study	25
References	26
ANNEX : Types of plant formations in the Ouémé Delta	28

1

2

3

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Boxes, figures and tables

Box 1:	Summary of Drivers of change and research gaps	6
Box 2:	Summary of pressures; Occupational layer	10
Box 3:	Summary of Pressures; Network layer	13
Box 4:	Summary of Governance issues	16
Figure 1:	the Ouémé River Delta	5
Figure 2:	Origins of the Ouémé Delta population	7
Figure 3:	Hydrological movements and variations in types of exploitation in the Ouémé Delta	15
Table 1:	Overview of the institutional framework of the Ouémé Delta	28

List of Abbreviations

ABE	Benin Environment Agency
ASECNA	Agency for the Safety of Air Navigation in Africa and Madagascar
UNFCCC	United Nations Framework Convention on Climate Change
CEA	African Economic Community
Ha	Hectare
IGN	National Geographic Institute
INSAE	National Institute for Statistics and Economic Analysis
IPPC	Intergovernmental panel on climate change
Km2	Square Kilometre
MARP	Accelerated method of participatory research
MEHU	Ministry of Environment, Habitat and Urban Planning
MFE	Ministry of Finance and Economy
MICPE	Department of Industry, Trade and Small Business
MTPT	Ministry of Public Works and Transport
NG	Geographic North
OBMINE	Benin Mining Authority
PAIAVO	Agricultural development and intervention project in the valley of Ouémé
RGPH	General Population and Habitat Census
SADEVO	Valley Economic Development and Development Corporation of the Ouémé
SAP	Early Warning System
SDAGE	Water Management and Management Master Plan
SWOT	Strengths Weaknesses Opportunities Treats
IUCN	International Union for the Conservation of Nature
UNESCO	United Nations Educational, Scientific and Cultural Organization.
IBA	Area of Importance for Bird Conservation



The focus of this study is the lower valley of the Ouémé River. It consists of the medium and lower delta. The medium delta is a 50 km long plain that stretches from the city of Bonou to that of Azowlissè via Adjohoun. Its width is relatively uniform in this area and does not exceed 10 km (Nonfon, 1988). The river bed is sandy. The water is shallow during the dry season and the banks are quite high. As for the lower delta, it starts from the Azowlissè downstream, where the valley sharply widens to 20 km and ends at the southern frontage where the river flows into the Porto-Novo lagoon. At this place, the river bed is deep and muddy in dry seasons and the banks are low. The low plain is subject to floods and remains marshy all the year round.

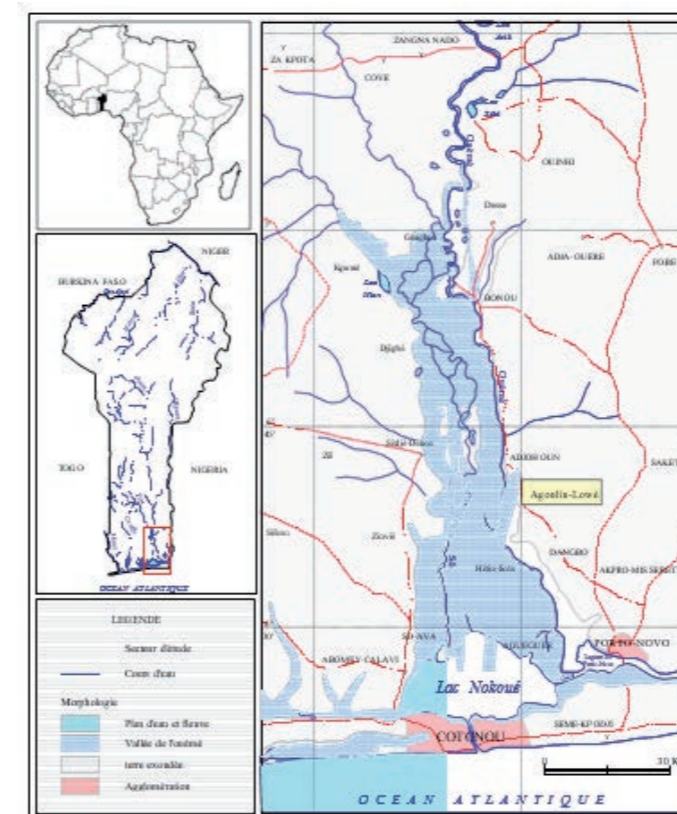


Figure 1 : the Ouémé River Delta

1.1 Drivers of change

Summary of drivers of change

Demographic trends: The Ouémé Delta is a mixture of different peoples and has a population of 209,000 inhabitants. This population increased by 81,844 inhabitants between 2002 and 2013. The population growth rates per municipalities are respectively, 4.65% for the Aguégoués 6% for Sèmè-Podji and 3.97% for So-Ava for the lower delta. With an average percentage of 4.87%, these growth rates are well above the national average rate (INSAE, 2013). The population of the Ouémé Delta represents 3.85% of the country population.

Economic development: The goods and services produced in the Ouémé Delta by using natural resources are varied. Socio-economic activities include agriculture practiced during drop in water level periods, inland fishing and livestock farming. However, the opening and the operation of sand quarries is an emerging activity throughout the Delta.

Major Climate Developments: The Ouémé Delta benefits from the climate prevailing in southern Benin. This climate is characterized by two rainy seasons and two dry seasons. In recent decades, rainfall has declined considerably. However, in the Delta, rainfall records show that the difference (158 mm) between rainfall volumes over years is relatively high, that is 15% of the annual average volume. Climate change can be assessed according to thermometric and rainfall trends. Between 1961 and 1990, they were considered normal and stood as standards. As a result of rainfall and temperatures analysis in southern Benin, the precipitations heights gradually decrease and temperatures are increasing. In southern Benin, the rainfall trend declined, referring to normal. The climatic conditions are characterized by a very strong irregularity and a very poor distribution of precipitation in time and space. The Ouémé River and the Sô River as well as their tributaries and effluents are the Delta's water resources. The movements of the floods in addition to the drop in water level and the low water level periods of the of the river impact the functioning of the delta.

Subsidence Unknown due to lack of data. Subsidence has not been measured in the delta, but the high development of anthropogenic activities in the delta has increased the vulnerability of coastal ecosystems, which were already highly threatened by natural processes such as continual erosion and deposition of catchment materials. As such, like other deltas along the western Atlantic coasts, down warping of the continental margin leads to the subsidence of the West African coast mainly from Nigeria to Côte d'Ivoire.

Technological developments:

As the coastal area is subject to erosion due to sea level rise, most technological improvements are in the form of sea defence structures to control rates of erosion of coastal to protect major infrastructures. There is also a project for Agricultural Infrastructures in Ouémé Valley (PAIA-VO): Rehabilitating irrigation. It has planned the construction in the port of Cotonou a Liquefied Natural gas re-gasifying floating terminal (total capacity of the power plants to operate: 500 MW), the construction of the hydroelectric power plants of Dogo (bis) 128 MW; and building three multi-purpose dams on the main stream of the Ouémé River with plans for integrated and effective watershed management.

Research gaps: Research is required on how transformative adaptation would be developed and data collection on how salinity will impact people livelihood need to be performed. There is a crucial need of climate change impact on both the coastal area and on the communities.

Socio-economics (population growth- migration, economic development + most relevant sectoral developments, e.g. for agriculture, fisheries, industry)

• *Origins of the settlement*

The population of the Ouémé River Delta is a mix of different peoples from different backgrounds (Berthot, 1967; cited by Tohozin, 1999). People come from North (Mahi origin), East (Yoruba origin), and West (Adja origin) of the delta. Commonly referred to as the "Ouémènou", they consist of a mosaic of groups of various origins and lineages :The Fanvinou, the Tossonou or Glonou (Yoruba/Egba, respectively, originating in Ilé-Ifè and Abéokouta, Nigeria);the Blinou and Lossonou (two small groups of small extension from Ifangni and Sakété); the Hounhouènou, the Houédonou and the Houé-Sadonou, the Djigbenou and the Kpomènou (Djigbé and Kpomè) from Allada and its peripheries and

the "Ouémènou" strictly speaking who came from the plateau of Abomey (Figure 2).

• *Administrative bodies*

The Ouémé Delta encompasses, from North to South, the territories of the municipalities of Bonou, Adjohoun, Dangbo and the Aguégoués. In fact, there are 17 municipalities neighbouring the delta, with a total population of 209,000 inhabitants. (Table I). It is an area that is part of the lower Ouémé River basin. It is a set of hydromorphic seasonal and permanently submerged and emerged lands that spread on both the left bank (between the Ouémé and the Wèwè in Nigeria) and the right bank (between the Ouémé and the Sô). Some institutional interventions are located on the land. They consist in water and electricity facilities, to serve the Delta neighbouring communities. In view of the biophysical conditions in the delta, rural coastal communities practice a variety of activities, in particular agriculture, livestock and fishing.

Evolution of key climate elements

Climate features

The Ouémé Delta is influenced by a subequatorial climate. This climate is that of southern Benin, and is characterized by four sharp seasons organized in two dry seasons from December to March and from August to September on the one hand, and two rainy seasons from April to July, and from September to November on the other hand. Such a climate regime is based on the relations between radiative and thermal balances and atmospheric circulation of air. It is noticeable by the interaction between two air masses: the dry and hot tropical continental air, and the warm and humid equatorial maritime air with contrasting traits.

Average rainfall and thermometric features

• *Annual average accrual*

Studies of the average rainfall features in southern Benin have shown that rainfall has declined significantly in recent decades. In the Ouémé Delta, the mean annual rainfall totals accumulated over the period 1971-2017 is modest and varies between 1067 mm and 1225 mm. However, rainfall records show that the difference (158 mm) between rainfall volumes is relatively high that is 15% of the mean annual volume.

• *Average seasonal rhythm of minimum and maximum temperatures*

The annual average temperature is 27°C over the period (1971-2017) in the Ouémé Delta as in southern Benin. However, these figures conceal significant disparities between extreme temperatures, with reach and exceed 30°C in January-February (32°C), and minima drop below 26°C in July-August (23°C).

• *Average rate of vapour pressure*

The closeness of the rivers surface waters (Nokoué Lake, Porto Novo Lagoon and the Atlantic Ocean) and the brevity of dry wind blows from the mainland trade wind give the Ouémé Delta a very high degree of humidity all year round. Relative humidity maxima culminate on June (95%) and October (95%). However, low values, ranging from 90 to 91%, are recorded from February to April.

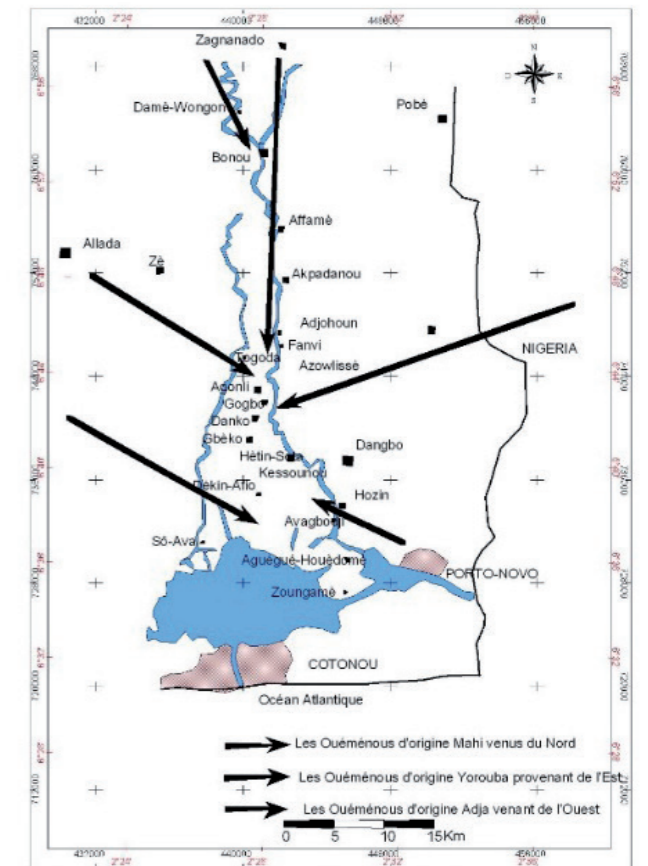


Figure 2: Origins of the Ouémé Delta population: Source: IGN, 1992



Realities of Climate Change

Climate change in addition to other factors increases the complex challenges of development issues, especially those of rural development. Climate change and development are two dynamics that are inextricably linked and worth equal attention. Benin like other vulnerable developing countries has to tackle the challenges and threats of climate change. Studies by IPCC (1990) on thermometric and rainfall trends over the standards of the 1961-1990 period in the southern regions of Benin appear as indicators of climate change. This period is considered as a reference period for major changes in the contemporary climate.

- *Monthly Precipitations and Temperatures in South Benin over the (1961-1990) period*
The evolution of average monthly precipitations over 1961-1990 shows that southern Benin has been relatively watered. Temperatures are gradually rising.
- *Monthly Temperatures in South Benin over the (1961-1990) period*
Contrasting precipitations, the thermal gradient is identical across southern Benin (Figure 5). It is a South-North gradient. Maximum temperatures are around 32 °C and 34 °C. The minimum temperatures vary between 22 and 24 °C. The months of June and July remain the least hot of the year. From an analysis of the rainfall and temperatures in southern Benin, and thus in the Ouémé Delta, it appears that (Ogoualé, 2006):
 - rainfall variations are gradually decreasing;
 - Temperatures are increasing, especially when one goes from the coastal plain to the crystallin peneplain.

To summarize, the 1961-1990 period is remarkable by an increase in temperatures. Moreover, rainfall has declined. Under such circumstances, it is necessary to inquire about the trends that underline the prevailing climate features during the study period.

- *Thermometric trends over normal (1961-1990)*
Maximum and minimum temperatures over the (1961-1990) period show that the regions of South Benin are affected by warming. Maximum temperatures have been constantly increasing over the standards indicated. The rise noticed is on average 0.9 °C. As for the minimum temperatures, they have also experienced an upward trend: between 1961 and 1990, the overall increase is estimated at 1.5 °C. This increase in temperatures in the regions studied is linked to a rainfall decline as shown in Figures 32.1 and 32.2.

- *Rainfall trends over normal (1961-1990)*
The literature shows that there is an obvious downward trend in annual rainfall variations in southern Benin. Actually, the evolution of rainfall parameters in the southern Benin region strongly contrasts from year to year. During the period (1961-1990), there was a recurrence of dry years such as 1977, 1980, 1983, 1987, 1986, 1989, etc. After the heavy precipitations of the 1968's, a downward trend now characterizes the rainfall of southern Benin. In addition, a very strong irregularity and a very poor distribution of precipitations over time and space distinguish (Houndenou, 1999) the climatic conditions. Apart from the city of Sakété, which has undergone a singular evolution due to its relative stability, the rainfall trend is downwards at the other stations. The impacts of warming and decline in rainfall are fundamentally negative on agriculture. Afouda (1990), Houndenou (1999), Ogoualé (2004), Houessou (2014) has investigated the decline in annual rainfall records in South Benin. They state that:
 - normal period (1961-1990) records an upward trend in temperatures around 0.9 °C,
 - after the outstandingly rainy sequences of the 1960s, noticeable dry sequences characterized the climatic facets of southern Benin and thus of the Ouémé delta from the 1970s. Declines in precipitation are estimated at 2.84 per cent per year in southern Benin.

The issue is to know whether this new climate in southern Benin has changed the periods of moisture, disrupted the vegetative cycle and undermined the capacity of crops to adapt to environmental challenges, particularly climatic constraints. In this context, in what terms should be assessed the use of natural resources in the Ouémé Delta?

Delta Water Resources and Hydrological Movement

- *Water Resources*
Water resources of the delta come from the Ouémé and the River Sô in addition to tributaries of the Ouovi and the Zouvi, rivers. These tributaries link the Ouémé and the river Sô. In fact, the Sô comes out of the marshes of Lake Hlan (upstream of the delta) and is fed by the overflows of the Zou. Water flowing in these two streams depends on the water level in the Ouémé and the Sô. These two rivers constitute two axes of drainage of the same hydrological system.
- *The Delta Hydrology: flood, drop in water and low water level*
The Ouémé is the main river that sets the features of the delta. The hydrological regime of the watercourse varies considerably throughout the year. The following rivers receive their waters from the Ouémé:
 - River Sô: It drains the southern part of the city of Abomey from the Lama depression to the marshes of Lake Hlan. It flows parallel to the Ouémé and receives the latter overflow waters.
 - River Sissè: it is about 7.5 km long and its source is Sissè-kpa (1 km from Azowlissè).
 - Lake Hounhoun: it is located 0.5 km west of Adjohoun at the boundary of the plateau on the right bank of the Ouémé. It spreads over a surface area of about 20.5 ha during low water periods.
 - Lake Hondjè: it is located near the village of Aglangbin, about 7 km west of Affame. Its surface area is estimated at 20 ha.
 - The Dazon is a pond located west of Azowlissè. Its surface area is approximately 18 ha.
 - The Porto-Novo lagoon is the outlet through which the waters of the Ouémé River flow into the ocean through the channel of Lagos.

Hydrological movements regulate the functioning of the delta. They fundamentally depend on the propagation of the Ouémé's flood waters (from the upper basin), the topography and rainfall inputs of the delta's own sub-basin. In addition, the water level of Lake Nokoué and that of the lagoons of Porto-Novo and Cotonou also induce hydrological movements. Moreover, ground waters influence the redistribution of water within the delta.

- **Flood and High Water period:** it covers the mean period from July to September -October. With the start of the rainy season in the upper basin, the flow of the river starts and gradually increases. The waters reach maximum storage (high water) in the delta between September and October, due to rains from June-July- August;
- **Drop in water level period:** from December onwards, the discharge of the water will lead to a decline in the water level of the bed and the drying up of the floodplains,
- **Low water period:** it generally runs from January to April. This period of low water coincides with that of the dry season over the entire Ouémé basin. It is noticeable by a low flow that sometimes may not exist. Lower flows may occur. There are more critical upstream than downstream of the delta. Bonou sometimes records 0 m³/s.

Water exchanges between the Ouémé and the Sô depend on the size of the flood. As long as the flood of the Ouémé falls within the heights 5, 50 m (NG) and 7, 50 m (NG) at the Bonou hydrometric station, the records for the Sô remain lower than that of the Ouémé. As a result the Ouovi and the Zouvi flow from the Ouémé towards the Sô, when the flood exceeds the height of 7.50 m (NG) in Bonou, the one of the So may exceed the Ouémé. The annual flooding of the Ouémé drains alluvial sediments from the upper basin to the delta. These sediments contribute to the enrichment of cultivable lands.

1.2 Pressures – potential problems / Challenges – opportunities

Summary of pressures

Overview of the risks in the Ouémé Delta: Natural disasters are seen as extreme events that result from changes in physical conditions (temperatures, precipitation...) coupled with human actions. They lead to consequences (forms of vulnerability) that are detrimental to the functioning of the delta and to the riverside communities that develop resilience strategies to tackle these consequences if they could not adapt to them. Anthropogenic actions as well as natural disasters have consequences on the Delta's functioning and on the local coastal communities.

Vulnerability of the Delta: Hydrological disturbances result in changes in peak flow rates along with a reduction of flood duration and frequency. As a result, the delta is subject to a gradual degradation of its resources, added value and functions.

Nutrient: A nutrient budget in for Lake Nokoué indicates a great influence of the anthropogenic pressure on nutrient enrichment in the Lake. This anthropogenic nutrient could be classified in local and regional pressures based on the level of decision making. Local anthropogenic pressure includes nutrient input from Ouémé catchment, from surrounding cities and from the villages on stilts (Ganvié, So-Ava, Vekky, HouedoGbadji) while regional anthropogenic pressure includes wet and dry atmospheric deposition

Pollution of soil, water and fisheries resources: The main issues of interferences in the Ouémé Basin, particularly in the delta, are the pollution of soil, water resources, fish species and the resulting water diseases. Indeed, studies have shown that through runoff water, quantities of synthetic chemicals are discharged into cotton fields from upper and middle basins and pollute the Ouémé surface water and groundwater. This pollution affects both crop soils and fish species. Moreover, the excessive use of fertilizers and plant protection products in the delta rice fields also contributes to this pollution.

Delta Vulnerability: The natural fertilization of the delta soils is reduced along with a decrease in the productivity of agriculture. There is then a hindrance to the decontamination of the delta's water. As a result one observes an occurrence of water-borne diseases (diarrhoea, onchocerciasis...) and food poisoning as the river's water is intoxicated and fish are consumed without sanitation prerequisites.

Eutrophication: The invasion of the Ouémé delta by aquatic plants, especially water hyacinth, is the concern of local communities. They consider it as an ecological disaster. The development of this floating aquatic plant species is due to the richness of the water in nutrients (phosphorus).

Types of Vulnerability: Due to the water hyacinth, there is a decrease of oxygen and light level in the water (enhancing eutrophication) and some difficulties as far as transportation of goods and people on the river axes are concerned.

Threats related to interferences in the Delta

Explanatory factors for the hydrological disturbance in the delta include a decrease in the scale of the flooding. Hydrological disturbances are related to the large volume of water per year brought about by precipitations over the entire basin. The exposure of the Delta results in a change in peak of flows along with a reduction in the duration and frequency of flooding. Consequently, the delta is subject to a gradual degradation of its resources, importance and functions.

With regard to pollution of soil, water and fisheries resources, the most important factor is that through overflow water, large quantities of synthetic chemicals are discharged into the fields from the upper and middle basins, polluting the waters of the Ouémé. This reduces soil fertility and hinders the purification of the delta. As a result fisheries products are used without any prior sanitation.

Eutrophication is also one of the concerns of the local communities. It is characterized by the intrusion in the delta through flooding of aquatic plants, mainly water hyacinth. Local communities consider it as an ecological disaster. The development of this floating aquatic plant species derives from the richness of the water in nutrients (phosphorus). However this aquatic plant turns to be an opportunity to create added values. Actually, in the Aguégoués, a private company collects and picks up water hyacinth, dried it and processes into a product that cleans the water surface of water from any form of contamination especially that related to petroleum products.

Any harsh rainfall variability is influencing flow and therefore flooding. Indeed, flooding is one of the most damaging natural disasters. This is due to natural causes, such as climate change attributable to human pollution related to greenhouse gas emissions. Different ecological units are vulnerable in the delta. This is the case of crop fields which are too late liberated from water to be sown. The variation in rainfall also threatens the delta's neighbouring population houses and buildings. Riparian habitats are flooded with water and reared animals (especially cattle) disappear or die. However, the Early Warning System is not deterrent. In spite of warnings, local communities do not often leave flooding sites, except when forced to evacuate by the authorities. The salinity of the Ouémé Delta water is the result of the combination of the continental waters and those of the lagoon, rather by different occurrences: the high water level and the low water level. A significant level of salinization of the deltaic water could be a serious hindrance to water turbidity and would gradually make the delta soils unproductive.

Threats related to interferences in the delta

Hydrological disturbances

- **Explanatory factors**
When the scale of the intervention is large (for example, the installation of a hydroelectric dam), more often the disturbances become severe. Nevertheless, there is no facility in the Ouémé delta such as a hydroelectric dam. Hydrological disturbances are therefore due to the high volume of precipitated water per year over the entire basin. The higher rainwater volume, the larger is the annual flood (with peak of flows) covering larger area.
- **Resilience and Adaptation the water hyacinth phenomenon**
The proliferation of this plant in the Ouémé Delta can be an opportunity to create wealth. In fact, in the Aguégoués a company collects and picks up water hyacinth, dries it and processes it into a product that cleans up oily waster products (from petroleum sector or for example from the fuel and oil transport from Nigeria).

Overflowing flood

Rainfall factors directly play a major role in the flow of the Ouémé; the correlation between rainfall and hydrological seasons is strong. Any severe rainfall variability influences flow and consequently the flooding. Overflowing flooding events - defined from record peak flow records- rarely exceeds 30 per year. It is one of the main natural disasters that cause the most damage. Extreme weather events are generally responsible for this type of flooding. In the Ouémé Delta, annual floods and high water levels can often drain large amounts of water to the point where floodplains are overflowed and infiltration of water takes longer than necessary. As a result, the withdrawal of the waters could then be delayed, causing the late start of the crop seasons. Those crops are destroyed (submerged) by the rains of March-April. It is a "double flood" which impacts are severe since they affect the existence of local populations, or even beyond.

- **Explanatory factors**
Natural causes (those related to climate change) are at the origin of overflowing floods. One of the manifestations of climate change is the shift in rainy seasons, with shorter wet periods along with a high intensity of rains and longer dry periods. The natural causes considered are those directly or indirectly related to human activities. In fact, through their activities and behaviours, humans continue to generate additional greenhouse gas emissions that are responsible for climate change. Hence, a steady increase of temperature of rising nearby ocean water combined with intensified local precipitations patterns lead to increased river flow and consequently the flooding of the Ouémé delta.
- **Forms of Vulnerability**
In the delta, the different ecological units are exposed especially the crop fields. Floods quit them too late to be sown. Local communities' residencies are under threat as the piled habitats are flooded with water and reared animals (especially cattle) disappear or die as a result. In addition all populations (human, animal and plant) remain exposed to all forms of water-related diseases.
- **Resilience and Adaptation to overflowing floods**
They are preventive, with the procedure of the flood Early Warning System (SAP). However, the SAP is still not deterrent. Despite the alert, coastal communities do not often leave the flood sites, except on forced evacuation by the executive branch.

Salinization of the delta waters

Studies on the salinity of the waters of the Ouémé were carried out when the Cotonou channel is open, and therefore the lagoon complex "Ouémé / lagoons of Porto-Novo - Cotonou / Lac Nokoué" communicates with the coastal sea of south Benin (Texier, 1984a). It should be noted that the salinity of Lake Nokoué as well as that of the lagoon of Porto-Novo and Cotonou varies significantly depending on whether the lake communicate to marine waters or not.

- **Explanatory factors**
The salinity of the Ouémé delta water results from the combination of two masses of water: the continental water and the lagoon water. In fact, the level of salt in deltaic waters is analyzed by considering two occurrences, that of high water and that of low water.
- **High Water Period**
The rise of the Ouémé water prevents any intrusion of marine water into the lagoon system. As a result, the renewal of Lake Nokoué water is significant, and its waters are soft, with a mean salinity of 0.2% (Texier 1960). The salt levels in the delta's tributaries are close to 0.1%. The small difference between continental and lagoon salinity levels, as well as the strength of the current, makes it hardly possible for the lake to return to the delta. The salinity of the deltaic water is therefore that of the continental water.

- **Low water level period**
During the low water level period, water inputs into the lake become important and even exceed the outputs of the lagoon waters. The lake is then enriched in salt. Therefore, at the mouth of the river Sô, the salinity is close to 2%. It is only 1% close to that of the Ouémé.
- **Vulnerability Forms**
Salinization of the deltaic waters, when of a significant level, could be a serious hindrance to water turbidity and would gradually render unproductive the soils of the delta.

1.3 Natural resources

Summary of pressures of natural resource layer

Summary of pressures

Mangroves Mangrove ecosystems constitute valuable resource for community livelihoods in the delta. They provide habitats for flora and fauna species, protect the coast against erosion and supply various products for local communities. Unfortunately, mangroves are overused and degraded.

Species diversity This diversity of the Ouémé delta is characterized by a plethora of animal, plant and microbial species. Not all organisms living there are fully inventoried although knowledge about existing biological resources is intensive. The most comprehensive study of the fish fauna of the Ouémé identified 122 species of fish in general and 50 families. The most representative species were Mormyridae, Cichlidae, Characidae, Cyprinidae and Gobiidae, respectively. Avifauna is dominated by the francolins (*Francolinus bicalcaratus*), water hens (*Gallinula chloropus meridionalis*), *Ploceus cuculatus* (weavers) and *Spermites nonettes* (Adjakpa, 2001). The manatee and otters are the most common aquatic mammals (Kidjo and Guédou, 2001). Reported terrestrial wildlife include: cephalopes (*Sylvicarpa grimmia*, *Cephalopus niger*), warthogs (*Phacochoerus aethiopicus*), hares (*Lepus crawsharyi*), primates (*Papio anubis*, *Cercopithecus aethiops*), many rodents (*Thryonomys swindwrianus*, *Xerus erythropus*, *Heliopsis sciurus gambianus*, *Arvicanthis niloticus*, *Cricetomys gambianus*), and reptiles (*Python sebae*, *Varanus niloticus*, *Crocodylus niloticus*).

Fish resources The foundation of traditional active fishery activities in the Agouégués is the wealth in fishes in the Ouémé delta and then in animal proteins. A wide range of fishing techniques with devices and instruments are locally designed and manufactured: canoe, net, line, cup, basket... They are adapted to the different hydrological phases of the Ouémé delta (rising water, high water and low water level periods) for the capture of specific species. Fishing activities are carried out both in the river and also in the fish holes. The latter is a natural aquaculture technique, an intensive way of raising and exploiting fisheries resources.

- Research gaps**
- perceptions of local communities on the dynamic of mangrove forest and their acceptable participation forms for mangroves restoration
 - understanding the shift in the system from freshwater species to marine water species and from insectivorous fish to detritivores fish
 - valuation on ecosystem services provided by the delta

Ecosystem services in the Ouémé Delta

The value of a wetland, particularly a delta, can be assessed according to the direct use of the natural resources available to produce goods and services to meet human needs. In the Ouémé Delta, natural resources are extensively exploited. Table III shows the distribution of natural resources according to the topo-sequence.

Major socio-economic activities

The Ouémé delta is hydrologically dynamic by nature. This is reflected in the seasonal patterns of use of natural resources available. In the course of the year, different activities are carried out according to the availability of resources in the one hand, and the different

phases of the hydrological regime of the Ouémé on the other hand. The main socio-economic development activities are agriculture of low water level period, inland fishing and livestock. However, sand mining is an emerging activity throughout the delta.

• *Soil Resources and Agriculture*

The factors that make the Ouémé Delta soils suitable for agriculture include the moisture in dry season, the addition of sediments and nutrients through flooding and the alternation of dry and wet conditions. In this part of the wetlands of South Benin, crops growing system is that of off-season or low water level period. It is usually a traditional monoculture farming mainly practiced in the municipalities of Bonou, Adjohoun, Dangbo and part of the Aguégus.

Farming is practiced every year, without pressure on the land according to cultivated speculations, in the floodplain, on riverbank beads and the outskirts of the holes to catch fishes. The soil of the riverbank and that of embankments are usually used to grow peppers, tomatoes, gombo, and other vegetables.

While floodplain soils are used to grow corn, cassava, beans, and potato crops, taro is grown on lowlands soils. However, bank beads may also be used to grow crops grown in floodplains. Cropping activities start on during the shift period between the end of low water level period and the start of cultivation operations extend over the entire period during which crops are harvested. Shoreline burrows are cultivated earlier because they are more quickly cleared, while floodplains receive crops late due to the late withdrawal of river waters.

• *Water resources and supply of local communities*

The River water in the delta is used by riparian communities for drinking, household work (crocker and laundry) and a wide range of activities. This water is also the throwing away ground for human waste from local populations, and therefore a source of pollution.

• *Plant Resources and Livestock*

The herbaceous environment in the Ouémé Delta is a feed resource for oxen feeding. Farmers-breeders lead their herds of oxen to the water reserves and grassland during low and high water periods. During the flood and high water periods, oxen are parked in barns where they are fed (Picture3): It is a period of great vulnerability for the herd.

• *Other activities*

In addition to transportation and tourism services the Ouémé delta communities carry out other activities.

Transport by motorized boat of forest and products and goods



Sand extraction from the bed of the Ouémé during low water level period

• *Transportation and Tourism Services*

Transportation The Ouémé Delta Water facilitates the transport of people and goods. The transport service is carried out at all times throughout the year, especially during high waters seasons. The service operates canoes and motorized boats or not.

Tourism service As a natural environment, the Ouémé Delta is an important scenic attraction. As it is more nature-oriented, ecological tourism is an emerging activity with a considerable contribution to local development.

Sand mining Since the closure of the coastal sea quarries of sand in Benin, several other sites have been opened in the Ouémé delta and around Porto-Novo lagoon. In the event of flood or low water, or even of low tide, the sand of the bed of the Ouémé is exploited by the coastal communities. Men are more suitable for submerged sand quarries, while women are suitable for emerged ones. Sand extraction from the bed of the Ouémé during low water level period

Attributes of natural resources

Biological diversity is one of the indisputable assets of the Ouémé Delta. Indeed, the term 'biological diversity' has now become a cult concept. It appears as the whole variety of life (part of an interdependent system) in a milieu. Thus, biodiversity applies to genes, animal and plant species, ecosystems and landscapes. The Ouémé Delta as an integral part of the southern Benin freshwater wetlands is a major area of biological diversity due to its geomorphologic and ecological units. The Ouémé delta is characterized by its alluvial plains (floodplains) and a large concentration of animal and plant species, endemic species. It is even a refuge for many rare or endangered species. In most cases, it provides temporary but essential habitats for a wide variety of migratory species, particularly avian ones. As a result, the Ouémé Delta is home to a plural life marked by diverse species, genetics, ecosystems and landscapes: it is thus a major area for the conservation of regional and international biodiversity.

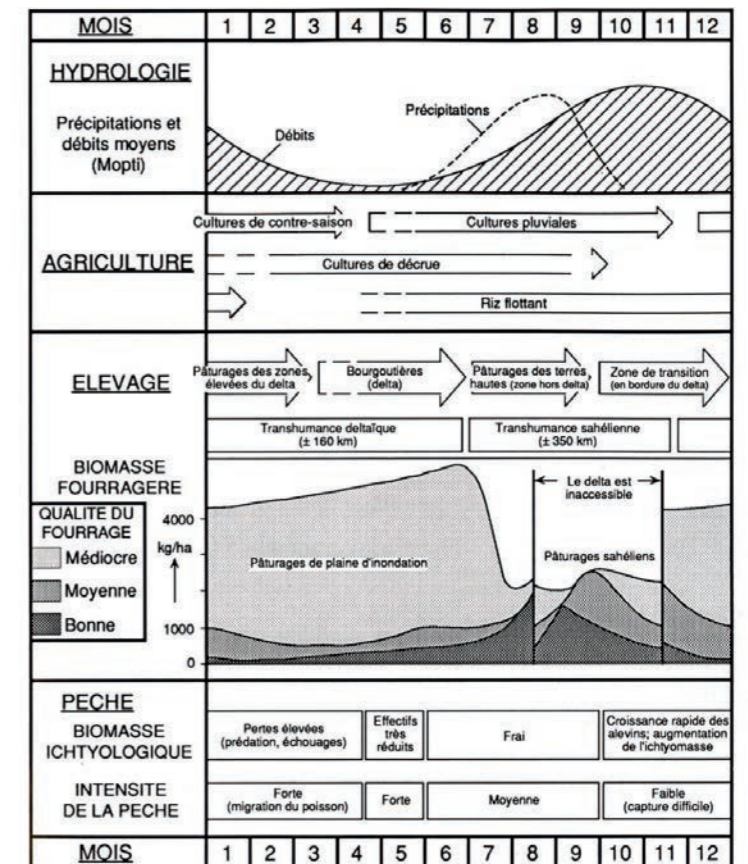


Figure 3: Hydrological movements and variations in types of exploitation in the Ouémé Delta (Drijver & Marchand)

- Genetic diversity**
This type of diversity calls to minds the variety of genes within species. The vast wealth of species in the delta induces variety of appearances or faces and reflects the genetic specificity of each appearance.
- Diversity of ecosystems**
The Ouémé delta is a set of ecosystems made up of different plant formations, designed by the tributaries and a valley in a constant evolution. Prior to human interventions, plant formations in the lower Ouémé Valley used to belong to a dense domain of wetland forests. Each year these forests were occasionally flooded on their high sandy soils part. The neighbouring rainforests are rather inundated on their clay soils. Today, the wetland forests have been transformed into palm groves or cultivated fields with the exception of a few sacred islets. As for the riparian rainforests, they are reduced to only a dense shrub filled with climbing plants (Sokpon and Adjakidjè, 2001). In the delta, almost all of the herbaceous strata disappear during low water level period for given place to crops.
- Landscape Diversity**
This diversity reflects the human footprint on the environment. In fact, through the development of socio-economic activities in the delta, the human species has developed and transformed plant formations and biotopes. The communities bordering the Ouémé delta refers to various traditional techniques as far as agriculture and fishing are concerned. They have, over time, shaped the environment in landscapes whose qualities and diversity bring a cultural aesthetic touch or not to the delta.
- Access to Natural Resources**
According to regulations in Benin, water bodies and neighbouring lands standing less than one meter above sea level are public property. However, in the Ouémé Delta, this legal measure is insufficiently enforced. Indeed, all areas where natural resources are available are exploited by the coastal communities. These communities rely on customary law (traditional inheritance law) and claim to be the legitimate owners on fields or sites of exploitation of other natural resources. While laws in Benin are supposed to regulate access to natural resources for a rational use by the population, in the Ouémé Delta legislation is not respected by any actor for access to and protection of natural resources. These facts are to the detriment of international conventions to which Benin has adhered.

1.4 Governance (institutional/organizational aspects of delta management)

Benin's legislation for environmental management

In Benin, the rational and efficient exploitation of natural resources are governed by legislation (under the national and communal agendas) and by international conventions to which the country has adhered to. This policy is following a view to sustainable development conducive to the protection or conservation of natural resources on a human scale, and thus of the environment

Institutional interventions: The Beninese State is making interventions in the Ouémé Delta, especially through the Ministry of Agri-

culture, Energy and Mines in cooperation with other international partner institutions. To this end, a number of hydroelectric development projects in the delta have been initiated and carried out by the State, especially in the municipalities of Adjohoun and Dangbo. These projects include : the Pilot Project for Hydro-Agricultural Development in the Ouémé Valley, Dahomey, Phase II (1974), the Project for the Rehabilitation of Agricultural Land in the Ouémé Valley (1995), the Project for Agricultural Development and Intervention in the Ouémé Valley (PAIAVO, 2016) ... etc.

Summary of governance issues

These various projects are part the continuation of agricultural development and development projects in the Ouémé Valley, particularly those devoted to rice farming in the 1960s. It should be noted that by now in the 1940s, the Ouémé delta was the focus of several French cooperation projects relating to hydro agricultural development.

Governance and management framework Governance within the Delta involves a variety of actors. Traditional and modern bodies work out a certain authority in natural resources and land management at the local level. Traditional power rests primarily on heads of families, communities and traditional leaders. Community involvement in environmental issues and natural resource management are based on the specific characteristics of each area. In addition, socio-professional organizations actively exercise management power over the resources in the Ouémé Delta

Table 1: Overview of the institutional framework of the Ouémé Delta.

Socio professional organizations	Business domains
Fishermen Association	<ul style="list-style-type: none"> Fight against the use of tight mesh nets commonly known as 'Mèdokpokonou Ensuring proper management of resources and proper organization of fishing activities Cleaning up the lake by clearing the water Jacinths
Todjinagnon Syndicate	<ul style="list-style-type: none"> Settlement of conflicts around Lake Nokoué Fight against the use of 'Medokpokonou' and Acadja Combating the collection of fry and other small fisheries resources
Association of Acadja Practitioners	Settlement of conflicts related to use of Acajas
Farmers Association	Promoting Agriculture
Hunters Association	Prohibiting Wildlife Hunting of endangered species and protected wildlife
Associations of market gardener women	Ensuring Good Resource Management
Women's Association; Gbedougbe; Wangninangbe	Ensuring higher economic profitability of fishing activities
Net weavers group	Fighting against weaving very tight mesh nets
Fishermen Group	Shrimp Industry Promotion
Fishing Committee	Settlement of fisheries-related disputes
Allomawle wèvi	Practicing sustainable hand fishing
Youth Associations	Developing the locality

It is worth noting that some Community Committees for Environmental Protection (CCPE) have been established. As an instrument for the conservation of natural resources, the CCPEs are involved in education, awareness raising and information to communities on the issues and risks associated with habitat destruction and the loss or decline of the Delta's fisheries resources. State-based forms of modern management of intervention alongside the Delta follow an administrative hierarchy: village or neighbourhood chief, district chief and mayor. As modern structures, many NGOs operate in the different areas of the Delta and go for a sustainable management of natural resources and environmental protection. For example, CREDI NGO works for the protection of biodiversity and the promotion of tourism in the municipality of Sô-ava. It is specialized on forests and agricultural estates protection. Its activities consist in monitoring the fauna and its habitat and reforestation. Nature Tropicale NGO in Hozin also takes actions in biodiversity and tourism. It deals with the protection and monitoring of manatees and sea turtles. AMAF-BENIN NGO involved in environmental protection with campaigns for mangrove reforestation and manatee protection.

BEES NGOs, more active in the field, is involved in the protection and monitoring of birds, in the wildlife habitat protection and in local development. Although these NGOs are well represented in the Delta, their activities do not cover the extent of the lake and above all do not impact the major effects of the degradation of the reserve's resources. This is due to sand quarries which remain the major sources of coastal erosion. In addition, the establishment of the Acadja systems or fish holes appears to be a source of congestion and alteration of the quality of the lake's water. As a result, it follows a degradation of the Delta's resources.

There is a need of urgent action to prevent the progressive loss of wildlife habitat, the congestion and eutrophication of waters. As well, field surveys have shown that the various structures involved in the site management lack technical coordination. Cooperation between these structures deserves to be strengthened.

The institutional framework of the Ouémé Delta

The institutional framework is embodied by ministries, agencies and diverse structures. They are responsible for the management of natural resource, wetland and land on the one hand, and of water use planning and regulation on the other hand. These structures are:

- Ministry of living and Sustainable Development (MCVDD) and its Technical Directorates
- Ministry of Agriculture for Livestock and Fisheries for hydro agricultural and hydro-pastoral development and regulation of fisheries;
- Ministry in charge of water through the General Directorate for Water and its technical departments;
- Ministry of Decentralization and Local Governance (MDGL) through local authorities;
- Beninese Environment Agency (ABE), which is the Administrative Authority of the Ramsar Convention in Benin and therefore quarters the focal point;
- General Directorate for Water, Forests and Hunting (DGEFC) and its local representative structures;
- National Wildlife Area Management Center (CENAGREF);
- Delegation to the Planning of the Territory (DAT);
- Benin Institute for Fisheries and Ocean Research (IRHOB).

Major undergoing projects

PAIAVO (2016)

The overall objective of this ongoing project is to improve land productivity, to value and increase the volume and export of farmers.

This project will specially contribute to:

- developing production infrastructure;
- exploit the lands of the lower and middle Ouémé Valley for the promotion of growth-enhancing sectors.

The project is structured around three main components: (i) Development of agricultural infrastructure; (ii) Development support and capacity-building; and (iii) Project management.

Clean water supply

The Ouémé delta is an area of big human concentration. This space has remained for a long time without any sanitation and it continues to be so. There is lack of the sanitation that must provide clean water to local populations. However, the thermal springs of Hêtin-Sota and Gbeko have recently been developed, with the installation of water pumping and retention plant. This intervention permits the supply of drinking water to the local communities.



Drinking water collection plant, built on the site of the thermal spring of Hêtin-Sota.

OmiDelta Program 2017 - 2021

This program is designed to improve water and sanitation sectors in the Ouémé River Delta. Even in 2017, many Beninenses are still facing clean water supply and suffering from water-borne diseases because of the poor sanitation of their living environment. To tackle this issue, the Embassy of the Kingdom of the Netherlands, through the Dutch Development Organization (SNV), has initiated a program called OmiDelta Non-State Actors Fund (ANE) to respond to the Government of Benin's desire to provide clean water to the local population by 2021. This anticipates Goal 6 of Sustainable Development (SDG), which calls for universal access to clean water by 2030.

Planned institutional interventions

Other types of the State interventions to make the Ouémé Delta viable, such as electricity supply through the construction of hydroelectric dams, clean water supply, etc., remain at the project stage. However they are included in the government's action plan (2016-2021). These following can be mentioned:

- Innovate in the development of the lake city of Ganvié;
- developing the low and middle Ouémé valley;
- Converting the shores of the Cotonou lagoon and clean up its water;
- development of the Porto-Novo lagoon.

Actions by civil society organizations

The sustainable management of the Ouémé delta wetlands includes several national NGOs. They are involved in the protection of biodiversity and ecosystems.

The program Shared Resources, Joint Solutions (SRJS), i.e. "Shared Resources, Common Solutions (SRJS)

In Benin, the SRJS program operates at the level of the Ouémé Delta. It is jointly managed by a national committee which comprises three (3) national NGOs that collaborate with several other NGOs acting as service providers. The aim of CSOs involved in the agenda is that "by 2030, actors at the national and local levels are fully aware of their impacts on ecosystems, are working at the political, strategic and operational levels for a sustainable ecosystem management so that they can provide the services needed for the World Public Goods (GPP) in an optimal manner".

- *Support for the establishment of the Grand Nokoué Inter-Community Reserve (RIGN) implemented by BEES NGO*

The lower Ouémé delta (Lake Nokoué, the Porto Novo lagoon and the Ouémé and Sô rivers) or the "Grand Nokoué" complex of the RAMSAR 1018 site is Benin's largest wetland complex in terms of biodiversity and one of the largest lagoon complex in West Africa. However, the increasing escalation in the development of natural resources by a growing local population poses a major risk of resources scarcity and decline. The impact of these various pressures on this ecosystem is reflected in the gradual disappearance of species of flora and fauna (especially mangrove and fish species), a gradual drying up of floodplains and a degradation of shorelines because they have to be cleared for fisheries. Moreover, there is a significant reduction of spawning grounds, and silting increase through solid deposits due to erosion of soils in the watershed. The project "Support for the creation of the Grand Nokoué Inter-community Reserve (RIGN)" of the FFEM/IUCN-CF PPI program and IUCN-NL will help the establishment in the main municipalities of more effective mechanisms for the management of wetland ecosystems.

- *Sitatunga Valley Initiative implemented by CREDI NGO*

In 2006, CREDI-ONG discovered the biological richness of the wetland in which it had settled through the creation and operation of the farm Pantodon. Under the charm of this particular ecosystem, it has been campaigning since November 2007 for the creation of the Community Natural Reserve of the Sitatunga Valley. This reserve protects a natural depression of southern Benin. The Wawa River, located upstream of the RAMSAR complex No. 1017 and tributary of the Sô River (in the process of being filled in) crosses over the Community Natural Reserve of the Sitatunga Valley. (Cf. maps and satellite photo). This reserve is essentially made up of shallow waters and floodplains. It covers nearly 13,000 acres and includes some fifteen villages belonging to three municipalities: Abomey-Calavi, which holds the largest area (district of Zinvé), Zè upstream with a dead arm of the Sô River and finally Sô-Ava with three lakeside villages bordering the reserve. Near the villages, one can find forest islands and groves. These are sacred forests that have an essentially religious and ethnobotanical value, and play an important role in biodiversity.

- *Project for the Development of Water Jacinth through Composting implemented by ACED NGO*

Water hyacinth, one of the fastest growing in the plant world, is an invasive species that affects the aquatic biodiversity of Lake Nokoué. As it decomposes in the natural environment, it emits methane, a potent greenhouse gas. The objective of the project is to contribute to the reduction of greenhouse gas emissions and to the sustainable protection of the fisheries biodiversity of Lake Nokoué.



Delta Sustainable Management: a summary

Guiding Principles

Sustainable use in this context is defined as the human use of delta resources (soil, water, flora, fauna, nutrients) so that present generations can derive maximum satisfaction and benefit, while maintaining the delta's capacity to meet the needs of future generations. Several principles contribute to a sustainable management of the Delta. These principles include: Preserving the functions of the delta; involving local communities and the integration of conservation activities.

Analysis restricted to the SWOT model

The requirements of any environment for improving biophysical and human conditions are based on a SWOT diagnostic analysis (Strength - Weakness - Opportunity - Threat) which highlights, among other things, the opportunities and the threats. The Ouémé Delta was analysed under such SWOT principles.

The Ouémé delta: Opportunities and Threats

The goods and services (ecosystem services) produced from the (potential) exploitation of the various natural resources that proliferate in the Ouémé Delta, constitute opportunities for the actors involved in its development especially the peasant communities. The natural resources represent sustainable means for living or may supply other consumer markets to satisfy the existential needs of other populations. Inconsistencies in accessing these natural resources producing these goods and services are threats to livelihoods in the delta and their future growth opportunities.

2.1 Levers for sustainable management

In spite of the opportunities and threats mentioned above, there are ways to strengthen the opportunities offered by the Ouémé delta on the one hand, but also to gradually mitigate the threats that constrain the efficient exploitation of the fragile Ouémé delta environment from a sustainable development perspective. Such a management vision integrates human resources leadership, the guiding principles of management as well as their administration. These aspects can ideally be considered to be the levers of an efficient hydro-agricultural development project. This section provides a comprehensive approach for managing the delta. In this context, it is imperative to integrate the anticipated needs of the coastal communities, the constraints they have to tackle, and the delta's human development potential. Regardless of management options, the choice of the type of development to be carried out must be made in full knowledge of all the characteristics of the delta. The SWOT model of analysis is one of the appropriate tools for assessing an eco-productive wealth management.

2.2 Impacts of sustainable management

The rational use of the Ouémé Delta must consist of sustainable exploitation benefiting the bordering catchment communities and Benin and neighbouring countries. Exploitation levels that are compatible with safeguarding the delta ecosystem properties and carrying capacity. Sustainable use is defined in this context as the human use of delta resources (soil, water, flora, fauna, nutrients) so that present generations can derive maximum satisfaction and benefits, while maintaining the delta's capacity to meet the needs of future generations. The approach advocated here is largely based on considerations of sustainable use. It has several guiding principles.

Guiding Principles

Through these principles, the value of the resources (natural and human) of the Ouémé Delta could be maintained, as well as the essential benefits that these resources provide. Indeed, when the benefits of delta goods and services are altered or disappear as a result of an ill-considered intervention (for example, mismanagement of resources, overexploitation or contamination), it is only possible –in the best case - to recover them partially and at great expense.

- *Preservation of the Ouémé delta functions*
The Ouémé Delta is an environment with a large and diversified potential for goods and services in addition to many other functions. Any sectoral approach in terms of development and protection of natural resources aims to increase a certain category of benefits related to such resources (agricultural, fisheries, biological, building materials, land reclamation, et .) to the detriment of other benefits or interests. Therefore, in accordance with the sustainable use, as previously stated, it is imperative that resource development and protection plans and projects aim to maintain or, even better, to optimise the level of productivity and resilience of the resource mosaic that characterizes the Ouémé Delta.
- *Involvement of local communities*
It is not uncommon to see the effective involvement of local communities at all stages (from conception to operationalization to elaboration) of a project in the Ouémé delta. This lack of participation of local communities is one of the most important reasons the management of natural resources often do not improve. Exemplary are the failure of for example hydro-agricultural development programs like SONIAH and SADEVO in the delta. Also, most approaches of involving local communities commonly ignore the priorities of these communities, and the ways and knowledge they use to tackle delta constraints.

In addition, this vision of projects does not take into account the heterogeneity of the local population and the different interests of the various social groups therein may have. As a result, projects lack essential information, ignore opportunities to promote sustainable self-centred development, and marginalize local or rural populations socially and economically.

Integration of conservation activities

The principles of rational delta resource use imply that conservation actions in the Ouémé delta should be undertaken to protect the value, attributes and functions of natural resources of the Ouémé Delta. The value of the delta's natural resources to human depends on the maintenance of its properties. In addition, conservation measures may require only for a period of the year the prohibition or limitation of some activities of local communities and other ones that depend on the Delta resources.

In fact, protection and conservation actions are a long-term enterprise. Their expected benefits to date have rarely made it possible to increase the income of local communities, or to meet their short-term needs. These actions must not only integrate educational activities, but must also provide local communities with new sources of income or alternative solutions that can at least sustain the lives of these communities.

Analysis restricted to the SWOT model

Improving biophysical and human conditions in any environment requires a SWOT diagnostic analysis (Strength - Weakness - Opportunity - Threat) which highlights, among other aspects, opportunities and threats. The Ouémé Delta was analysed through that lens.

The Ouémé delta: Opportunities and Threats

The goods and services (ecosystem services) produced from the exploitation of the various natural resources that proliferate in the Ouémé Delta constitute opportunities for the actors involved in its development especially the peasant communities. Actually, the natural resources represent means for living or may supply other consumer markets to satisfy the existential needs of other populations. By contrast, all issues challenging access to these natural resources in order to produce these goods and services are threats to these opportunities.

2.3 Opportunities / Assets

Opportunities in the Ouémé Delta greatly depend on the natural resource strengths or potential for development. Some of the advantages that favour the development of the Ouémé delta include:

- availability of natural resources (water, soil, flora, fauna) with a great development potential;
- natural fertilization of the soil by annual floods;
- possibility of crop diversification;
- possibility of relaunching the rice sector by making the environment favourable to rice culturing;
- generalizing group use of small equipment of common interest by farmers, thus giving them autonomy for threshing and machining
- availability of agriculture-oriented workforce;
- full support from all the peasants for the idea of developing the delta;
- strengthening the links between research and support structures and farmers;
- possibilities in the short term to transfer a technological package (high-performance plant material, appropriate farming techniques, smart landuse, etc.) to a farming environment which is adapted to the delta;

2.4 Threats / Constraints

The local communities have to tackle numerous constraints. Different laws define prospective threats: (National Agenda 21, 1997; Environmental Framework Act, 1999, National Environmental Action Plan). In this regard, the major constraints which hinder the real-time development of natural resources for sustainable human development include:

- difficult access to natural resources and loan for exploitation;
- lack of water control;
- a traditional extensive culture system which cannot support a substantial and increasing improvement of productions;
- Siltation of the lowest parts of the delta;
- lack of drainage of the soil, which along with the shallow groundwater, frequently leads to rainwater upwelling that floods crops;
- congestion of the river bed by fishing dam materials;
- pollution of continental waters (surface or groundwater) due to the different emissions (solid and/or liquid wastes, synthetic chemical fertilizers, etc.) from communities bordering the delta or elsewhere;
- Blockage of delta circulation limiting exchange of migrating and spawning biota and also disrupting natural sand and water balances.
- invasion of the delta water by floating vegetation, in particular water hyacinth;
- plunder of crops ,in particular cereals, by granivorous birds and other parasites;

With regard to these opportunities and threats, some levers are suggested for a dual objective: strengthening opportunities and mitigating threats. These levers incorporate the imperatives of effective and sustainable management of the Ouémé Delta. These imperatives include management, leadership and administration.

2.5 Prospects

The Ouémé River Delta (DFO) is one of the special and richest ecosystems in Africa due to its biodiversity, its potential in ecosystems, and its membership in the Ramsar 1018 site and on which the survival of several municipalities depends. It needs specific strategies for its sustainable exploitation. In view of the problems and challenges mentioned above in table IV, which could be summed up as poor land use, over-exploitation of resources, various pollutions, floods, etc. Therefore it is urgent to take concrete actions for its development by 2020-2030, these actions may include:

- the completion of other programs such as the Omi Delta program, which is committed to the DFO's implementation through the achievement of AEPHA projects and IWRM with key cross-cutting themes (governance, climate change, etc.),
- the promotion of DFO as one of the leading destinations in South Benin and as one of the main objectives of CSOs through eco-tourism activities,
- EIE on the exploitation of existing sand quarries and other quarries and the prospective to be exploited,
- the legal protection of emerging areas or deteriorating biodiversity,
- the establishment of capacity building initiatives of local actors to promote natural practices and techniques for the breeding and exploitation of natural resources,
- the implementation of key developments (hydro-agricultural, electric, etc to meet certain population survival needs.



The Ouémé Delta is unique in terms of social and ecological richness and signifies one of the few West African regions with an extraordinary range of ecosystem services, functions, values and attributes. Despite the fact that the Ouémé Delta, being an integral part of the wetlands of South Benin (Ramsar sub-site 1018, 1971), is an UNESCO World Heritage Site, current practices and interventions by both local communities and institutions (in public-private partnerships), inside or outside the delta basin, continue to lead to a further degradation with severe delta resources impacts to come.

Our assessment on the status and trends of the Ouémé delta show clearly that the resources in the Delta, in particular the available soil resources, were to a great deal driven by natural dynamics favourable to the renewal of soil quantity and quality. As a result, these delta resources have a considerable advantage offering better opportunities to the coastal and institutional communities. Consequently different forms of intervention are still being upscaled and extended in the delta in order to take advantage of these natural resources, including soil and water.

Nowadays these interventions have gradually contributed to a reduction of these underlying dynamics as well as the availability of the natural resources, lowering the opportunities offered by the delta. Now the delta system is degraded by various forms of threats and clearly challenges current development objectives and environmental protection. For the Ouémé delta, there is then an urgent need for an appropriate hands-on sustainable management approach. A proactive integrated approach, more inspired by legislation, that could reintroduce the natural dynamics and enable the Ouémé Delta to gradually recover its functions, values and attributes.

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ANNEX: Types of plant formations in the Ouémé Delta

N°	Types	Floristic composition	Dominant species	observations
1	Dense humid and Semi-deciduous rainforest	<i>Albizia ferruginea</i> <i>Antiaris toxicaria</i> <i>Chrysophyllum albidum</i> <i>Milicia excelsa</i> <i>Albizia glaberrima</i> <i>Lannea welwitschii</i> <i>Terminalia superba</i> <i>Daniellia ogea</i> <i>Pycnanthus angolensis</i> <i>Celtis mildbraedii</i> <i>Celis adolfi-friderici</i> <i>Celtis zenkeri</i> <i>Holoptelea grandis</i> Etc	<i>Albizia spp</i> <i>Terminalia superba</i> <i>Celtis spp</i>	Relics of forests on discharged from water soils. Most are "fetish forests"
2	Gallery forests	<i>Cynometra megallophylla</i> <i>Pterocarpus santalinoides</i> <i>Cola gigantea</i> <i>Cola laurifolia</i> <i>Dialium guineense</i> <i>Vitex chrysocarpa</i> <i>Kigelia africana</i> <i>Berlinia grandiflora</i> <i>Mimosa pigra</i> <i>Napoleonaea leonensis</i> <i>Quisqualis indica</i> <i>Morelia senegalensis</i> <i>Antidesma venosum</i> Etc	<i>Cola laurifolia</i> <i>Dialium guineense</i> <i>Pterocarpus santalinoides</i>	These forests are located around the river and its tributaries.
3	Shrub savannah	<i>Tarkia biglobosa</i> <i>Vitellaria paradosea</i> <i>Terminalia glaucescens</i> <i>Terminalia avicennioides</i> <i>Anogeissus biocarpus</i> <i>Bridelia ferruginea</i> <i>Ficus gnaphalocarpa</i> <i>Albizia zygia</i> <i>Morinda lucida</i> Etc	<i>Terminalia spp</i>	This type of savannah form a mosaic with gallery forests and islets of forests
4	Summerfallows	<i>Paspalum vaginatum</i> <i>Echinochloa pyramidalis</i> <i>Phragmites karka</i> <i>Ipomoea aquatica</i> <i>Andropogon gayanus</i> <i>Ludwigia spp</i> Etc	<i>Echinochloa pyramidalis</i> <i>Phragmites karka</i>	These wetlands occupy the largest part of the delta
5	Marsh grasslands	<i>Paspalum vaginatum</i> <i>Echinochloa pyramidalis</i> <i>Phragmites karka</i> <i>Ipomoea aquatica</i> <i>Andropogon gayanus</i> <i>Ludwigia spp</i> Etc	<i>Echinochloa pyramidalis</i> <i>Phragmites karka</i>	These wetlands occupy the largest part of the delta
6	Swampy forests	<i>Mitragyna inermis</i> <i>Nauclea pobeguunii</i> <i>Anthostema senegalense</i> <i>Alstonia boonei</i> <i>Cleistopholis patens</i> <i>Bosqueia angolensis</i> <i>Ficus vogeliana</i> <i>Anthocleista vogelii</i> <i>Berlinia grandiflora</i> Etc	<i>Cleistopholis patens</i> <i>Bosqueia angolensis</i> <i>Ficus vogeliana</i> <i>Nauclea pobeguunii</i>	These wetlands occupy the largest part of the delta

N°	Types	Floristic composition	Dominant species	observations
7	Floating pastures	<i>Eichornia crassipès</i> <i>Pistia stratiotes</i> <i>Lemna paucicosta</i>	<i>Eichornia crassipès</i>	These pastures are on the water
8	Artificial pastures	<i>Cocos nucifera</i> <i>Tectona grandis</i> <i>Acacia auriculiformis</i> <i>Cassia siamea</i> <i>Alaëis guineensis</i> Etc	-	-
9	Cultivated farmlands	<i>Panicum maximum</i> <i>Melochia corchorifolia</i> <i>Tridax procumbens</i> <i>Pennisetum purpureum</i> <i>Pennisetum polystachyon</i> <i>Sorghum arundinaceum</i> <i>Malvastrum cocomandelianum</i> <i>Ludwigia spp</i> <i>Corchorus spp</i> Etc	<i>Panicum maximum</i> <i>Sorghum arundinaceum</i> <i>Pennisetum purpureum</i> <i>Pennisetum polystachyon</i>	These are fields of corn, cassava, tomatoes, beans, etc.

