Chapter 9
Extensive Fish Farming, a Complementary Diversification of Plantation Economies

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Perennial crops cultivated in the humid tropics have often been introduced into existing slash-and-burn agriculture systems that are practiced in still-forested areas. This is particularly the case of cocoa and coffee in West Africa. Family plantation economies that developed in this sub-region were capable of providing, for a long time, enough tubers, cereals and other sources of carbohydrates to meet the needs of a growing rural population. Even though there were chronic seasonal shortfalls and even though crises of a more severe nature were not unknown, carbohydrate production remained in surplus for a very long time. However, the situation has been very different with respect to proteins, especially those of animal origin; their structural scarcity has resulted in severe nutritional deficiencies (WFP 2009). Based on observations and on occasional field data, these forest agricultural systems have been observed to be acutely deficient in animal proteins for a long time now. Vague memories refer to a time when game was abundant, during a period of large scale deforestation accompanied by a burst of hunting which quickly depleted animal stocks that were doomed to extinction.

Yet in these regions, hunting and river fishing have always been regarded as the means of meeting basic protein requirements. Thus, the forest tribes of western Côte d'Ivoire have been sometimes described as hunters who are unsuited to agriculture —even though there is evidence that, on the contrary, they are genuine farmers (Léonard and Vimard 2005). In 1985, Dozon (1985) reminded us that collective hunting, traditionally important in some Bété communities before the advent of the plantation economy, provided only a secondary source of food. The earliest descriptions of trade on the northern limits of the forest note a relative abundance of smoked fish from the Niger Delta (Oswald 1997).

In 1957, Brasseur (cited by Fargeot, 1994), was amazed at the rapid disappearance of many large game animals in Kpelle inhabited areas (Guinea)—especially elephants since 1954. Does this then lead us to conclude that all animal

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species that were a likely source of protein were systematically consumed in these regions (small rodents, fish, reptiles, amphibians, bats and insects)?

There was a similar situation in Ghana where studies undertaken as far back as in the 1930s showed that farming communities depended on dried sea fish (Beckett 1944; Ruf 2007).

Food requirements were thus met through a mainly external supply of protein in the form of fish. This longstanding dependence has only become more pronounced. With an increasing population density stemming from the plantation economy, the quantity of common resources is in decline.

In western Côte d'Ivoire, as in the forests of Guinea, it is mainly women who do the fishing. In fact the women do so with enthusiasm, most often together in small groups, using small traditional spoon-nets. This activity, though socially important, is inadequate; the catch is small and insignificant. However, this contribution is appreciated and considered valuable.

As expected, there have been countless attempts to establish livestock farming in these areas, but these activities were not at all integrated with the farmers' other activities. Furthermore, there are several deterrents to livestock farming: numerous animal diseases, high parasitism and difficulties in maintaining pastures. Brou (2005) and Ruf (2010) have described recent, localized attempts to compensate for aging cocoa through livestock farming, mainly of sheep. There was a renewed interest in pig rearing in Guinea and Côte d'Ivoire, supported by the availability of large volumes of palm-kernel oil cake. Fishing, however, remains the primary source of animal protein.

Grosse (2009) observed that in similar forest areas of central Cameroon, more that 90 % of the animal protein consumed came from fish. In these plantation economy regions, the main food item that is purchased by families is fish, far ahead of cereals and other foods. In this situation, it seemed logically inevitable for fish farming to develop, even without specific policies for the sector. Indeed, numerous attempts were made to develop fish farming in different contexts with different objectives (food self-sufficiency, production of bagrid catfish, shrimp for export, etc.). Unfortunately, these actions were not—and are still not—guided by the desire to meet the needs of rural communities in these regions. Projects propose intensive fish farming systems, giving as a pretext a higher profitability. Subsidies have often been offered to overcome investment constraints and enable a quick start to production, but the realities of fish production in rural conditions were not taken into account. It is not surprising then that most of these attempts ended in failure.

However, when the government, funding entities and non-governmental organizations come together to propose actions designed to meet the expectations of farmers, results are much more encouraging and original, assuming, of course, that enough time is given to these projects to arrive to fruition. Two institutional associations have managed to create such an environment around two projects in Côte d'Ivoire and Guinea: Central-Western Fish Farming Project (French abbreviation: PPCO) and Fish Farming Project in the Forest Region of Guinea (French

abbreviation: PPGF).[1] These experiments quickly came to be considered national benchmarks on either side of the border. PPCO's former area of intervention in Côte d'Ivoire is today the country's primary fish farming area (Assi Kaudjhis 2005). Both these fish farming projects took decisions at variance with prevalent norms: extensive models, significant investment implemented with labour, and farmers' capital.

9.1 Methodology

This chapter analyzes the benefits of diversification into fish farming for plantation economies in order to satisfy the strong domestic demand for fish and to fulfil the desire for fish farming. It compares the results of the development of this activity in two villages in different contexts: Gbotoÿe (Guinea), 8 km north of N'Zérékoré, and Luénoufla, 35 km north-east of Daloa (Côte d'Ivoire). These villages benefited from interventions by, respectively, PPGF and PPCO.

We first discuss the regional agricultural situations at the time fish farming was introduced as well as the environment specific to fish farming. The approaches adopted to promote fish farming by the two projects are compared. Based on project documents, we discuss the methods used to disseminate the innovation. The economic performances of farmers who chose to farm fish are analyzed. The consequences of these developments identified outside the farms are summarized.

[1]For PPCO, originally conducted from 1992 to 1998 and subsequently extended to 2000 to encompass those farmers missed out initially, the entities involved were AFVP (French Association of Volunteers for Progress) assisted by CCFD (Catholic Committee against Hunger and for Development), the Ministry of Cooperation and the Directorate of Fisheries and Aquaculture. These institutions welcomed the involvement of other actors in the implementation phase: the Central Region, AFD (French Development Agency), APDRA-CI (Association Pisciculture-Rural Development in Tropical Humid Africa, Côte d'Ivoire) and APDRA-France. Research institutions like IDESSA (Savannah Institute) associated with CIRAD (French Agricultural Research Centre for International Development) and CRO (Centre for Oceanographic Research) were also included as partners. However, this project faced stiff resistance from a large section of the Ivorian research establishment which led to the suspension of the Chinese carp program (Assi Kaudjhis 2005). For PPGF, AFVP (in partnership with APDRA-France) helped implement the project on behalf of the National Directorate of Aquaculture and Inland Fisheries (DNAPC), financed by AFD from 2000 until June 2008. Other partners, including CCFD and MAE (the French Ministry of Foreign Affairs) and USAID (United States Agency for International Development) supported this project that spanned several crises (war with Liberia, the 2003 crisis between the government and funding entities, conflicts arising from national political transitions since early 2007).

9.1.1 Regional Contexts

Both villages are located in forested areas. The project area in Côte d'Ivoire receives less rainfall than its counterpart in Guinea. Its dry season is much more severe, but it has richer soils: these are lateritic and slightly to moderately desaturated. The two regions also have different agrarian histories.

9.1.1.1 Luénoufla in Côte d'Ivoire

Luénoufla is located in the Gouro people's territory, not far from the edge of the savannah. Coffee cultivation grew rapidly in the 1930s and 1940s to become a major part of local farming systems. A large number of migrants arrived in the late 1950s and were actively involved on the agricultural frontiers in the centre-west. They mainly grew cocoa and soon it became the main crop in the local agriculture.

Few opportunities were available to farmers to invest money saved from their income from cocoa cultivation. Several attempts were made to diversify into livestock rearing (broilers and laying hens, pasture raised sheep, modern pig farms, and fish farming) but they all ended in failure. Farmers were left with little option but to buy new forest lands to plant cocoa. Some farmers, however, successfully diversified into trade and real estate (Chaléard 1993). The rapid growth in population contributed significantly to environmental degradation. Forests regressed, to be replaced by bush, and the spread of bushfires often endangered plantations. Savannahs began gaining in significance, especially in the lowlands where systematic burning promoted *Pennisetum*-dominated savannah which, subsequently, was gradually converted into food crop fields.

The boom period, based mainly on the cocoa cycle, began to show signs of slowing down in the late 1980s. The continued increase in population made it increasingly difficult to meet domestic food requirements. Land rent for annual crops began to increase, resulting in an enhanced interest in lowlands (Oswald 1997; Ruf 1988).

Consumption of frozen fish dominated the market for a long time despite the availability of beef. Traders interviewed in Daloa in 2000 indicated that the quantity of frozen fish[2] distributed in the markets of Luénoufla, with a population of 12,000 inhabitants, was well in excess of 100 tonnes/year (Trellu et al. 2002).

[2]In Côte d'Ivoire, the frozen fish from Daloa arrives on market days, partially thawed. What is not immediately sold is smoked for resale at a later date.

9.1.1.2 Gbotoÿe in Guinea

Gbotoÿe village is located in an area inhabited by the Kpelle people. Its population density exceeds 100 people/km^2 (Guillaume and Cissé 2000). Agroforests have come up on hillsides in this coffee-dominated region.

The growth of the coffee industry was significantly constrained under the rule of President Sékou Touré. It was not until the late 1980s that this crop was revived with the support of promotional activities (Delarue 2007a). Other tree crops, in particular kola and oil palm, retained an important role in this agroforestry system. The presence of cocoa is marginal here as the soil and climate are not favourable. Some cocoa trees can, however, be found in small plantations around the wetlands.

Upland rice, the main food crop and source of starch, is cultivated on fallow lands. Just like in other humid tropical areas, the optimal fallow period is around 7 years. This fallow period could be maintained until the 1990s as the population density was low. The situation in neighbouring countries at the end of the 1990s forced many Guineans to return to their country, thus greatly increasing pressure on the land and natural resources. With the expansion of plantations and population growth in the most densely settled areas, rice cultivation on 7-year-old fallow lands was no longer possible (Guillaume and Cissé 2000; Wey and Guillaume 2001). Although lowlands were cultivated to overcome this scarcity of land, the daily wage offered for cultivating rice here was much lower. On the whole, rural communities found it increasingly difficult to meet domestic food requirements.

Fish Consumption

While official statistics may indicate a consumption of 1 kg/person/year of fish, the reality is very different. Surveys conducted over a year, between 2001 and 2002, in rural markets showed that consumption exceeded 10 kg/person/year. More than half of this consisted of frozen and imported fish.[3] Humanitarian NGOs working with refugees from Liberia and Sierra Leone also conducted nutritional surveys on people in and around camps. The results clearly indicated that protein deficiency was the most severe problem amongst all the nutritional deficiencies found here. It is known to lead to several ailments in children under 5 years of age, which can result in growth disorders and even death.

Henderson (2001) estimated the number of working people in Gbotoÿe to be 2000. This active labour force was less than half of the total population of the village. The village's annual fish consumption can then be estimated to be more than 40 tonnes.

[3]On this topic, refer to PPGF activity reports of 2001 and 2002. From 2003 to date, the only companies to have invested in N'Zérékoré were a saw mill, a bank and a large warehouse for storage and marketing of frozen fish.

In both of these regions, access to land was becoming increasingly complex and took divergent paths. In Côte d'Ivoire, it became a political issue and even a factor in the national crisis (Chauveau 2000, 2006).

Even though rapid changes were observed in Guinea, local accords remained predominant. These were negotiated mainly in village forums or based on lineage and, occasionally, between villages. Two major factors explain the specificity of these changes in this country: the decentralization policy with the implementation of Rural Development Communities, and violent conflicts between the Malinké and the Kpelle who, at different periods, enjoyed the support of authorities.

9.1.2 History of Fish Farming and Genesis of Diversification Projects

The history of fish farming in the Luénoufla (Côte d'Ivoire) region is very different from that in the Gbotoÿe (Guinea) region.

In Côte d'Ivoire, significant means were allocated to support this activity at a very early stage. Government agencies were set up in the bigger prefectures starting in the mid-1960s. United Nations Development Programme (UNDP) and the Food and Agriculture Organization of the United Nations (FAO) subsequently implemented a nation-wide project to develop fish farming in rural areas in the late 1970s. These were not isolated efforts: the area also played host to other initiatives by NGOs or those set up with the help of smaller funding sources. These include AFVP[4] initiatives in peri-urban areas, trainings in farming centres, interventions of INADES (African Institute for Social and Economic Development), religious missions initiatives and the FRAR (Regional Rural Infrastructure Fund) subsidies programme for GVC (*Groupements à vocation coopérative*[5]). In addition to these actions, we often tend to overlook the many private hawking operations in the country. In particular, generations of pond-excavating gangs strove to disseminate fish farming awareness by providing related ready-to-use know-how to farmers. The amounts invested were substantial. In 1998, a survey conducted in a *département* in the south-west, where no official dissemination of fish farming had been undertaken, revealed that at least 16 million FCFA had been distributed to small entrepreneurs during the preceding 12 months (Coulibaly and Oswald 1999). In addition to these gangs, we must also note the role of loggers whose bulldozers were often rented or appropriated to develop much of the infrastructure. All these facilities were, at best,

[4]See Footnote no. 1.

[5]A *Groupement à Vocation Coopérative* (GVC) is a statutory entity consisting of group of individuals who are supposed to participate in its operation on a voluntary basis. Promoted since 1966, the GVC maintained its transitory spirit up to the ends of the 1990s.

left to fall into disrepair, with the exception of those in peri-urban areas. They are sometimes not even visible, so overgrown are they now with vegetation. Only a few fairly large reservoirs, built with mechanized equipment, show sporadic activity. Most of the ponds were sub-standard to begin with and were soon reduced to nothing more than abandoned holes. Sometimes fishing is still done here in the dry season; this explains the term 'hollow-cultivation',[6] a vivid indication of the kind of activity possible in these facilities.

Fish farming is a relatively new topic for the Guinean government. Although occasional attempts were made by NGOs and the Catholic mission in this regard, they did not result in any sustained development. Nevertheless, we observed numerous individual or family initiatives in which, at best, fishing was done in small ponds during the dry season. However, interest in fish farming constantly grew, due in great part to the return of migrants from Côte d'Ivoire and, particularly, Liberia, and also due to the first official actions undertaken in this area in the late 2000s. This confirms Keita's observations (2002), who found an unprecedented increase in the number of informal efforts. Farmers in all these villages practiced a kind of ancient fish farming technique that involved catching small fish from their natural environment and rearing them in specially dug holes. These small ponds were often the result of know-how passed on by old migrants. Theareas used remain very limited in extent.

9.1.3 Type of Actions Implemented, the Major Features of the Approach

The main objective was therefore to encourage agricultural farms to diversify into fish-farming, while meeting the expectations and objectives of farmers: a step towards a successful transplantation of fish farming into agrarian systems (Oswald and Sanchez 1995).

In order to assess the suitability of the goal and test the motivations of farmers, no subsidies were given to them for setting up or running the fish farming operations. The challenge was to initiate a process that would not stop with the few farms receiving project support. Agriculture- and fish-farmers mainly received an in situ, extensive training spanning several years. This support was justified on the assumption that information played a key role in an emerging industry. The establishment of a fish-farm sector in a village had to be accompanied with all the necessary technical information and with a training framework that could boost the development of fish farming in the future.

At an operational level, organizing fish farmers into groups or associations proved to be one of the keys to success (Darré 1999).

[6]Literally '*trous-culture*' in French.

In Guinea, project support was even formalized via agreements between the project, the fish farmers' group and individuals who wished to be part of a group for receiving training in setting up fish farming in their village. In exchange for a commitment by the project of a certain production level (0.6–1 tonne/ha/year depending on the type of fish reservoir built) and product quality (fish size), farmers promised to adhere to guidelines, carry out the development with their own funds, share their knowledge and establish an organization that could provide guidance and support on fish farming. The facilitator conducted fish farming classes for groups of candidates for a week every 2 months. He was responsible for assessing the state of fish farming within the group, mainly through site visits and individual interviews. He hosted a workshop on the first evening for the group of motivated farmers to explain immediate priorities. He then conducted collective training, provided individual support and organized informal exchanges.[7] Over time, the services that farmers could reliably provide were transferred to the core group of farmers. The facilitator then took on the role of advisor and evaluator. There was also the idea of creating, later on, a professional organization able to represent all the fish farmers' groups.

Instructions given to the groups of farmers as part of the support extended to them were only offered as advice. When these instructions were not followed, reasons were sought: was the training imparted not properly assimilated, or did personal reasons lead to a different interpretation—or even the questioning—of the suitability of the techniques proposed. Fish farming practices that were performed routinely and the manner in which farmers modified them over time were always regarded by operators as decisive criteria for assessing the suitability of the proposed techniques.

The technical model has been described in detail (APDRA France 2002a, b). In short, it is an extensive fish farming model that enhances the natural production of fish in small catchment reservoirs with the help of a polyculture associating *Oreochromis niloticus* (tilapia), *Heterotis niloticus* and catfish. *Hemichromis fasciatus* is also used as a predator to control tilapia propagation. Sex determination is done for tilapia in order to grow large fish that some village markets demand.[8] The catchment dam ponds are adjacent to service ponds that ensure stocking needs, including pre-fattened sex-determined allevins. The base yield amounts to 600 kg/ha/year. It can easily be increased to 1 tonne/ha/year if the permanent flow of water in the pond can be controlled with proper management. Building a

[7]Assessment of extension methods carried out by Borderon (1999) of Agence Française de Développement showed the advantages of this type of organization compared to more conventional interventions in the agricultural sector.

[8]There are many bibliographic references extolling the economic merits for an African fish farmer of producing small fish. In the context of the environments described, these considerations do not reflect the social effects on the development of fish farming: production of large fish allows the processing of much more fish at the same price. This helps foster a spirit of cooperation between producers, resulting in the lowering of the cost of certain production factors (fry and fingerlings, mutual help for fishing, use of fishing gear, such as nets and cages).

diversion ditch (or a bypass canal) is often found to be useful. The yield can be boosted further by the addition of organic fertilizer. However, experience shows that few fertilizer by-products are available in villages with a primarily plantation economy. This situation is easily explained since livestock rearing is not integrated into these agrarian systems, and for carrying the crops from the fields or plantations, the almost exclusive form of transport is on people's heads.

The reasons for farmers opting to develop small catchment reservoirs on the upper borders of lowlands are, a posteriori, quite simple:

- the amount of earthwork in relation to the productive surface created, that is to say, the surface area of the water in which the fish will develop, is minimized, as is, therefore, the investment required;
- the investment can be progressive. Upon completion of a dike that blocks the water flow, the fish farmer obtains a productive area which will progressively increase as and when the dike is built up;
- the existing vegetation on the productive surface perishes as the area gets flooded, making way for aquatic plants to grow over time. This greatly alleviates the work of preparing and maintaining the productive area. This benefit satisfies the apprehension of the farmers who typically wonder, 'How can we reclaim and maintain the lowlands?'

All dam ponds and service ponds were equipped with a monk to help drain water and harvest the fish (even without the use of a net). Such devices also help empty out the production area (for sufficiently long periods to dry the bottom of the pond) and facilitate maintenance of the dam (clearing aquatic plants, for example) or the water holding area (removal of harmful plants).

9.2 Results and Discussion

9.2.1 Chronological Markers in the Development of Fish Farming

9.2.1.1 Luénoufla

Three farmers had already established fish farming activities prior to the implementation of the project in Luénoufla:

- a rich Gouro resident, who had used bulldozers available in the village on several occasions, had built a dike and a monk with help from the fish farming section of the Water and Forests department (which was then part of the UNDP-FAO project). He eventually managed to create a 1-ha reservoir. The investment put into the project, which was started in 1984, allowed him to obtain a fish yield every 2 years starting in 1990. Related structures (storage

Table 9.1 Development of fish farmers in Luénoufla from 1997 to 2002 (Trellu et al. 2002)

Description of fish farmers	Before 1997	1997	1998	1999	2000	2002
Fish farmers in production	3	3	9	22	28	46
Area used (ha)		2.85	7	14.6	16.9	
Estimated production (t)		1.1	8.5	15	25.6	
Duration of action of the project		Continued presence of the project				

ponds) also helped him dispense with aid from the nurseries of the Water and Forests department;

- two simultaneous initiatives by Burkinabé farmers were also implemented in 1991. These farmers also had access to a bulldozer. Their initiatives had two aims: to obtain a yield of catfish at the end of the dry season, and to have a water reserve.

After working with PPCO from 1993 to 1995, the project decided to open up the area in 1996. The ensuing developments, summarized by Trellu et al. in 2002, are described in Table 9.1.

In the course of the ensuing project intervention, the new fish farming facilities proposed to farmers allowed accurate control over the water: the ability to empty the reservoir or maintain the water surface at a desired level. These facilities were quickly perceived and used as farmland in their own right. Nearly 25 % of the area was used to grow paddy as water was easily available because of the monk and the water column created by the dike. Some crops were grown during the rainy season, including rice which was grown on the borders or downstream, and was replaced by maize on the more elevated slopes. In the dry season, women used the dike water to irrigate vegetable crops grown on the borders of the ponds. This activity consumed a lot of water: at the end of the dry season in 2002, two-thirds of the water in the dam was used up to irrigate the adjoining vegetable gardens! Fish from these fish farms is currently the main livestock reared in this area, and is present in every market. With respect to the social conventions that allowed services to come up around fish farming, it must also be noted that a large portion of the catch is fried. It is supplied to the local restaurant market, thereby adding value through this sector. In terms of investment, the use of bulldozers, which was favoured in the early 1990s, was quickly abandoned. Teams of efficient men and women specializing in earthwork soon emerged. Simple standards were used to quantify the volume of dikes to backfill, and channel and spillway levels to be built. A general acceptance of these standards by people who were involved clearly helped shape this development.

After 2002, the Luénoufla region found itself near the buffer zone during the worst period of the Ivorian crisis. Fragmented information[9] showed that, regardless

[9]Periodic information from APDRA-CI, training reports and internal notes of APDRA-F.

of their ethnicity, all the fish farmers who had established themselves during the project continued and expanded their production. While fish farmers who received support over several years through the project successfully consolidated their fish farming activities, many other farmers attempted to diversify into fish farming during the crisis. Interviews conducted in 2008 put this figure at more than 60. However, the quality of the facilities created by farmers who started late portends difficult times for fish farming.

9.2.1.2 Gbotoÿe

In this area too, there was a spontaneous enthusiasm for fish farming when the project was launched. A prospective fish farmer supported by the regional rural planning department has implemented a little pond. Following a request from PPGF, and after much hesitation, two farmers who were already involved in the project to revive coffee cultivation (RC2) accepted the responsibility of coordinating a group of local candidates starting in 2001.

In 2004, there were 12 candidates who owned lowlands and who wished to undertake fish farming. In addition to fish production, all these farmers also maintained a flooded rice paddy in their dam pond. Rice production was estimated at over 8 tonnes in 2004, more than twice the harvest in these lowlands without the installation of state-sponsored irrigated rice plots. The establishment of rice cycles in the pond areas in 2002 and 2003 seemed to have triggered a strong local movement (Table 9.2).

Table 9.2 Development of fish farmers in Gbotoÿe (*sources* PPGF activity reports: 2001, 2002, 2003, 2004 and 2006)

Year	Before 2002	2002	2003	2004	2006
Fish farmers in production	0	3	4	9	13[a]
Area used (ha)		1.35	2.5		>3.4[b]
Estimated production (t)	0	0.04	0.47	1.99	
Duration of action of the project	Continued presence of the project from 2001 to 2004 and since 2006				

[a]This number does not include 8 new fish farmers who were in the process of building their first ponds. In 2006, the large number of candidates in the village, more than a dozen who wished to take up the activity, and in neighbouring villages showed that the significant investment was no longer perceived as a constraint by the farmers, but rather as an opportunity to improve the situation of their farms

[b]This area was measured in the dry season—when it dropped to less than 30 % of the maximum area, in the rainy season—and therefore did not correspond to the area of water when ponds are filled up

9.2.2 Role of Fish Farming in Farming Systems

9.2.2.1 Performance of Fish Farming Systems

Interviews with fish farmers showed that fish farming is a profitable and very popular activity in both areas. A comparatively detailed study conducted in 1998 (Coulibaly and Oswald 1999) on a sample of farmers in a neighbouring region (the south-east of Gagnoa) had already highlighted the performance of fish farming activities. Those from Luénoufla also corroborate these observations.

9.2.2.2 First Lessons from the Survey Conducted in 1998 in Côte D'Ivoire

The farming systems of a sample group of farmers (those already involved in fish farming and those evincing interest in it) were analyzed in order to understand the role of fish farming in the farms (Coulibaly and Oswald 1999). This sample included large farms specialized in cocoa cultivation, and whose gross margin per unit area had been calculated (Table 9.4). The surface area of fallow land was included when rice was grown in slash-and-burn plots. The results showed that the gross margin per hectare for fish farming was significantly higher than that for cocoa. This margin could further increase by 30 % when the farmer grew flooded rice inside his dam pond. In fact, a rice-fish association is capable of providing the farmer with a gross margin per unit area almost double that obtained from cocoa.

The overall homogeneity of the value drawn from a day of labour on cocoa plantations highlights the farmers' professionalism. They manage to extract value from their labour force uniformly, regardless of the state of their plantations (Tables 9.3).

As for fish farming (Table 9.5), several farms were coming into production while others had not yet done so. It was thus difficult to determine the value of the working day in a fish farm under normal circumstances. For fish farms that had entered production, the average value of a workday was 16.5 €/day against 5.75 € for cocoa. The exceptional value for farm no. 4 was due to the skilful management of a very large pond. When this farmer was excluded from calculations, the average at 7.2 €/day was slightly above the figure for cocoa. This figure would have been much higher if the sampling included only those farms operating for a sufficiently long period of time.

These figures reveal the ability of this type of fish farming to lead to a real intensification of agriculture per unit area, while, at the same time, improving labour productivity. During the setting up phase, the requirement of labour, and consequently of investment, is high. After that, however, not much work is required to maintain and manage the fish farm. In other words, once the reservoirs are in place, farmers revert to the previous, pre-investment, level of labour requirement. In any case, all work related to fish farms can be done in addition to work required for cocoa cultivation, thus increasing further the remuneration of the working day.

Table 9.3 Economic characteristics of the sample

Farm	Total workers (MWU)	Family workers (MWU)	Capital for cultivation (FCFA)	Cultivated area (ha)	Total gross proceeds (FCFA)	Share of home consumption in total gross proceeds (%)	Labour productivity (FCFA/MWU)
1	10.7	7.5	112,553	33.8	2,444,838	22	203,040
2	5.4	4.1	283,245	12.0	1,777,775	18	263,870
3	8.6	3.7	100,828	45.0	3,252,363	10	337,657
4	21.6	13.6	653,370	64.0	6,051,950	17	224,664
5	9.0	8.7	145,965	16.5	1,795,175	11	128,109
6	10.0	6.5	153,725	26.8	2,521,125	12	201,555
7	7.4	4.1	85,398	18.0	2,254,363	19	275,249
8	6.6	4.2	264,443	17.8	3,054,723	12	406,712
9	10.8	4.5	90,378	69.0	4,620,463	20	406,154
10	22.4	13.3	583,238	100.0	17,123,963	07	696,521
11	11.1	7.4	150,468	55.0	4,368,663	07	338,890
12	7.6	6.1	259,723	23.5	5,599,688	04	653,086
13	8.2	5.6	423,528	40.3	2,701,045	09	219,342
14	9.0	4.5	305,975	22.0	1,462,200	18	111,213
15	8.5	7.0	85,000	18.0	1,935,950	08	204,807
Average	10.5	6.7	246,526	37.4	4,064,285	13.0 %	331,391
Amount in €			376.40		6,205.00		505.90

Table 9.4 Gross margins per hectare of different crops in FCFA

Farm	Fish farming only	Contribution of rice to fish farming (%)	Cocoa	Rain-fed rice on plains and unmanaged lowlands
1	134,667	34	94,344	16,800
2	625,000	–	173,600	15,833
3	218,000	32	122,829	–
4	629,375	21	158,956	10,208
5	246,667	–	247,600	–
6	200,000	–	113,021	6,462
7	314,200	–	201,429	8400
8	232,500	–	388,733	13,938
9	–	–	225,927	9,000
10	224,500	–	422,683	11,523
11	20,833	–	85,744	–
12		–	264,981	18,600
13		–	127,368	7,978
14		–	159,714	5,922
15		–	120,843	11,600
Average	287,380	29	193,869	11,355
Std. dev.	196,364	7	101,801	4,150
Average (€/ha)	438.70		296.00	17.30

Table 9.5 Valuation of the work day in fish farming and a cocoa plantation

Farm	Value drawn from a day's labour exclusively on fish farming	Value drawn from a day's labour on cocoa cultivation
1	2,971	2,769
2	6,375	4,014
3	11,474	3,197
4	53,000	4,731
5	1,510	3,533
6	1,020	2,267
7	n.a.	3,464
8	n.a.	4,952
9	n.a.	4,202
10	9,163	6,186
11	1,020	2,488
12	n.a.	4,801
13	n.a.	3,006
14	n.a.	3,263
15	n.a.	3.196
Average	10,817	3,736
Average (€)	16.50	5.74

9.2.2.3 Review of the Guinea Forest Situation

This study (Barthes 2007), more recent than the one undertaken in Côte d'Ivoire, shows results that are not very different. It was conducted using similar methods on a sample of Guinean farmers, including a number of fish farmers from Gbotoÿe. As in the case of Côte d'Ivoire, not all the fish farmers in this sample (Fig. 9.1) had started producing fish.

The estimated average gross margin was 658 €/year, of which nearly 326 € was obtained from rice cultivation. It should be noted that the performance of fish farming here seems slightly weaker than that obtained in Côte d'Ivoire. This was perhaps due to smaller pond areas and smaller quantities of fish sold on the market, although selling prices were slightly higher. Environmental factors also contributed to this difference: the soils were highly desaturated in Guinea and cooler temperatures could lead to lower yields.

As part of its efforts to compare these systems' performances with the main local cash crop (coffee), the study also analyzed the economic performance of coffee cultivation. However, the fluctuating price of coffee made the task of comparing its effectiveness to that of fish farming very difficult. Two price situations were combined with two different production systems ('wild coffee'[10] and RC2[11]) to

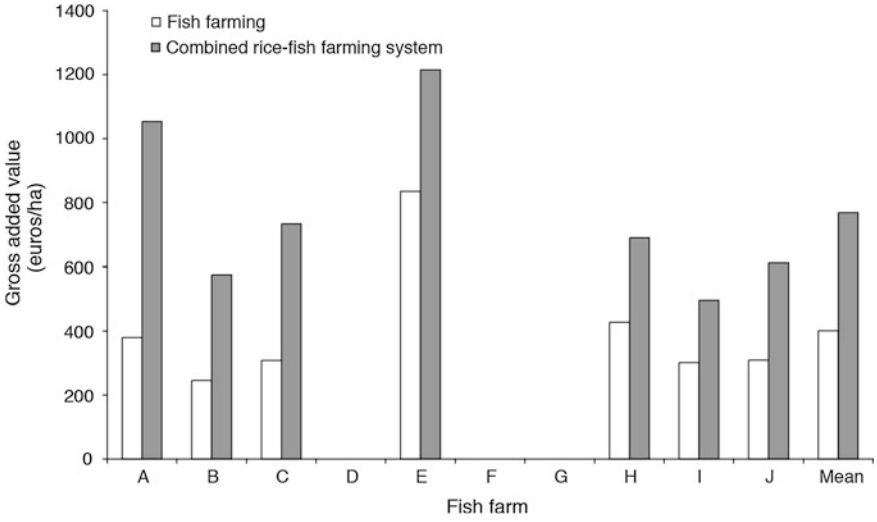

Fig. 9.1 Gross margin per hectare of the fish farming system alone and of the combined rice-fish farming system (Barthes 2007)

[10]Wild coffee ('*sauvageon*' in French) is the local term to describe the coffee planted with young trees taken from old plantations.

[11]RC2: variety introduced by a programme to revive coffee cultivation.

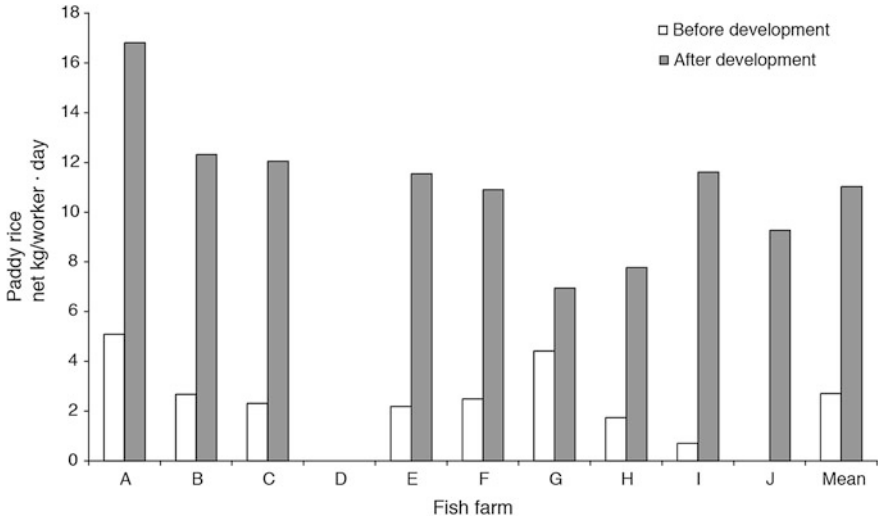

Fig. 9.2 Comparing the value of one working day in a rice field before and after fish-farming development work

obtain the following results: the value of 1 ha of a 'wild coffee' system was always less than that of the rice-fish system (less than 225 €/ha, even in the best price situation). In a situation with an unfavourable price, like in 2004, even the best plots that grew RC2 could not bring in that much revenue. In contrast, when the price was favourable, like in January 2007 (farm-gate prices per kilogram of berries of 0.48 €/kg), the plot of coffee offered a greater margin, subject to a production of more than one tonne per hectare.

A comparison with rain-fed rice, which was in the throes of a crisis in the region, needs no explanation: 149 €/ha considering only the cultivated area. This takes the gross margin per hectare down to less than 30 € if land that is left fallow for at least 5 years is taken into account. The comparison is also clear when we evaluated lowland rice. Farmers, especially those from Gbotoÿe, preferred a traditional arrangement without bunds. The gross margin for this system was only 90 €/year.

Sharp fluctuations in the price of rice and the Guinean currency make it more difficult to estimate the value of the labour put into the rice-fish farming system, especially since most of the fish farming activities account for only a small part of the farmer's working day. On the other hand, the work done in a rice field before and after the creation of a dike for fish farming can be compared based on estimates of the quantity of rice produced in a working day (Fig. 9.2).

The spectacular gains in productivity explain the active involvement in the construction of large dikes. The average pre-development value of the work day was 2.7 kg of paddy/day (excluding seeds). It rose dramatically to 11 kg/day after development.

In Guinea, fish farming addresses the constraints of intensification of surface areas, while adding value to the working day. An added benefit was the potential intensification of agricultural activities without increasing competition in any way. In fact, fish farming alleviates pressure on farmers to grow rice for home consumption (Simon and Benhamou 2009).

9.2.3 Place of Fish Farming in Earning Revenue

The share of the total income brought in by fish farming is variable. If the techniques for managing and producing fish are mastered, the limiting factor then becomes access to lowlands that can be developed. This gives rise to several land-use strategies.

9.2.3.1 Significant Income

In any case, fish farming provides a good income to farms, and it is sometimes the most remunerative activity. Most often, however, it is found in the second or third place behind the main plantation crops, but generally ahead of food crops.

9.2.3.2 Marketing, Food Self-sufficiency and Nutritional Balance

Fish is primarily produced as a marketable product. However, the by-products of the catch (unsalable fish or ones considered as pests for fish farming) are consumed within the farm household. It can also be used to pay casual workers hired for the more labour-intensive fishing operations. While it is difficult to arrive at an authoritative ratio, qualitative surveys show that nearly 30 % of the fish caught is finally home consumed. The farms that now have fish farms have recorded an increase in their fish consumption over the years. Some farmers mentioned that their fish consumption has doubled, compared to when they exclusively purchased fish from the market. We can certainly conclude that this has had a positive effect on the nutritional balance of their families. Many farmers involved with fish farming say they no longer buy fish. Mini-ponds have appeared at almost all fish farms to serve as ‘pantries’ so that farmer families have an easy and continuous supply of fish.

9.2.3.3 Flexibility of Income

Fish farmers in the Luénoufla and Gbotoÿe regions appreciate in particular the flexibility afforded by fish farming. Remember that once the dike walls are built, fish farming no longer requires any extra farm labour. The fish-farming system offers the farmer the flexibility of harvesting the fish when he wants to sell it,

allowing him to schedule it when the agricultural calendar permits. Although the value of a workday in a functioning fish farming system is most often greater than that for other crops, the number of days of labour required for this activity remains generally low.

9.2.4 Unexpected Scale of Investments

All visitors to the Luénoufla and Gbotoÿe villages who have seen the surrounding lowlands with its fish farms have marvelled at the extent of manually constructed earthwork. The investment is on the order of what would be required to develop primary forests.

How did farmers carry out development work of this magnitude? How much did it cost?

9.2.4.1 What Value to Attribute to Fish Farming Facilities?

The monetary expenditure involved in constructing fish farming facilities is relatively easy to quantify. However, any comprehensive evaluation of the cost of these facilities runs up against two common difficulties inherent to family agriculture. The first is to assess the amount of labour invested in developing the fish farming facilities (especially family labour). The second problem is to estimate the value of this labour, both casual labour and family labour, since it is very difficult to establish the opportunity cost.

For the remainder of this chapter, we shall work with two estimates:

- the first, which overvalues the labour, considers that all labour was paid for (including family labour);
- the second, which undervalues it, considers only the actual expenditure.

A dike in Côte d'Ivoire—of a height of 2 m (from the drain) and 3 m wide, and enclosing 60 m of regularly sloped lowlands—corresponds to a soil volume of 300 m^3. This represents about 60–90 man-days of labour. Only the lean periods in the agricultural calendar can accommodate such investments in rural areas. The cost of a hired labourer (on contract, who ensures the completion of the embankment) varies depending on the hardship involved in the work. It is often 230 € for a derivating pond and 460 € for a dam. A 0.3–0.4 ha facility, with a service pond and a bypass canal, can involve a cost of 850 €/dam (Coulibally et al. 1999) and around 2100 €/ha. The minimum cost for a dam, without earthwork, was 46 €/dam.

In Guinea, the volatile currency makes comparisons more difficult. Barthes (2007) estimates that development work costs 1000 €/ha, by considering that family labour can be valued at market rates. Family labour, on an average, accounted for around 20 % of the total investment cost. The PPGF report (2003) estimates the

investment made, taking into account the opportunity cost of family labour, to be, on an average, close to 750 €/ha.

Under specific circumstances, taking the farmer's declared opportunity cost into account triples the investment cost. Thus, a Guinean farmer who declares a direct cost of 180 € knows that the amount he spent to build the dam was actually closer to 405 €. This opportunity cost includes the amount not earned because of a decrease in the area cleared for rice and the reduction in coffee-related work. The cost also, and especially so, includes the loss of earnings from the use of rolling capital that would have allowed him to extract palm oil and cultivate peanuts and rice.

Farmers on both sides of the border establish fish farms mainly by relying on family labour to minimize financial risks. Large farmers in Côte d'Ivoire convert labour contracts from an annual payment basis to the *abusan* system. This is a simplified form of sharecropping, where a third of the harvest is given to sharecroppers as payment, in addition to any other agreement. Under the terms of the *abusan* contract, the sharecropper is required to work an extra day per week for the owner outside of the plot. Here too the goal is to minimize the financial risk posed by the construction of the dam.

Consequently, fish farmers who had learnt the fish farming techniques no longer dipped into their savings for investments. A virtuous process then developed which democratized fish farming to some extent. The presence of the initial fish farms, in fact, helped the poorest farmers gain easier access to certain services (Grosse and Oswald 2010), usually in the form of labour exchanged for investment support. Large farms were the first to use this type of exchange. This kind of relationship, for example, was actually mentioned by a Gouro fish farmer who worked for his elder brother in exchange for the latter's support in constructing his pond.

Finally, it must be noted that for farmers who construct a pond by dipping into their capital, there are few comparable investment opportunities other than in real estate in the town. Statements from this category of farmers indicated that they hoped for an annual income of about 15–30 % of the capital invested. Apparently, this is easy to achieve with the kind of fish farming offered by these projects.

As in other strategies for minimizing risk, prospective fish farmers do not hesitate to use the least fertile lowlands for growing rice. We thus return to the notion of risk associated with an investment: the loss of income is not so important during the construction of the pond. This strategy also highlights the ecological aspect of diversification: fish farm development helps restore a satisfactory level of yields of lowlands that have been degraded by years of rice cultivation. Finally, and more obviously, dikes are mainly constructed when there is less work in the fields. When the agricultural workload is heavy, the groups working on the construction of ponds temporarily suspend their work and wait for a less busy period.

9.2.4.2 How to Assess the Investment Capacity of Production Systems?

The huge investments made highlight the complexity of evaluating the financing capacity of rural farms. We were able to describe this investment capacity here mainly due to a relationship of trust built over time, where each person (farmer, project manager, hired labourers, service providers) assumed his responsibilities. The strong motivation to introduce fish farming and the possibility of sharing skills and know-how with the villagers over a long period of time are certainly key factors in this exceptional mobilization.

The coordination of local groups was a valuable tool for a true adaptation of technical guidelines to farmers' needs. In a PPCO assessment, farmers stated that they acquired their knowledge most often from colleagues rather than through formal training sessions. Nevertheless, such training activities were important for the dissemination of new knowledge (reason for sex determination, management of stocking density, etc.) (Huet 2001; Halftermeyer 2009).

The success of the fish farming sector in these two villages highlights the appropriation of the fish farming project by one or more groups of farmers who, in addition to the obvious economic contribution of this activity to their farms, also regarded it as a tool to further their ambitions. And the larger their ambitions, the larger the capacity of this innovation to fulfil them and to invoke deep interest in others.

We are witness to a model of fish farming development which is very different from the traditional and basic model recommended by extension programs. The innovation is not insignificant at the farm level: it monopolizes the investment capacity of the farm for several years, while demonstrating its sustainability. The events of Côte d'Ivoire help prove this. The 'participatory' aspect then consists of sharing of risks taken by the farmer in the setting up of the facilities, and then during the period his fish farm reaches its full production.

9.2.5 Dynamics on Either Side of the Border

9.2.5.1 A Project that Overcomes Local Constraints Differently

These examples from the two regions show that fish farming can help address water-related matters of the agricultural sector. In this way, the plantation economy context can encompass issues other than the development of cash crops. Other than traditional projects for the development of irrigated rice—which saw mixed success (Delarue 2007b)–, little was attempted to help farmers develop irrigated agricultural systems. In the specific case of fish farming, nothing was done to allow farmers to manage fish farming activities on their own, within the framework of their farm operations.

In Guinea, the exclusive development of fish farming would hardly have had the same relevance. It is only the association with rice cultivation that is capable of producing more per unit area than both systems individually, while also providing a better value for the working day. This outcome has more than adequately addressed the development constraints. Furthermore, the huge investment can be even better justified if it helps make degraded or barren lands fertile. This development underlines the importance of a holistic appreciation of the impacts of fish farming on farming systems.

The example of vegetable gardening in Luénoufla (Côte d'Ivoire) also offers many lessons: the development of water-based agricultural systems is very useful, over and above the simple purpose of producing fish. Water readily available in the fish farming reservoir quickly becomes available for other activities, such as vegetable gardening here.

9.2.5.2 A Project Integrated into Local Policies

At another level, these successes often lead to strong local commitments made by their promoters. Fish farming is fast becoming a political and strategic issue. Two facts are evidence of this:

- in Guinea in 2005, elections were held for the posts of presidents of districts and of rural development communities. Wherever a member of the group of fish farmers stood for the post, the group would proudly announce that their candidate had won. This showed the extent to which fish farming had become an integral part of local debates. Diallo (2003) also noted, with surprise, that local governmental and traditional authorities were well aware of the growing number of fish farmers and their groups and maintained links with various candidates;
- during the Ivorian political crisis, a Sénoufo group, which was a scapegoat of the incumbent government, chose to nominate the only Muslim Gouro who provided several services to them. The Gouro were considered culturally very close to the power centre of the time.

To construct fish farming facilities, several land-related negotiations have to be entered into. Sometimes control over water helps assert the right over a plot or to negotiate for it. We observed here a widespread consistency in the plantation economies of West Africa: a context where land, transferable or exchangeable, is a positive factor in a dynamic of development. Property boundaries in the lowlands often do not reflect ideal demarcations, neither in terms of topography nor water. With a strong process put in place, many land transactions result. Access to lowlands remains a major factor in the process of establishing a fish farm. When fish farming does not meet the expectations of farmers, the area developed for the purpose is neglected; however, such neglect has little impact on the conduct of transactions that are effected over the short term. It is a different matter when the process is sustained. Thus, the Gouro farmer of Luénoufla was denied access to family lowlands by other family members. They were afraid that he would develop

the entire lowlands owned by the family and thus lay claim to them. He was first asked to demarcate individual access to the lowlands for each family. In Guinea, the right to purchase lowlands, contrary to existing traditional law, has become common practice, concurrently with the development of fish farming.

9.3 Conclusion

The implementation of the PPCO (Central Western Fish Culture Project, Côte d'Ivoire) and PPGF (Fish Farming Project in the Forest Region of Guinea) projects shows that fish farming is, or should be, an important method of diversification in plantation economies. Its development depends on farm-specific factors: a major issue, in addition to socio-economic criteria, is access to lowlands which can be used for fish farming.

Although the results are not noticeable in national statistics, especially given the large fish quantities imported for consumption, these fish farms demonstrate two major local successes. On the one hand, a true private sector has embraced this activity. On the other, the development of fish farming in these areas had become a significant and structured process, i.e., a transformation and adaptation of the local human environment (Assi Kaudjhis 2005). This step is significant: Chauveau and Richards (2007) emphasize the relationship between, on the one hand, the crises in Liberia, Côte d'Ivoire, Sierra Leone and, to a lesser extent, in Guinea, and, on the other hand, the meagre opportunities offered to the youth and the lack of successful diversification related to water management.

A negative impact of these projects is the building up of a demand that exceeds the capacity to provide support in terms of space and time. This is the price to pay for local success. This impact should be seen as a stage that has definitely been achieved, and which holds lessons for the future.

For the time being, these examples of fish farm development and innovations perfectly illustrate the overall analysis of this book on the economic and ecological determinants of diversification.

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