SUSTAINABLE FISHERIES MANAGEMENT AND CULTURE-BASED FISHERIES IN RESERVOIRS

A CASE STUDY FROM BURKINA FASO

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1. INTRODUCTION

Fish and other aquatic products are an important food source, and in the world as a whole, they contribute approximately 16% to the animal protein and 12% to the total calorie consumption per capita. Rivers, lakes and wetlands cover 1% of the global surface but yield 8.6 million tons per year or 8% of the global fish production. From this yield, 73% are caught in 15 developing countries, six of them from the African continent: Uganda, Tanzania, Egypt, Kenya, Congo and Ghana.

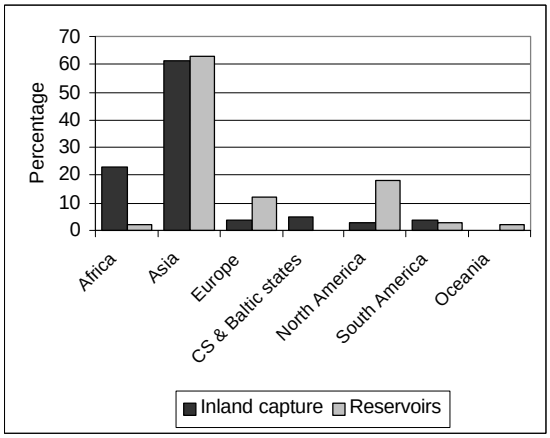

Figure 1: World distribution of inland captured fisheries production and reservoirs (dam height > 15 m, FAO, 1999)

Fish and other aquatic resources are captured from a great variety of inland systems, including artificial lakes, which have a combined area of about 1.7 million km^2, nearly 1 million km^2 of which are accounted for by large lakes (>100 km^2) Fished artificial water bodies range from large hydroelectric reservoirs to small multipurpose community ponds, irrigation channels, etc. There are about 60,000 large reservoirs (>15 m dam height) in the world, totalling 400,000 km^2. Nearly 65% of them are located in Asia and only about 2% in Africa (Figure 1).

In light of increasing human population growth, these small reservoirs could make a greater contribution, if they were managed appropriately, to food production and employment opportunities, particularly to poorer sectors of the community, which also often happen to be rural.

Burkina Faso, a country in the Sahel, with over 11,000,000 inhabitants, and covering an area of 274,250 km^2, has an economy based primarily on agriculture, cattle and the exploitation of natural resources. Eight-five percent of the population is engaged in agriculture or cattle raising, and this sector accounts for 40% of the GDP. However, this sector does not guarantee the food supply for the population. Burkina

Faso is classified among the poorest countries of the world, with 45% of the population living below the poverty line, especially the population in the rural areas.

The fisheries sector produces about 8,500 tons of fish per year and generates income for approximately 11,000 households or 50,000 to 60,000 persons. With an annual turnover of more than 2.5 billion FCFA per annum, fishing represents about 1% of the national GDP. Based on fish consumption (1.5 kg/capita/year) and number of inhabitants at present, 15,450 ton of fish would be required to cover the needs. Even if all the potentials are exploited, between 10,000 and 12,500 tons could be produced annually and Burkina Faso remains far from meeting the needs.

Burkina Faso has about 2,100 artificial lakes, 80% of these lakes have a surface of less than 70 hectares during the dry season (Figure 2). The fish stocks in these lakes are heavily exploited. Within the framework of the fight against the food insecurity and the reduction of poverty, in 1988 the project "Management of Fisheries in the South-West of Burkina Faso" started, with a main objective to **increase the fish production in the southwest of Burkina Faso.**

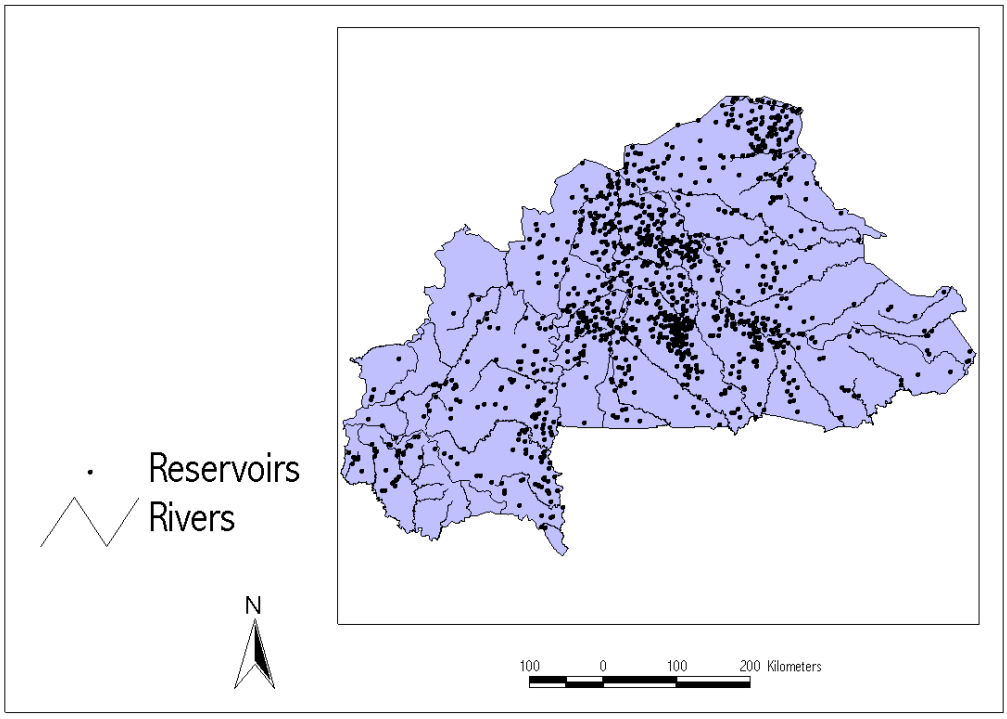

Figure 2: Reservoirs in Burkina Faso

2. PROBLEM IDENTIFICATION

The initial problems identified in 1988 were:

- Over-exploitation (recruitment over fishing) of the natural fish stocks due to the use of fishing gears with small mesh sizes.
- Reduction of natural recruitment of commercial fish species due to the high abundance of predatory species.

The project had two distinct phases:
Development of culture-based fisheries, 1988-1995
Development of participatory management of natural resources, 1995-2002

Each phase had its distinct concept, implementation, and results, which will be discussed separately.

3. PHASE 1: CULTURE-BASED FISHERIES

3.1. THE PROJECT CONCEPT

During its first phase, the interventions were based on the following technical assumptions:

- The natural productivity of the water bodies was not used maximally,
- The fisheries potentials were not fully utilised,
- Regular annual stocking of the water bodies with fingerlings of the Nile Tilapia (*Oreochromis niloticus*) could increase the annual fish yields. Nile Tilapia was chosen because of its high market value, high growth, and easy reproduction.

3.2. PROJECT SITES

During its first phase, the project intervened at the following eight water bodies (Figure 3).

1. Mare aux hippopotames (140 ha)
2. Lobi (120 ha) ;
3. Tounoura (14 ha);
4. Koumbia (100 ha);
5. Lémouroudougou (140 ha);

6. Comoé (600 ha);
7. Tiéfora (125 ha);
8. Vallée de Kou (140 ha)

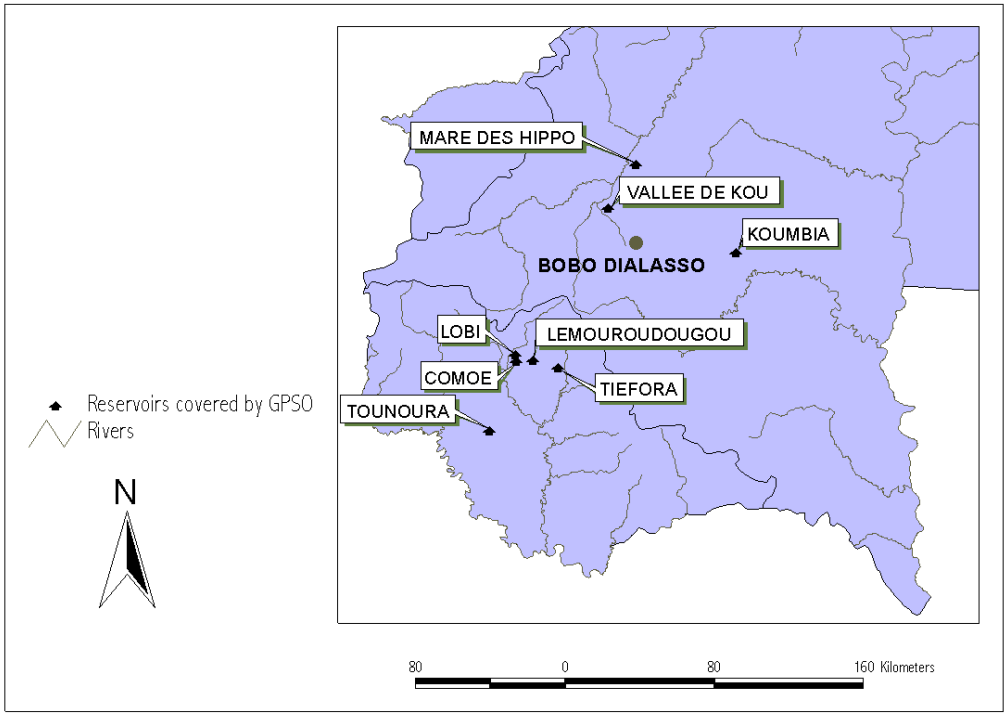

Figure 3: Reservoirs covered during phase 1 of GPSO

3.3. FISHERY POTENTIAL OF THE DIFFERENT RESERVOIRS

Almost no baseline data on fisheries were available in 1988, partly because the majority of the reservoirs were just impounded. In addition, potential fisheries yields were assessed with the empirical models of Marshall (1984) and Crul (1992), which takes into account the conductivity, water area and water depth of the reservoirs. The estimates are presented in Table 1.

Table 1: Potential yields as estimated with the empirical models of Marshall and Crul for reservoirs covered during phase 1 of GPSO

Reservoir	Area (ha)	Mean depth (m)	Conductivity (us/cm)	MEI	Marshall (kg/ha/year)	Crul (kg/ha/year)
Comoe	600	6.3	48	7.60	58	68
Koumbia	75	1.2	65	54.20	139	105
Lemouroudougou	145	1.5	125	83	170	88
Lobi	120	5	34	6.80	55	95
Mare aux hippopotames	140	1	127	127.00	203	92
Tiéfora	125	1	46	46.40	129	94
Tounoura	14	0.7	229	327.10	312	148
Vallée du Kou	140	0.5	65	130.00	205	92

The estimated potential yields ranged from 55 kg/ha/year in the larger reservoirs to 312 kg/ha/year in the smallest one.

3.4. INVOLVEMENT AND TRAINING OF THE COMMUNITIES

3.4.1. Identification of the stakeholders at the different sites

Once a site was selected for improvement by the project, staff members of the project met with the local traditional authorities to discuss whether they agreed with the interventions proposed. During this stage, the future fishers were also identified.

The number of fishers allowed in each reservoir was estimated according to the productivity of the water body, whereby a minimum annual catch of 800-1000 kg per fisher was used as criteria. A kind of lottery to select the fishers was organised in places where the number of persons who wanted to start fishing was higher than the allowable fishing. Thus, the basic strategy of the project was to work with more or less “professional fishers.”

3.4.2. Organization of the fishers

In order to develop a fisheries management plan at each site, a kind of legal organisation of fishers had to be established. To remain within the legal and economic frame work of Burkina Faso, the fishers were organised in Economic Interest Groups (GIE). The GIE is defined as a legal instrument in which people having a similar economic activity associate some their means in order to facilitate or to develop their activities in one or more given fields. The members of the GIE are

jointly responsible for their structure in the form of thirds. During the first phase of the project, eight GIE were organised; Lobi, the Vallee de Kou, Tounoura, Tiéfora, Bounouna, Mare de Hippo, Wramba, and Comoe.

3.5. TRAINING OF THE FISHERS

As most of the reservoirs were newly impounded, the new fishers had almost no experience in fishing. Therefore, at all sites the members of the GIE were trained in:

- Fishing techniques
- Net-making and repair
- Fish processing
- Operation and financial management of the GIE

3.6. FINGERLING PRODUCTION AND RESULTS OF STOCKING

In order to assure the potential fish yields, the project set the target-stocking rate at 20 kg of fingerlings/ha/year (800 fingerlings/ha/year) or about 1 million fingerlings had to be produced each year.

Table 2: Fingerling ponds constructed by GPSO and their realised average production

Site	No of ponds	Pond size (ha)	Total area (ha)	Mean annual fingerling production (No/year)
Tiéfora	2	0.25	0.5	28840
Lobi	3	0.08	0.24	6960
Tounoura	1	0.8	0.8	79560
Vallée du Kou	2	0.4	0.8	360
Lémouroudougou	2	0.25	0.5	11840
Mare aux hippopotames	2	0.02	0.04	Not available
Koumbia	1	0.03	0.03	Not available

In order to meet this demand for fingerlings 2.9 ha of Tilapia, reproduction and fingerling-rearing ponds were constructed by the project at the different sites (Table 2). The fishermen were trained in the rearing of the fingerlings and over the period 1989-1994, approximately 750,000 fingerlings were produced, which was largely insufficient to stock the water bodies at the intended target rate (Table 3).

Table 3: Realised stocking and yields of *Nile Tilapia* during phase 1 of GPSO

Lake	Area (ha)	Target stocking rate (kg/ha/year)	Realised mean stocking rate (kg/ha/year)	Mean stocked number (no/ha/year)	Mean annual yield of Nile Tilapia (kg/ha/year)
Comoe	600	20	1.9	76	9
Lemouroudougou	140	20	4.8	193	11
Mare aux Hippo	140	20	0.1	5	100
Tiefora	125	20	3.8	151	8
Lobi	120	20	1.5	59	22
Tounoura	14	20	97.1	3885	269

Only in one water body (Tounoura) was the interventions from a technical point of view successful as yields increased drastically after stocking. For the larger water bodies, not enough fingerlings could be produced and therefore the impact of stocking was limited.

3.7. TECHNICAL AND BIOLOGICAL ASPECTS OF THE EXPERIENCES OF GPSO

3.7.1. Analysis of the results

The training program of GPSO was successful within a relatively short period. The involved fishers, who had almost no previous experience with fishing, where able to catch fish, earn a reasonable secondary income through fishing, maintain their gears, and understand and implement basic fisheries management plans.

The GPSO project started with a target-stocking rate of 20 kg of fingerlings/ha with the expectation that this would increase the yields of *O. niloticus* with 80-100 kg/ha/year. However, the results were disappointing as only in Tounoura, a small lake of 14 ha, the yields of stocked *O. niloticus* increased significantly to 269 kg/ha/year. However, biological modelling (de Graaf, 2002) indicated that the low stocking rates were the major reason why no significant

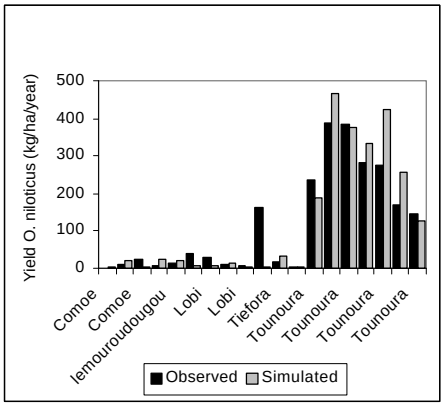

Figure 4: Simulated and observed yields of *O. niloticus* for all water bodies covered by GPSO

improvements were observed in the other water bodies (Figure 4).

Stocking at densities of 1-5 kg/ha/year still increased the yield with 3-15 kg/ha/year. However, this improvement was difficult to detect as it was in the range of the annual variation of natural yields, **but it is still an improvement**.

Major reasons why not enough fingerlings could be produced were:

- Insufficient number of fingerling ponds was constructed. In order to meet the capacity, about 5 ha were needed.
- Low production of the fingerling units due to the fishers' lack of experience with the raising of fingerlings and technical production problems.
- Activities related to the rearing of fingerlings were sometimes in conflict with other economic activities and was not given enough attention by the fishers, as fishing was for them a secondary income-generating activity.

It can be concluded that the results of rearing fingerlings at each individual site by the fishers involved were not satisfactory and not coherent with the socio-economic reality of the fishers as the investments (1500 U$/fisher) and operational costs (520 U$/fisher/year) were too high (Table 9). This is more or less concurrent with experiences all over the world; the sustainable development of culture-based fisheries requires a well-established aquaculture industry, capable of producing sufficient fingerlings for a competitive price.

Table 4: Pond-rearing facilities to stock 100 ha of water with fingerlings of Nile Tilapia at a rate of 20 kg per ha

Area water body	100	Ha
Stocking density fingerlings (20 gram)	800	No/ha/year
No of fishers	6	
Fingerlings needed	80000	Fingerlings per year
Fingerling ponds needed	3000	Square meters
Reproduction ponds needed	750	Square meters
Investments for facilities	10000	U$

Table 5: Production cost of a fingerling-rearing facility for stocking a 100 ha reservoir (based on cost and production of Tounoura rearing station in Burkina Faso)

Item	Costs (U$/year)	
Brood stock	11	
Feed	271	
Depreciation equipment	212	
Depreciation ponds	1624	
Tax	135	
Others	812	
Total annual costs	**3071**	
Fingerling production	2000	Kg/year
Production costs	1.53	U$/kg

A major technical parameter of culture-based fisheries is the survival rate or recapture rate of the stocked fingerlings.

The main idea of culture-based fisheries is: we stock small fingerlings; enough natural food is available for growth; consequently we capture them one or two years after stocking once they have reached a commercial size. The fingerlings are bought or produced by the fishers and are the major investment in terms of money or time[1]. If for whatever reason not enough fingerlings are reaching the commercial size or not enough large fish are recaptured, the investments will not be recovered and the system becomes financial unfeasible.

Major reasons for a low recapture rates are:

- Low quality of the fingerlings
- Overstocking
- High escape of the stocked fingerlings
- Fingerlings are too small and consumed by natural predators such as Catfish, Nile perch, Snakehead, etc. These predators can easily catch preys that have a size of 5% of their own body weight. For example, a Tilapia fingerling of 10 cm or a weight of 25 gram is absolutely no problem for a Catfish, Snakehead or Nile Perch of one kilogram.
- There are too many natural predators.

[1] Time; If they are collected from nature

- Too many *"human predators"* or poachers. Even if the survival rate of the stocked fingerlings is good, the system can be still become financially unfeasible if large numbers of good-size fish are caught by outsiders who did not bear the costs of the stocking.

Thus, there are two principle parameters indicating the success or failure of culture-based fisheries: stocking efficiency and economic efficiency.

Stocking Efficiency is defined as the ratio of the yield of the stocked fish (kg/ha) to the weight of the stocked fish (kg/ha) or:

$$StockingEfficiency = \frac{YieldStockedFish}{WeightStockedFingerlings}$$

In Burkina Faso for each kilogram of stocked fingerlings of *O. niloticus,* about 3.4 kg of large *O. niloticus* were caught one year later. A stocking efficiency of 3.4 is low and in general, we are aiming at an efficiency of 4-6 or a survival rate of 30-40% (Table 6).

Table 6: Relation between stocking efficiency and survival rate of stocked fingerlings of *O. niloticus* in Burkina Faso (stocking weight 20 g, weight at harvest 400 g)

Survival rate	Stocking efficiency
10%	1.6
20%	3.2
30%	4.8
40%	6.4
50%	8
60%	9.6
70%	11.2
80%	12.8
90%	14.4
100%	16

The stocking efficiency in itself is only an indicator for survival of the fingerlings, and the overall financial results are determined by the investments costs and the income. The price of the fingerlings and the survival rate are of utmost importance in such an economic analysis. However, with low fingerling prices and a high wholesale price of the caught adult fish, even at a low stocking efficiency the system can be financially feasible.

In general, culture-based fisheries requires substantial investments and the final goal is that the investments are recovered and that some profit is made. The costs of culture-based fisheries encompass:

- The cost of stocking material, which often amounts to 40-70% of total costs
- Cost of harvesting
- Cost of removal of unwanted species
- Licensing costs
- Cost of guarding the water body (anti poaching)
- Costs of physical intervening to maintain the environmental quality needed (draining, weed removal dredging, etc)
- Cost of physically modifying the environment (creation of bunds, embankments, creation of spawning and shelter habitats, etc)
- Cost of fertilizers, feed in case of very intensive culture-based fisheries

The GPSO project collected biological and financial/economic data on fisheries and culture-based fisheries in small water bodies in Burkina Faso and this allowed for a financial/economic analysis. The key financial characteristics of fishing are represented in Table 7.

Table 7: Key financial characteristics of fishing in small water bodies in Burkina Faso (adapted from Magnini and Konate, 2002)

Annual catch per fisher or fishing unit	800	kg
Whole sale price	0.81	U$/kg
Gross Income from fishing	648	U$/fisher/year
Fishing costs	146	U$/fisher/year
Net income from fishing	502	U$/fisher/year

On the average the fishers are earning 502 U$/year from fishing[2], they catch about 800 kg/year. To catch this fish, they have to invest in gears, boats, and repairs their gears, which all totals at 146 U$/fisher/year. Alternatively, the fishing costs are 146/800 = 0.18 U$/per kg of fish caught. If the fishers are already fishing efficiently, these fishing costs will remain, if the annual catch increases due to stocking of fingerlings. This and the costs of stocking material are the major inputs in a financial analysis (Table 8).

[2] Fishing is a secondary activity of the fishers in Burkina Faso.

Table 8: Financial analysis of culture-based fisheries wit Nile Tilapia in small water bodies in Burkina Faso

Technical Parameters			Financial parameters		
Stocking rate	20	Kg/ha/year	Price of fingerlings	1.72	U$/ kg
Stocking efficiency	3.45		Costs of stocking	34	U$/ha/year
Annual catch adult Tilapia	69	Kg/ha/year	Fishing costs	0.18	U$/kg
			Total fishing costs	13	U$/ha/year
			Total costs	**47**	**U**$/ha/year
			Whole sale price	0.81	U$/kg
			Gross benefits	**56**	U$/ha/year
			Net Benefits	**9**	U$/ha/year
			Return on investments	**25%**	

An overall return on investments of 25% as calculated for culture-based fisheries in Burkina Faso is reasonable. However, the situation changes if looked at what it means for the individual fishers involved (Table 9).

Table 9: Financial analysis of income generation due to culture-based fisheries of individual fishers at a water body of 100 ha in Burkina Faso

Area water body (ha)	100	
Number of fishers	6	
Stocking efficiency	3.45	
Stocking rate (kg/ha)	20	
	No stocking	**With stocking**
Annual yield (kg/ha/year)	48	117
Total yield (kg/year)	4800	11700
Catch per fisher (kg/year)	800	1950
Gross benefit per fisher (US/year)	648	1580
Fishing costs per fisher (US/year)	146	357
Stocking cost per fisher (US/year)	0	575
Total cost per fisher (US/year)	146	931
Net benefit per fisher (US/year)	502	648
Percentage income increase after stocking		29%
% investment of annual income		115%

Without stocking, the fishers are earning 502 U$/year. If they invest 575 U$/year or 115% of their annual net income from fishing, their income will increase with 29% to 648 U$/year. Within the socio-economic reality of the rural poor in Burkina Faso, where risk are spread in order to survive, this is not a feasible option.

The major reason for the poor performance culture-based fisheries during phase 1 of GPSO is the low survival rate of the stocked fingerlings due to the high abundance of predators and the relatively high price of the fingerlings due to the absence of an aquaculture industry. However, this performance improves if the price of the fingerlings can be reduced and/or if the predators are removed (Figure 5).

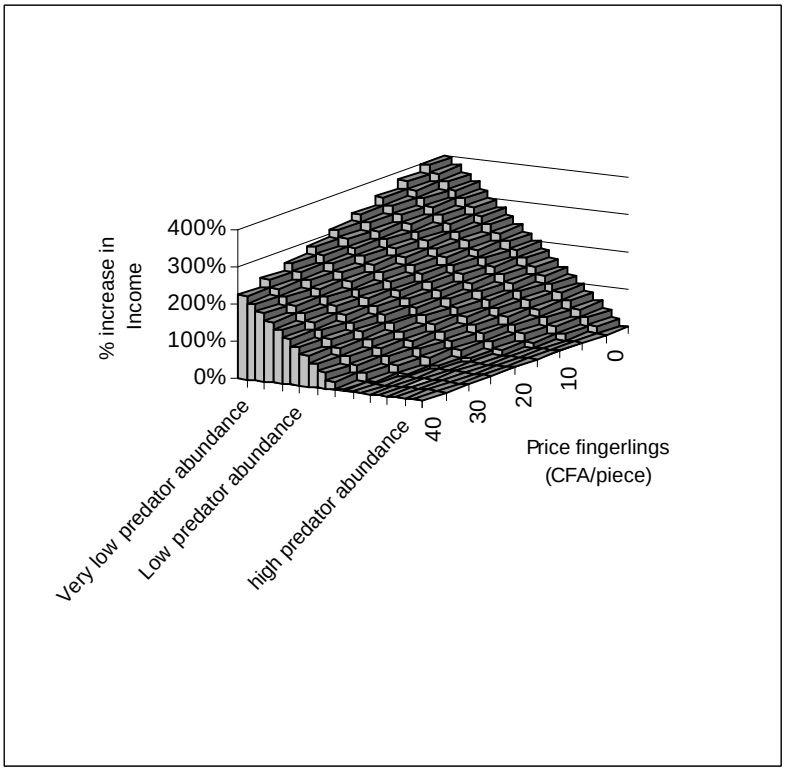

Figure 5: Relation between the increase in income of fishers after implementation of cultured-based fisheries and the price of the stocked fingerlings and predator control

3.8. FISHERIES MANAGEMENT AND CULTURE-BASED FISHERIES

Major bottlenecks for the implementation of culture-based fisheries in Burkina Faso were related to fisheries management, and this is discussed in the next chapters.

3.8.1. Exclusive fishing rights

During the first phase of GPSO, in cooperation with traditional authorities and the community the project trained and formed fishing groups. From a practical point of view, the training of the fishers involved was successful as:

- The fishers learned how to fish and were catching about 500-1000 kg/year, which provided them a reasonable secondary income.
- They respected the gear and mesh sizes as proposed by the project.
- They respected closed fishing seasons proposed just after stocking.
- They learned to produce fingerlings needed for stocking.

However, successful implementation of culture-based fisheries requires the following:

- A positive return on investments made by the participants.
- Exclusive fishing rights in order to assure the return on investments to the ones who invested.

The first point is already critical as discussed in the previous chapters, but the second point “exclusive fishing rights” proved to be even more critical.

The community and its traditional leaders agreed upon an “exclusive fishing right” for the formed fishing groups and this was the basis for the project to work. However, overtime, it showed that this agreement on exclusive fishing right did not work. Fishers from neighbouring villages or even from the same village started fishing in the reservoirs. This resulted in social conflicts, which could not be resolved by the project or the local traditional community leaders. A major bottleneck in resolving these conflicts was the reality that the provision of “exclusive fishing rights” was not concurrent with the national fisheries legislation, which provides fishing rights to anybody having a fishing permit. Therefore, the project and the traditional authorities had no legal means to act under.

In view of the latter, it cannot be stated enough: **“Before any enhancement or regular stocking is done, fisheries in the water bodies should already be managed properly and on a sustainable basis by the fishers or the communities living near the water bodies.**

Such a participatory management requires two basic institutional conditions:

1. ***A decentralisation of government structures and institutional decision-making processes***. If all rules on management are decided in the capital, then participatory management will be again doomed to fail.
2. ***A legal framework*** or a fisheries legislation that allows the handing over of the resources to communities.

3.8.2. The tragedy of the commons and culture-based fisheries

The experiences of GPSO indicated that the sustainability of the system is often hampered by the ownership status of the water bodies and the distribution of exclusive fishing rights to the involved fishers. In most cases, the ownership could not be obtained by the local traditional authorities. When it could be obtained, it could not be enforced as it had no legal framework and outsiders could not be sent away.

In general, it can be stated that the larger the water body, the larger the problems, all related to the "tragedy of the commons" (Box 1). Some of the key elements are presented in Table 10.

Table 10: Key elements of problems encountered with the implementation of culture-based fisheries (adapted from Oswald 2002)

Large water bodies (20-700 ha)	Small water bodies (5-20 ha)	Very small water bodies (1-5 ha)
Management and ownership often encompass several villages	Management and ownership mostly contained within 1 village	Management in the hands of one community or family
Management is often considered as a 'State affair'	Management can be organised with local authorities if a legal frame work exists	Management is often already locally controlled with strict access rights or traditional distribution of the benefits
Difficult to obtain exclusive fishing rights for participants	Exclusive fishing rights can be organised by the local population	Exclusive fishing rights often existing
High investments	Medium investments	Low investments
Impact of stocking difficult to monitor and inequality in covering the costs of the investments	Rather easy to monitor and investments and benefits equally distributed among the participants	More or less a private busniness
Generally not sustainable, and the system will collapse after interventions are withdrawn	Can be sustainable if covered by a legal frame work	Good chance to be sustainable

In addition, it was concluded by GPSO that the culture-based fisheries in Burkina Faso are easier to apply in small water bodies or in water bodies with clear ownership/management structures. Further, it is recognised that working in small

water bodies reduces the investments needed, which is of utmost importance considering the socio-economic reality of the rural poor.

Box 1
The Tragedy of the Commons

The Tragedy of the Commons is a theory that says that if people share a resource (land, fishing grounds, etc.) and do not have ownership rights or responsibilities toward that resource, and then the resource will be exploited. This theory is based on the belief that it is human nature for an individual to use as much of the resource as possible before someone else uses it, regardless of the effects on the resource. The tragedy arises when everyone overuses the resource, rendering it spoiled or devoid of future value. If the resource is open-access, where anyone can use it at any time (i.e., if there is no individual investment or responsibility), then Tragedy of the Commons is more likely to happen. Fishing is usually considered an open-access resource and has been used many times as the classic example of Tragedy of the Commons. A related theory states that if a resource is shared by a group of people that have a say in how it is managed, they will take better care of it because they have a stake in it and a responsibility toward the resource. (Source: https://www.sitesalive.com/tg/wl/private/hs/hstgwlwk08.htm)

3.9. LESSONS LEARNED

From a technical, biological and fisheries management point of view, the experiences of GPSO on culture-based fisheries provided the following valuable lessons:

Species choice: The Nile Tilapia (*Oreochromis niloticus*) is a suitable species for culture-based fisheries for the Sub Saharan countries.

Site selection and sustainability: Culture-based fisheries in Burkina Faso should focus only on small water bodies (up to 20 ha) as from an economic, financial and socio-economic viewpoint they are manageable.

Staging of developments: Development of reservoir fisheries should follow its appropriate stages and the introduction of culture-based fisheries will be only successful if a proper sustainable fisheries management system ***is already installed and maintained by the involved fishers.***

Institutional settings: A participatory management requires two basic institutional conditions: ***A decentralisation of government structures and institutional decision-making processes***. If all rules on management are decided in the capital, then participatory management will be again doomed to fail. ***A legal framework*** or a fisheries legislation that allows the handing over of the resources to communities is required.

Group formation: As GIE's are considered a legal entity in Burkina Faso, using them to establish culture-based fisheries is a good option as culture-based fisheries requires a professional attitude towards fishing, which can only be obtained through professional fishers.

Training of stakeholders: With relatively simple training programs, it is possible to teach non-experienced fishers the basic techniques of fishing, gear maintenance and implementation of fisheries management plans.

Bottlenecks for financial feasibility: Culture-based fisheries is technically feasible, but major bottle necks are the high price of fingerlings due to the absence of an established aquaculture industry and the low survival rate due to the high abundance of natural predators.

Stocking rates: Stocking rates of 20 kg/ha/year are appropriate and will provide an incremental yield 50-60 kg/ha/year, which is within the safe limits of natural potential fish yields, and they can be easily applied to all reservoirs.

Fingerling production: Producing of fingerlings by the fishers involved is not an appropriate option as the activities are sometimes in conflict with their other economic activities. Investments and operation costs surpass their financial capacity. Purchasing the needed fingerlings from specialised fingerling producers gives a better guarantee for proper annual stocking. If it is still decided to produce the fingerlings by the fishers, then establishment of fingerling units should be sized according to the needs for proper stocking.

Recapture rates: The relatively low recapture rates of the stocked fingerlings, highly affecting the financial viability could be improved by selective fishing on the predators. However, this requires an adaptation of the fisheries legislation in Burkina Faso.

Socio-economic sustainability: If the recapture rates cannot be improved or the price of the fingerlings cannot be reduced, it must be questioned if culture-based fisheries are compatible with the financial reality of the involved communities in Burkina Faso. Without stocking, the fishers are earning 471 U$/year, if they invest 520 U$/year or 110% of their annual net income from fishing, their income will increase with 20% to 563 U$/year. Within the socio-economic reality of the rural poor in Burkina Faso, where risk are spread in order to survive, this is not a feasible option. Therefore, financial capacity of the stakeholders to carry out the annual investments should be one of the major criteria for the implementation of culture-based fisheries.

Ownership and fishing rights: Culture-based fisheries can only be successfully implemented if exclusive fishing rights can be obtained and maintained in an institutional setting, which is compatible with traditional local powers and the national legislation.

Institutional settings: Before any enhancement or regular stocking is done, fisheries in the water bodies should already be managed properly and on a sustainable basis by the fishers or the communities living near the water bodies.

4. PHASE 2 DEVELOPMENT OF PARTICIPATORY MANAGEMENT OF NATURAL FISH RESOURCES

In the mid ‘90s, the project realised that the approach of the first phase was too technical, not leading to sustainable developments and not dealing with one of the major questions: “sustainable fisheries management.” Therefore, the approach was abandoned in 1994, and the project shifted towards the development of participative management of natural fish resources.

4.1. THE PROJECT CONCEPT

During this second phase of GPSO, the interventions were based on the concept that the fishers can be made responsible for the sustainable management of their aquatic resources and that this can be achieved through awareness building, training and empowerment of the local population.

4.2. ASSUMPTIONS

A major assumption of the strategy was that the decentralisation process, which started in Burkina Faso in the mid ‘90s, would facilitate the participative approach of the project.

4.3. INTERVENTIONS

During the second phase of GPSO, 24 water bodies were covered (Figure 6) ranging in size from 14 to 600 ha.

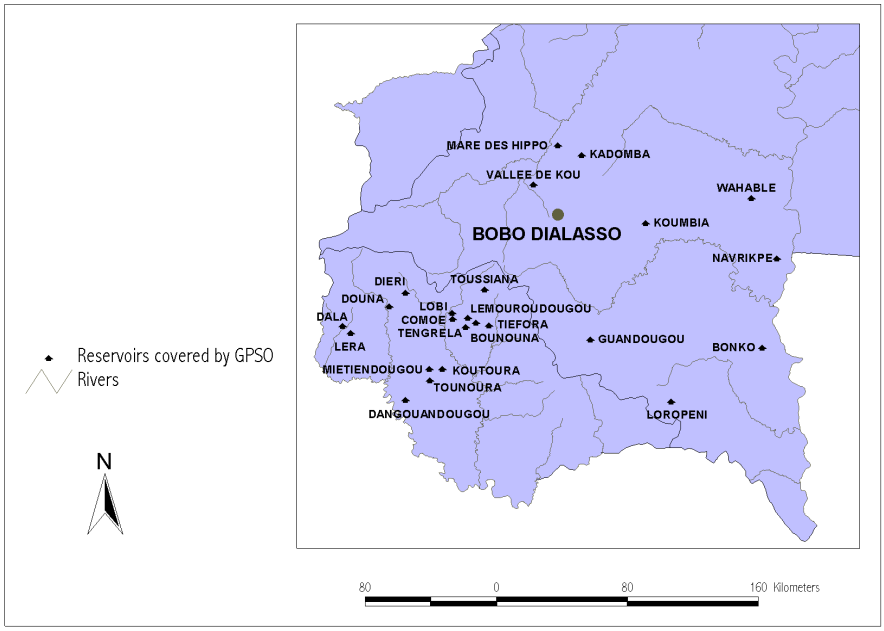

Figure 6: Reservoirs covered during phase 2 of GPSO

At each site the interventions went through the following phases:

Preparation phase: Participatory Rapid Rural Appraisal techniques were used to get an idea of the existing situation, management and problems around the water bodies. At each water body a Fisheries Management Committee was formed as being representative from the local population, and they were responsible for selection of the fishers.

Training phase: Fishers were trained in fishing, net-repairing and basic ideas of fisheries management.

Planning phase: The project carried out fisheries surveys and formulated a fisheries management plan in cooperation with the fishermen and the Fisheries Management Committee.

Implementation phase: Once the management plan was accepted by all, it was implemented and monitored by project staff and fishermen.

Evaluation: Each year the adopted fisheries strategy was evaluated with the participants and adapted when necessary.

5. RESULTS

During the second phase, the following achievements were made:

Fishers groups were formed at 28 water bodies and most of the groups succeeded in putting the management plans into practice and generate income through fishing.
A national and regional fishers association was created.
A major achievement was made on the institutional level; the whole chain of decision-makers in aquatic resource management in Burkina Faso were actively involved in the discussion on participatory resource management. The lessons learned in this process became a genuine part of their institutions and are not donor driven, as the involvement of GTZ in the internal discussion was neglect able.

5.1. FISH CATCHES

The fishers mainly fish with a battery of gill nets (mesh size 35 mm or more) operated from a non-motorized wooden canoe. Fishing is a secondary economic activity for the majority of the fishers, and number of times they go fishing varies and depends on their other income-generating activities. Only from six reservoirs, reliable catch statistics could be obtained during the second phase of the project, and they are summarized in Table 11.The annual yields ranged from 14-310 kg/ha/year on average, and they are less if compared with the potential yields as estimated with the empirical models of Marshall and Crul.

Table 11: Catch statistics of six reservoirs covered by GPSO over the period 1995-2000

Lake	Area (ha)	Yield (kg/ha/year)	Marshall (kg/ha/year	Crul (kg/ha/year)	Fishing effort (no fishing trips/ha/year)	CPUE (kg/fishing trip/year)
Comoe	600	42	58	68	6.4	6.8
Tiéfora	125	28	129	94	7.0	4.0
Lemouroudougou	140	67	145	80	11.4	5.9
Tounoura	14	110	312	148	17.7	5.5
Lobi	120	33	55	95	7.8	4.2
Mare aux hippos	140	153	1203	92	12.2	12.2

In the observed reservoirs, there is a positive relation between the fishing effort and the annual yields; higher effort gives higher yields (Figure 7).

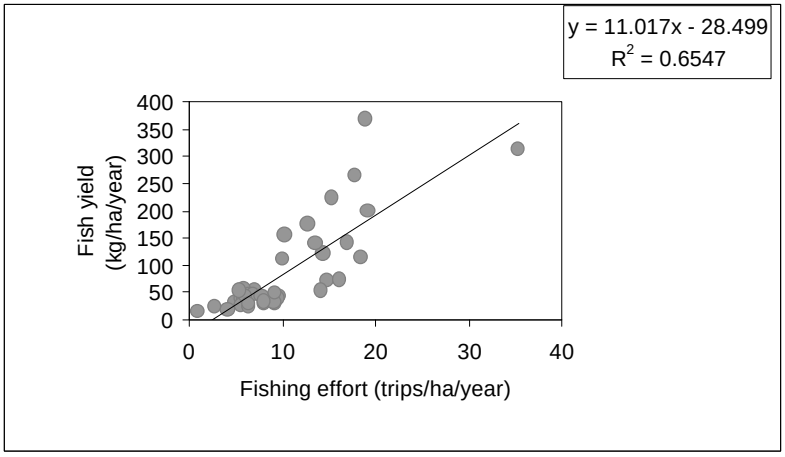

Figure 7: Relation between fishing effort and annual yields

Regression analysis indicated that fishing effort was the major factor (77%) determining the annual yields of the reservoirs followed by CPUE (7%) and the area of the water body (3%) indicating that the empirical models have to used with care.

Species composition in the biomass was followed with experimental gill netting and the results are presented in Table 12.

Table 12: Percentage of commercial and non-commercial species as observed in the overall fish biomass

Reservoir	Percentage of commercial species	Percentage of non commercial or small species
Niofila	37%	63%
Tiefora	31%	69%
Comoe	64%	36%
Lobi	65%	35%
Kadombo	55%	45%
Koutoura	10%	90%
Bonko	19%	81%
Loropeni	33%	67%
Tounoura	13%	87%
Navrikpê	22%	78%
Dangouandougou	14%	86%
Gouandougou	15%	85%

The majority of the fish biomass in the lakes consists of small species such as *Brycinus spp* or *Schilbe spp.* This raises the important technical question: *"What is fisheries?"* Is it a *"Tilapia fisheries,"* or could it be a *"Small species fisheries?"* If provision of animal protein to the local population is a major objective, aiming at small species could be an alternative. However, targeting the small species requires fishing gear with small mesh sizes, which by law are illegal and this topic is seriously discussed at present.

5.2. FISHERIES MANAGEMENT

From a management point of view, it was expected that the more participatory approach would resolve or at least diminish the conflicts as observed during phase 1 of GPSO. However, this proved to be wrong and the major reasons were:

- The fisher groups formed during the first phase of GPSO still considered the water bodies as their own, while from a technical point of view, fishing on natural stocks, this resource could be shared by a large part of the communities.
- Community-based fisheries management still requires handing over of the responsibility to the communities. Even during the second phase of GPSO this could not be achieved as the project was ahead of the decentralisation process. This was realised in an early stage of the second phase and project staff and staff of the Department of Fisheries were actively involved in the decentralisation process and the development of a more appropriate "Fisheries Act."

From a management point of view, it was realised that as being a fisheries project from the beginning, "Fish yields" and "Income generation through fishing" was a focusing point of the project. However, fishing is a secondary activity of the population living near the water bodies and for them the water body supports a large number of other economic activities (cattle raising, agriculture). Therefore, for the improvement of the livelihood of the population, living around the water bodies a more holistic approach is needed, and fisheries developments should be placed in the overall rural development plans.

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5.3. LESSONS LEARNED

Community-based management and conflict resolution: Participatory fisheries management requires a legal framework. Without such a framework/status, all good intentions to implement participatory management are doomed to fail. Further, the implementation of such a strategy requires an active, functional decentralisation process in place. Once a legal frame work exists and it is decided to implement and maintain the management strategy through traditional authorities, a first step will be to ensure that the traditional authorities are capable and have the power for resolving conflicts, which will certainly occur.

Group formation: As GIE's are considered a legal entity in Burkina Faso, using them to establish culture-based fisheries is a good option. However, for the development of participatory management of natural fish stocks, less rigid structures could be used allowing the involvement of more households in fishing. This will most likely results in fewer conflicts.

Time frame: Development of participatory resource management involves a process of changes in social behaviour and decision-making of all stakeholders and requires a long time horizon.

Implementation strategies: Considering the socio-economic reality of the population living near the water bodies in Burkina Faso, "They are Agriculture-Fishers." The development of "Participatory aquatic resources management" should be placed in an overall rural development approach aiming at the reduction of poverty and food security for the whole population by all means.

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