

Diagnostic study of the Volta Basin fisheries

Part 1 Overview of the fisheries resources



Christophe Béné

WorldFish Center
Regional Office for Africa and West Asia
Cairo

2007

Volta Basin Focal Project Report No. 6

CGIAR Challenge Program on Water and Food

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Introduction and background

The Volta Basin Focal Project

The Basin Focal Project for the Volta (BFP-Volta) is a research project funded by the Challenge Programme on Water and Food (CPWF). Its aim is to provide an in-depth analysis of the basin through three main thematic issues: water-poverty, water availability/use and water productivity. The overall objective of the BFP-Volta is to contribute to the main goal of the CPWF, that is, to alleviate poverty through better management of water in order to enhance agricultural productivity and environment conservation¹.

Objective and scope of the present report

In this context, the WorldFish Center has been commissioned to produce a series of two complementary reports focusing more specifically on the fisheries resources and the link that may exist between poverty and fisheries in the Volta basin. The present report is the first of these two documents. It should be seen as a preliminary analysis presenting a background of the fisheries resources in the Volta Basin essentially from a biological perspective. Its specific objective is to conduct a diagnostic analysis of the status of the Volta basin's inland fisheries, with a particular focus on the biological productivity of the various water bodies existing in the basin. Whenever possible, the diagnostic will be proposed in relation to the current exploitation rate of the fisheries resources. The analysis will include the Volta Lake, but also the other hydropower reservoirs, rivers, floodplains, and the numerous small-scale seasonal or permanent ponds that are scattered throughout the basin. Particular attention will be paid, however, to Lake Volta, reflecting the large number of fishery-dependent communities that live on its shores. The report will also concentrate on two countries within the basin: Ghana and Burkina Faso as together they cover more than 83% of the total basin surface.

Volta water resources – a Basin overview

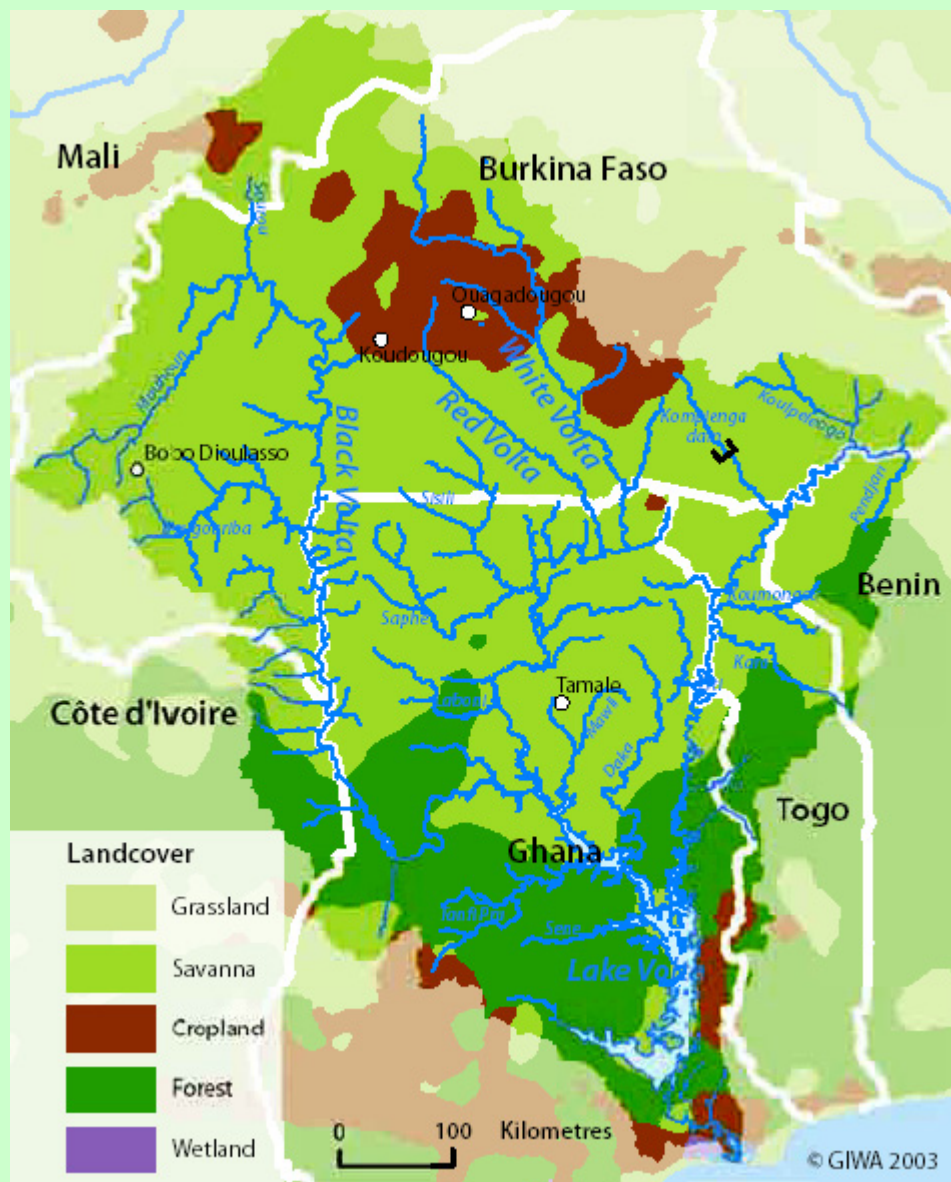
Generalities

The Volta River Basin is the ninth largest basin in Sub-Saharan Africa, covering an estimated area of 400,000 km². The Volta basin stretches from approximately latitude 5° 30' N in Ghana to 14° 30' N in Mali. The widest stretch is from approximately longitude 5° 30' W to 2° 00' E, but the basin becomes more narrow towards the coast of the Gulf of Guinea (**Fig.1**).

The Volta Basin is drained by several major rivers: the Mouhoun (ex- Black Volta), the Nakambé (ex-White Volta) with the Nazinon (ex-Red Volta) as its tributary, the Oti River and the Lower Volta. The mean annual flows of the Mouhoun, Nakambé, and Oti River are $7,673 \times 10^6$, $9,565 \times 10^6$, and $11,215 \times 10^6$ m³ respectively (MWH, 1998). The Oti River

¹ A more detailed description of the general approach, methodology and specific objectives of the BFP-Volta can be found in the document "Challenge Programme on Water and Food Basin - Focal Project for the Volta Proposal" downloadable at http://www.waterforfood.org/fileadmin/CPWF_Documents/Documents/Basin_Focal_Projects/BFP_Proposals/VoltaPropApril2006vf.pdf

Fig.1. The Volta Basin and its main rivers



Source map: Abe et al. 2004

comprising only about 18% of the total catchment area, contributes between 30% and 40% of the annual flow of the Volta River System. This situation is due to the steep topography and the relatively high rainfall in the Oti sub-basin.

A dominant feature in the basin is Lake Volta that covers about 4% of the total area in Ghana. It generates hydropower (1060MW) at Akosombo and Kpong, about 100 km north of Accra. Some 95% of the generated power in the basin comes from these two sites. **Table 1** presents the catchment area of sub-basins and length of the main tributaries of the Volta River. The Volta basin is spread over six West African countries: 43% in Burkina Faso, 42% in Ghana, and the remaining 15% in Togo, Benin, Cote d'Ivoire and Mali (**Table 2**).

Table 1. Catchment areas and length of main rivers in the Volta basin

Sub-basins	Total area (km ²)	Length (km)
Mouhoun (ex-Black Volta)	149,015	1,363
Nakambé (ex-White Volta)	104,749	1,136
Oti	72,778	936
Lower Volta	62,651	
Total	400,710	

Source: Barry et al. 2005

Table 2. Distribution of the Basin among the six riparian countries

Country	Area of Volta River Basin (km ²)	% of basin	% of country in basin
Benin	17,098	4.10	15.2
Burkina Faso	178,000	42.65	63.0
Cote d'Ivoire	12,500	2.99	3.9
Mali	15,392	3.69	1.2
Togo	26,700	6.40	47.3
Ghana	167,692	40.18	70.0
Total	417,382	100%	

Source: Asante 2006

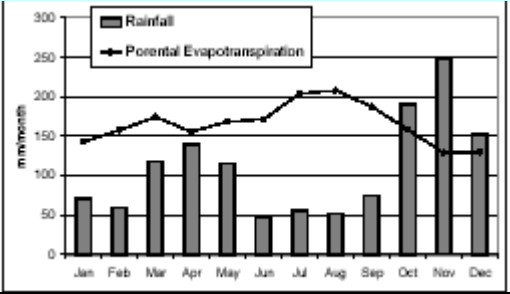
Economic development of the Volta basin countries

A short general profile of the basin is provided in **Box 1**. The riparian countries of the Volta River Basin are some of the poorest in the world. Mali has the highest proportion of the population below the poverty line (64%, 2001 estimate), Burkina Faso has 52.4% (2003 est.) and Ghana 49% (1999 est.). According to the World Development Report 2000/2001, all of the Volta River Basin countries are considered to be in the low-income category (GNP per capita of \$755 or less).

Major water bodies in the basin

The Akosombo dam is by far the most significant structure built in the basin (**Box 2**). The Volta Lake reservoir itself has a surface area of about 8,500 km². Water available from the reservoirs is primarily used for hydro-energy production. In combination with the Kpong dam, the Akosombo dam is of strategic importance to the economy of Ghana, generating together more than 95% of the power produced in the country.

In the other riparian countries of the basin, small and larger dams have been built to secure food production after the severe droughts that occurred in the 1970s and 1980s. For instance in the Nakambe sub-basin alone (Burkina Faso) more that 600 small dams have been built most of them during that period. More recently, power-generating dams have also been built in some of the main Volta tributaries, Bagre and Kompienga, (Burkina Faso) with generating capacities of 41.5 GWH and 31.0 GWH respectively and on the Oti River, at the border between Togo and Benin, with a power generating capacity of 35 GWH.

Box 1. Overview of the Volta Basin	
Country	Ghana, Burkina Faso, Togo, Benin, Cote d'Ivoire and Mali
Area:	400,710 km ² Altitude: from 920 m to the sea
Rainfall/Evapotranspiration:	<p>Average rainfall: 1000 mm Max: >1565 mm Min: 876 mm: UniModal/bimodal: bimodal in the South and modal in the North Crop reference ETo: 1850 mm/year</p> 
Irrigation	Approximately 10,000 ha formal irrigation, informal unknown. Between 1 and 2% of crop area.
Water Indicators	Runoff coefficient: 8 % Renewable water available: m ³ /year/pers Regulated water (% rainfall and % run-off): % and % Beneficial (process) depleted fraction: 10% Non-committed outflow to the sea: ≈ 8% of total runoff Water diverted per person: ≈ /day/capita Water use per sector (depletion): Agriculture 66%, Industry/domestic use: 24%
Drinking water	Mostly from wells, river water (treated and piped) for 2 cities
Main crop(s)/yield	Yams, maize, millet and sorghum
Population	17,200,000 people; Pop. Density: 49 ha/km ² . Religion: Muslim, Christian, and Animists, Population growth: 2.5 % per annum.
Floods	Occasional flooding in the upper catchments
Groundwater	Only % of withdrawals in the basin are from groundwater. Groundwater levels drop during the dry season. Groundwater available along streams and in some deep fractured zones in the basement rock.
Environmental and health issues	Estuary ecology changed by inflow of fresh water Unacceptably high fluoride and arsenic concentrations locally in some of wells used for drinking water erosion, burning ??
Protected areas	Mole National Park, Réserve Totale du Singou, Réserve Partielle de Pama, Réserve Partielle Madjoari, Parc National de l'Arli, Réserve Partielle de la Kourtiagou and other smaller parks
Land/labour	Average farm size (irrig): 1.5 ha Rural daily wage: variable
Land tenure	Most land allocated by traditional authorities
Water Management	Volta Basin Authority created in 2006. The DGIRH and WRC are in charge of water management in Burkina Faso and Ghana respectively.
Hydropower	1060 MW from the Akosombo and Kpong Dams
Legal framework	In Burkina Faso and Ghana water management is now in the hands of the DGIRH and WRC
Politics, Civil Society	Stakeholders participation in natural resource management is very limited. Several NGOs are present in the basin and deal with water harvesting, public health initiatives, nutrition, agricultural technical support and training. Weak presence on institutional issues.

Source: Comprehensive Assessment of Water Management in Agriculture 2002

Ghana water resources

Ghana is relatively well watered and is drained principally by the Black (Mouhoun), White (Nakambé) and Red (Nazinon) Volta Rivers and the Oti River. Several other smaller water rivers including the Pra, Tano, Ankobra, Densu and Bia also drain the forested southern area. There are, in all, 15 rivers (with a total catchment area of 237,870 km²) and 12

Box 2. The Lake Volta



Photo: The Akosombo dam

The Akosombo dam was until recently the largest man-made lake in the World. The Volta Lake reservoir itself has a surface area of about 8,500 km², an average depth of about 18.8m and a shoreline of about 5,500 km. The deepest portions of the lake are about 90 m. The total volume of water in the reservoir at full supply level (about 84.73 m) is approximately 150 billion m³. The seasonal rise and fall is about 2.0 - 6.0 m and the areas covered by seasonal fluctuations are about 100,000 ha. Water available from the reservoirs is primarily used for hydro-energy production, other significant uses being transportation, fishery, water supply (commercial and domestic purposes), tourism and irrigation. Contrary to many hydro-power dams that are generally built upstream, the Akosombo dam is built close to the ocean because of the flat relief of the basin and the difficulty to find potential locations. Construction of the Volta Lake led to the resettlement of about 80,000 people from several hundred villages to fifty newly built townships (more than 1% of Ghana's population at that time). In addition to the resettlement of the river communities, damming affected local health, agriculture, fishing, and navigation.

reservoirs. The largest of the reservoirs is Kpong (36.5 km²), down stream of the Volta Lake; but the other reservoirs of importance include Vea and Tono, in the Upper East Region; Weija and Dawhenya near Accra (outside the Volta basin); and Barekese near Kumasi. About 92% of the reservoirs are 100 ha or less. In addition there are about 90 brackish water lagoons situated along the coast of Ghana, with a total surface area of about 400 km² (a large part of which are outside the Volta basin). The largest of these is the Keta lagoon situated close to the delta of the Volta River. Other major lagoons include Songaw, Sakumono and Muni (outside the basin). **Table 3** summarises the main rivers of the Volta basin in Ghana.

The number of dams and dugouts is about 310 and more than half are in the Upper East and West Regions (169); the Northern Region has 90 and the Volta Region has 51. Overall, the total surface area of inland water bodies is estimated to be 10,089 km², with Volta Lake comprising 92.6% of this total surface, followed by swamps, lagoons and reservoirs in that order (**Table 4**).

Table 3. Area of Volta River basin in Ghana

Rivers	Ghana (km ²)	outside Ghana (km ²)	Total area (km ²)
Mouhoun	35,107	113,908	149,015
White Volta	45,804	58,945	104,749
Oti	16,213	56,565	72,778
Lower Volta	59,414	3,237	62,651
Dake	9,174	-	9,174
Todzie/Aka	1,865	363	2,228
Songhor	115	-	115
Total	167,692	233,054	400,710

Source: Asante 2006

Table 4. Surface area of inland water bodies in Ghana

Water bodies	Dugout	Lakes	River backwaters	Reservoirs	Lagoons	Swamps	Volta Lake	Total
Surface (in km ²)	14.4	31.9	65.4	118.2	174	240	8500	10,089
Percentage of the total	0.16%	0.35%	0.72%	1.29%	1.90%	2.62%	92.6%	100%

Source: Barry et al. 2005

Burkina Faso water resources

In Burkina Faso, the hydrographic network of the country is characterised by three great river basins: the basin of the Volta, the basin of the River Comoé and the basin of the River Niger (**Fig.2**). In Burkina Faso, the Volta basin covers 40% of the whole country and includes the main tributaries of the Volta, including the Mouhoun in the South West. It drains other sub-tributaries such as the Siou, Voun Hou, Sourou, Vranso, Le Grand Balé, the Bougouriba, and the Poni over its 820 km route within the country. **Table 5** presents the distribution of the available surface water resources of the Volta River Basin in Burkina Faso.

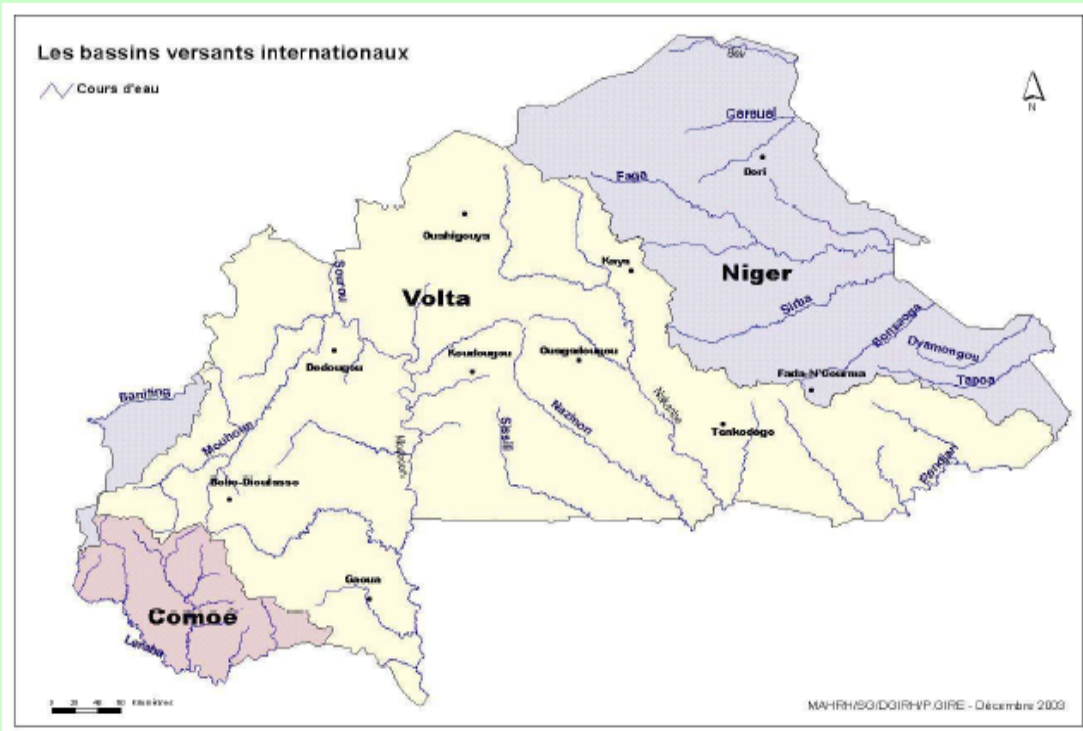
Table 5. Available surface water resources of the Volta basin in Burkina Faso

Sub-basin	Annual flow ($\times 10^9$ m ³)	Volume in reservoirs ($\times 10^9$ m ³)	Potential in the basin ($\times 10^9$ m ³)
Mouhoun	2.64	0.29	2.75
Nakambé	2.44	2.20	3.32
Total	5.08	2.49	6.07

Source Barry et al. 2005

Apart for the main Mouhoun and Nakambé rivers, the country has other smaller streams – for example the Bougouriba, Comoé, Béli, Sirba and Tapoa. Many of these rivers dry up in the dry season (October-June), with the exception of the Mouhoun and Comoé in the south-west which are fed by springs and have their sources in more humid regions. In addition to

Fig.2. The 3 main basins in Burkina Faso: the Comoé, the Volta and the Niger basins



Source: Barry et al. 2005

these tributaries and rivers, seasonal ponds in floodplains make a relatively dense network, and an increasing number of small-scale irrigation reservoirs are being built up. In the Nakambé basin alone, more than 600 already exist, and more are to be constructed across the country, along with two big barrages (Samandeni and Bougouriba).

In summary, the resources of the system are relatively 'diffuse', due to the fact that there are no big water-bodies (larger than 500 ha, except Bagré and Kompienga) that are permanent, nor zones where rivers display large channels.

Fisheries in Burkina Faso

Overview

In Burkina Faso, two main types of fisheries are distinguished, based on their hydrological nature (Table 6):

- riverine fisheries along rivers and their primary and secondary tributaries, with a total area estimated around 27500 ha, i.e. 22.5% of the country's total water-body surface (122,000 ha); and
- seasonal ponds, lakes, floodplains, and reservoirs with a total area of 94,500 ha, i.e. 77.5% of the total water-body surface

Note that Table 6 includes water-bodies of the three river basins (Volta, Comoé and Niger). Although only partial data exists, it was initially estimated that between 8,000 and 8,500 tons of fish are caught annually at a national level and that this amount constitutes roughly 60-70% of biological capacity (Breuil 1995). More recently, the fishery potential has been

Table 6. Characteristics of the main fisheries in Burkina Faso

	maximum water surface (ha)	maximum volume (x 1.000 m3)	Potential (tonne / year)	% of total potential
River				
Comoé	3.640	na	360	4,3
Mouhoun and tributaries	7.960	na	800	9,4
Pendjari (river and associated floodplains)	15.900	na	8.400	10,0
Nazinon and tributaries	2.340	na	230	
Nakambé and tributaries	4.740	na	470	
Natural Lakes with surface > 100 ha				
Ponds: Oursi Bango, Kou, Karfiguéla, Lémouroudougou Lakes : Bam, Tengréla, Dem	1.970	> 40.000	> 200	2,3
Permanent reservoirs > 2.000 ha				
Sourou Valley	10.000	370.000	500-1.000	8,8
Kompienga	16.000	1.500.000	1.000	11,8
Bagré	20.000	1.700.000	1.700	13,3
Reservoirs with surface between 500 and 2.000 ha				
Comoé, Karamasso, Douna, Mogtedo, Donsé, Koubry ² , Loumbila, Yalogo, Tougouri, Sitenga, Tapoa, Liptougou, Dakiri, Sirba, Dablo, Korsimoro, Ziguédégou	13.780	> 196.000	830	9,8
Reservoirs with surface between 100 et 500 ha				
47 reservoirs	8.700	123.490	520	6,1
Reservoirs with surface < 100 ha				
640 reservoirs	17.000	na	1350	15,9
Total	122.030	-	8100 - 8850	100

Compiled from Breuil 1995

re-estimated -since a production of 12,500 had effectively been recorded in 2003, suggesting that the actual potential may be higher. This potential certainly increased recently with the creation of additional reservoirs (MOFA 2003).

Within this potential, the Volta basin includes a set of water bodies covering about 75,000 ha in flooded season (Baijot 1984, van den Boosche and Bernacsek 1990)². These authors have estimated that the fisheries potential of the part of the Volta basin located in Burkina Faso is about 3750 tonnes per year, that is, about 28% of the national potential. This estimate did not however include the Bagré and Kompienga reservoirs which are now providing the largest part of the production.

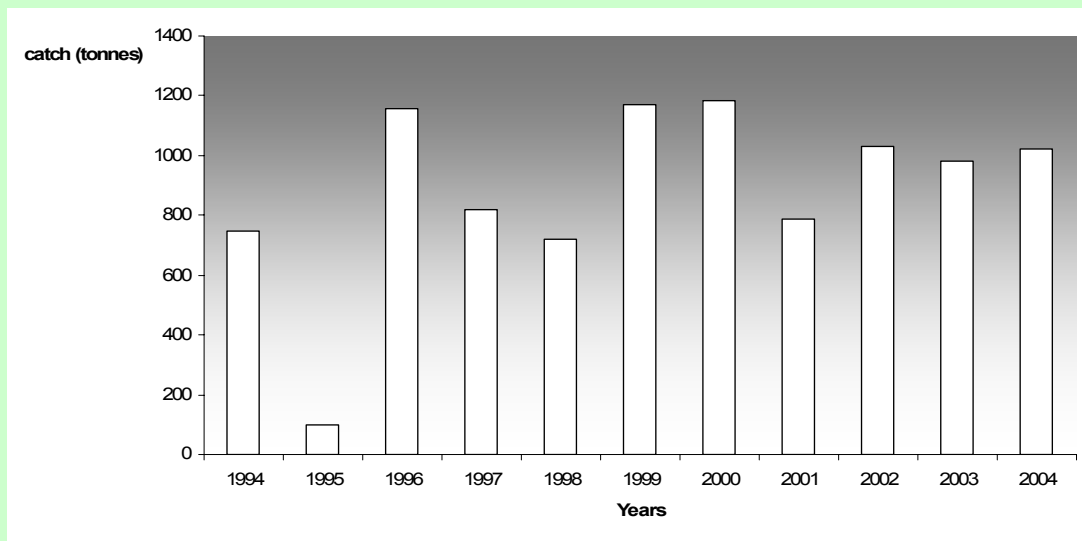
Bagré reservoir

Located in the South of the country (30 and 50 km respectively from the Ghana and Togo borders), the reservoir of Bagré was filled up in 1992. The main purpose of this 25000 ha reservoir is the production of hydro-electricity and irrigation³. Since 1994, the average fish

² This figure differs substantially from Zigani (2000) who estimates that only 35000 ha are flooded during the flooding season.

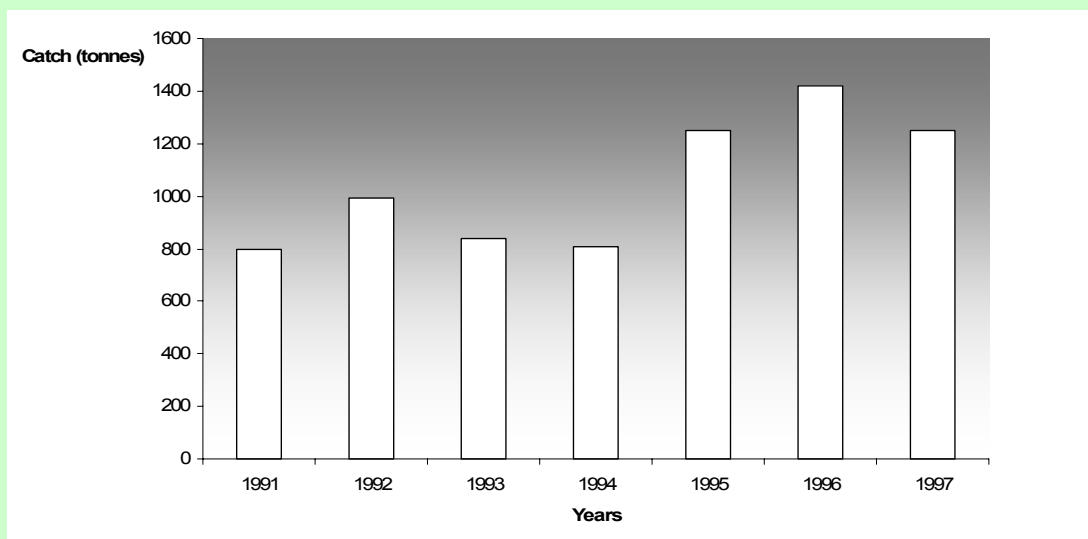
³ Planners originally expected nearly 30,000 hectares would be cultivated for rice production after the construction of the dam, but to date only 6,000 ha are under cultivation.

Fig.3. Production of the Bagré reservoir 1994-2004



Source: Anon. 2005

Fig.4. Production of the Kompienga reservoir 1991-1997



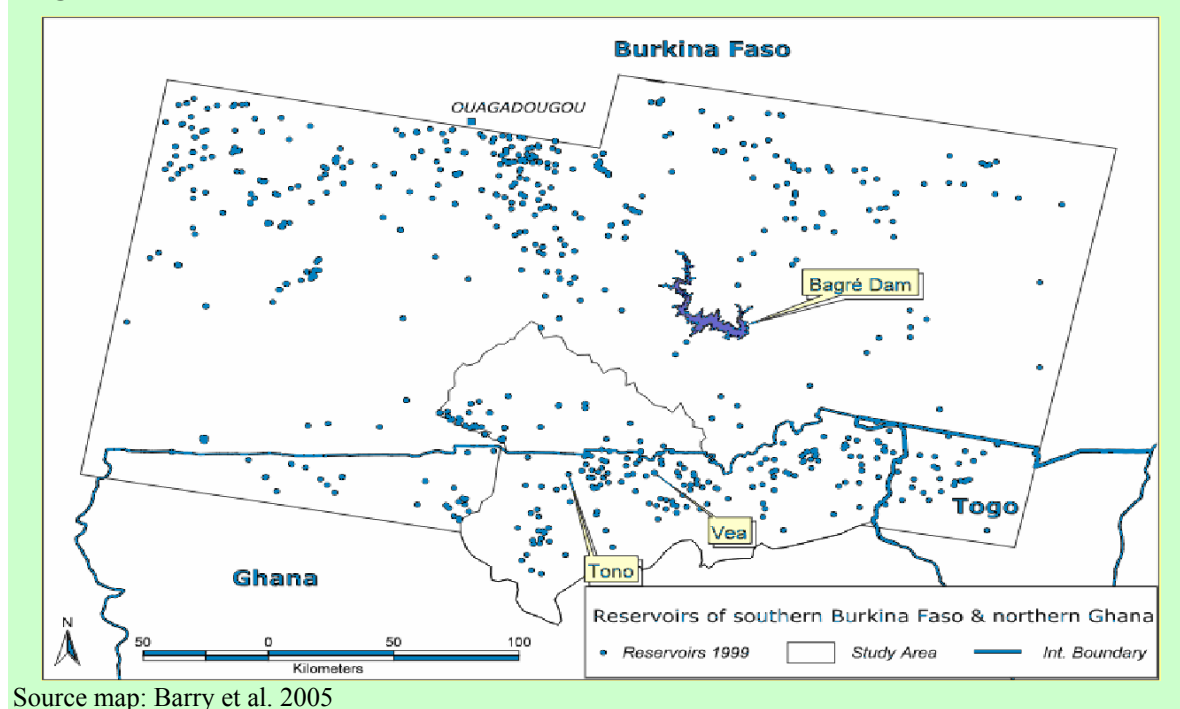
Source: Morand 1998

production has been 975 tonnes of mainly (small) Tilapia (**Fig.3**) while the potential is estimated to be around 1500 t.

Kompienga reservoir

Kompienga reservoir was built in 1988, initially for hydro-power generation, on the river of the same name. It is located in the East part of the country (about 400 km from Ouagadougou). Its maximum surface is 20,000 ha. In terms of fisheries, Morand talks about the “remarkable fisheries quality of the reservoir” (1998, p.5) stressing that the productivity of the reservoir is estimated to be 100 kg/ha/year, i.e. close to the upper limit of the productivity range for lake and reservoirs in tropical areas [35-120 kg / ha/ yr]. **Fig.4** shows the production of the reservoir since 1991, when statistics were first recorded.

Fig.5. Reservoirs in Southern Burkina Faso and Northern Ghana



Small-scale artificial reservoirs and their potential for fisheries

Burkina Faso has engaged in an active policy of surface water control since the 1970s, which has resulted in the construction of an important number of water reservoirs (**Fig. 5**). In 1995 there were approximately 2100 artificial reservoirs in Burkina Faso, 80% of which are less than 70 ha (during flooding season). The majority of reservoirs are in the north of the country where the climatic conditions are the harshest⁴ and many are reduced to very low water levels (or even dry up) with important effects (through fishing pressure or natural mortality) on the fisheries stocks. A more effective use of these reservoirs seems therefore to be possible through stocking as the natural stock is not always sufficient to ensure a full recruitment from one year to the next.

Potential for culture-based fisheries?

Recognizing these natural limitations, a German Cooperation (GTZ) project has been implemented from 1988 till 2002 with the objective of increasing the fish production in the South-western part of the country, relying on fisheries enhancement activities. On average, in the 8 water-bodies included in the programme, the production of Nile Tilapia increased from 50 kg/ha to 115 kg/ha. This was, however, less than the initial objective set by the project. After 14 years of activities, GTZ concluded that cultured-based fisheries in Burkina Faso was technically feasible but the up-scaling of the project was impeded by two major bottlenecks: the high price of fingerlings, due to the absence of an established aquaculture industry, and their low survival rate, due to the abundance of natural predators (GTZ 2003).

⁴ The Mouhoun area is the region with the lowest number of artificial reservoirs, but with two projects of large barrages : Samandeni and Bourouriba.

Fisheries in Burkina Faso: labour buffer or marginal activity?

Since the 1980s, there has been a significant increase in the flow of migrants to inland lakes, beginning with Sourou (1984), then Kompienga (1989) and Bagré (1994). The rapid increase in the number of people is thought to threaten the management and stability of the aquatic resources of these reservoirs (Anon. 2005). In particular, Lake Bagré is now one of the most populated zones in the country (58 h /km²), and continues to receive many migrants. Since 1994, more than 10,000 people have migrated to the area, bringing the population to an estimated 162,000 inhabitants. Fisheries may however not be the cause of these migrations. Only about 600 full-time fishers were operating in 2003 around the Lake Bagré, slightly less than at the beginning (1994).

These reservoir fisheries are operated by local populations with limited (rudimentary) fishing gears (baskets, hooks) and as a secondary activity (after farming). Farming and livestock remain the main activities for most of the local population and fishing is operated by only 25% of the population on a seasonal basis. In fact, in the Mouhoun basin, similar to the rest of the country, there is no real 'fishing tradition'. This point was made by several authors (e.g. Blin 1977, Breuil 1995). One of the reasons is probably the absence of a stable and constant high concentration of the resource in particular water-bodies (diffuse resource), and the economic context (subsistence economy). Instead, aquatic resources have always been one component of an integrated (multi-activity-based) livelihood (Seidel 1997). This is probably why no (ethnic) group has specialised in aquatic resource use in Burkina Faso, in contrast to other regions such as the central delta of Niger (Kassibo 2000).

There are, however, some professional full-time fishers in the country. The majority of them are migrant fishers from other countries (Mali, Nigeria, Senegal, Ghana). They own their own fishing gears and pirogues and migrate on rivers and other water-bodies to follow the resources. A few national professional fishers (Burkinabese) are also operating but they are less mobile (sedentary) and may also be involved in farming activities. Overall, it is estimated that the fisheries sector provides a direct livelihood support to about 11,000 households: 8,000 full-time fishers and 3000 fish processors (men and women). In addition to the 12,000 t of fish produced, another 8000 are imported essentially from Senegal, Cote d'Ivoire, and Mauritania.

Summary

In Burkina Faso, fisheries are still not well structured, very much informal, and marginalised at the macro-economic level. According to Breuil (1995) the contribution of the sector to the GDP is less than 1%. It is therefore essentially at the local level, in rural areas where fishing occurs, that the socio-economic contribution of fisheries is the most significant. In these rural, isolated parts, these fishery resources constitute important complementary sources of proteins, employment and cash-income for a large number of households.

Inland fisheries in Ghana

Ghana has often been presented as the ‘African fisheries nation’ *par excellence*, reflecting the importance of the sector in the economy of the country (Marquette et al. 2002, Atta-Mills et al. 2004). The Ministry of Fisheries noted recently in this respect “The fisheries sector is of huge socio-economic significance to the country as fish and fish products provide nearly 70% of the country’s animal protein requirements. This significant contribution is made available mainly through marine and inland capture fisheries as well as freshwater aquaculture” (MOFA 2006). In recent years, however, several studies have concluded that the marine fishery sector in Ghana has now reached its limits and may even be over-exploited (Atta-Mills et al. 2004).

Volta Lake fishery

Landings

More than 90% of the inland fresh water fish are produced from the Volta Lake (**Box 3**). Fish production figures for Volta Lake from its creation in 1964 to 1979 were estimated by Vanderpuye (1984). The fish yield pattern showed an initial steady rise to a maximum of almost 62,000 t in 1969 - the highest yield ever recorded for a man-made lake - followed by a decline and stabilization at around 40,000 t in 1979. This figure of 40,000 t has then been proposed by Vanderpuye as the long-term yield of the lake. However, from 1994 the landings started to rise again, reaching 80,000 t in the late 1990s. This increase in fish landings is thought to be the result of deployment of active gear, such as the winch net in the lake. For management purposes, the lake has been divided into eight strata (**Fig.6**).

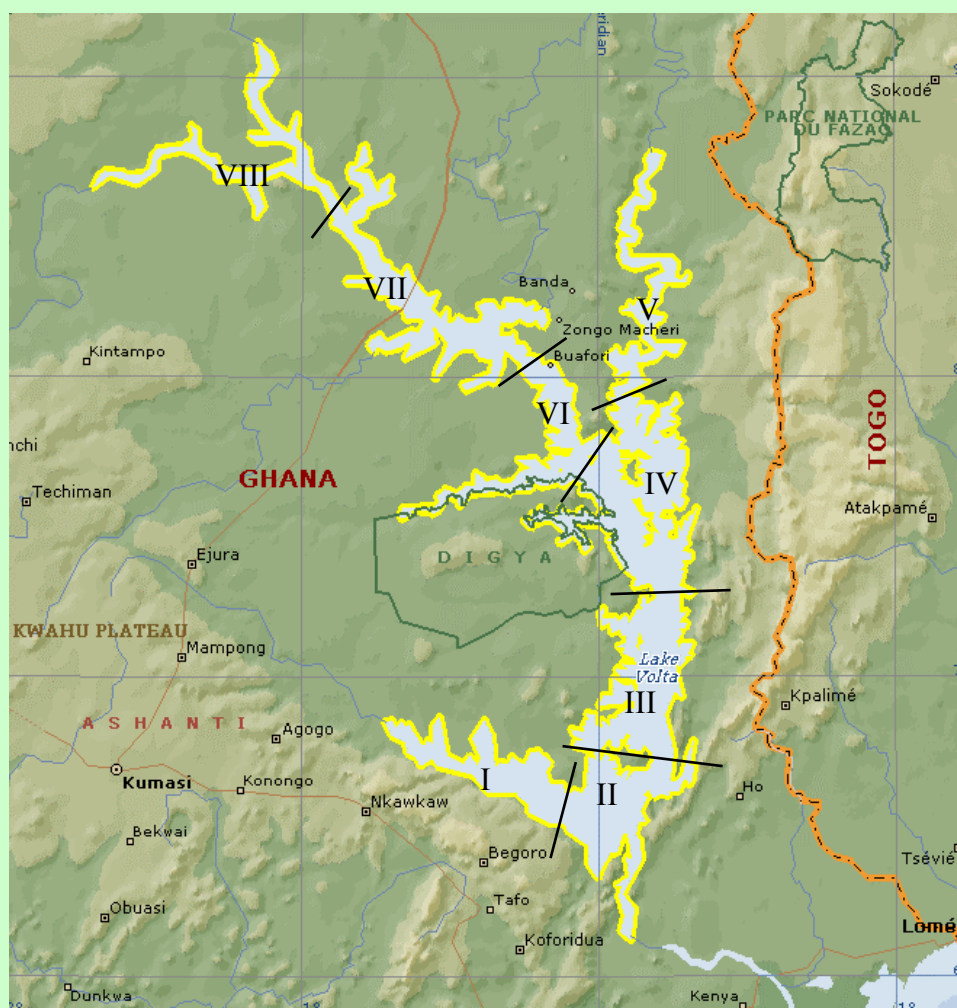
Box 3: The Lake Volta fishery

The Volta River basin dominates the country's riverine system and includes the 8,480km² Lake Volta. Fishing in Lake Volta contributes about 90% of the total inland fishery production in Ghana. Formed about 40 years ago, Lake Volta is the largest man-made lake in Africa and the second largest in the world. A tremendous fishing opportunity was offered by the creation of the lake and a large number of fishers from various parts of Ghana moved into the lake area. It is estimated that a total of 300,000 people depend on the lake for their livelihood of which 80,000 are fishers and 20,000 fish processors and traders (Braumah 1995). The fishery is solely artisanal with about 17,500 canoes actively fishing in the Lake operating from about 2,000 fishing villages.

Fishing villages, fishers and fishing boats

A frame survey conducted by the then-Directorate of Fisheries of Ghana in 1998 provides the most recent data on the characteristics of the fisheries. The distribution of fishing villages, population, fishing boats and outboard motors in the various strata of the Lake is shown in **Table 7**. Briefly, the data indicated that there were 1232 fishing villages along the Lake with a total 71861 fishers operating 24,035 fishing boats. Two earlier frame surveys conducted in 1970 and 1975 recorded 18,358 and 20,615 fishers and 12,074 and 13,815 canoes respectively (Bazigos 1970, Coppola and Agadzi 1976).

Fig.6. Fishery stratification of Volta Lake



Source map: Encarta®

Table 7. Distribution of fisheries characteristics in the various strata of Volta Lake

Characteristics	STRATA								TOTAL
	I	II	III	IV	V	VI	VII	VIII	
Fishing villages	161	152	167	115	182	146	237	72	1232
Population of fishers	9574	5612	9333	8187	8378	8715	17278	1704	71861
Fishing boats	3620	1795	3059	2685	6636	3167	5369	1704	24035
Outboard motors	134	126	260	105	110	33	111	33	973

Source: MOFA, 2003

Fish biodiversity

The Lake is rich in fish fauna. Roberts (1967) recorded 112 fish species during the pre-impoundment phase while 108 species were recorded during the filling stage (Denyoh, 1969). Currently 121 species have been recorded (Dankwa *et al.*, 1999). It is also known that 32 fish species are present which were not recorded during the early stages of the Lake (Denyoh, 1969). The species list recorded during the filling stage is likely to change mostly due to upgraded taxonomy and also to the disappearance of some fish species as a

consequence of the change from riverine to lacustrine conditions. The native fish species, however, fill all the niches in the ecosystem and it has not been necessary to introduce any exotic species (Vanderpuye, 1984). The open offshore waters, which considerably expanded following impoundment, have been populated mostly by small-sized clupeids, e.g., *Odaxothrissa mento*, all of which are utilised for food.

Changes in fish species composition

The change from riverine to a lacustrine condition during the formation of the Lake, which started at the beginning of the rainy season in May 1964, led to the death of a variety of fish species, including *Chrysichthys* spp. which are very sensitive to oxygen depletion (Petr, 1968). The ecological change also brought about substantial changes in the fish community structure. During the Lake's initial two years, some of the riverine species, especially Mormyridae almost completely disappeared. The basic trend was towards the development of a community of fish species which had vegetarian food habits such as the Tilapias (mostly *Sarotherodon galilaeus*, *Oreochromis niloticus* and *Tilapia zillii*), and the less common *Citharinus* (*C. citharus*, *C. latus*), *Labeo* (*L. senegalensis*, *L. caubie*), *Distichodus* (*D. rostratus*, *D. engycephalus*) and some *Synodontis* species. The predominance of insectivorous feeders e.g., Characidae (*Alestes baremoze*, *A. dentex*, *Brycinus nurse*), *Schilbe intermedius*, *Schilbe mystus*, *Chrysichthys nigrodigitatus* and some species of *Synodontis* kept decreasing (Petr, 1968, 1969).

Predators were distributed throughout the Lake where they found an abundance of food such as the clupeid *Microthrissa* and schilbeid *Physalia pellucida*. In the more accentuated lacustrine environment in the main fishing areas in the south of the Lake a variety of major commercial species, e.g., the mormyrids and the characid *Alestes* decreased (Petr, 1969). In the south, fishing started in the open waters and the fish catches indicated the suitability of deeper water for some important commercial species of fish - indicating improved oxygenation of deeper layers. The northern part of the Lake kept its more riverine character, especially during the flood season, and served as an important breeding and feeding place for many commercial species of fish (Petr, 1968).

Thirty-six years after the formation of the Lake, commercial fish landings are dominated by tilapiine species, not only in the lacustrine south but throughout the Lake. Also those species previously considered to be mainly limited to riverine conditions (*Hydrocynus* spp., *Labeo* spp., *Mormyrids*, *Schilbeids*, *Odaxothrissa mento*, *Brycinus nurse*, *Alestes baremoze*, *Alestes dentex* and *Citharinus* spp.) have returned to what were originally described as lacustrine parts of the Lake. Stabilization of suitable conditions has probably enabled these species to exist in areas where they previously were not commonly found. The composition of the commercial catch (by weight) from 1991- 1998 comprise *Chrysichthys* spp. (34.4%), tilapias (28.1%), *Synodontis* spp. (11.4%) *Labeo* (3.4%) *Mormyrids* (2.0%), *Heterotis* spp. (1.5%), *Clarias* spp. (1.5%), *Schilbeids* (1.4%), *Odaxothrissa mento* (1.4%), *Bragrus* spp. (1.3%) and *Citharinus* spp. (1.2%). The remainders, which include *Alestes* spp., *Brycinus* spp., *Distichodus* spp., *Gymnarchus* spp., *Hydrocynus* spp. and *Lates niloticus*, account for less than 1.0% each of the commercial catch by weight (MOFA, 2003).

Fishing gears/methods

In 1970 and 1975, the principal fishing gears used in the Lake were: gill nets, cast nets, lines and traps (Bazigos 1970, Coppola and Agadzi 1976). At that time, the mesh sizes of

gill nets used by fishers ranged from 102 to 205 mm (Vanderpuy, 1984). Nowadays, the smallest mesh sizes are reported to be below 25 mm (MOFA, 2003) and include mosquito net for the small pelagic clupeids. The main types and number of fishing gears in Lake Volta are presented in **Table 8**.

Table 8 Composition of fishing gears used on the Volta Lake

Type of fishing gear	Number
Gill nets	998250
Line fishing	791571
Traps	338667
Cast nets	8972
Nifa nifa	5700
Beach seines	10895
Winch nets	447
Atigya	3500
Wangara	6046
Bamboo-pipes	4,180,630
Spears	76
Poisoning	

Source: MOFA, 2003

Gears introduced in recent years are mostly unauthorized and include drive-in gear (locally known as *Wangara*), bamboo pipes (specifically for *Chrysichthys* spp.), combined gill nets and traps (*nifa nifa*) and some active gears, such as beach seines (*adranyi*), purse seines (*winch nets*) and other forms of encircling gears. These active gears are supposedly illegal on the Lake, but currently contribute between 65 and 70% of the total fish landings from the Lake (Brammah, 1989, 1991).

The introduction of purse seines (*winch nets*) on the Lake since the mid-1980s was seen as a result of the deployment of a new type of fishing craft called a 'winch boat'. This fishing technique can accommodate 10 to 15 fishers and work conveniently with nets which can be as long as 500 to 800 m and 20 to 30 m deep. Normal canoes still predominate but their capacity has increased from 6 -7 boards to 10 - 12 for a length ranging between 5 and 10 m, and they are now operated by 2 to 4 fishermen.

Other inland fisheries in Ghana

Apart from Lake Volta, inland fisheries cover fish production from dams, other lakes and lagoons. The total inland fishery production in Ghana is not totally clear (see below) and it is difficult to draw any definite figure. According to the Directorate of Fisheries, other inland systems, except lagoons, are underdeveloped and under-exploited, needing substantial improvements to be made in yield performance in order to make a significant contribution to the inland catch in comparison with the Volta Lake's output (MOFA 2006). In several reservoirs quite large individual fish are still being caught. Fisher densities on lakes and reservoirs range up to 6 fishers per km of shoreline, which is a relatively high figure compared to what is observed in Southern Africa (Jul-Larsen et al. 2003). This combination of a relatively high density of fishers with still under-exploited water-bodies

can be explained by the part-time nature of fishing operated on these water-bodies by households who also farm or have other means of earnings.

Potential under-estimations?

Some documents (e.g. MOFA 2006) state that the current national fish production figures for dams, dugouts and rivers (except Lake Volta) are under-estimates and represent probably only a quarter of the actual fish production from these water bodies. The reason for this statement is that catch data from representative samples of these water bodies are reported directly as total fish production figures without due adjustments to make up for the total number of water bodies concerned. Based on this, an estimate of 319,000 t (comprising 251,000 t from the Volta Lake and 68,000 t from other sources) has been proposed for the year 2000, making the contribution of inland fisheries equal to nearly 83% of the total marine output of 383,000 t for that year (MOFA 2006).

This hypothesis (which should be considered with great caution -see next section), outlines the extent to which the inland fisheries sub-sector may effectively contribute to economic growth and poverty reduction, a consideration that has hitherto not been recognized.

Fisheries resources and recording issues

Based on the official statistics, the inland fisheries sub-sector contributes about 20% of the total domestic fish production. Some stock assessment studies, however, show a discrepancy with these official figures and suggest that the actual contribution of inland water bodies may well be over three times the national figure reported for each year (de Graaf and Ofori Danson 1997, Kunzel 1998, Braimah 2000). For instance, while in 1997 some 60,000 t was reported as the national fish production figure for the Volta Lake alone, studies based on stock assessments argued that the real figure should be between 150,000 and 200,000 t (de Graaf and Ofori Danson 1997, Kunzel 1998). Other unpublished lake-wide frame surveys and catch assessment programmes indicated that 251,000 t were landed from the Volta Lake in 2000, while the national account showed a meagre quantity of 65,000 t.

Overfishing in Volta Lake: narrative or reality?

Beyond the recording issue mentioned above, which is not necessarily specific to Ghana but rather general to a large number of developing countries (reflecting the frequently limited financial and human resources of the institution in charge of monitoring inland fisheries), the review of the literature on Volta Lake highlights another potential issue. Although the current estimates of the landings show an increasing or (at least in their more conservative forms) a stable trend, most of the assessments and reports produced in the last 30 years claim that the lake resources are seriously over-exploited. The Ministry of Fisheries for instance in 2006 stated: “Of the inland sources, the Volta Lake is the most significant, but is currently confronted *with overexploitation and overcapitalization* phenomena that inhibit the optimum use of the available fisheries resources”. Prior to this recent report, other studies had already highlighted this issue: “Fish catches on Lake Volta are steadily decreasing according to various studies conducted over the past decades (Cappolla and Agadzi 1976, Agyenin Boateng 1989, Braimah 1995, and de Graaf and Ofori-Danson 1997)” (Pittaluga et al. 2003, p. 25).

The decline in catch volume is generally attributed to a reduction in total rainfall, in conjunction with an increasing fishermen population, the use of illegal fishing methods (including the use of chemical poisons), as well as the development of farming along the banks of the lake that destroys bushes in which fish dwell. It is also often reported that fishers themselves complain about a greater proportion of very small fish in their catches. Pittaluga et al. report from their survey that almost all interviewed fishers (97%) said that the fish catches were declining. According to these fishers, a major reason for the decline was increased population of fishers, followed by a lower water level and the use of beach seines and winch-boats.

In 1993, length frequency data on 26 commercially important fish species collected by the Integrated Development of Artisanal Fisheries programme (IDAF) project indicated that 17 fish species were caught before reaching the age of one year (Goudswaard and Avoke, 1993). According to the report, the high mortality of the juvenile length classes was caused by the extensive use of small-meshed gill nets and the then-recently introduced new active gears, in particular the purse and beach seines that provided between 65 and 70% of the total commercial landings (unpublished IDAF report, 1993).

While these reports provided some evidence that a risk of overfishing could not be ruled out, this narrative of over-exploitation has been widely adopted and repeated for more than 20 years, while no clear negative trend has been observed in the fishery catch⁵. To the contrary, some of these reports even show an increase in production in the lake over the last two decades. Nevertheless, the over-exploitation narrative is now well established as the prevailing view of the status of fish stocks in Lake Volta. One consequence is that this narrative now strongly influences other sectors experts' view on fisheries (with the potential danger that this may shape the way future investments are planned). For instance in the recent Global International Water Assessment conducted in West Africa (Abe et al. 2004), the GIWA expert panel recognised that unsustainable exploitations of inland fish and other living resources was the second major issue for the Volta Basin. Their assessment was exclusively based on Braimah 2001 report.

Review of past studies

In this section, we review more systematically some of the main conclusions proposed in the key documents published on the Volta Lake over the last 15 years. The first of these documents is the FAO Technical Report produced by de Graaf and Ofori-Danson in 1997.

de Graaf and Ofori-Danson report

In 1995/1996 the IDAF carried out a fisheries monitoring programme in stratum VII of Lake Volta. The programme encompassed a full frame survey, a catch and effort monitoring programme and a length-based stock-assessment programme.

At that time (1995-96), the frame survey indicated the presence of 40,000 fishers in the stratum. Comparing these figures with the earlier socio-economic survey conducted in 1992 suggests that the number of canoes had increased by 23%, from 6,500 to 8,068, and

⁵ One potential explanation for this 'stability' of the production will be explored in the next section below.

the number of fishers by 122%, from 18,000 to 40,000. In contrast, the number of winch-boats had slightly declined from 380 to 358.

Surplus production model

From the catch and effort data for Stratum VII, de Graaf and Ofori-Danson calculated an estimated total production of 33,800 tonnes for 1996. Based on this figure, they concluded that the previously used production estimate of 44,000 t/year for the whole of Lake Volta (derived from Vanderpuye 1984) was an under-estimate. Instead, based on their own estimates derived from a surplus production (Schaefer) model, de Graaf and Ofori-Danson estimated that the total production of Lake Volta should be around 150,000 - 200,000 t/year (180-240 kg/ha), with a maximum sustainable yield of 36500 t/year for the stratum VII. De Graaf and Ofori-Danson pointed out, however, the great uncertainty of their results due to the limitation of the data (see **Box 4**). In particular, they admitted that the Schaefer curve had been fitted with only two valid data points.

Box 4. de Graaf and Ofori-Danson's surplus model.

De Graaf and Ofori-Danson used their catch and effort data of stratum VII in a surplus production model. The data indicates that a maximum sustainable yield of 36500 t/year can be obtained from stratum VII at a fishing effort of 5500 canoes and a CPUE of 6.6 t/canoe/year. Such an analysis would indicate that at present stratum VII is overexploited due to the activities of 8060 canoes. Extrapolated to the whole Lake these figures would indicate a maximum fishing effort of 41,000 canoes and a MSY of 271,000 t/year for the whole of Lake Volta. de Graaf and Ofori-Danson however point out that these estimates would “certainly [be] an overestimation” and that the total production of Lake Volta was most likely to be around 150,000 - 200,000 t/year (180-240 kg/ha) with a total annual value of 30 million USD.

Beyond the *empirical* limitation induced by the poor quality of the data, the adoption of a surplus model to extrapolate the production levels of the lake may also be problematic from a *conceptual* point of view. Indeed the use of conventional surplus model such as the Schaefer model has been questioned by inland fisheries specialists for more than 20 years. Based on empirical studies of rivers, lagoons or lakes (Welcomme 1989, Malvestuto and Meredith 1989, Laë, 1997), or numerical simulations (Welcomme and Hagborg 1977, Morand and Bousquet 1994), many of these fisheries specialists argue that the response of inland aquatic resources to fishing effort may not be a parabola as commonly represented in the traditional models but a ‘plateau’, reflecting the fact that inland resources seem to be characterised by a certain degree of ‘resilience’ to fishing effort (**Box 5**).

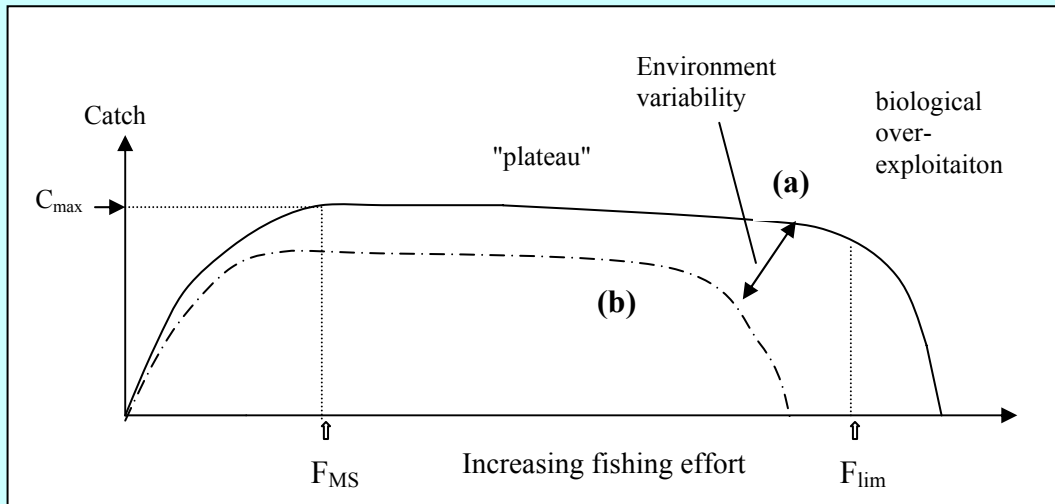
Length frequency analysis

de Graaf and Ofori-Danson also conducted a length-based stock assessment using a multi-species multi-gear Thompson and Bell analysis. Based on these results and assuming that “the data were reliable”, de Graaf and Ofori-Danson concluded that “the stocks [were] “seriously over-exploited” (p.iii) but recognised that “Small sample sizes, as sometimes was the case in the programme executed in Stratum VII, seriously hampers the analysis and reduces the reliability of the results”. They concluded “from a scientific point of view it is difficult to draw conclusions on the [then]-present status of the stock in stratum VII of the Lake Volta”. Unfortunately, de Graaf and Ofori-Danson did not compare the results of their length frequency analysis with the findings of their surplus production model.

Box. 5. The plateau response of inland resource to fishing effort

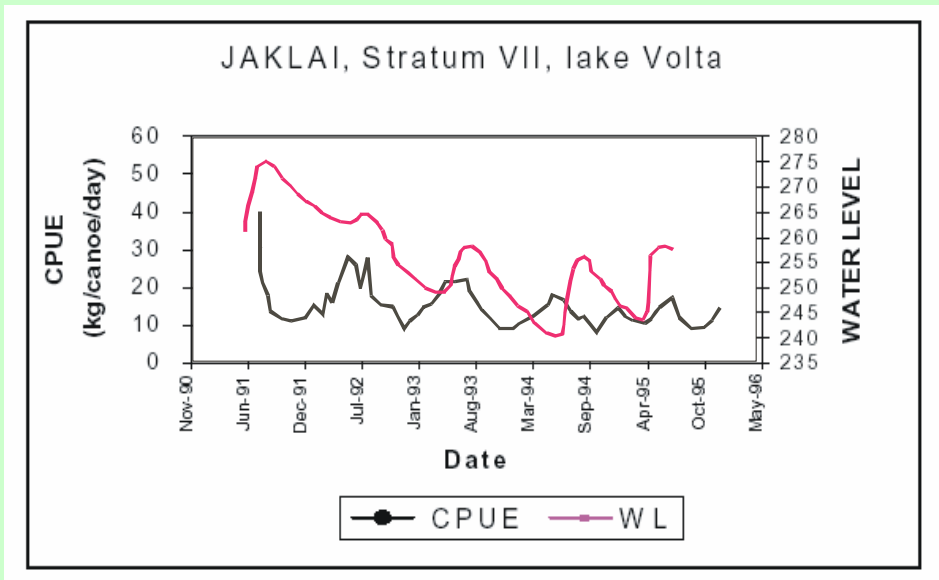
Many fisheries specialists argue that inland aquatic resource are more ‘resilient’ than assumed in the traditional surplus models, and that their response to fishing effort may thus take the shape of a ‘plateau’ (instead of a parabola) along which the production remains stable (or slightly decreasing) for a large range of fishing effort values, up to a limit level F_{lim} , from which eventually the stock starts to decline. This limit F_{lim} can however be equivalent to 3 to 5 times the conventional F_{MSY} . Within this new approach, environmental variations (such as nutrient pulse – see schema below) will influence further the response by modifying the plateau level—as illustrated by the curves (a) and (b) in the schema.

The ‘plateau’ response of the resource under increasing fishing pressure



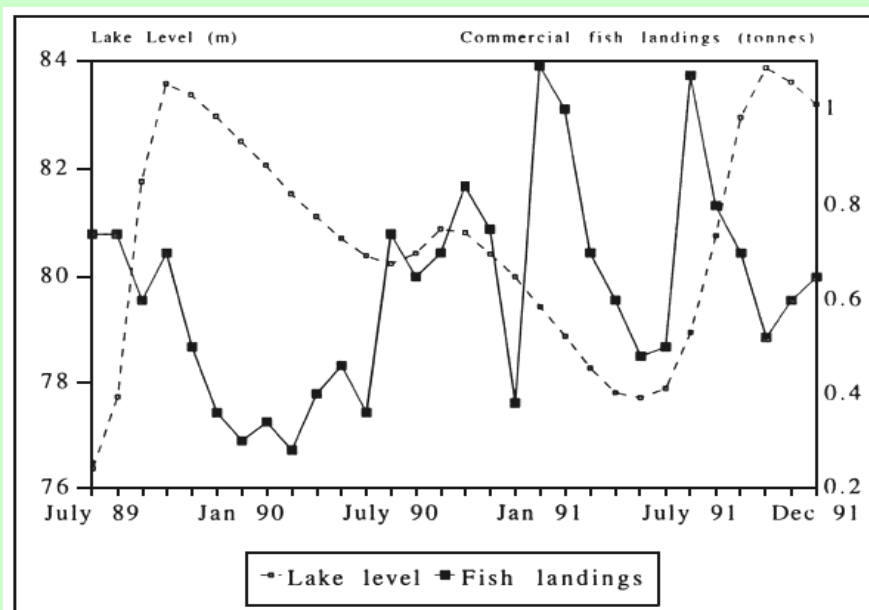
Source: redrawn from Morand 2000

Fig.7. Relationship between Volta Lake’s fishery productivity and the lake water level



Source: redrawn from de Graaf and Ofori-Danson 1997

Fig.8. Relationship between Volta Lake's fishery productivity and the lake water level



Source: Braimah (1995)

Relationship between CPUE and water level

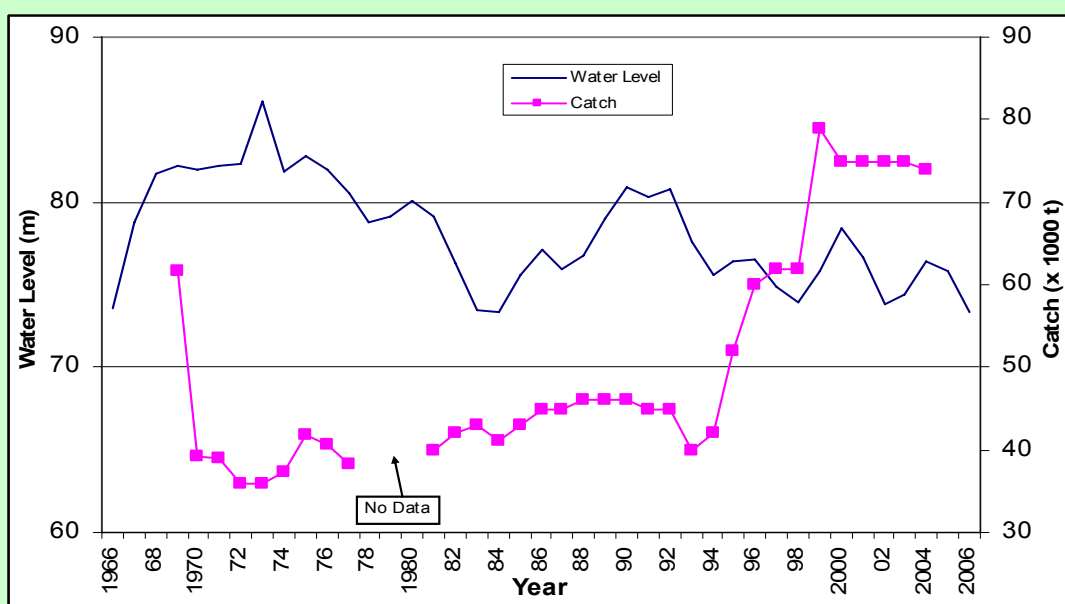
The third major analysis conducted during the IDAF survey was an attempt to link productivity of the fisheries, measured through Catch per Unit of Effort (CPUE), with the water level of the lake. Using monthly water levels measured at Akosombo and correlating them (with one period lag) to the CPUE obtained for the Stratum VII (Fig.7), de Graaf and Ofori-Danson investigated the fit of the relation through a multi linear regression analysis. They also included in their regression a proxy for fishing effort through the number of canoes. They found that both water-level and fishing effort partial coefficients were significant ($P < 0.05$) and the relation was:

$$CPUE = -0.00275 \times \text{No. of canoes} + 0.0958 \times \text{Water level} + 10,0327$$

The relationship shows that the CPUE is positively related to the water level. This finding, however, is in contradiction (at least at first sight) with an earlier analysis made by Braimah (1995). Using lake level fluctuations and monthly commercial fish catches recorded in the Yeji part of the lake (located in Stratum VII) from July 1989 to December 1991, Braimah showed an inverse relationship between catch and lake level: fish catches were high when lake levels were low and vice versa (Fig.8).

A third attempt was made recently to revisit the relationship between catch and lake water level. The yearly total catch estimates from surveys carried out by the Volta Lake Research Project phase II (UNDP/FAO/VRA) from 1969 till 1977 and the total catch estimates from the Fisheries Directorate from 1981 to 2004 were correlated, together with annual water level fluctuations. The data are displayed in Fig.9. It shows that at the annual scale the correlation between the water level and landings seems to be negative, in line with Braimah's earlier observation. When the water level is high, catches are low.

Fig.9. Trends in total fish catch from the Volta Lake and annual water level fluctuations



Source: WRI 2006

One possible solution to reconcile these different empirical studies would be to consider that water levels can influence fish catch through two opposite mechanisms operating at two different time-scales: one positive effect at the short-time scale (as observed by de Graaf and Ofori-Danson) and one negative at the longer time scale as suggested by Braimah and WRI's latest analysis⁶. The overall hypothesis is that the water level plays a central role in the productivity of the Lake Volta fishery. In addition, some non-linearity in these effects may be also at work, which would explain the current difficulty of the researchers to identify clear correlations.

The environment as the main driver of lake productivity?

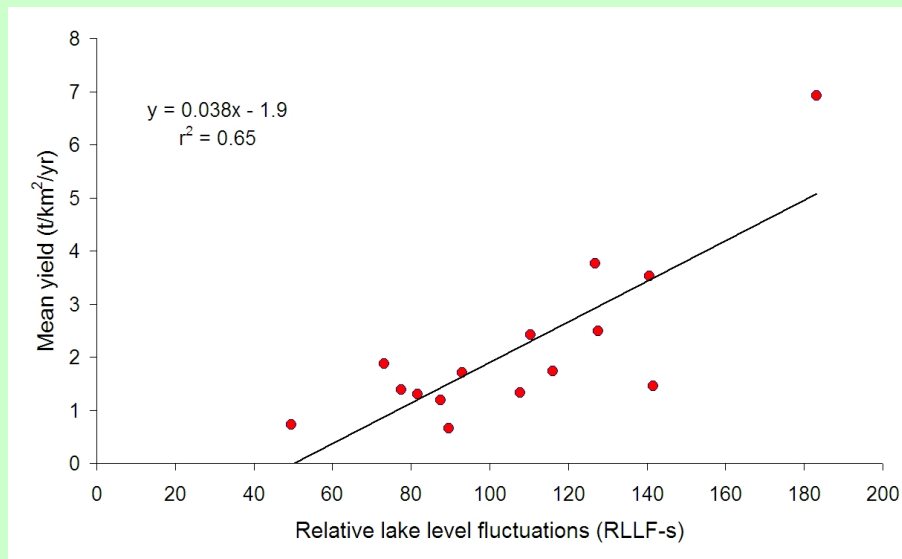
The hypothesis that the lake's productivity is driven by water level may be seen as related to the "flood pulse" concept suggesting that seasonal flooding is the major driver of the biotic productivity of river-floodplain systems (Junk *et al.*, 1989). Although Lake Volta is not a river-floodplain system *per se*, it is characterized by season fluctuations of its water level (on average 2 to 6 meter), with an area of about 100,000 ha covered by these seasonal fluctuations.

For reservoirs in other parts of the world, Kolding and van Zweiten (2006) have proposed an index that captures the idea suggested by the flood-pulse hypothesis. This is the Relative Lake Level Fluctuation (RLLF) index, defined as follows:

$$\text{RLLF} = \text{mean lake level amplitude} / \text{mean lake depth.}$$

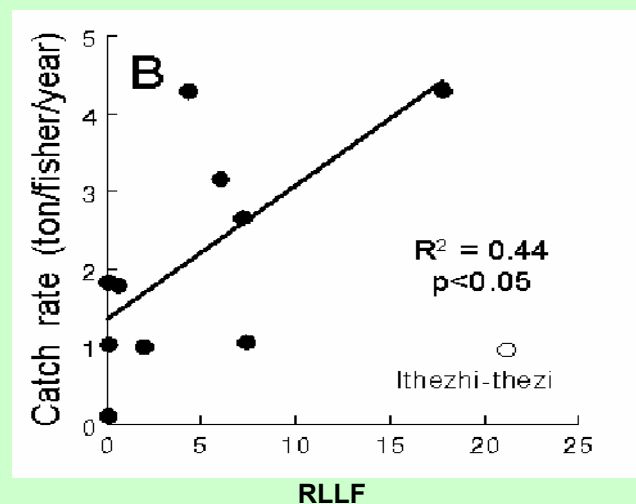
⁶ This type of double interaction has already been observed, for instance in the case the recruitment of wild shrimp over the Brazilian continental shelf where the local rivers' flow have been shown to have a negative effect at a monthly scale while the Amazon river has a positive effect at longer (annual) scale (Béné and Moguedet 1998).

Fig.10. Correlation between the RLLF index and the productivity of 15 Asian Lakes



Source: Kolding and van Zweiten (2006)

Fig.11. Relationship between RLLF and fishers' productivity in Southern African's lakes



Source: Jul Larsen et al. 2003

Using data from 15 lakes in Asia they showed a significant correlation between RLLF and the fish productivity of these lakes (Fig.10). In a complementary analysis, those same authors also applied this index to several lakes in the Southern Africa region (Jul Larsen et al. 2003). In that case, they did not correlate the RLLF to the lake's productivity per se but to fisher productivity (Fig.11).

In the case of Lake Volta, assuming a 2 to 6 m seasonal fluctuation and an average depth of 18.8 m, the RLLF of the lake would be in the range of 10 to 30, which, compared with other African lakes, falls in the 'more productive' end (comparable with Mweru and Malombe lakes), and is higher than Kariba (Kolding pers. comm. June 2007). Reading from Fig.11, this means that Lake Volta may yield approximately 3 to 5 tonnes/yr/fisher, which again is in the upper range compared to Southern African lakes. If such speculations proved to be true then it would lead to very different conclusions about the productivity of the lake, and the management regime to support it.

Prior to this RLLF concept, several authors had already explored possible avenues along the “water-level” hypothesis for Lake Volta (Braumah 1995, de Graaf and Ofori 1997). None of these studies, however, seems to generate a strong consensus that would allow the confirmation (or refutation) of the “flood pulse” hypothesis. Even the status of the lake in terms of productivity remains unclear. While the poor nutrient content suggests an oligotrophic lake (Antwi, 1990), Braimah, using catch statistics, claimed that the lake’s yield was around 43 kg/ha/yr (see **Table 9**). This would make the Lake mesotrophic-eutrophic. This last estimate of 43 kg/ha/yr also diverges from the potential yield calculated with the Morpho-Edaphic Index Model, which was found to be approximately 12 kg/ha (Braumah 1995).

Table 9. Estimated yield of Volta Lake based on catch statistics in 1991

Total processed fish landings in 1991	29 624 t
Total landings of fresh fish in 1991	1 464 t
Total fish landings	31 088 t
Plus adjustment for self-consumption by fisherfolks (11.7% of total landings)	3 636 t
Plus adjustment for post-harvest losses (5.3% of total landings)	1 636 t
Total fish production from Volta Lake	36 360 t
Surface area of Lake at 275 ft water level	837 617 ha
Estimated yield in 1991	43.4 kg/ha

Source: Braimah 1995

How do these different values compare with the rest of the literature on reservoir and lake fisheries in Africa? Several authors have proposed general estimates of the relationship between fisheries productivity and bio-physical characteristics of the water-body considered⁷. Based on a data base of 71 African lakes and reservoirs (46 lakes and 25 reservoirs), Crul (1992) proposed the following relationships:

$$\text{Catch} = 8.32 (\text{water body area, km}^2)^{0.92} \quad (R^2 = 0.93)$$

Using the 46 lakes’ data only, the correlation is :

$$\text{Catch} = 8.93 (\text{lake area, km}^2)^{0.92} \quad (R^2 = 0.92) ;$$

and for the 25 reservoirs:

$$\text{Catch} = 7.09 (\text{reservoir area})^{0.94} \quad (R^2 = 0.94).$$

The overall model suggests an average catch of 60 kg/ha/yr, with values slightly lower in large lakes than in smaller ones, but with a large uncertainty when applied to a single water body (Crul 1992). In a later review including 65 African lakes, Laë (1997) observed that many relationships formerly proposed were not enough accurate and reliable to be used to

⁷ This last part draws mainly from Lemoalle J., Clanet J.C., and Terrasson I. (2007). Fish and livestock water productivity. Introduction. Mimeo, 7 p.

predict potential fish catches in individual lakes or reservoirs. The best predictors for total catch is total surface area ($R^2 = 0.76$) and for catch per fisher, the morpho-edaphic index ($R^2 = 0.42$) when the fishing effort is higher than 2 fishermen per km^2 .

A number of studies have used the catch per unit effort (CPUE) as a standard measure. Rough figures for lake or reservoir have been proposed by Henderson and Welcomme (1974) and (Crul, 1992). The relationship by Henderson and Welcomme (1974) is a combination of physio-chemical characters of the lake and the density of fishing activity. It relates the catch per fisher (tonnes/year) and the morpho-edaphic index (MEI) as follows

$$\text{Catch per fisherman (tonnes)} = 14.3136 (\text{MEI})^{0.4681}$$

More generally, Crul has proposed a mean yield per fisher around 2.3 tonnes/year for the combined series of lakes and reservoirs and 2 tonnes/year for reservoirs only.

For Lake Volta, the recent (unpublished) estimates of 251,000 tonnes/year would mean a catch of 295 kg/ha/yr, suggesting a quite high but possible annual catch per fisherman of 3.5 tonnes/year –assuming that the number of fishers operating around the lake is 71,800. (Brammah 2000)

This figure can be compared with two other large African reservoirs, the fisheries production of Lake Kainji (1270 km^2) and that of Lake Nasser (6216 km^2). Lake Kainji fishery is reported to yield between 4,500 and 6,000 tonnes/yr, while Lake Nasser production ranges from 15,700 to 34,000 tonnes. The productivity of these reservoirs ranges from 24 to 55 kg/ha/yr (Crul and Roest, 1995).

Summary of the section

Despite many scientific studies and several international research programmes, great uncertainty remains about the actual and potential productivity of Lake Volta. Part of this uncertainty reflects the ‘natural’ variability of the lake’s ecosystem, its size, and the relative difficulty to access some parts of the shorelines, making extrapolations of local sampling to the whole lake difficult. There is an urgent need to address this uncertainty if one is really serious about promoting fisheries as an entry point for poverty alleviation and food security for communities surrounding the lake.

Experience suggests that water policy-makers and rural development planners will be willing to consider small-scale fisheries, such as those operating on the Lake Volta, only if one is able to demonstrate with concrete and tangible evidence the real importance of these fisheries for the national economy and the livelihood of the local population living along the shores of the lake. It seems to us that generating concrete and tangible evidence is possible. A more rigorous and systematic analysis of the fragmented but numerous data that exist should allow this overdue comprehensive assessment of the Volta Lake fisheries’ productivity to be conducted and possibly result in new understanding of the role of the environment in this productivity. It would also allow analysis to go beyond what seems to be a paradigmatic view on the “over-exploitation of the lake’s current resources”.

Conclusion

From this review of the Volta Basin fishery resources, a series of conclusions follows. First, it should be recalled that only Burkina Faso and Ghana have been considered in this document as the four other countries of the basin (Cote d'Ivoire, Togo, Mali, Benin) have only limited fisheries activities within the basin.

In Burkina Faso, the fisheries potential of the Volta basin has been estimated to be about 3750 tonnes per year. The reservoirs of Bagré and Kompienga generate the majority of these captures, but the country is also endowed with a very large number of small-scale reservoirs which could be used for fisheries. Fisheries in Burkina Faso are still informal and under-exploited for the most part and largely marginalised in the rest of the economy. Nevertheless, in the rural areas where fisheries operate, they may constitute an important complementary source of protein, employment and cash-income for many households.

In Ghana, Lake Volta is the main 'component' of the inland fisheries. Some practitioners and researchers argue that the production of other water-bodies (rivers, swamps, lagoons, ponds, and other reservoirs) is largely under-estimated and under-exploited. A relatively high density of seasonal fishers operates in these smaller water-bodies but with a relatively low productivity as fishing is only part of a multiple-activity livelihood strategy. Recent research in other parts of Africa (e.g. DRC) stresses, however, the critical role that fishing plays as a primary source of cash-income for these inland fishing-farming communities (Béné et al., 2006).

Estimates of Volta Lake's fishery potential range from 40,000 to 271,000 tonnes and there remains no consensus of where, within this broad range, the most likely true production lies. Great uncertainty also characterises the current production figures. Despite (or perhaps because of) this high uncertainty, a large number of documents claim that the resources of the lake are over-exploited. While this hypothesis should not be ruled out, we also noted that much of this literature, including scientific publications, adopted an 'over-exploitation narrative', even when the data presented did not necessarily support these statements. This paradigm may subsequently be adopted by other, non-fishing, institutions and policy-makers and reinforce the marginalisation of the fishing communities.

The second major point concerning Lake Volta is the central hypothesis put forward and tested by many that water level plays a central role in the productivity of the Lake fishery. Here again however, no consensus seems to emerge regarding the exact mechanisms at work.

All these different points call for an urgent and comprehensive assessment of Lake Volta fisheries. This can be done, in part by a careful and thorough re-analysis of the fragmented but long-term data sets that been collected in the past. Such an assessment will better inform policies on how to improve the water productivity of the lake and to reduce poverty in the local populations, while, at the same time, preserving the ecological sustainability of its resources. It will also lead to the definition of an appropriate methodology for the production of the needed fisheries statistics.

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