The Integration of Extensive Aquaculture (Acadja-enclos) into the Lagoon Village Environment in Côte d'Ivoire

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Abstract

With a production of 150 to 200 kg·ha^{-1}·an^{-1}, capture fisheries in West African coastal lagoons no longer meet the local demand for fish. This situation is aggravated by the increasing pressures of urban expansion in the lagoon areas. The Ebrié lagoon in Côte d'Ivoire is affected by the development of the city of Abidjan and provides a good example of this expansion. Improved production for lagoon areas is consequently drawing increasing interest. The adoption of acadja-enclos and pen production systems in the Ivorian lagoons reflect this development. Pen culture is essentially based on the intensive culture of catfish and requires private investment, but acadja-enclos systems are extensive, village-based farming systems. The problems of competition (for space and resources) between the acadja-enclos culture system and capture fisheries are discussed, as well as the introduction of acadja-enclos into villages and their economic efficiency.

Introduction

The integration of a new production system always affects an entire farming system. This article investigates and discusses the prospects of acadja development in Côte d'Ivoire, based on the acadja systems of Benin. Although there are differences in terms of environment and technical adaptation between the lagoons of Benin and Côte d'Ivoire, competition with capture fisheries and the appropriation aquatic space are problems common to both (Durand and Verdeaux 1991; Verdeaux 1994).

Towards Aquaculture Systems

Natural living aquatic resources are potentially renewable resources. Their quantity and rate of renewal depend on the efficiency of the successive transformations within the various food webs, leading to final production, and upon their level of exploitation, this process implies that resources are variable. Resource variability is affected by intrinsic factors (competition among species and success in the reproduction) and climate fluctuations. This combination of factors introduces various degrees of variability,

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both in seasonal and interannual terms. Final production also fluctuates and so do the catches, as they are based on a complex resource management system.

The lagoons in the northern parts of the Gulf of Guinea are among the world's most productive environments, yielding annually 150-200 $kg \cdot ha^{-1}$ under optimum conditions. However, demand for animal protein and the difficulty of controlling fisheries operations have generally resulted in excessive pressures on the stocks and in frequent conflicts between fisheries operators. This suggests the development of aquaculture which theoretically should free the fishing communities from natural conditions or, at least, minimize their effects while providing additional yields.

Although an extreme enthusiasm for aquaculture has resulted in many frustrations, this analysis concerning Africa is made within the framework of this symposium (see especially Lazard et al. 1990; Lazard, this vol.) and our intention is not to deny all development prospects. On the contrary, we encourage the adaptation of techniques to develop extensive aquaculture in lagoon environments. It is clear that any new project must take into account the analysis of previous failures, the major causes of which are:

- the lack of basic knowledge;
- the absence of a long-term reflection;
- the weakness of the economic analyses; and
- the underestimation of sociocultural aspects.

Finally, it may be useful to specify the type of aquaculture that concerns us here. The principle of farming is clearly understood in highly productive, controlled systems, but this may not be the case for extensive farming which depends on the natural environment. The following general definition can be suggested: one can speak of aquaculture when the controlled modifications of the natural conditions generate an increase in productivity. Such a definition applies to the "acadja" farming system.

Acadjas and Pens

Acadjas and pens have in common that they are part of natural environments, on shallow, soft bottoms. The pen system is not a native concept; it evolved from Southeast Asian traditions (Hem 1982). Implanted on shallows or along banks, pens are made of commercial, small mesh nets (14 mm) stretched on poles that are imbedded in sediments. The pens can be used alone, as for example in the semi-intensive farming of catfish (*Heterobranchus longifilis* and *Chrysichthys nigrodigitatus*: Hem et al. 1994) or in combination with the acadja system (Hem and Avit, this vol.).

According to Pliya (1980), the term "acadja" is of Goun (Oueme) origin. Acadja construction can vary, but the principle consists in imbedding branches in 1-1.5 m-deep soft bottoms. The type of acadja is determined by the nature, density and coverage of the branches. Although this system can be found in many regions of the world (Kapetsky 1981), it is in Benin that it has known its greatest development: 245 ha in Lake Aheme in 1969 (Pliya 1980). The acadja, a unique form of "artificial reef," provides a refuge against predation, can play a role in the reproduction of some species and is particularly useful in food production. Dead branches promote natural productivity in providing opportunities for the rapid, spontaneous growth of periphyton and associated fauna for grazers such as the Cichlidae.

For the past 30 years, scientists and developers have been increasingly interested in the use of acadjas in the lakes and coastal lagoons of Benin (Buffe

1958; Pélissier 1963; CTFT 1965; Hurault 1965; FAO/UNDP 1971; Bourgoignie 1972). Particular attention should be given to Welcomme (1971, 1972) who attempted a fisheries approach to farming and to Pliya (1980) for his comprehensive description of fish farming in the waters of southwestern Benin and of the acadja crisis.

The socioeconomic origins of the conflicts arising from the use of acadjas must be emphasized, but their potential impact on the environment must not be overlooked (Rabier et al. 1979; Tixier et al. 1979). Increased silting in the lagoons as a result of erosion is closely related to:

- the presence of accumulated branches imbedded in the water that slow down runoffs and accelerate the sedimentation of materials in suspension; and especially,
- the lack of vegetative cover in the catchment areas which accelerates land erosion.

The use of branches (raw material to construct acadjas) has led to the deforestation of surrounding areas.

The rapid decay of the branches also plays an important role (70% have to be replaced annually, representing some 30 $t \cdot ha^{-1}$ [Welcomme 1972]). This is a source of organic matter which can pollute the environment.

Natural Environments and Farming Systems

"Fisheries require at least three elements to exist: fishing operations, fish and traders. Each of these elements influences the two others... either directly or indirectly" (Quensière 1990). In a given environment, the management of living aquatic resources through fisheries therefore constitutes a system. The modification of any element of a system can have an effect on the whole. Any new system of production has therefore, directly or indirectly, important repercussions because it implies modifications in the sharing of and/or access to the resources. Generally, what is at play is the "combination of forces and social interests...which define the rules and practices for the use of such environment" (Verdeaux 1986).

In environments with high productivity, old fisheries traditions and high demand, such as in West Africa, as well as the lack of consideration of the potential effect of a new production system often result in conflicts as can be shown in several coastal environments in the Gulf of Guinea (Durand and Verdeaux 1991).

Along the Ebrié lagoon (Verdeaux 1981, 1986), the use by some villagers of a small beach seine designed for particular species has led to conflicting interpretations as to the fishing grounds where it can be used. Villagers using passive gears refused to use seines on their traditional fishing grounds. The ensuing inter-community conflicts forced the administration to intercede by asking the villages concerned to set territorial limits within which each village would be free to use the techniques of its choice. The old system, which consisted in seasonally alternating techniques in the entire lagoon area, was now split in as many subsystems as there were villages.

The major crisis which occurred some 10 years ago should be recalled. First accepted and restricted to some lagoon areas, beach seines had such impact on the resources that they were totally banned under the pressure of local fishers (Ecoutin et al. 1994).

In Lake Aheme (Pliya 1980), the acadjas introduced by the fisheries administration were not only very much appreciated by some of the riverine populations, but also by outside entrepreneurs who were attracted by the high returns guaranteed by this production system. Other fishers opposed this technique objecting that multiplying the acadjas reduced the availability of fish in

open waters. The impossibility for both the local and central authorities to stop this phenomenon and to solve the conflicts caused by the acadjas compelled the State to have the branches removed by force and to ban their use indefinitely, allowing only the use of traditional fishing techniques. A similar process led to the same restrictions in Lake Togo in 1975 (Weigel et al. 1989).

In the Abi lagoon (Charles-Dominique 1988; Verdeaux 1989), purse seines were introduced by the fisheries administration, a development bank and an organization for rural support, in a context of competition between two social groups: the owners of beach seines, on the one hand, and the direct producers brought together around the "unionized" net, on the other. The latter group, in the process of being marginalized, took the opportunity of the funding programs offered to them to acquire these units which were more efficient than their old nets. The number of these units grew rapidly; production was over 10,000 tons in 1979-1980 but dropped to less than 1,000 tons the following year, forcing the authorities to order the temporary suspension of the fishing activities.

All innovations, each according to a particular combination, are a new challenge in terms of access to the environment.

It is with these examples in mind that the prospects of integration of the acadja system in the Ivorian lagoons should be considered. The proposed innovation will certainly have an impact on the farming system and, in order to succeed, it must be accepted by the fishers and villagers. Problems can be analyzed in terms of potential competition for resources, on the one hand, and for space, on the other.

Competition for Resources

If the installation of pens in shallow lagoons poses the problem of space appropriation, in contrast, its effects on the resources are marginal. These are limited to the passing of the fry (predominantly cichlids) through the nets (14 mm). The resulting stock modification does not constitute so much of a problem in itself, but traditional aquaculture may suffer from the proliferation of fish in the acadjas and, consequently, from stunted growth or from the presence of undesirable species.

The implantation of traditional acadjas must be considered from different angles since the function of this production system varies according to its age. Three periods can be distinguished:

- At first, the acadja plays a role of *refuge*, and, at this stage the young acadja functions as a simple trap which competes with other artisanal gears in open waters. The initial stock in the acadja is equal to a biomass produced in the lagoon open waters. Note here that the stock in the acadja is dominated by usually one or a few particular species. In mixohaline areas close to Abidjan, *Lutjanus goreensis* is the dominant species (Hem and Avit 1991; A. Bert, pers. comm.); in oligohaline waters, *Sarotherodon melanotheron* is dominant with 70-90% of the biomass. The same phenomenon has been observed in Ebrié lagoon (Hem and Avit 1991) and in Lake Nokoue (Welcomme 1972).
- Later, the acadja plays the role of an "artificial reef" where branches contribute to the development of algae, protists and zooplankton on which the fish feed. The entire system benefits from this considerable increase of natural productivity.
- Finally, reproduction and growth contribute to the development of a balanced biomass in relation to the volume of water

and its trophic potential. Under these conditions, the acadja may even contribute to the export of resources to open waters.

Regarding competition between acadjas and other artisanal fisheries, the following must be clarified:

- the stocks in the acadjas are clearly different from those found in open waters; therefore, competition, if it occurs, will concern only the species that can colonize the acadja; and
- for these species, competition depends on the use of the acadja. If the acadja serves as a trap that is harvested frequently (every two to three months, for example), the fish trapped inside could have been caught by other traditional techniques. In contrast, if the acadja is harvested less frequently, production (reproduction and growth) wins out, and the catches do not depend on the external stocks.

Provided that harvesting is sufficiently spread out in time, acadjas can generate additional productivity and do not at all obstruct access to resources by other artisanal fisheries. In fact, the yields of other fisheries are even likely to increase due to the export of part of this new production from the acadjas. Note also that the yields from the acadjas are much higher than those from open water fisheries. Based on branch densities, acadja size and production cycles, Welcomme (1972) reported yields of 2-9 $t \cdot ha^{-1} \cdot year^{-1}$. In Lake Aheme, the 35 hectares of acadjas gave, in 1969, mean yields of 5-6 $t \cdot ha^{-1} \cdot year^{-1}$.

However, while overall acadja production increased without detriment to traditional fishers, conflicts developed very rapidly because of the poor organization of the acadja implantation: "the lack of a sound management system, of a rigorous administrative organization and of sufficient understanding of the sociological environment would contribute to the failure of the otherwise technically sound acadja system..." (Pliya 1980).

Space Appropriation

Permanent Appropriation

Acadja and pen production systems monopolize entire areas permanently, discouraging any other activity. To this problem of space control is added the problem of fishing limits imposed in the proximity of acadjas. As the grounds that are suitable for the implantation of acadjas are unevenly distributed, a concentration of fishing activities in these areas is likely to occur, particularly as these grounds can be accessed freely. Lake Aheme provides a good example of this situation: at the end of the experiment, entire areas were off-limits for other fishing activities. Permanent appropriation of space can only lead to conflicts if such practice is not governed by principles agreed upon by all and respected. In Benin, the theoretical, complementary existence of fisheries and extensive aquaculture finally turned out to be a source of conflicts mainly because of the transformation of the lake into a pioneer front, conquering and confiscating the environment (space and resources) for the benefit of a socially heterogeneous fishing population that eluded control. The misuse of the acadja as a simple fish trap is another manifestation of this problem: if the traditional authorities cannot channel and limit the spatial expansion of this phenomenon, neither will the fisheries administration be able to enforce the resources management regulations it has established. In general, the permanent appropriation of aquatic space to accommodate such an exclusive technique constitutes a bias against the most common fisheries activities. The justifications

offered and the precautions taken, in the context of this traditional (or more recent) production systems, show the extent to which these forms of environment may have negative social impacts. They should therefore be closely controlled.

Strategic Spaces

The type of space used for aquaculture, i.e., the shallows, may, like the Ivorian lagoons, fulfill an important symbolic function (Verdeaux 1981, 1986). Even if, at first, these spaces appear not to be utilized, they are collectively appropriated for the establishment of "fixed fishing gears," the constructions which consolidate the entire system of social relationships. The proximity of shallows has always encouraged the establishment of traditional community settlements. Each given a name, the shallows are included in the community's aquatic territories and are only accessible to mobile fishing gears.

The reintroduction of permanent appropriation of these spaces for aquaculture is not without creating conflicts. It is indeed difficult to accept that outside entrepreneurs should be given these grounds without the preliminary agreement of the family and village authorities. The above, concerning the village territorial waters in the Ebrié lagoon, which includes fishing grounds (and shallows) formerly managed by villages, limits at least the risks of dispute to each of these villages. This being said, the villagers should not be made to suffer from such arrangements; they should, on the contrary, benefit from them. If research efforts do not focus on the role that these new techniques can play within the local social systems (and the situation can change from one village to the next), projects for the extension of fish farming techniques may well face unmanageable conflicts.

From Appropriation to Privatization

Ultimately, the implantation of aquaculture systems in the natural environment transforms the status of the spaces thus used. By being treated almost as are agricultural lands, these grounds acquire commercial value and encourage privatization. If fish farming produces "n" tons of fish in one hectare of lagoon area, the value of this hectare can be established since the productivity and the profitability of this area depend only on the fish farmer's management system and no longer on the overall intensity of the fisheries as in capture fisheries.

However, in terms of gross margins, one hectare covered with pens is equivalent to several tens of hectares of palm trees (Lirola 1986). This comparison is also valid for acadjas. Regardless of the particular use of the environment, these techniques may create social problems with unexpected consequences. In the context of agricultural land saturation, for example, these farming techniques may be a palliative to the lack of land and lead to the appearance of unexpected claimants for tenure of lagoon areas.

Discussion

In view of the difficulties encountered in Benin and the analysis of the causes of the conflicts, the prospects of exporting the acadja technique to other African contexts appear at first to be bound to fail. This is not necessarily the case, however, if the specific characteristics of the Beninese and Ivorian coastal environments are taken into account.

Concerning the effects on the environment in Benin, several major inconveniences have been pointed out, including deforestation, rapid silting and organic pollution. None of these problems should affect the Ivorian environment. The hydroclimatic conditions contribute to the

growth of a thick, lush ground cover (annual rainfall = about 2,000 mm on the coast) and the use of wood would not lead to increased erosion and sedimentation in the lagoons. In addition, wood could be substituted with bamboo which presents several advantages (Hem and Avit 1991) and especially releases less organic matter. It should also be noted that Ivorian lagoons are much larger and deeper (average of 5 m in the Ebrié Lagoon). Assuming the shallows and coastal zones to be covered with acadjas in the western oligohaline areas which are the only truly suitable areas would still only represent 1-2% of the total surface area. Competition for resources with the artisanal fisheries does not constitute a rational objection either: due to the specific composition of the catches, acadjas do not significantly affect the other forms of fishing activities. Moreover, the use of this technique increases total production. Still, the permanent and visible appropriation of part of the lagoon territory may be resented by the fishers who would be excluded from the acadja production system. Finally, the full-scale analysis of the technical feasibility and economic efficiency of the acadja-enclos production system in various hypothetical instances of implementation show very encouraging results (Hem and Avit 1991).

It is therefore at the sociocultural level that the major knowledge gaps are to be found. Assuming that aquaculture takes an important place in the lagoon, the two potentially most destabilizing effects would be a change in the challenges and stakes involved, on the one hand, and the transfer of the management of resources to new categories of participants, on the other. The social role that these methods occupy in production systems is in fact the main issue. The potentially ensuing divide between fishers and aquaculturists would imply the formation of two unequal social groups. This situation would be similar to that which prevailed in the Ivorian lagoon capture fisheries. The opposition between direct producers and seine owners has resulted either in conflicts or in increased activities and overfishing. In contrast, the long-term appropriation of space and the returns guaranteed by pen and acadja farming techniques form a system that is similar to that found in plantations. The latter, an extensive production system, reaches land saturation in these areas. In this context, the acadjas could be an extension or timely substitute to the plantation crops, as world commodity market prices are declining. However, at this point, it is still not clear whether an important contribution of cultured fish in the domestic market would affect production costs.

Conclusion

The conception of a new production system in the Ivorian lagoons is the fruit of comparative and multidisciplinary approaches on the environment, resources and societies. It takes into account the lessons learnt from the many failures of aquaculture projects and the conflicts related to the management of aquatic resources. It finally draws on a particular farming concept which is extensive-oriented and favors minimized inputs, hence encouraging the use of native species and an implantation in the natural environment. These considerations have led us to suggest the following recommendations:

- biological and economic "monitoring" of the performance of the acadjas and implementation of the necessary adaptations (combination with pens or not, forms and size of acadjas, materials, etc.);
- anthropo-historical analyses of the changing relationship between societies and the environment: representation and appropriation of space, role of the fisheries in the farming systems, etc.; and

• ecological mapping of the physically suitable sites with a description of their potential use and users.

Regardless of the choice of aquaculture production systems and beyond the immediate satisfaction of the needs of the local populations, the impact of cultured fish on the *market* is yet to be assessed: consumers' attitude, prices and marketing potential.

Important research and development efforts will be necessary for the sustainable integration of this new production system. We believe that the adaptation of the acadja technique can constitute a new, appropriate activity in the lagoon context which, combined with traditional fisheries, will improve the management of species and contribute to better control and increased production.

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