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Review paper

Acadja and Whédo fisheries in southern Benin (West Africa): Functioning and impacts on waterways and local communities (Bibliographic approach)

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Abstract

Acadjas (fish parks) and whédos (fish holes) are traditional fishing devices widely used in southern Benin, particularly in coastal lagoons and lakes (Nokoué, Porto-Novo, Ahémé). Using a bibliographic approach, we reviewed the history, characteristics, fish species caught, productivity, and socio-economic and environmental impacts of each system. These techniques play an important role in local fish production by increasing fish concentration and facilitating their capture. The productivity of traditional acadjas varies from 150 to 200 kg/ha/year and can range from 4 to 20 tons/ha/year with a highly diversified fish fauna (nearly 55 species) dominated by Cichlids (up to 95%), notably Sarotherodon melanotheron. The productivity of whédos is on average 1.31 tons/ha/year, comprising around 11 species with a predominance of catfish (up to 83.9%), notably Clarias gariepinus and Clarias ebriensis. These fishing techniques contribute significantly to food security, income generation, and the preservation of indigenous knowledge in riverside communities. However, the unregulated expansion of acadjas and whédos has significant environmental impacts, such as reduced navigation areas, degradation of aquatic habitats, eutrophication, and overexploitation of fishery resources. Long-term declines in productivity are increasingly being observed. Thus, although these systems are effective and culturally important, their sustainability depends on integrated management, combining regulation, ecosystem restoration, and the involvement of local communities.

Keywords: Traditional systems; Acadja; Whédo; Socio-economic impacts, Environmental impacts.

Introduction

Fisheries production in Benin, particularly in the south of the country, is an essential activity for the local economy and the livelihoods of coastal communities[1]. In addition to individual fishing techniques such as nets, lines, and traps, local communities in lower Benin have developed innovative methods to make the most of the fisheries resources in their waterways. Among these, the use of acadjas and whédos stands out as traditional techniques deeply rooted in the cultural practices of local communities[2]. These methods are widely used in the marshlands and lagoons of southern Benin, where aquatic ecosystems play a crucial role in both biodiversity and the economy of local residents[3]. Acadjas, often described as artificial fishing enclosures created using branches and other plant materials, are installed in marshy areas to attract and capture various species of fish[2]. Whédos, on the other hand, are fishing techniques that use nets or traps to catch fish in specific areas of waterways[4].

However, although these methods are effective in maximizing fish yields, their operation and impact on waterways are raising growing environmental concerns. Whédos, for example, alter aquatic habitats by trapping young fish and disrupting the natural balance of aquatic ecosystems. Similarly, the impact of whédos on biodiversity and water quality remains a subject of analysis. This study, which uses a bibliographic approach, aims to examine the history and functioning of cadjas and whédos, as well as their direct and indirect impacts on waterways and local communities. By analyzing the economic benefits for local populations as well as the environmental effects, this study will provide a better understanding of how these different practices can be improved.

Fish production from Acadja fisheries

History of acadjas: Acadjas first appeared on Lake Nokoué in southern Benin (West Africa) and owe their origin to the fishermen of Sô-Tchanhoué in the commune of Sô-Ava (Figure-1). The fishermen first came up with the idea of "*ahlos*" which we will define later, when they noticed the abundance of fish around the mangrove stilts that once lined Lake Nokoué[5]. But during the last years of the 19th century, the aquatic plants that covered the marshes had withered and disappeared due to the artificial opening of Lake Nokoué to the sea by the colonial administration on September 21, 1885, which had made the water of Lake Nokoué salty[6]. The amphibious forest formations had died out. To compensate for the disappearance of the "*ahlos*", a substitute technique was developed by a fisherman named WINSOU from Sô-Tchanhoué. The idea was to recreate a similar artificial environment by creating real parks out of branches.

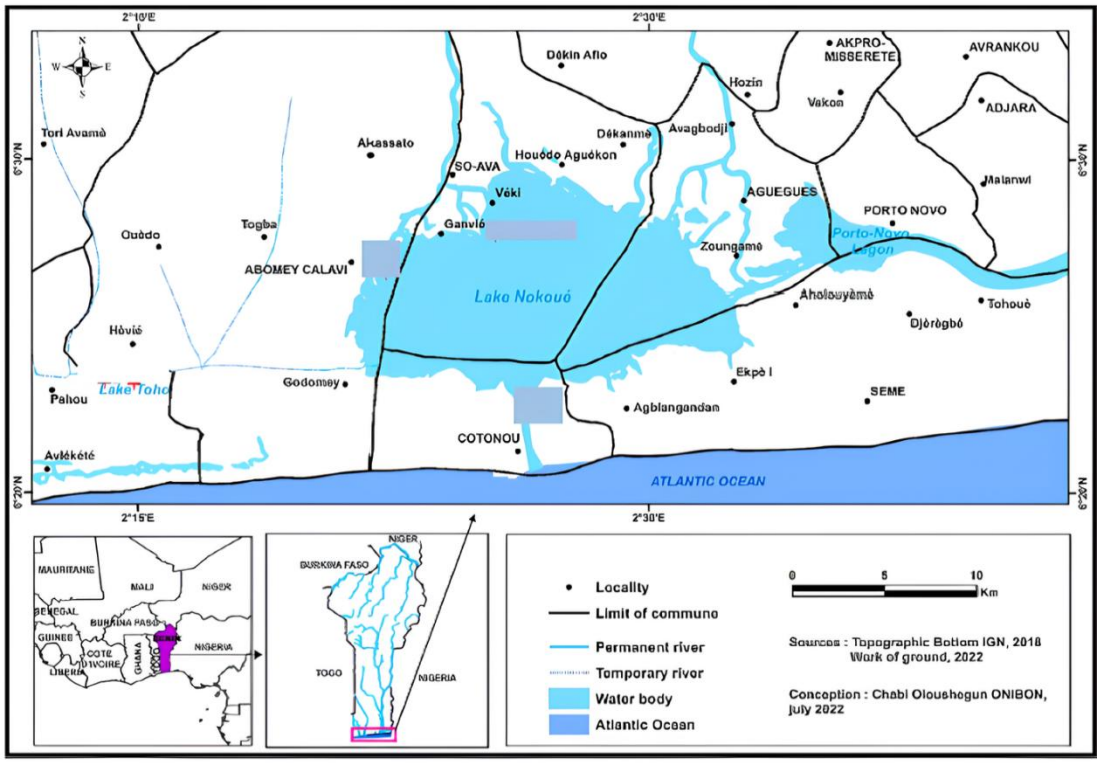

Figure-1: Map showing Lake Nokoué and other waterways in southern Benin (West Africa).

Definition of an Acadja: An acadja is an artificial thicket formed by a collection of branches of various species planted in the mud, creating a circular or rectangular park of varying size. Regardless of its size, the acadja is a favorable habitat for fish because it provides fresh water and abundant food, as well as serving as a spawning ground[7].

Lake Nokoué has a depth ranging from 40 centimeters to 3 meters and offers a shallow environment ideal for the reef aquaculture system known as acadja. Inspired by natural habitats such as reefs and mangrove forests, fishermen have developed an aquaculture system that recreates habitats that can support self-sufficient fish farming throughout the entire growth cycle[8]. This autonomous aquaculture system allows microfauna and algae to develop on bundles of branches, providing an essential food source for fish. It also attracts species that naturally live in mangroves, riverbanks, lakes, floodplains, and lagoons[7].

The "*ahlos*" were aquatic plants cut from the marshy banks, then placed on the surface of the water and held in place by a belt of stakes. These rafts of floating grasses formed a shelter under which fish could take refuge[7].

Characteristics of an Acadja: The best locations for building acadjas are on the edge of the lake where there are no currents. Furthermore, when the water recedes, these sites must not exceed a depth of 1.5 meters. The branches are arranged so that there are gaps of 30 to 50 centimeters between them.

The plant species traditionally used are the same regardless of the area. These are *Oxytenanthera abyssinica*, *Blighia sapida*, *Dialium guineense*, *Vitex doniana*, *Psydium goyava*, *Olax subscorpioïdae*, *Milletia Thoningii*, and *Elaeis guineensis*[9]. However, these species are no longer readily available, forcing stakeholders to use other more accessible species such as *Tectona grandis*, *Acacia auriculiformis*, *Elaeis guineensis*, *Eucalyptus camadulensis*, *Dialium guineense*, *Vitex doniana*, and *Pterocarpus santalinoides*.

Figure-2: Acadja made from *Elaeis guineensis*[9].

Different types of acadja: There are two main types of acadja: i. Small acadjas or "acadjavi," which are circular in shape, measuring 5 to 8 meters in diameter, and use a simple and quick fishing method. They also have a significantly higher yield per surface area than large acadjas. Acadjavi are fished using a truncated cast net known as an "acadjado" (acadja net), which is a truncated cone-shaped net with 15 mm mesh, 4 to 5 meters high and up to 14 meters in diameter[8]. ii. Large acadjas or "acadjava" or "ava" which are usually rectangular in shape, can reach 2 hectares, requiring significant financial resources and abundant labor. They are the subject of collective fishing operations that can last several weeks[8].

Some authors have identified two other types of acadja[9]: i. "Acadjagbos", the largest of which cover an area of 6 to 8 ha : ii. "Hococodja", practiced by very few fishermen.

Evolution of acadjas: Today, the ancient forms of acadjas are only found in the branches of the Sô River. The settlements currently found on the lake offer very complex configurations with combinations of the two ancient basic types (acadjavi, ava). With the invasion of woodworms affecting Lake Nokoué due to exchanges between the sea and the lagoon, the branches covering the entire surface are giving way to uncovered structures made of soft branches fixed upright. However, the forms vary from region to region, while retaining the same name. Thus, we have acadjas of the Ganvié type, acadjas of the Sô-Tchanhoué type, and acadjas of the Houédo type[5].

Today, the acadja system, recognized in the sub-region as a highly productive technique, is being copied and improved upon in Peru, Togo, and Côte d'Ivoire, where we find structures made entirely of bamboo (*Oxythenanthera abyssinica*) and permanently surrounded by nets: these are known as acadja-enclos[10,11].

Steps for setting up an acadja: Before setting up the branches, the seabed must be surveyed and branches purchased. This involves first finding a seabed with sufficient silt to allow the branches to be fixed and held in place [11]. The seabed must also be free of harmful organisms such as woodworms, oysters, and barnacles. The location is chosen during the low water period, when salinity is low and the water depth ranges between 80 and 150 cm, which is ideal for installation and harvesting[5]. After prospecting, the fisherman can purchase the branches (Figure-3), which are transported from the forests to the riverbank by truck (Figure-4A) and from the riverbank to the installation site on the lake by motorized or non-motorized boats (Figure-4B).

The installation begins with the demarcation of the area. The stakes are first driven into the ground on three sides if, for example, the park is rectangular. The actual installation begins with the construction of the main fence. The branches are fixed into the mud by a movement that requires the operator to go underwater each time a branch is fixed. This fence must be dense enough to withstand the wind. Inside, 5 or 6 acadjavis are built per hectare, creating secondary, less dense fences using branches that are also planted upright, while creating paths for the canoes that will be used for farming. The bottom of these small enclosed areas is filled with large quantities of branches. Finally, the fourth side is closed off and the entire perimeter of the park is reinforced with long branches or reeds to protect the park from frequent looting on the lake[5]. The open spaces inside the park are filled with pieces of reeds and tires in order to diversify the species that will make up the catch. Installing one hectare of acadja requires 3,500 to 6,000 bundles of branches, depending on the plant species used, the thickness of the branches, and the shape of the enclosure, with each bundle weighing between 15 and 20 kg[5].

The planting work is done by men. The head of the family who owns an acadja is often helped by his sons, other family members, friends, or hired labor, especially when it comes to a large fishery.

The bundles of branches already at the planting site are untied, soaked in water, and distributed to the planters already in the water, who then plant them. For one hectare of acadja, at least 10 people work tirelessly for 15 days, 10 hours a day[5].

Figure-3: Display of bundles of branches for acadjas[9].

Figure-4: Transport of brushwood bundles from forests to riverbanks (A) and from riverbanks to the lake (B)[9].

Fish species caught and productivity of the acadjas: A study by Niyonkuru and Lalèyè[12] reported a total of 25 fish species belonging to 17 families identified within the acadjas out of a total of 51 fish species divided into 34 families inventoried in 2001 in Lake Nokoué. This specific richness of the acadjas thus represents 49% of the specific richness of Lake Nokoué as a whole. Twenty-eight percent (28%) of these species identified in the acadjas are freshwater species (*Erpetoichthys calabaricus*, *Clarias gariepinus*, *Clarias ebriensis*, *Brienomyrus niger*, *Hepsetus odoe*, *Schilbe intermedius*, and *Hemichromis bimaculatus*), 16% are brackish-marine species (*Liza falcipinnis*, *Lutjanus goreensis*, *Monodactylus seba*, *and Pomadasys jubelini*), and 56% are brackish water species (*Sarotherodon melanotheron*, *Hemichromis fasciatus*, *Tilapia guineensis*, *Eleotris vittata*, *Chrysichthys nigrodigitatus*, *Eleotris senegalensis*, *Dormitator lebretonis*, and *Bathygobius soporator*). Acadjas are selective for certain fish species such as cichlids, which account for nearly 95% of the total numerical abundance and contribute to nearly 90% of the total biomass of fish caught in acadjas. This observation was also made by Welcomme[13], who indicated that branch parks are selective in terms of species and are more favorable to Cichlids in Africa. The same study reports a dominance of *S. melanotheron* (72.6%) and *C. nigrodigitatus* (23.8%) in Lake Nokoué in 1969-1970. A study of bamboo acadjas in the lagoons of Côte d'Ivoire also indicated a dominance (80%) of *S. melanotheron*[14]. The most important factors influencing species diversity are the physical and chemical characteristics and their spatial and temporal variations, trophic richness, resource availability, the presence and location of mangrove swamps, human interventions, the organization of communications with the ocean, and fishing activities[12,15]. The productivity of acadjas depends on the size of the acadja, the proximity of the acadjas to the watercourse, the lifespan of the substrates used, the frequency of fish harvesting in the acadjas, and the nature of the substrates used to install the acadja (tree branches, oil palm branches, bamboo stems, etc.) . The productivity of traditional acadjas varies from 150 to 200kg/ha/year[16] and can reach 4 to 20 tons/ha/year[14]. In the floodplains of the Ouémé River in Benin, the productivity of acadjas ranges from 0.76 to 23.37 tons/ha/year for small acadjas and from 2 to 7.1 tons/ha/year for large acadjas[2]. Studies have reported that successive selective fishing by skimming seems to be the most suitable technique for the reproductive cycle of Cichlids, particularly the species *S. melanotheron*, which accounts for the majority of catches. Through this method of exploitation, acadja fishing can be identified as a form of rational management rather than a form of gathering.

Impacts of acadjas on waterways: Acadjas can have several effects on waterways, both positive and negative. These fisheries create refuge areas for fish and other aquatic organisms, promoting biodiversity. By attracting fish, acadjas can help maintain balance in aquatic ecosystems. They increase fishing opportunities for local communities, contributing to food security and income[5]. However, acadjas can lead to sediment accumulation, which can alter natural habitats and affect water quality. If acadjas are too numerous or poorly managed, they can disrupt aquatic ecosystems by altering currents and habitats. Over-exploitation of resources can lead to declining fish populations and ecological imbalance[14].

It is therefore essential to manage the use of acadjas sustainably in order to maximize their benefits while minimizing their negative impacts on waterways.

Socio-economic impacts of acadjas: Acadjas have significant socio-economic impacts, particularly in coastal communities. They enable fishermen to catch larger quantities of fish, which can increase their income and improve their standard of living. By promoting fishing, acadjas contribute to the availability of fresh fish, an important source of protein for local communities. Fishing and related activities (such as fish processing and sales) create jobs, thereby supporting the local economy. The income generated by fishing can be reinvested in community projects, such as education and infrastructure[15]. However, increased fishing can lead to conflicts between fishermen, especially if resources become limited. Communities can become overly dependent on fishing, making them vulnerable to fluctuations in fish stocks or environmental changes. Over-exploitation of fishery resources can lead to the degradation of aquatic ecosystems, which can affect the long-term sustainability of

fishing. Changes in fishery resources may cause some fishers to migrate to other areas in search of better opportunities, which can have social and economic consequences for their communities of origin[12].

In short, acadjas play a crucial role in the socio-economic life of coastal communities, but it is essential to manage them sustainably in order to maximize their benefits while minimizing negative impacts.

Fish production in whédos fisheries

History of whédos : According to Floquet *et al*.[17], whédo-type fish holes are initially either natural depressions or holes, traditional ponds, or ditches dug in floodplains to trap fish during high water. They are located in marshes where water can still be retained during the dry season. Historically, they were essential for catching fish when the waters receded (between December and June), using vegetation as a refuge for the fish before gathering and fishing them. This innovation probably began in the 19th century in the Ouémé Valley in Benin and, over time, became increasingly popular. This infrastructure allows for very intensive use of floodplains by promoting fish farming in trenches and irrigated crops. From the 1960s onwards, nets were used for fishing in this infrastructure instead of the branches previously used. In 1980, methods for attracting fish to fish pits were developed. In addition, from 2000 onwards, in order to adapt to climate change, off-season crops were developed on the fish hole dikes. The first experiments to make these infrastructures profitable by producing a second harvest through a second production cycle began in 2005[18].

Definition of a whedo: Whedos are excavations made near bodies of water or in river floodplains. They fill up during floods and are naturally colonized by fish, which remain trapped there when the water recedes[3]. However, they differ from "*ahlos*" in that they are not connected to the river channel and are fed by water from flooding caused by the river overflowing its banks. Whédos can reach more than 1 km in length, 3 to 5 m in width, and 0.5 to 1.5 m in depth[4]. Like ahlos, they are covered by floating plants before they are exploited and therefore have a very low oxygen content. These fish holes are found in the Ouémé Valley (Benin) and in the Niger Basin.

Characteristics, construction, and operation of a whédo: Whédos are generally rectangular or square in shape. They are also more often found in irregular shapes and rarely circular, depending on the area in southern Benin. These fish pits are trenches several meters long (15 to over 200 m), 3 to 4 m wide and 0.5 to 1.7 m deep, dug in the lower parts of a river, lake or lagoon[2]. Whédos over a kilometer long have been observed in certain places in the Ouémé Valley. The current dimensions of a whédo depend on its dimensions at the time of construction, but also on its age and the nature of the improvements made to it each year after exploitation. The gradual degradation of the banks of a whédo by water, most often their collapse, and the maintenance work carried out on whédos alter the initial dimensions of the holes.

Fish pits are dug in wetlands during the dry season after the floods (November-December) when the water table is no longer high. They are constructed using the same methods as fish ponds. It begins with staking out the perimeter of the hole, then using a hoe and a daba to dig[18]. The labor used for construction does not need to receive special training but must have some experience in the field. These whédos are completely submerged in water during the flood. When the water recedes from the plain, the fish are trapped in the holes and then caught[2]. Some whédo owners throw in some food made from corn dough balls at the beginning of the receding of the water from the plain in order to retain as many fish as possible. As the water recedes and the dry season progresses, the water level in the whédos drops and can reach an average depth of 40 cm. Fortunately, the vegetation around and in the whédos provides shelter from the sun's heat[18]. Otherwise, living conditions in the holes would become unfavorable for fish due to high temperatures. For fishing in whédos, a rectangular trawl net with 8 to 10 mm mesh, locally known as "Kpodjègan" in the Ouémé Valley, is used[2]. The whédos are exploited in successive sections. Before catching the fish, each section is marked out using a fine-mesh net known locally as a "Todado." The whédos are exploited once a year during the ebb tide. After exploitation, the holes are cleared of as much silt as possible and then re-dug.

Fish species and productivity of the Whédos: Several authors have reported low fish diversity in the Whédos, limited in some cases to 11 species belonging to 9 families[2]. The dominant species are catfish, particularly Clarias, which, in the study by Lalèye *et al*.[2], accounts for nearly 83.9% of the total population, represented by *C. gariepinus* (68.5%) and *C. ebriensis* (15.4%). The relative abundance of catfish is linked to the fact that they are bottom-dwelling species in contact with river sediments and are therefore the species most trapped when floods recede. In addition, the low faunal diversity and abundance of bottom-dwelling fish in the whédos is also linked to the difficult ecological conditions of the environment, which only hardy fish equipped with a gill rakers can withstand[2]. Indeed, in fish holes, the dissolved oxygen content is often low, indicating relatively poor primary production and the formation of various gases and toxic substances. These levels exceed the tolerable limits for most fish species. The other species identified by Lalèye et al.[2] in their study in the Ouémé Valley are: *Parachanna obscura*, *Ctenopoma petherici*, *Polypterus senegalus*, *Bryenomirus niger*, *Protopterus annectens*, *Heterotis niloticus*, and a few individuals of four other unidentified species. The size of fish caught in whédos is often relatively large. The average yield was 1.31 tons/ha/year in 2006[2] but appears to be declining, as in 1958 it was 2.13 tons/ha/year[19] and in 1970 it was 1.57 tons/ha/year[20]. The decline in yield is thought to be linked, among other things, to the increasing use of chemical inputs in fields often located close to whédos, which undoubtedly has a negative impact on the fish fauna of the whédos.

Figure-5: Images of whédos in operation in Lake Nokoué (Southern Benin).

Improvements to the whédo system: Seen as ponds, whédo-type fish holes have undergone several changes to increase their productivity. After floodwaters receded, some researchers realized that small fish trapped in the holes could be fed for a certain period of time before being caught[3]. These fish holes can be developed and used to promote the farming of *C. gariepinus* and *H. longifilis*[4]. Some authors have experimented with compensatory hyperphagia in fish[21] and Clarias-tilapia co-culture[22] in these traditional ponds, with very conclusive results. Several avenues remain to be explored to improve this innovation.

Environmental and socio-economic impacts of whédos: Traditional whédo-type fish pits in floodplains have mixed environmental impacts. They concentrate fish fauna for sustainable fishing but can degrade water quality through sedimentation, eutrophication (excess nutrients), and changes in the water regime, while reducing fish biodiversity compared to other systems such as acadjas[4]. The reduction in fish species diversity (11 species in whédos compared to 25 in acadjas) is very noticeable, although they concentrate important species such as Mochokidae[2]. The annual exploitation of whédos during the dry season, although traditional, alters the environment by digging and cleaning the holes, which affects the aquatic ecosystem, but they can also reduce pressure on wild resources by providing a local source of fish, reducing the need to import frozen fish and decreasing pressure on other stocks[23]. In addition, whédos rely on local knowledge and are well accepted by the population, making their improvement more effective than the introduction of new technologies[3]. Some analyses suggest that traditional systems such as whédos may have a lower environmental impact than other models[23,24]. Whédos are a source of income, enabling agro-fish farmers to generate revenue. They also represent traditional techniques for adapting to their aquatic environment[3].

Conclusion

Acadjas and whédos are traditional fishing techniques widely used in the lagoon and lake ecosystems of southern Benin. Their importance in fish production is undeniable, both economically and socially. By promoting the concentration and reproduction of many fish species, these devices contribute to increased catches and improved incomes for local fishermen.

However, despite their advantages, the uncontrolled use of acadjas and whédos has negative impacts on the aquatic environment, including habitat degradation, reduced biodiversity, and overexploitation of fishery resources. Therefore, to ensure the sustainability of fisheries production in southern Benin, it is necessary to strengthen the management and regulation of these practices, while raising awareness among local stakeholders about responsible exploitation. Integrating traditional knowledge into modern fisheries resource management policies appears to be an essential way to reconcile food security, environmental preservation, and the socio-economic development of coastal communities.

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