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Recommendation Domains for Pond Aquaculture

Country Case Study: Development and Status of Freshwater Aquaculture in Cameroon

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RECOMMENDATION DOMAINS FOR POND AQUACULTURE

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Victor Pouomogne
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Recommendation Domains for Pond Aquaculture. Country Case Study: Development and Status of Freshwater Aquaculture in Cameroon

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LIST OF ABBREVIATIONS

AGCD	Belgium Administration for Development Cooperation
APDRA-F	Association Pisciculture et Développement Rural en Afrique tropicale humide – France (Association for Aquaculture and Rural Development in Humid Tropical Africa – France)
AQUACAM	Aquaculteurs du Cameroun (Cameroon fish farmers' association)
AVZ	agent vulgarisateur de zone (zone extension agent)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
CABA	Caisses Villageoises de Base (Grassroots Village Savings Banks)
CAMCCUL	Cameroon Cooperative Credit Union League
CEPID	Centre d'excellence pour la Production, l'Innovation et le Développement (Centre of Excellence for Production, Innovation and Development)
CIFORD	Centre d'Information, de Formation et de Recherche pour le Développement (Centre for Information, Training and Research for Development)
CIG	common initiative group
CIRAD	Centre de Coopération en Recherche Agronomique pour le Développement (Centre for International Cooperation in Agronomic Research for Development)
CNFZV	Centre National de Formation Zootechnique et Vétérinaire de Foumban (Vocational Training High School in Animal Husbandry and Veterinary Sciences)
COOPEC	Coopératives d'Epargne et de Crédit (Saving and Credit Cooperative)
CV	Caisses Villageoises (Village Savings Banks)
DFID	Department for International Development (United Kingdom)
DirPêches	Direction des Pêches (Department of Fisheries)
DSCN	Direction de la Statistique et de la Comptabilité Nationale (Department of Statistics and National Accounts)
DSDSR	Document de Stratégie pour le Développement du Secteur Rural (Document on Rural Development Strategy)
DSRP	Document de Stratégie de Réduction de la Pauvreté (Document on Poverty Alleviation Strategy)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCFA	franc de la Communauté France Afrique (local currency, used by former French colonies in sub-Saharan Africa; the fixed euro exchange rate is €1 = FCFA655.95)
FSRP	farmer-scientist research partnership
GTZ	Gesellschaft für Technische Zusammenarbeit GmbH (German technical cooperation agency)
IDRC	International Development and Research Centre (Canada)
IFAD	International Fund for Agricultural Development
INS	Institut National de la Statistique (National Statistics Institute)
IRAD	Institut de Recherche Agricole pour le Développement (Institute of Agricultural Research for Development)
JORC	Journal Officiel de la République du Cameroun (Official Journal of the Republic of Cameroon)

MC^2	Mutuelle Communautaire de Croissance (Community Mutual for Growth)
MINADER	Ministère de l'Agriculture et du Développement Rural (Ministry of Agriculture and Rural Development)
MINEPIA	Ministère de l'Elevage, des Pêches et des Industries Animales (Ministry of Livestock, Fisheries and Animal Industries)
MINRESI	Ministère de la Recherche Scientifique et de l'Innovation (Ministry of Scientific Research and Innovation)
NEPAD	New Partnership for African Development
NGO	nongovernmental organization
PCP	pôle de compétence en partenariat (partnership competency network)
PNRVA	Programme National de Recherche et de Vulgarisation Agricole (National Programme for Agricultural Research and Extension)
PSSA	FAO Special Programme for Food Security
REPARAC	Renforcement des Partenariats pour la Recherche Agricole au Cameroun (Strengthening Partnerships in Cameroon for Agricultural Research)
RET	Research Extension Team
SEAPB	Service d'Appui aux populations à la Base (Support Service for the Population at the Grassroots Level)
SOGREAH	Société Grenobloise d'Etudes et d'Applications Hydrauliques (Water Research and (Management) Applications Society of Grenoble)
TS	Technicien Spécialisé (Subject Matter Specialist in the PNRVA)
UDs	Université de Dschang (University of Dschang)
UK	United Kingdom
UNDP	United Nations Development Programme
UNESCO	United Nations Organisation for Education, Science and Culture
USAID	United State Agency for International Development

NOTE: In this report, "$" refers to US dollars ($1 = FCFA530).

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We particularly thank Dr Randall Brummett at the WorldFish Center in Cameroon and Dr Kam Suan Pheng at WorldFish headquarters in Malaysia for their valuable comments and suggestions in response to an earlier draft of this report.

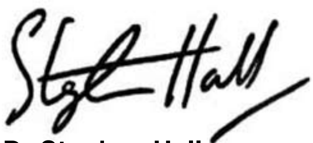
FOREWORD

This monograph is a result of a 3-year project to produce a decision-support toolkit with supporting databases and case studies to help researchers, planners and extension agents working on freshwater pond aquaculture. The purpose of the work was to provide tools and information to help practitioners identify places and conditions where pond aquaculture can benefit the poor, both as producers and as consumers of fish. By undertaking the project in four countries (Cameroon and Malawi in Africa, and Bangladesh and China in Asia), each at a different stage of aquaculture development, project researchers were better able to test the toolkit for wide applicability and utility.

Applying such a toolkit requires a clear understanding of the existing state of pond aquaculture in each country, the circumstances underpinning its development, and the factors driving its adoption or discontinuation. To achieve this, country case studies were conducted by extensive literature review supplemented with analysis of primary and secondary data.

This monograph is the case study for Cameroon. Written in three parts, it describes the historical background, practices, stakeholder profiles, production levels, economic and institutional environment, policy issues, and prospects for aquaculture in the country. First, it documents the history and current status of the aquaculture in the country. Second, it assesses the technologies and approaches that either succeeded or failed to foster aquaculture development and discusses why. Third, it identifies the key reasons for aquaculture adoption.

I hope that this monograph will help development practitioners and researchers interested in aquaculture development in Cameroon. The WorldFish Center and its research and national partners[1] are grateful to the Federal Ministry for Economic Cooperation and Development, Germany, for funding the project. We also thank all other partners, including fish farmer respondents, who have contributed to this effort.



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1 Research partners: University of Kassel and the University of Hohenheim, Germany; National partners: The Institut de Recherche Agricole pour le Développement in Cameroon, Fisheries Department in Malawi, Department of Fisheries in Bangladesh and Chinese Academy of Fishery Sciences.

SUMMARY

The biophysical potential for fish culture is very high in Cameroon, which has natural inland waters covering over 40,000 square kilometres. Coupled with a fish-eating population (17.9 kilograms per capita per year) that is growing by 2.8% annually, and with rapid urbanization that has raised the percentage of urban residents from 38% in 1987 to 55% in 2006, the potential for productive and profitable aquaculture is large and growing. To meet domestic fish demand, the government of Cameroon has imported over 100,000 tonnes of fish per year for the past decade. Unfortunately, pond fish farming, which started in Cameroon in the early 1950s, is still poorly established and far from realizing its potential.

Following Cameroonian independence in 1960, aquaculture development was driven largely by international donors through grants and technical assistance from such institutions as the Food and Agriculture Organization of the United Nations, United States Peace Corps, French Agricultural Research Centre for International Development (CIRAD by its French abbreviation), International Development and Research Centre of Canada, Belgian Administration for Development Cooperation, and World Bank, among others. Given the stop-start, top-down nature of this support, the evolution of the sector through the mid-1990s was erratic and discontinuous. In 1995, after evaluating past experiences, the Cameroonian government promoted a more participatory approach, which has been followed in projects launched in the new millennium and supported by the French cooperation agency and United Kingdom's Department for International Development. With the end of the "state does all" attitude signalled by the recently elaborated Strategic Framework for Aquaculture Development and the promotion of private enterprise and common initiative groups, the aquaculture sector may be on the verge of rebirth.

Small-scale aquaculture using compost cribs is the most common system in Cameroon. These cribs occupy on average 10% of the pond surface. In addition, a commercial sector is emerging primarily in the periurban areas of the capital cities of the Centre, West and East provinces. Commercial farmers practise polyculture of Nile tilapia and African catfish in fertilized ponds using chicken manure and single-feed ingredients such as wheat bran and cotton seed oilcake. Common carp is, to a lesser extent, part of the polyculture in high plateaus near Bafoussam and Bamenda, as is *Heterotis* in forest regions around Yaoundé and Bertoua. Production statistics are confusing, but the best estimates from the most reliable field technicians counted, by end-2006, approximately 4,500 active farmers with 7,700 ponds (more than half of them new or rebuilt since 1995) with an average size of 350 square metres. Annual fish production from earthen ponds was estimated at 950 tonnes, of which more than 90% is produced by small-scale farmers. Steady production growth of about 10% annually has been recorded since 1995, a likely result of the more participatory approaches adopted by research and extension in recent years.

Recent surveys, including the current German-funded recommendation domains project, have identified socioeconomic and institutional factors — specifically regarding access to such inputs as seed, feed and human expertise, and capital and market development (road, population density, market infrastructure) — to have more influence (weighted up to 70%) on aquaculture development than such agro-ecologic or technological factors as water availability, topography, soil texture and know-how. It is expected that, with progressive improvement in the management of human capital and natural resources, Cameroonian aquaculture may finally fulfil its potential as an engine for development in Cameroon.

1. INTRODUCTION

Fish is a preferred protein source for most Cameroonians because it is cheap compared with such other meats as bush meat, pork, chicken and beef. Prices for fish vary from 700-3,000 francs de la Communauté France Afrique (FCFA) per kilogram (kg) according to the quality and the place of purchase. Additionally, fish is available in conveniently small units that can be easily purchased by the poor, with small heaps of smoked fish selling for FCFA100, or $0.20.

In 2004, national fish production was estimated at 175,000 tonnes (t), 100,000 t from marine fisheries and 75,000 t from inland, including 650 t from aquaculture. Sixty percent of national fish production is sold in smoked form mainly because of poor communications and access to fishers' settlements, as well as insufficient infrastructure for other forms of processing (e.g., freezing, canning, salt-drying or fermenting). In addition, consumers prefer fish species such as Madeiran sardinella (*Sardinella* sp.), Bonga shad (*Ethmalosa* sp.) and African catfish smoked rather than fresh (Essomba personal communication).

Average fish consumption nationally is estimated at 17.9 kg per person per year. This figure varies according to location, rising to 30-35 kg in the large cities of Yaoundé and Douala and falling to 10 kg in villages far from fish-production sites. As national fish production has not been able to meet fish demand, the government of Cameroon has for the past decade imported over 100,000 t of fish per year. In 2004, 135,000 t of frozen fish were imported (Ngok et al. 2005, Groupement Professionnel des Acconiers 2007). An estimated 2.8% growth rate in the fish-consuming population and rapid urbanization (38% in 1987 rising to 55% in 2006) ensure that the potential for productive and profitable aquaculture is high, especially as increased production from capture fisheries cannot be expected. So far, however, the large potential for aquaculture has yet to be realized.

Aquaculture was first introduced to Cameroon in 1948. Subsequently, the Cameroon Department of Fisheries (DirPêches) and international partners, especially the Food and Agriculture Organization (FAO) of the United Nations and the United States Peace Corps, undertook aquaculture development projects from the 1960s to the 1980s (Lemasson and Bard 1964, Anon. 1976, SOGREAH 1982, Balarin 1985, FAO 1993). Since then, many changes have occurred in the Cameroonian economy arising from the (1) World Bank and International Monetary Fund structural adjustment policies of 1988-1990, (2) emergence of a real civil society as a result of laws promulgated in 1990-1992 that consecrated individual rights and freedom of association, and (3) devaluation of the FCFA in January 1994. These developments brought tremendous changes to rural communities, including the role fish farming plays in livelihoods (JORC 1991 and 1992, Pouomogne et al. 1998).

1.1 AGRO-ECOLOGICAL CONDITIONS AND AQUATIC ECOSYSTEMS

Cameroon has a surface area of 475,442 square kilometres (km^2) located between longitudes 9°30' and 16° East and latitudes 2° and 12°30' North. The country is divided into ten provinces, the seven most southerly presenting the greatest potential for freshwater pond aquaculture. Pond construction is best done in areas with moderate slopes, soils capable of holding water and year-round water availability. In addition, access to adequate fish-farming technologies and markets are key requirements.

Topography

According to Laclavère and Loung (1980), Cameroon is divided into three distinct zones by a range of ancient volcanoes running southwest to northeast:

1. The North Cameroon Lowlands consist of the Benoue-Niger basin in the south up to the Lake Chad basin in the north, with the Mandara Mountains (rising to 1,440 metres [m]) acting as a watershed between the two basins.

2. The Central Highlands include the Adamaoua, Bamoun and Bamileke plateaus and the Grassfield region in the northwest. The plains of the extensive South Cameroon Plateau are undulating highlands between 650 m and 900 m in altitude, gently dropping away to the Congo basin in the southeast corner.
3. The coastal plains lie along the Atlantic coast at an altitude below 200 m, rising along a steep escarpment at the boundary with the highland region.

Soils

Cameroon is entirely composed of materials of the African shield, with volcanic deposits in the west, granite outcrops located centrally and sandy stretches around the Lake Chad basin. Of interest to aquaculture is that nearly 67% of southern Cameroonian soils are ferralitic, which is a result of high rainfall and hot temperatures. Their physical properties, such as a high capacity for water retention, make ferralitic soils better suited for aquaculture than volcanic soils. The unproductive ferralitic soil was created as leaching and erosion at high altitudes exposed underlying rock. The south is characterized by dense forest. Vertisols are found along river valleys, and alluvial material underlies mangrove swamps along the coast.

Climate

The country's varied topography, proximity to the sea and length stretching over 11 degrees of latitude offer a complete range of intertropical climates. Along with Cameroon's wide range of ethnic groups, this has led many to call Cameroon "Africa in miniature". Three main climates emerge:

1. The Equatorial climate has two sub-types, namely (a) Guinean, with four seasons, on the whole of the Southern Cameroonian Plateau (dry December-January and July-August) and (b) Cameroonian, with two seasons, in the Western Cameroon Highlands (peak rain in August-September). Rainfall exceeds 1,500 millimetres (mm) in the equatorial zone.
2. The Sudanian climate, covering the whole of the Adamaoua Plateau, with 900-1,500 mm of rainfall annually and a high seasonal amplitude in temperature (up to 45° centigrade [C] at the end of the dry season in April and as low as 10°C in January).
3. The Soudano-Sahelian climate has less than 900 mm of rainfall annually and a dry season that lasts over seven months.

Based of these climatic features and natural geomorphology and broad landscape, the reform of agricultural research in 1995 divided the country into five main agro-ecologic regions (Figure 1), within which more coherent activities could be conducted in terms of focused development targets (DSDSR 2002).

Rainfall decreases with distance from the coast in a northerly direction. At the coast, Douala has 260 days of rain, while Kousseri, near Lake Chad, has only 64 wet days per year. Humidity varies with rainfall and latitude, from an average high of 83% at the coast (e.g., Douala) to less than 10% in the north (e.g., Kousseri). Annual hours of sunlight are lower in the south, with an average of 1,023 hours in Douala and over 2,970 hours in Garoua. Evaporation is therefore likely to be higher in the north of Cameroon than in the south.

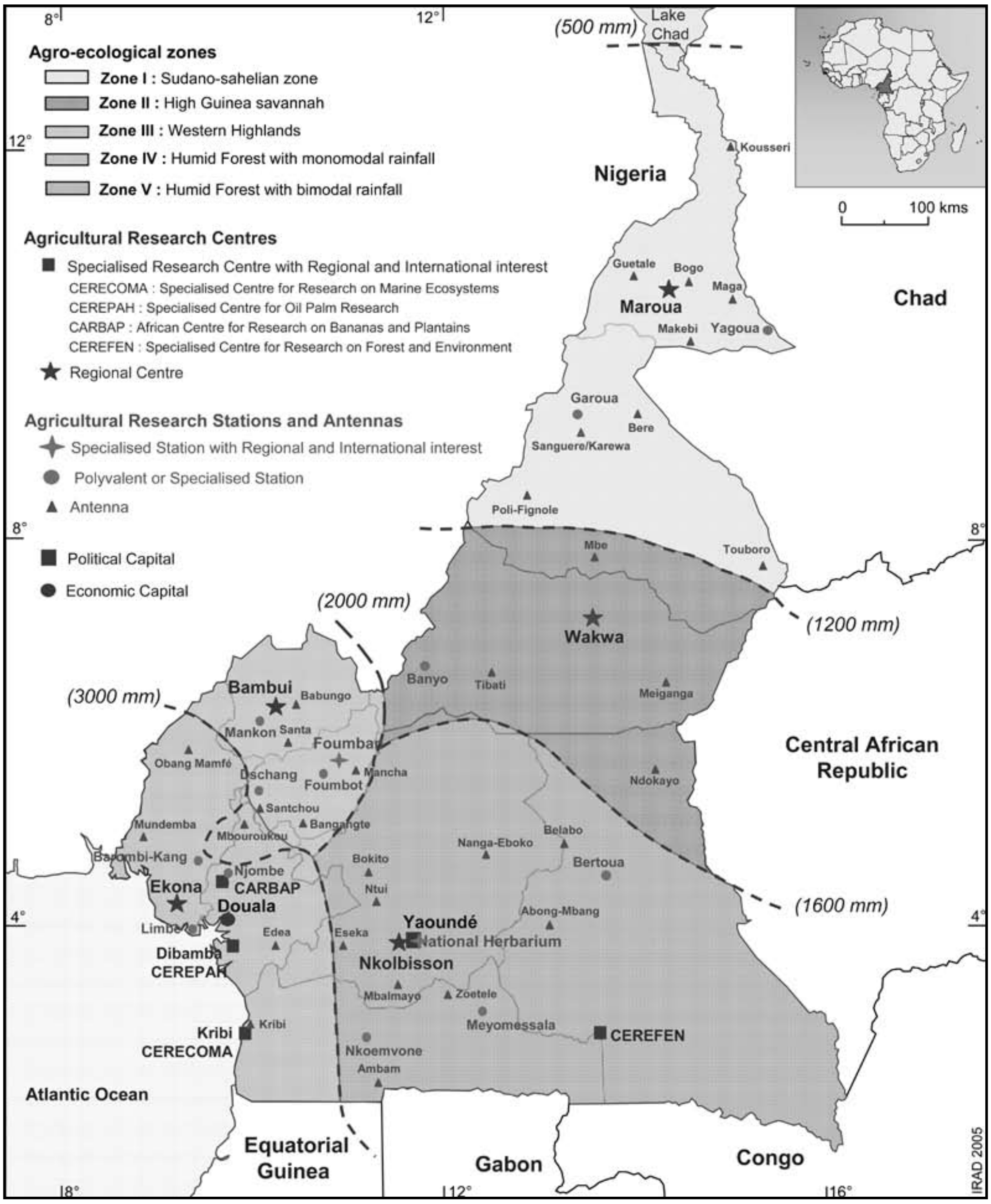
With water-availability and current technological constraints, sustainable semi-extensive pond fish farming may be limited to areas with equatorial climates, that is, all the region south of the Adamaoua Plateau (i.e., zones III to V in Figure 1).

Hydrology

Cameroon is extremely dry in the north but very wet in the high altitudes of the western region. Almost 3.5 million hectares (ha) of aquatic habitats can be grouped into four hydrographic basins (Figure 2) as follows:

1. Lake Chad, comprising its main tributaries (the Logone, Chari, El Beïd, Serbewel and Mayo Tsanaga rivers), 900,000 ha of floodplains (Yaérés), Lakes Chad and Fianga, and the dams at Maga and Mount Mandara;

Figure 1: Map of Cameroon showing the main agro-ecological zones

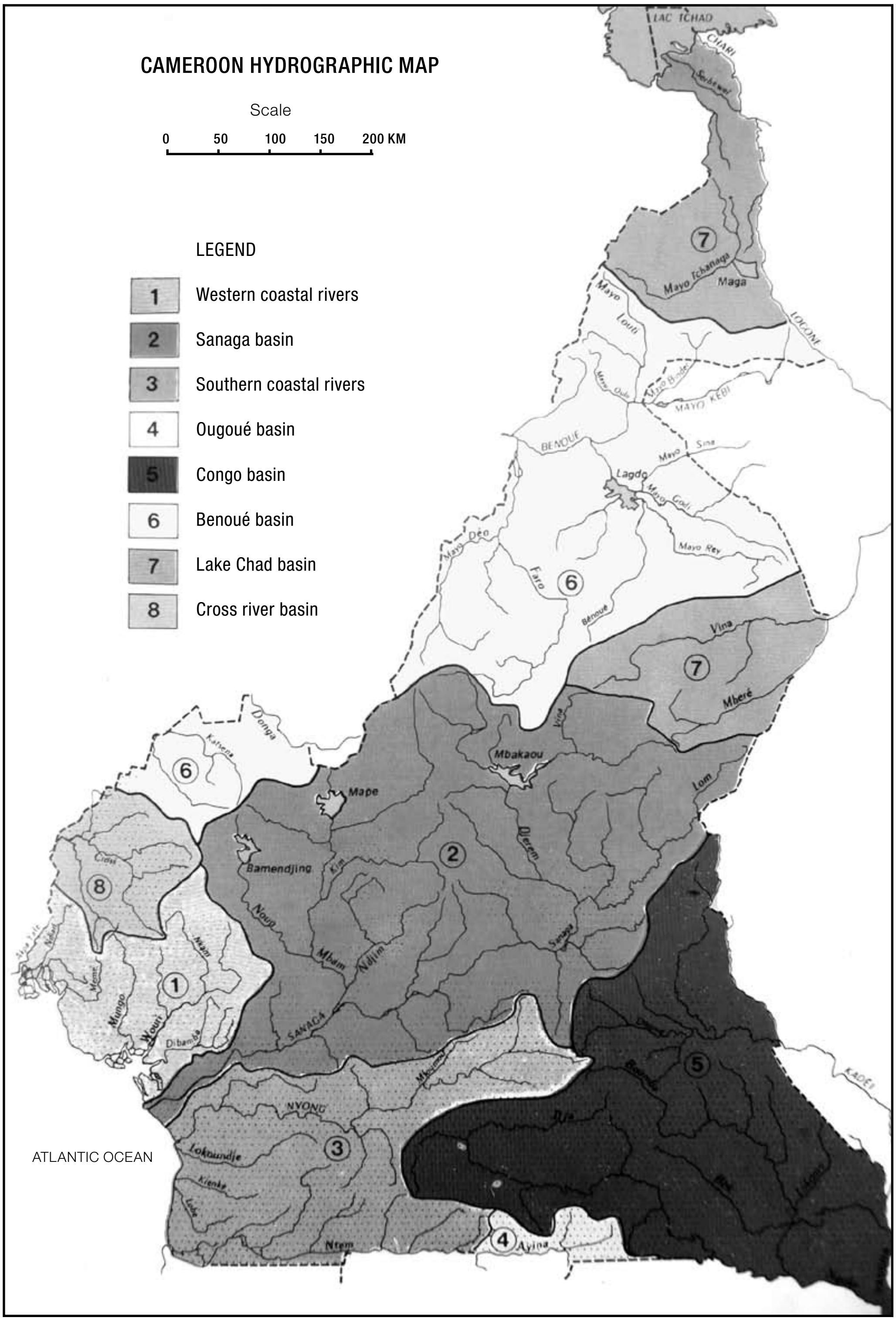


Source: DSDSR 2002.

2. Niger, including the Benoue River and its tributaries (Mayo Rey, Mayo Kebi and Faro) and the 60,000 ha Lagdo Reservoir;
3. Congo, whose main rivers are the Sangha and its main tributary, the Kadei, and the Ngoko and its tributaries, the Dja and the Boumba; and
4. Atlantic, with (progressing to the south) (a) the western coastal rivers Akpa, Ndian, Moko, Mémé, Cross, five Mount Cameroon-generated torrents (Mokoko, Sanje, Limbe, Ndomgo and Ombé), Mungo, Wouri and Dibamba; (b) the Sanaga, the widest sub-basin; and (c) the southern coastal rivers Nyong (with its floodplain), Lokoundjé, Kienké, Lobé, Ntem and the tributaries of the Ogoué in Gabon (the Ayina, Miété, Koumou and Lélé rivers).

A number of crater lakes are also found in western Cameroon: Nyos, Barombi, Tison, Manengouba, Baleng, Bapit, etc. In addition, there are reservoirs behind dams built on the Atlantic rivers, including the Mbakaou, Bamendjin and Mapé. The surface areas of Cameroon's major reservoirs and river basins are shown in Table 1.

Figure 2: Hydrological map of Cameroon with the main river basins



Source: Figure provided courtesy of Vivien 1992.

Table 1: Surface area of reservoirs and river basins in Cameroon

	Lake Chad basin	Lagdo reservoir	Mbakaou reservoir	Mapé reservoir	Bamend-jin reservoir	Nyong River basin	Sanaga River basin
Surface (ha)	4,000,000	60,000	60,000	50,000	33,000	2,780,000	13,299,000

ha = hectare.

Source: Adapted from MINEPIA 2003.

1.2 DEMOGRAPHICS

The most recent census in Cameroon was conducted in 2006. Though official results have yet to be published, observers agree that an annual growth rate of over 2% is likely, creating a population of almost 17 million people in 2005, up from about 7.66 million in 1976 (Table 2). The population is very young, with more than 40% below 15 years old, and high migration from rural areas to cities pushed the Cameroonian government to create in 2002 a ministry in charge of urban affairs. In 1960, only 15% of Cameroonians lived in urban areas; this rose to 46% in 2000 and above 50% in 2005. Demand for fishery products is proportionally high and rising. With average

Table 2: Development indicators for Cameroon (1976-2006)

Indicators	1976	1987	2001*	2002*	2006*
Total population ('000)	7,663	10,494	15,731	16,170	18,025
Urban residents (%)	28.5	37.8	51.0	51.9	55.5
Population density per km^2	16.4	22.5	33.8	34.70	38.9
Annual growth rate (%)	3.0	2.9	2.81	2.81	2.80
Mortality rate (‰)	20.4	13.7	10.1	10.1	8.8
Infant mortality rate (‰)	156.5	82.9	na	na	na
Life expectancy at birth (years)					
Males	43.2	52.4	56.7	56.7	na
Females	45.6	56.2	61.3	61.3	na
All	44.4	54.3	59.0	59.0	na
Structure of the population by age group (%)					
0 to 14 years	42.21	46.42	43.41	43,12	na
15 to 24 years	18.94	17.77	20.65	20.81	na
25 to 64 years	35.65	32.49	32.66	32.77	na
65 years and above	3.20	3.32	3.28	3.30	na

km^2 = square kilometre, na = not available.
* Estimation based on 2.9% growth rate.

Source: DSCN 2007.

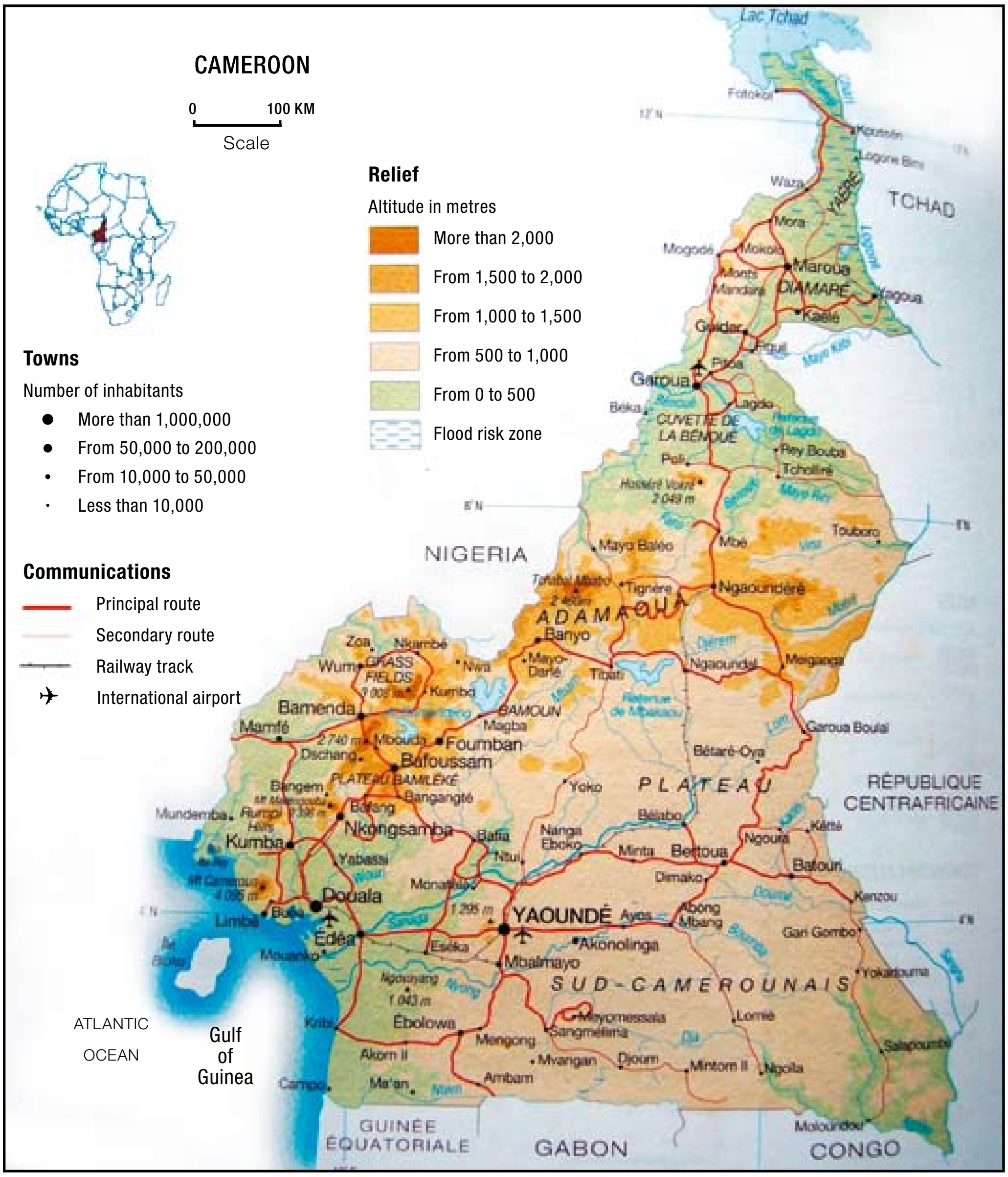
per capita consumption of fish at 18 kg per year, the Cameroonian government has imported about 100,000 t of fish per year since 2000 to complement the 170,000 t produced domestically (DSCN 2007).

Cameroon is officially bilingual, with French and English widely spoken in addition to seven major native language groups — Ewondo, Bassa, Bamileke, Fufuldé, Douala, Bamoun and Baya — encompassing over 200 dialects. The literacy rate is 72% among adults (INS 2001). The main towns are Douala and Yaoundé (both with more than 1 million inhabitants), Bafoussam, Maroua and Garoua (Figure 3).

1.3 NATIONAL ECONOMY AND THE ROLE OF THE FISHERIES SECTOR

Cameroon has three international airports, eight secondary airports, a main maritime port at Douala, and three secondary harbours at Kribi, Tiko and Limbé. It has 1,100 km of railways and 34,000 km of roads, of which about 5,000 km are tarred (Figure 3). Telecommunication companies include Camtel (fixed and cell phones), MTN and Orange (cell phones) and provide good network coverage for most settlements in the country. These cell phone networks are highly important, especially for connecting

Figure 3: Physical map of Cameroon with major cities and road network



Source: UNESCO 2000.

rural producers to markets and keeping them informed about prices and marketing opportunities.

Mines and industries contributed 22% of the gross national product in 1998, including oil (about 5.3 million t in 1998), natural gas, bauxite, iron and rutile. The gross national product in 2000 was $9 billion, or $610 per capita. The informal sector of artisanal activities, micro-trading and small jobs plays a very important role in the economy of Cameroon, with agriculture, forestry and fisheries employing more than 60% of the working population (UNESCO 2000). However, fluctuating international prices for most goods of these sectors prompted the Cameroonian government to adopt an inappropriate policy to stabilize prices, causing a huge migration from rural to urban areas that doubled the urbanized rate from 1976 to 2006 (Table 2). The main agricultural crops include cassava (2 million t produced annually), maize (1.2 million t), sorghum (0.8 million t), sweet potatoes, yams, plantains, beans, miscellaneous vegetables and fresh fruits (each over 0.1 million t). Exported crops include sugarcane, palm nuts, bananas, cotton, cocoa and coffee (all over 0.1 million t produced annually). The by-products of these crops can be used as fish feeds (Table 9). Animal production includes 7 million head of cattle, 8 million sheep and goats, 2 million pigs, and 20 million chickens.

In the fisheries sector in Cameroon, marine fisheries contribute some 55% of fish caught (Table 3). Though inland fisheries are smaller in terms of quantity (44%), the fish are of higher value (Table A5.1), thus accounting for more than half of total production value. The fisheries sector is dominated by artisanal fisheries, both maritime and inland, with little industrial fishing taking place (Table 3). The contribution of aquaculture within the inland fisheries sub-sector is still small, estimated at 650 t in 2004 and accounting for only 9.5% of inland fish production. At the same time, a large amount of low-value fish is annually imported into the country (see Annex 5) while high-value marine products are exported. A significant share of the fish trade is informal and thus may not be adequately captured by available statistics.

Table 3: Fish production in Cameroon and value of produce by sub-sector

	Production (tonnes)	Production (%)	Value (billion FCFA)	Value (%)
Artisanal maritime fisheries	79,236	51.0	30,285	35.3
Industrial fisheries (fish)	6,898	4.4	8,719	10.2
Industrial fisheries (crustaceans)	530	0.3	3,448	4.0
Inland fisheries and aquaculture	68,750	44.3	43,250	50.5
Total	155,414	100	85,702	100

Sources: Translated and modified from Ngok et al. 2005.

2. OVERVIEW OF THE AQUACULTURE SECTOR

2.1 EVOLUTION AND STATUS OF AQUACULTURE IN CAMEROON

Fish farming started in Cameroon in 1948. By 1952, the colonial administration had built 22 aquaculture demonstration stations to strengthen the sector; in 1960, the number of private fishponds exceeded 10,000 (Satia 1991). However, soon after independence in 1960, the extension effort collapsed, and most ponds were abandoned. During the early 1970s, a regional project supported by the United Nations Development Programme (UNDP) and FAO increased the number of public aquaculture stations to 32. In 1980, administrative responsibility for aquaculture was transferred from the Forestry Department to DirPêches and on to the newly created Ministry of Livestock, Fisheries and Animal Industries (MINEPIA by its French abbreviation). As a result, there was a revival in donor support for aquaculture. The United States Agency for International Development (USAID) developed common carp farming in the Western Highlands (1980-1984), and US Peace Corps volunteers were active until 1998 (Kouam 2002). As listed in Table 4, Canada's International Development and Research Centre (IDRC) provided support for integrated fish, pig and chicken farming from 1987 to 1991; the Belgian Administration for Development Cooperation (AGCD by its French abbreviation) provided support for catfish seed production at the Foumban research station from 1991 to 1995; and the French cooperation agency provided support for participatory aquaculture development in the Yaoundé region from 1994 to 1997. From 2000 to 2005, the WorldFish Center, International Institute of Tropical Agriculture (IITA), and United Kingdom Department for International Development (DFID) implemented a participatory research project in partnership with the government of Cameroon and a number of local nongovernmental organizations (NGOs). By linking small-scale rural producers to markets, this project managed to increase their cash income, thus creating much greater interest in intensified production systems (WorldFish 2005). Currently, the French department for foreign affairs supports the Action Research in Partnership Project in the seven southern provinces of Cameroon (REPARAC 2006).

The development of the Cameroonian aquaculture sector since independence has been driven largely by international donors. Because of the stop-start, top-down nature of this support, the evolution of the sector was erratic and discontinuous until the mid-1990s.

In 1995, after evaluating past experiences, the Cameroonian government promoted more participatory approaches such as those supported by the French cooperation agency and DFID projects. This has brought considerable change in aquaculture practice and improved the use of local knowledge and practical experience at the farm and village level. Another incentive for aquaculture production is continuing population growth and the concomitant increase in demand for animal protein, which caused significant increases in fish prices (Groupement Professionnel des Acconiers 2007). In response to the increase in demand for fish, many abandoned ponds have recently been rehabilitated, but this has often been done without technical input from specialized extension services. This positive trend in pond aquaculture is linked to the new market environment and facilitated by recent changes in policy. Of these policy changes, the recent Strategic Framework for the Development of Aquaculture, elaborated with the assistance of FAO and WorldFish (Moehl et al. 2005), has great potential if effectively implemented to realize Cameroon's full potential to develop aquaculture production, which is estimated at above 20,000 t (Satia 1991).

One of the major lessons learnt from past efforts to develop aquaculture in Cameroon is that a strong emphasis on interventions' lasting impacts and sustainability has to be better incorporated in project design.

2.2 PRODUCTION TRENDS

An analysis of data from the National Agricultural Research and Extension Programme (PNRVA by its French

Table 4: Major aquaculture development projects in Cameroon

Period	Donor and funding volume ($)	Foreign implementer	Main achievements and production achieved by project completion	Performance/ sustainability
1954-1960		French colonial administration	Subsistence aquaculture, up to 10,000 private ponds created	Average
1969-1976		UNDP-FAO	Sector revival; pilot project; Foumban regional station; newly introduced fish species	Average
1980-1984	United States	Peace Corps	Training extension staff; small-scale aquaculture	Poor
1987-1991	IDRC (Canada) $400,000	Consultants	Integrated aquaculture research and extension (tilapia-*Clarias*, poultry, pigs)	Average
1987-1992	Netherlands $260,000	Haskoning Consultants	Station construction at Lagdo; develop technology for floodplain aquaculture (tilapia-*Clarias*, rice-fish)	Poor
1991-1995	AGCD (Belgium) $450,000	Catholic University of Leuven	New species for aquaculture; freshwater fish inventory	Poor
1994-1997	Coopération Française (France)	CEPID	Development of fish farming in Yemessoa through action research	Good
1988-2000	United States	Peace Corps	Participatory technology development (tilapia)	Average
2000-2005	DFID (UK) $1,500,000	WorldFish Center	Aquaculture development; participatory research	Good
2005-2008	Cameroon (HIPC project), France (REPARAC project) $1,000,000	CIRAD	Fish seed production; aquaculture development; participatory research	Ongoing

AGCD = Belgian Administration for Development Cooperation, CEPID = Centre of Excellence for Production, Innovation and Development, CIRAD = French Agricultural Research Centre for International Development, DFID = Department for International Development, FAO = Food and Agriculture Organization, HIPC = Highly Indebted Poor Countries, IDRC = International Development and Research Centre, REPARAC = Partnership Reinforcement on Agronomic Research in Cameroon, UK = United Kingdom, UNDP = United Nations Development Programme.

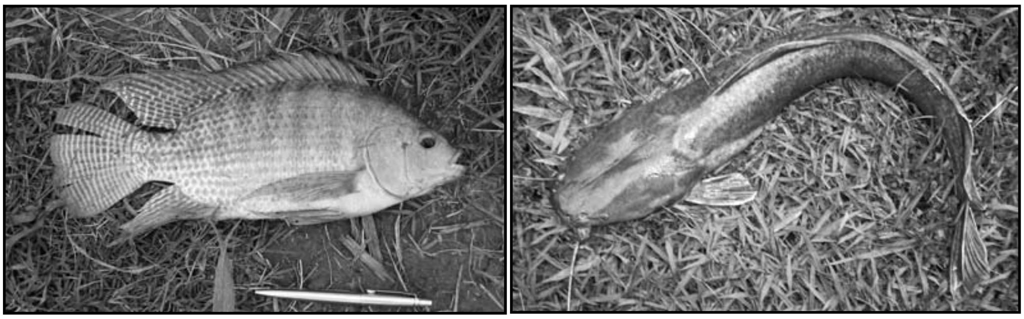
Source: Modified from Brummett et al. 2004c.

abbreviation), WorldFish, FAO Special Programme for Food Security (PSSA by its French abbreviation) and Department of Fisheries revealed that by the end of 2004 there were approximately 4,000 active fish farmers with 7,000 ponds (over half of them new or rebuilt since 1995) with an average size of 350 square metres (m^2). Total fish production from ponds was estimated at 650 t, of which more than 90% was produced by small-scale farmers. Nile tilapia (*Oreochromis niloticus*) is the most commonly farmed species, followed by African catfish (*Clarias gariepinus*). The most common practice is polyculture of Nile tilapia, either with African catfish where possible, or with other locally available species such as the African bonytongue (*Heterotis niloticus*), snakehead (*Parachanna obscura*), banded jewel fish (*Hemichromis fasciatus*), common carp (*Cyprinus carpio)* or gougeon (*Barbus* spp.). Figure 4 shows the most important fish species. The scientific and local names for commonly cultured fish species in Cameroon are provided in Annex 4.

Table 5 shows major indicators of aquaculture in Cameroon such as total production from 1990 to 2006. Overall, a steady yearly increase in pond aquaculture production of more than 10% is observed in Cameroon from 1995 onwards. This may correlate with the change in the extension paradigm to a more participatory- and partnership-oriented approach, replacing the previous top-down approaches, as explained above.

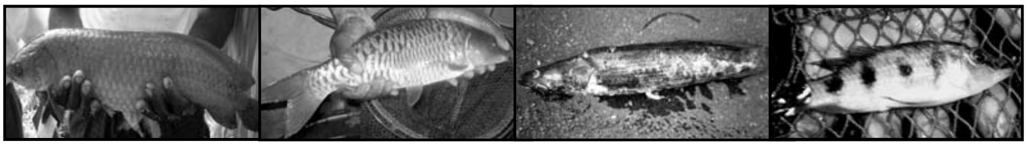
Compared with the high demand for fish, which pushes the government to spend

Figure 4: Most commonly cultured fish species in Cameroon



a. Nile tilapia (400 grams, Participatory Aquaculture Research Centre at Melen, 2003)

b. African catfish (2,500 grams, Santchou, 2005)



c. African bonytongue, Nyong, 2003

d. Common carp, Koupa Matapit, 2005

e. Snakehead, Sanaga, 2005

f. Banded jewel fish, Mapé, 2004

Table 5: Aquaculture indicators in Cameroon (1990-2006)

	1990	1997	2000	2003	2004	2006
Number of fish farmers	1,300	3,000	3,500	3,800	4,000	4,200
Number of fishponds	2,000	5,000	5,800	6,000	7,000	7,500
Total pond area (ha)	160		210	220	240	245
Annual production						
Nile tilapia (t)	80	120	180	250	350	450
African catfish (t)	6	130	120	180	230	330
Others (t)	20	50	50	70	70	90
Total production (t)	106	300	350	500	650	870
Sources:	FAO 1997	Authors' estimate based on actual field records from PNRVA, WorldFish, FAO Cameroon and the specialized NGOs CEPID and SEAPB, as well as Pouomogne et al. 1998 and Pouomogne 2007a				

CEPID = Centre d'Excellence pour la Production, l'Innovation et le Développement, FAO = Food and Agriculture Organization, ha = hectare, NGO = nongovernmental organization, PNRVA = National Agricultural Research and Extension Programme, SEAPB = Service d'Appui aux Populations à la Base, t = tonne.

more than FCFA20 billion annually on fish imports (see Annex 5), aquaculture production has remained insignificant for many reasons, which are discussed in subsequent sections of this report. Cameroonian aquaculture production is expected to continue to expand, even at an increased rate, with the progressive removal of socio-institutional constraints and problems affecting fish seed and feed supply, and with the improved research and development approach emphasizing partnership with farmers and garnering more interest from donors and research centres supported by the Consultative Group on International Agricultural Research.

2.3 PRODUCTION SYSTEMS AND PRODUCER PROFILES

PAST PLANNING

Based on the biophysical features described earlier, Balarin (1985) suggested three aquaculture zones as follows:

1. carp culture in the relatively temperate highlands of Bamenda and surroundings in the west and in the Mandara Mountains in the north;
2. year-round tilapia and catfish production north of Adamaoua and in the coastal region and Congo River basin, where the mean water temperature is above 25°C; and
3. seasonal tilapia and catfish production in the rest of the country, i.e., the whole evergreen forest and savannah of southern Cameroon and the Bamileke, Bamoun and Adamaoua plateaus, where a colder dry season may result in reduced growth rates.

On the basis of prior surveys by the Société Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH) (1982), the same author suggested up to 30 sites where the availability of by-products and capital could facilitate and support the installation of large-scale private fish farms. Unfortunately, none of the recommendations has been implemented, as the officers in charge of that period assessed the designed projects as too ambitious (MINEPIA 2006).

CURRENT SITUATION

Currently, the aquaculture sector in Cameroon comprises small-scale producers and larger-scale commercial activities (Figure 5) with the former predominant. At all levels, earthen ponds are the only rearing structure adopted. No cages or pens are used, and very few containers (whether concrete, plastic or metal) or raceways are available for typical fish farming. The current infrastructure and support environment in Cameroon (i.e., unreliable electric power and the lack of industrial plants for balanced feed or normal aquaculture equipment such as water pumps, nets, large buckets, etc.) does not encourage the adoption of more intensive systems.

The following section provides an overview of the extent and most common production systems for both large- and small-scale aquaculture in Cameroon.

SMALL-SCALE FISH FARMS

Semi-extensive aquaculture systems are common in Cameroon. More than 60% of ponds are located in rural areas on land belonging to owners with or without formal property rights. As most of the ponds were constructed only relatively recently (more than 70% built after 1990), fish farmers may not yet have had sufficient time to gather on-the-job experience. Table 6 shows some features of small-scale ponds that may explain their poor performance.

Each smallholder fish farm has 2-5 derivation ponds[2] averaging about 350 m^2 each. The ponds are all earthen and usually situated near the homestead. Nearly all pond construction and further management work is done by hand, which explains the relatively small size and shallowness of ponds (hardly 1 m water depth on average), even in areas with topography suitable for larger ponds. Cameroon is still under-industrialized, with a shortage of machinery and capital. Most ponds are dug in valley bottoms below the main field crops (Figure 5). At harvest, only part of the water can be drained by gravity, since the pond bottom is usually lower than the water table.

2 Whereas a dam pond is built in the streambed and receives the whole debit, a derivation pond is usually built alongside a stream and designed to have independent water supply and drainage systems, which allow more controlled water management.

Figure 5: Small-scale (a) and commercial (b) fish ponds in Cameroon

a b

Table 6: Some features of small-scale fish ponds in southern Cameroon

	Location			
Parameter	Noun	Menoua	Meme	Lékié
Number of farmers	360	133	200	300
Number of ponds	445	463	300	600
Average pond surface (m²)	250	125	260	300
Pond depth (%)				
< 50 cm	24	25	10	20
50-100 cm	52	50	49	55
Date of pond construction (%)				
Before 1960	60	2	1	5
1960-1990	31	10	27	10
After 1990	9	88	73	85
Pond status (%)				
Active	23	44	40	45
Abandoned	77	56	60	55
Motive for pond construction (%)				
Family food	50	54	50	20
Income	33	32	33	50
Recreation	16	17	17	16
Reasons for abandonment (%)				
Lack of capital	30	20	30	40
Lack of seed	9	14	15	15
Poor technical support	15	15	16	20
Average production (kg/ha/year)	1,263	1,600	2,000	2,100
Sources	Pouomogne et al. 2003	CIRAD 2005	CTS 2002	Pouomogne and Oswald 2002

cm = centimetre, ha = hectare, kg = kilogram, m^2 = square metre.

Small-scale grow-out ponds are usually integrated with other farm activities (Table 7). Indirect feeding is the general practice using compost cribs loaded with materials sourced from the farm, mainly grass, weeds and kitchen refuse. On average, the compost cribs occupy 10% of the pond surface area. Average pond production is around 2,000 kg of fish per hectare per year. Fish culture seldom constitutes a major part of the household income but is, in many cases, very important to the household diet.

Production is low and discouraging for many farmers, who remain at the subsistence level. Diagnostic surveys recently conducted in the Noun, Menoua, Meme and Lekié divisions in the equatorial climatic zone of Cameroon found not a single farmer actually satisfied with fish output weighed against the effort involved in pond construction, seed stocking, and fish feeding and care (Pouomogne and Oswald 2002, Pouomogne et al. 2003, CTS 2002, CIRAD 2005).

Table 7: Socioeconomic features of fish farmers in southern Cameroon

	Location			
Parameter	Noun	Menoua	Meme	Bafut
Sample size	N = 100	N = 133	N = 50	N = 40
Average age (years)	42	50	45	49
Religion	77% Moslem	75% Christian	100% Christian	100% Christian
Marital status (% married)	93, half polygamous	97	88	90
Member of mutual aid associations (%)	45	75	60	60
Average number of people in the household	14	15	8	7
Educational level (%)				
Above primary	75	90	96	95
University	1.6	12	10	7
Land area per household (ha)	5.5	5.7	4	na
Estimated per-capita fish consumption (kg)	13	na	25	na
Level of integration with other farm activities (%)	80	67	80	80
Sources of income (%)				na
All farm revenues	73	67	73	
Pond fish sales	7	12	13	
Expenditures (%)		na		na
Farm production input	51		51	
Additional family food	18		18	
Education and health	9		13	
Disposal of fish harvested (%)				
Home consumption	60	53	60	60
Sale	25	34	26	20
Gifts	15	13	14	20
Incentive to create ponds (%)				
Imitation, tradition, etc.	60	50	50	50
Supporting institutions	30	15	na	na
References	Pouomogne et al. 2003	CIRAD 2005	CTS 2002	Pouomogne 2005a

ha = hectare, kg = kilogram, na = not available.

Fish farmers are usually adults aged 40-50 years and married, with relatively large households. Though ponds are generally owned by men, all members of the household are involved in fish-farming activities. More than half of the fish-farming businesses were established after observing neighbours or following directives from traditional authorities or older relatives (Table 7).

More than a third of fish farmers were involved in pond aquaculture primarily for generating income, which can explain the high rate of abandoned ponds (more than 55%) given the poor outcomes (on average less than 2,000 kg of fish per hectare per year). Discouraging results arise from poor pond design, as farmers have insufficient technical support. Moreover, the lack of capital is a major constraint, as it precludes the producers hiring quality labour or acquiring sufficient inputs. The required water-management skills are definitely not easily acquired by farmers with experience only in crop and livestock farming.

The adoption of small-scale fish farming is driven mainly by imitation of other farmers (especially if they are successful), tradition and the importance of fish to household consumption. A successful private fish farm may thus contribute significantly to the development of the sector. However, despite their hard work, small-scale fish farmers, like most farmers in rural Cameroon, remain poor. Average annual household income for such farmers hardly reaches FCFA200,000 (or about $1.00 per day). Despite the poor performance, the ponds were maintained for other reasons, which include (1) establishing property rights in valley bottoms, (2) the expectation of attracting development project subsidies, (3) the expectation of improved production as a result of new innovative technologies delivered by extension agents and (4) the prestige of pond ownership.

In addition to generating cash and food, recreation and personal pride constitute other important reasons when analyzing the presence of fishponds in many areas. A fish farmer may lose money from the activity but continue to maintain the pond because he receives many visitors (mostly friends and relatives from outside but also fellow villagers and development project staff) and feels proud to be able to attract people to the farm. The satisfaction shown by visitors, and the utility the pond owner derives from being able to chat with extension workers about the aquaculture activity, is not quantifiable in terms of monetary value but can be a real incentive.

COMMERCIAL FISH FARMS

The most progressive farmers (about 15% of the total) are concentrated around Yaoundé, the capital city. Some of these commercial fish farmers are former subsistence farmers who were able to master improved production technologies. From a single 150 m² pond at the start, some have grown to have over 10 ponds exceeding 5,000 m² in aggregate. The majority, however, are businesspeople interested in diversifying their investments. Examples include Mr Kamté at Mendong, near Yaoundé, and Mr Azanghé Bernard at Djuttitsa, near Dschang. These two commercial farmers have broadly diversified their business investments in favour of agricultural activities with money provided by such off-farm components as trade, animal feed production and transportation. They successfully transfer to aquaculture management capabilities and experience gained from other activities. The farms are near big cities, or associated with intensive pig or chicken rearing. Brummett et al. (2004b) reported from a survey of 10 commercial fish farms surrounding Yaoundé rates of internal profitability above 33% in integrated fish farms (i.e., this system provided net revenue higher than 33% of the capital invested), compared with non-integrated fish farms, for which revenues failed to reach the 20% rate of return needed to cover average commercial banking charges.

Increasingly, richer people who have the capacity to hire bulldozers for pond construction and to purchase nutritionally balanced fish pellets to use as feed are becoming interested in commercial fish farming. The most promising of these new entrants to aquaculture have some experience in rearing chickens or pigs. The performance of small-scale commercial ponds is very encouraging for such investors around Yaoundé and Dschang (Figure 6). Technology development for these systems was supported by

1. FAO within the PSSA programme, funded by the African Development Bank, in 2000-2003 with about $1.5 million, under the auspices of the Ministry of Agriculture and Rural Development (MINADER by its French abbreviation), which paid field technicians' base salaries;

2. WorldFish through a DFID-funded project on integrated aquaculture-agriculture in 2000-2005 with $1.5 million, under the auspices of the Institute of Agricultural Research for Development (IRAD by its French abbreviation) and MINEPIA, which paid base salaries for national partners; and

3. CIRAD through the REPARAC project funded by the French Embassy, in 2006-2009 with $4.5 million, including $80,000 for aquaculture.

The performance of successful private fish farmers indicates that development in the commercial aquaculture sub-sector may have significant positive impacts for even smaller-scale operators. Public-private partnerships to improve the availability at reduced prices of such key inputs as capital and quality seed and feed could empower farmers in basic aquaculture technology, farm management and accounting, spurring important changes in the trajectory of aquaculture development.

As in other activities, financial management rules need to be strictly applied to aquaculture businesses so they remain sustainable. Because of poorly managed subsidies, many commercial fish farms have collapsed. Some promising farmers have received incentives from donors in the form of high-quality seed and feed and conducted two or three successful rearing cycles. However, fish farming falters when revenues from fish sales are not reinvested into fish farming. This happens mostly for a number of reasons that have nothing to do with the aquaculture business, typically as farmers strive to meet such social obligations as school fees, expenses related to traditional marriage and funeral ceremonies, improvement in family housing, and the acquisition of alternative livestock such as pigs and goats, etc. In other cases, rich private investors with no technical background become excited by the supposed high profitability of intensive aquaculture (often based on false information) and invest money but are disappointed by the outcomes.

An illustration of this common case is the former Food Fish Corp., a big commercial fish farm with four hectares of earthen ponds at the Centre National de Formation

Figure 6: Harvest from (a) small-scale commercial ponds and (b) flood ponds*

a. Nile tilapia and African catfish at Nkolguem, near Yaoundé, which were harvested in September 2004 at 400 kg per 350 m² (Pouomogne 2004a)

b. Catfish at Santchou, near Dschang, which were harvested in December 2005 at 600 kg per 100 m² (Pouomogne 2007b)

* Flood ponds are a base component of capture-based aquaculture in the Mbo community in western Cameroon near Dschang, Menoua Division. In the lowlands of the Nkam Valley, flooding annually provides millions of catfish juveniles, mainly of the *Clarias* genus, which are collected by fishers and fish farmers. Fish farmers dig 50-200 m² ponds in the valley, and fish migrating from the Nkam River concentrate where they find shelter and additional feed provided by fish farmers.

Zootechnique et Vétérinaire (CNFZV) in Foumban (Figure 5b). Based on a spectacular promise of production, with a target of up to 90 t of tilapia and catfish per hectare per year, a French expert was hired and paid close to four times the usual consulting rate. However, after the first 15 months, the owner found that the revenue from the first rearing cycles would hardly cover the operational costs.

POND INPUTS

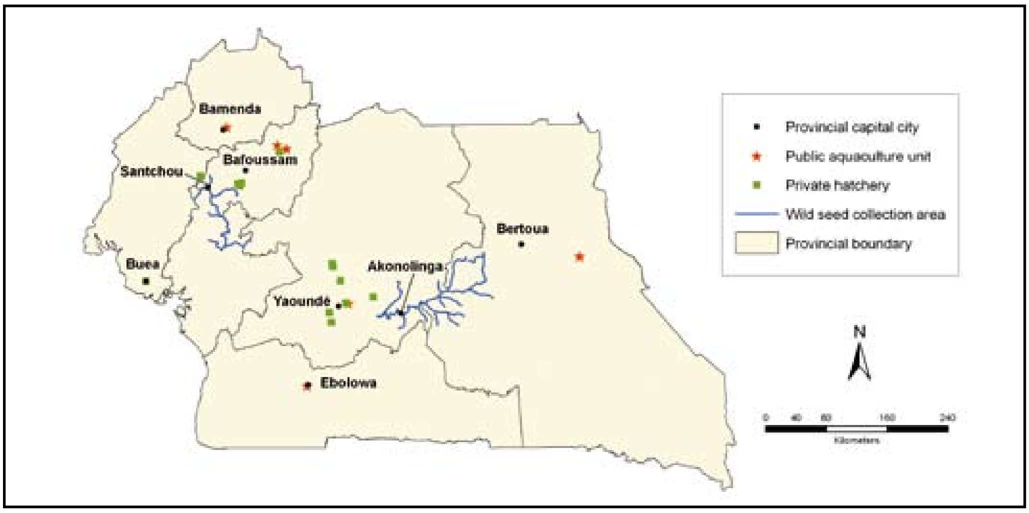
Fingerling supply

The scarcity of quality fingerlings at affordable prices is repeatedly mentioned as the key constraint faced by most farmers. Most small-scale farmers purchase tilapia seed only once upon venturing into fish farming, commonly of mixed-sex tilapia. They subsequently raise juveniles harvested from the preceding rearing cycle. The decline in stock quality resulting from this practice is one of the causes for low pond productivity.

Fingerlings used to be supplied through public hatcheries or aquaculture stations. However, as paradigms in the approach to aquaculture development began to change from 1992 (i.e., as in all sectors of the economy, the government role shifted from that of investor and corporate manager to that of facilitator and regulator, leaving the private sector in charge of developing the economy), activities in all public aquaculture units started to decline. At present, fewer than 5 of the 32 stations survive. Fingerling production from these public stations is highly erratic, varying from 1 million Nile tilapia and African catfish one year to fewer than 20,000 the following season, because of sporadic funding and generally poor management. The five surviving stations at Bamenda, Yaoundé, Foumban, Bertoua and Ebolowa (Figure 7) are those managed by aquaculture technicians who succeed in making a relatively self-sustaining business of the station. These are the major suppliers of hatchery-produced Nile tilapia fingerlings. The production of all-male Nile tilapia is being tested at the Foumban research station (about 50,000 fingerlings produced in 2005-2007). On the negative side, public stations compete with private operators. Under African Development Bank funding, another station comprising 13 ponds with a total surface area of 3 ha, a hatchery, two piggeries and three chicken coops is being completed at Barombi, near Kumba. Following lessons learned from previous experiences, this station will not be managed by the government but by a group of selected farmer leaders from Southwest Province.

As government stations have failed to alleviate any of the main constraints to aquaculture, fish farmers have increasingly turned to other suppliers for information and fingerlings. Common initiative groups (CIGs) were promoted, and a number of private hatcheries have evolved. Sixteen such hatcheries have been documented (Annex 6), and the number of fingerlings produced by these private operators is steadily increasing,

Figure 7: Active public and private hatcheries in southern Cameroon



partly from technical support received through partnership research arrangements with IRAD, WorldFish, FAO and CIRAD. Most hatcheries specialize in species to be produced in polyculture with Nile tilapia. In 2006, about 0.8 million fingerlings of African catfish, African bonytongue and common carp were produced by private hatchery operators (Brummett 2007).

However, nearly all small-scale fish farmers use tilapia fingerlings derived from the preceding production cycle, while fingerlings for African bonytongue, snakehead and gougeon are obtained mostly from the wild. Table 8 shows an example of fishers in the Nkam Valley catching African catfish fingerlings in the wild and in the Nyong Valley catching African bonytongue and snakehead. The total number of fingerlings caught was estimated at 0.2 million in 2006, and the impacts of this activity on inland fisheries are discussed in some detail by Pouomogne (2007b).

Specifically in the Nkam Valley, annual flooding provides millions of catfish juveniles that are collected by fishers and fish farmers for direct consumption or to restock flooded ponds extensively used by farmers in traditional aquaculture. As aquaculture expands in the region, farmers from the highlands in search of catfish juveniles have facilitated the emergence of a new economic activity supplying *Clarias gariepinus* fingerlings of homogenous size to fish farmers. This differs from the work of fishers by requiring (1) the sorting of species and sizes, (2) the handling the fish with greater care, (3) stocking and nursing them in better-controlled rearing structures, and (4) practicing better marketing. In addition to fish consumed in the household (31%) or given to relatives (34%), an estimated total cash revenue amounting to $20,000 was received by the 100 fishing households. Over the 4-month collecting season from December to March, fingerling collectors distributed an average of 11,700 juveniles for $1,630 (Table 8). Expectations are high in the valley that earnings could double if they are trained and master keeping juvenile *Clarias* alive to supply buyers outside the fishing season. Increased catches of juveniles in the wild may, however, threaten the sustainability of capture fisheries in the valley. The relatively high literacy rate, with more than 70% of fishers going beyond primary school, provides hope for their potential for training, as ancestral knowledge of the Mbô people, in addition to national law, gives natives priority in land ownership rights (Pouomogne 2006). This may constitute a guarantee of the sustainable management of the fishery resource in terms of both wild juveniles and brood stock for aquaculture purposes.

A typical private hatchery operator is a CIG leader, who initially produced fingerlings

Table 8: Collection of catfish juveniles from the wild (December 2005-March 2006)

Fingerling collector	*Clarias jaensis*		*Clarias gariepinus*		Total value of fingerlings sold (FCFA)
	Number of juveniles	Income (FCFA*)	Number of juveniles	Income (FCFA)	
1	27,000	1,350,000	3,000	300,000	1,650,000
2	10,500	262,500	4,500	675,000	937,500
3	6,000	600,000	4,000	600,000	1,200,000
4	600	15,000	400	20,000	35,000
5	3,150	236,250	1,350	202,500	438,750
6	12,000	600,000	8,000	800,000	1,400,000
7	700	17,500	500	25,000	42,500
Total	59,950	3,081,250	21,750	2,622,500	5,703,750

*$1.00 = FCFA530.

Source: Data from seven fingerling collectors in the Nkam Valley cited in Pouomogne 2007b.

only to stock his or her own ponds. Total pond surface varies from 2,000 m² to over 6,000 m², including a small indoor hatchery with a capacity of less than 50 cubic metres. As most of the small-scale fish farmers farm other crops such as vegetables and raise livestock, fish tends to be integrated with these other agriculture activities. All hatchery operators own their land with an official certificate. Regarding their leadership status and commitment to aquaculture, most have benefited from financial and technical support from international organizations and NGOs, including FAO, PNRVA, WorldFish, Association for Aquaculture and Rural Development in Humid Tropical Africa – France (APDRA-F by its French abbreviation), and REPARAC.

Although private-sector hatchery output is steadily growing, the current production capability of less than 0.5 million catfish fingerlings per year remains far below demand, which is over 3 million all-male tilapia, plus African catfish and common carp (IRAD 2003). About 25% of the catfish and kanga fingerlings supplied thus come from the wild. Several reasons may explain the great gap between demand for and supply of seed:

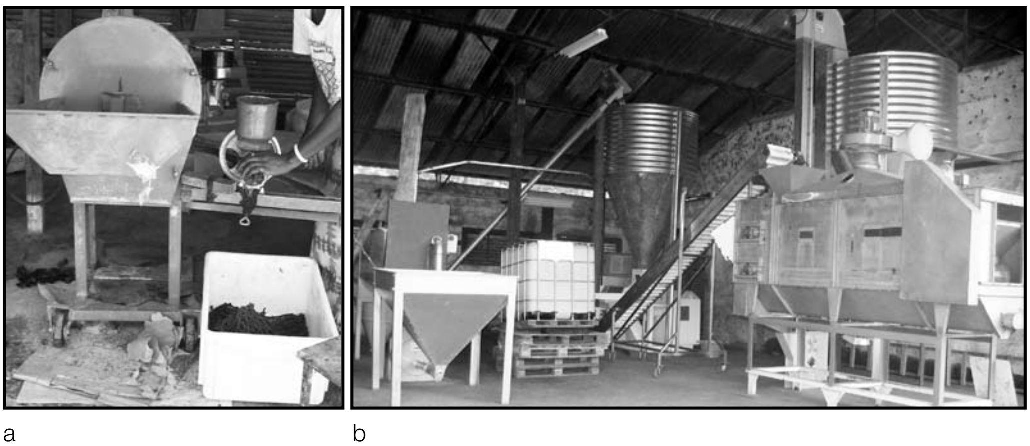
1. Communication is poor between seed producers and fish farmers. Fish farmers who need fingerlings often do not know where to find them, even though hatcheries may hold unsold stock. Improving the flow of supply-and-demand information could be one role of the research extension teams (RETs) that are a key component of the Cameroon Strategic Framework for Aquaculture Development (Annex 2).
2. Seed quality is poor, such that growth and survival rates of fingerlings are sometimes very low, discouraging farmers from depending on hatcheries.
3. Seed prices are variable, with demand from very rich, politically influential customers driving up prices. This may be good for the hatchery but bad for most fish farmers.
4. Above all, the importation of fish, mostly from West Africa, is uncontrolled. Competition with these low-cost, low-quality imports puts strong pressure on a fledgling domestic aquaculture industry. Policymakers have been slow to respond to this problem and, in some cases, have personal investments in fish importing, making reform difficult.

Fertilizer supply

The more progressive farmers use, as additional organic fertilizer, dry chicken droppings from commercial chicken farms or low-cost compounded pellets, which are available from the IRAD and WorldFish pilot feed manufacturing plants (Figure 8). A number of crop by-products can be used for making fish feed (Table 9).

The recent participatory research projects implemented by WorldFish and FAO have increased production levels on some farms to around 9,000 kg of fish per hectare per year. In addition, a limited number of richer farmers (e.g., the former Food Fish Corp. in Foumban) that used pelleted complete and balanced diets registered up to 16,000 kg per hectare per year but failed to achieve profitability for reasons unrelated to productivity.

Figure 8: Small (a) and medium-scale (b) fish food pelleting plants in Cameroon



a b

Table 9: Protein content, availability and price of fish feed ingredients in Cameroon

Ingredient	Crude protein (% dry matter)	Quantity (tonnes/ year)	Average price (FCFA*/kg)	Peak availability
Shrimp meal	60-76	na	700	Market, all year
White fishmeal	59-66	6,000	600	Feed retailers, all year
Cattle meat meal	50-58	na	600	SODEPA, all year
Blood meal	82-87	na	700	Same as above
Protein concentrate or premix	22	1,000	1,000	Import, retailers
Bone meal (dry powder)	na	na	175	Feed retailers
Groundnut cake	32-40	na	250	Same as above, Sodecoton Garoua, CHOCOCAM Douala
Soybean cake	45-49	15,000	360	Import, retailers
Cottonseed cake	48-50	70,000	160	SODECOTON, retailers
Brewery waste	18-26	30,000	15	Lager beer breweries, nationwide
Wheat bran	12-17	30,000	50	STC Group wheat flour factories at Foumbot and Sodeblé Ngaoundere, retailers
Rice bran	8-11	10,000	50	Semry, Soderim, retailers
Maize	8-12	1,200,000	140	Maiscam Ngaoundéré, markets, retailers
Millet and sorghum	8-12	400,000	150	Same as above, northern Cameroon
Palm nut cake	10-16	20,000	40	CDC, SOCAPALM, retailers
Cocoa husk	14	300,000	na	Farms in southern Cameroon (November-February)
Coffee pulp	11	75,000	na	Same as above, Western Cameroon highlands
Dried layer droppings (industrial)	22-28	5,000,000	50	SPC and EPA stores, nationwide, all year

CHOCOCAM = Chocolaterie de Cameroun, CDC = Cameroon Development Corporation, EPA = Elevage Promotion Afrique, kg = kilogram, na = not available, SOCAPALM = Société Camerounaise des Palmeraies, SPC = Société Camerounaise des Provenderies, SODECOTON = Société de Développement de Coton, SODEPA = Société de Développement et d'Exploitation des Production Animales.

*$1.00 = FCFA530.

Source: Pouomogne 2007a.

3. ECONOMICS OF AQUACULTURE PRODUCTION

For most rural farmers, aquaculture remains a subsistence activity, as their purchasing power is too low to efficiently conduct commercial fish farming. Poverty and lack of access to capital remain insurmountable constraints for most fish farmers. The public credit system is not adapted to poor farmers, who have neither credible collateral nor a formal social security system and are unable to provide bankers with convincing business plans for small-scale aquaculture.

3.1 PROFITABILITY OF INVESTMENT IN AQUACULTURE

However, interesting profit margins exist near cities, where market access and population densities are higher, and fish farming can become more widespread and sustainable if limiting factors — especially the lack of access to quality seed, feed and technical advice — are overcome. Most farmers located close to cities manage an average of three ponds generating annual incomes of about FCFA675,000, or FCFA231,000 per 350 m^2 pond (Table 10). Money invested here often comes from donor grants or micro-credit rather than from aquaculture origins. Often, however, after a few successful rearing cycles, revenues are no longer reinvested in aquaculture for miscellaneous reasons. Some reasons are technical, such as the lack of good seed or feed, inappropriate taxes and the frozen fish importation policy. Others are social, including the requirement to satisfy many competing needs for cash in the extended family.

The current state of affairs is that larger-scale farms have suffered mismanagement and poor business planning. If these wealthier investors can remedy this situation with help from suppliers of technology and support from enlightened policymakers, they may constitute the sector's best chance for sustainability.

3.2 TECHNICAL EFFICIENCY OF AQUACULTURE PRODUCTION

Subsistence fish farming as practiced by most farmers is based on water fertilization using organic materials available on the farm. These materials, including kitchen refuse and weedy grasses, are chopped and spread inside a compost crib occupying about 10% of the pond water surface. Unsexed Nile tilapia are stocked at about 1 fish per square metre, plus other fish species as available at densities of usually less than 1 fish per square metre. If properly managed, production from this system can reach about 2,000 kg/ha/year.

In contrast, commercial periurban farmers stock each square metre with 1.5 Nile tilapia, 1 African catfish and <1 African bonytongue and fertilize with, in addition to compost, dried chicken droppings and farm-made pellets with 30% crude protein. Feed-conversion rates approach 3:1 (i.e., 3 kg of manure or pellets produce 1 kg of fresh fish), and production varies from 5,000 to 12,000 kg/ha/year.

On larger farms, the production process is similar except that extruded balanced feed[3] is used (Table 11). Production of over 15,000 kg/ha/year has been obtained in this more intensive system.

3.3 VALUE ADDITION TO LAND AND LABOUR

Areas used for fish farming are usually marshy and not well suited to other farm activities. These areas are normally in the public domain according to land-use legislation and are not to be exploited by any individual. However, when a farmer succeeds in developing such a piece of land, in most cases he can be granted an ownership certificate by government officers. This is formal recognition of value added to land through fish farming.

Fish is a high-value commodity, more capable of adding value to manpower than any other farm crop. A kilogram of catfish is sold at 10 times the price of most agricultural commodities, such as the Cameroonian staples cassava or maize. Pond fish is advertised by local health practitioners as superior to bush meat, beef,

3 "Extruded balanced feed" refers to fish pellets that are extruded in such a way that they float, which improves direct ingestion, and have all required nutrients for a balanced diet, including energy content, essential amino-acids, fatty acids, vitamins and minerals.

Table 10: Average returns on aquaculture in Cameroon*

	Commercial farm**	**Small-scale farm*****
1. Costs (FCFA****)		
Fingerlings	70,000	25,000
Feeds (compounded low-cost pellets or a single ingredient such as wheat bran)	120,000	10,000
Fertilizers (mainly dried chicken droppings or weedy grass plus kitchen refuse in compost crib)	60,000	10,000
Labour (partly or all by family members)	60,000	25,000
Small materials (nets, containers, machete, etc.)	10,000	5,000
Pond (lifespan 15 years)	15,000	12,000
Total costs	335,000	87,000
2. Sales (FCFA)		
Nile tilapia	160 kg x 1,500 = 240,000	70 kg x 1,100 = 77,000
African catfish and/or common carp	130 kg x 2,200 = 286,000	20 kg x 1,500 = 30,000
Miscellaneous (snakehead, African bonytongue, Nile tilapia fingerlings and/or catfish (*Clarias jaensis*) plus banded jewelfish	20 kg x 1,700 = 34,000	10 kg x 1,200 = 12,000
Total sales (FCFA)	566,000	119,000
3. Net Profit (FCFA) (sales less costs)	231,000	32,000

kg = kilogram.

* Polyculture of Nile tilapia with African catfish, African bonytongue or common carp in 350 m^2 earthen ponds over 12 months.

** Sample of 10 harvests from farmers' ponds measuring 250-1,000 m^2 in the environs of Yaoundé between 1999 and 2006.

*** Sample of 30 harvests from farmers' ponds measuring 100-1,500 m^2 in seven provinces of southern Cameroon between 1994 and 2005.

**** $1.00 = FCFA530.

Sources: Data adapted from Pouomogne et al. 1998, Oswald and Pouomogne 2000, Pouomogne 2004a,b,c, Pouomogne 2005a, Worldfish 2005, Pouomogne and Mikolasek 2008.

pork and poultry, and they recommend fish consumption especially for children, pregnant women and the elderly. As stated above, fish is consumed in rural areas mostly in smoked form, which accounts for 60% of national production. This form of processing has real benefits for poor households, as they are able to purchase smaller quantities for consumption than is possible with other sources of animal protein. Nevertheless, these highly positive features of fish do not determine the development level of aquaculture, which remains a rather complicated activity. In Cameroon, as in most sub-Saharan countries, it is one thing for farmers to cultivate such familiar traditional crops as maize or cassava, but another thing for them to rear fish with insufficient capital or technical support.

3.4 SUSTAINABILITY OF AQUACULTURE ADOPTION

A pond harvest attracts many spectators and prospective buyers, and attendance appears to be a crucial experience motivating new pond creation (Kriesemer and Hoffmann 2006). However, observing the relative success of a friend is insufficient experience to survive in aquaculture, which is a rather

Table 11: Feed formulations for polyculture of Nile tilapia with African catfish and other species

Ingredients (%)	Grower, IRAD CP31* (fertilized ponds)	Grower tilapia 2 (intensive system formula)	Starter, IRAD CP45* (Nile tilapia or catfish below 10 grams)
Fishmeal	0	20	55
Soybean oil cake meal	13	15	5
Cotton seed oil cake meal	15	15	5
Groundnut oil cake meal	12	5	4
Brewery waste	10	15	10
Rice or wheat bran	20	15	4
Cocoa husk or coffee pulp	10	0	0
Layer droppings meal	15	0	0
Corn meal	0	8	3
Bone meal	1	0	4
Palm oil	2	2	5
Premix**	2	5	5
Proximate analysis			
Crude protein (%)***	28.5	34.5	43.3
Fat (%)	8	9	11
Gross energy (kJ/g)	na	19.2	20.4

IRAD = Institute of Agricultural Research for Development, kJ/g = kilojoules per gram, na = not available.

* CP31 and CP45 are measures of crude protein content.
** Premix is 50% Met-Lys-Thr-efa vitamin mix, 25% crayfish appetizer and 25% wheat flour binder.
*** Percentage or grams protein per 100 g dry feed.

Source: IRAD and private feed companies.

complex activity socially and technically, requiring support from competent extension workers. The Strategic Framework for Aquaculture Development, currently the major policy instrument, envisages a competitive, mobile, research extension team (RET) to overcome constraints using a farmer-scientist partnership approach in zones of high potential (Moehl et al. 2005).

For large-scale operators, most attempts have failed dismally, usually less from technical inefficiency than from mismanagement of the business. Projects were badly designed with little concern for economic performance (e.g., the Food Fish Corp. in Foumban is now bankrupt). Many farmers engage in the aquaculture business following positive marketing of well-managed research or development projects. However, the current state of the activity in Cameroon demands more lasting technical, managerial and institutional follow up from supporting agencies before large-scale aquaculture can be sustainable.

To achieve this sustainability in Cameroon, aquaculture must evolve from being primarily a mechanism for generating household food into a truly commercial activity capable of earning money for the fish farmer. Regardless of the scale of the farm, innovative and successful farmers may be the best advertisement to new investors. Such pioneers need to receive strong support from the government and NGOs in term of seed, feed, technical support in production and marketing, and help in strengthening fish farmers' associations. In general, the principle of comparative advantage must be applied, i.e., "doing things where they have the best chance of success and have them done by people who have the most vested interest combined with best technical ability" (Moehl et al. 2006).

As outlined above, agro-ecological requirements constitute only one necessary condition for the successful adoption of pond aquaculture. In addition, knowledge and training must be accessible, as must a generally enabling environment, including the institutional and policy environment. The next section describes the system of research and development in Cameroon and the support provided to fish farmers by the government of Cameroon.

4. AQUACULTURE AND FISHERIES RESEARCH AND DEVELOPMENT

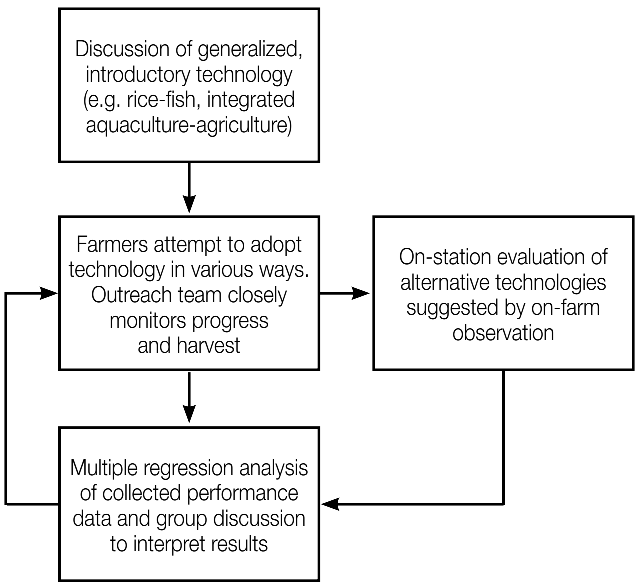
Cameroon has a relatively long history of aquaculture research. Trials conducted in the Belgian Congo in the 1950s resulted in the adoption of Nile tilapia in Cameroon in the early 1960s. A more detailed production technology was elaborated under the UNDP-FAO programme, which started in 1967 (CTFT 1972). Subsequent efforts concentrated on African catfish (*Clarias gariepinus*) reproduction through a 1973-1976 FAO project at the Foumban station (Hogendoorn and Wieme 1976). Research into Nile tilapia in polyculture with African catfish, common carp and/or African bonytongue was promoted under a USAID project in 1980 (Pouomogne 2002), by IDRC in 1986-1989 and with Belgian cooperation in 1990-1995.

4.1 RESEARCH SYSTEM

Starting in 1995, more focus was placed on a direct approach to research and development called the farmer-scientist research partnership (FSRP), with more participation, equal partnership and systemic paradigms. FSRP dominates recent French cooperation and DFID-funded projects. The approach follows the steps outlined in Figure 9 and is centred on closer collaboration among farmers, researchers and extension agents. For the assessment of technology performance, data are collected both (1) by the outreach team at farmers' ponds during routine follow up on activities and harvests and (2) during on-station evaluation of alternative technologies. These data are repeatedly subjected to multiple regression analysis, which is a very convenient statistical tool especially if data quality is not homogeneous. Results are then communicated back to and discussed with farmers.

National research in aquaculture is currently conducted by IRAD through a regional station in Foumban, in western Cameroon. IRAD is the agricultural research institution charged by the Cameroonian government with designing and implementing research activities to address the needs of agricultural development actors nationwide. With 1,033

Figure 9: The farmer-scientist research partnership, a participatory research and development tool to encourage intensification of farming systems



Source: modified from Brummett et al. 2004a.

personnel including 287 researchers, 560 technical supporting staff and 186 administrative staff, IRAD implements research activities through five regional centres with eleven stations (including Foumban for aquaculture research) and 20 substations. In 2006, IRAD's budget amounted to FCFA5.5 billion ($10 million), 60% of which was funded by the government, 27% by multilateral donors and 13% through self-financing.

Foumban station currently has ten staff: four researchers, two technicians and four workers. The station started to operate in 1985, and has been able to welcome and train hundreds of graduate students in many research subjects since then. From the investigations conducted, about 30 papers have been published in refereed journals, and hundreds of technical reports and bulletins have been produced for donors and fish farmers (Nguenga and Pouomogne 2006). Specific investigations are also conducted in training institutions at the vocational college CNFZV in Foumban, Faculty of Agronomy and Agricultural Sciences of the University of Dschang, and Faculty of Sciences of the University of Buea. The abstracts of major papers and technical bulletins produced by the national aquacultural research system are presented in Annex 1. Research activities are organized around the following themes:

1. improving seed production of African catfish (*Clarias* spp*, Heterobranchus longifilis*), common carp and African bonytongue using simple on-farm techniques;
2. adding value to by-products locally available from either agro-industry or farms by using them in fish feeds with a focus on Nile tilapia, African catfish and African bonytongue;
3. improving adoption of research findings through better understanding of such commonly used extension approaches as training and visiting, action research in partnership, and FSRP, etc.; and
4. appraising aquaculture systems within the local socio-technological environment, which includes capture-based aquaculture, integrated aquaculture-agriculture, intensive backyard cement tank culture, etc.).

International research institutions are represented by WorldFish, which opened a country office in Cameroon in 2000, and by CIRAD (France). Both institutions work in moderately good collaboration with IRAD, specifically on the third theme listed above. In partnership with institutions both national (PNRVA) and multilateral (FAO, embassies), as well as with some national NGOs (Service d'Appui aux Populations à la Base [SEAPB], Centre d'Excellence pour la Production, l'Innovation et le Développement [CEPID], and Centre d'Information, de Formation et de Recherche pour le Développement [CIFORD] and some international NGOs (APDRA-F) and farmer groups (CIGs), action research is employed to solve on-farm problems.

The Cameroonian aquaculture research programme has evolved greatly in recent years from on-station and on-farm trials based on information transmitted to researchers by the extension services, to more direct farmer-participatory paradigms. The former approach was based on 3- to 6-year plans starting with a discontinuous diagnosis of farmers' assets and current state of their valorization and constraints. The diagnosis involved multidisciplinary research teams and extension staff. The main problems identified were then prioritized, and a research programme was elaborated in each of the five agro-ecological zones (Figure 1). The resulting programme was then partitioned according to themes to be funded by donor agencies. The benefits of the shift from the former approach towards more partnership with farmers through the RET are evident. Placing competent researchers into direct contact with promising and motivated farmers immediately results in higher production, with annual production having tripled in less than 10 years (Table 5). Such a process needs to be better funded.

Since the end of the 1980's, aquaculture research has not been substantially funded by the Cameroonian government. The sector has survived largely on external funding and the tenacity of key researchers. The government's position can be generally summarized as "there has been enough research; stop new investigations and first apply the available results". In other words, the impacts of work already done are not sufficiently visible. This may explain the current success of the FSRP approach (Figure 9), implemented with the support of WorldFish and CIRAD. FSRP is oriented towards more immediate impacts by involving users of the technologies at the research stage.

4.2 EXTENSION SERVICES

PNRVA is the official agency for aquaculture extension in Cameroon. As in the area of research, the extension system has evolved from the traditional training-and-visit paradigm to a micro-project approach wherein extension intervenes across the whole market chain, not only at the production stage. This programme, formerly funded by the World Bank, is being implemented in all 10 of Cameroon's provinces. The layout of activities follows the most recent MINADER-MINEPIA joint decision (PNVRA 2006) and is shown in Figure 10.

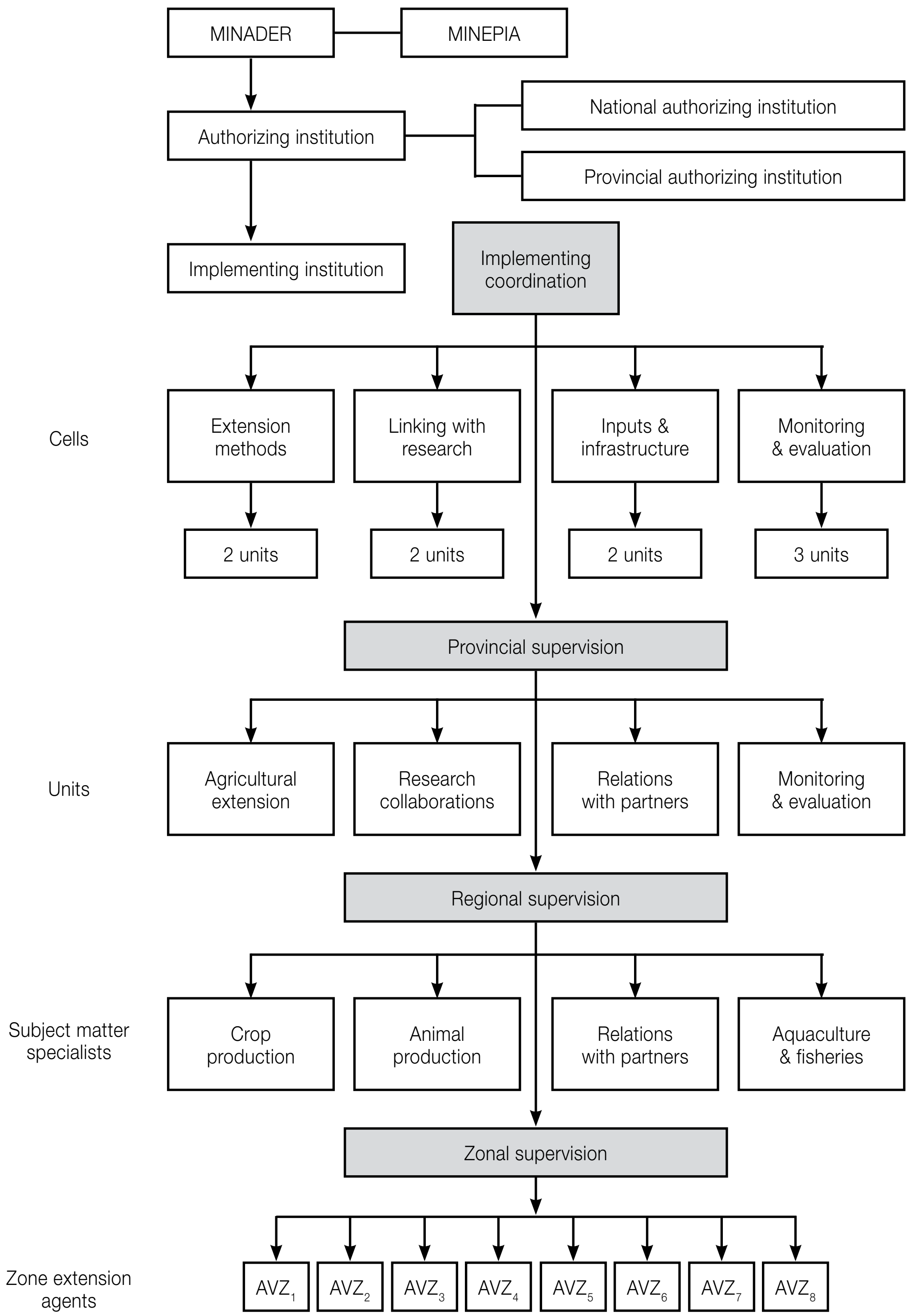
In West Province, for example, the provincial supervisor is assisted by four unit heads and nine regional supervisors at the divisional level. Each region has four subject-matter specialists (TS by the French abbreviation), one each for agriculture, animal husbandry, fisheries and aquaculture, with additional links to partners. The nine regions are divided into 33 sectors, within which a total of 224 zone extension agents (AVZs by the French abbreviation) work directly with farmers. Through this rather top-down hierarchy, research results from on-station and/or on-farm trials are transferred to the TS through regular training programmes conducted by researchers. The TS for aquaculture comes from MINEPIA, which is different from MINRESI, the ministry in charge of research. Each TS then trains the AVZs who in turn transfer information to farmers. The AVZs are typically from the rural development ministry MINADER and are, in general, the least trained in the system (i.e., graduates of technical vocational colleges, while the TS and researchers usually hold masters degrees and above). With so much responsibility placed on AVZs, arguably the weakest link in this long chain, it is not surprising that much important information is lost in the transfer from experiment to farmer. In addition, AVZs are normally young, so it is difficult for them to gain the respect of farmers. Complicating the whole system is the need to coordinate people from three different ministries that do not always have similar objectives. Many of the best researchers are primarily concerned with publishing, while most extension technicians are more interested in earning more money or being promoted out of fieldwork.

This bureaucratic system reflects a belief in the importance of government as an initiator and supervisor of economic development. Despite some limited successes with cassava-fish farming in East Province and maize in West Province (Kapemin personal communication) thanks to the efforts of some unusually qualified staff, PNRVA has essentially collapsed in favour of more specialized programmes such as a national programme for developing roots and tuber crops funded by the International Fund for Agricultural Development (IFAD), PSSA, etc. These projects work through contracts with specific consultants that involve precise task descriptions and outputs.

National or international NGOs are also active in the field of aquaculture extension, the most important being CIFORD, CEPID, SEAPB and APDRA-F. Through their efforts, the fish farmer federation AQUACAM was created in Western Province in 1998. AQUACAM's 100 farmers, which comprise some 17 CIGs (Annex 3), still strive for true viability more than 10 years after its creation. Leaders have failed to meet the membership's main concerns, namely improved access to fingerlings by setting up government fish stations and to feeds by establishing fish-feed plants and improved marketing for their limited production by influencing policy on fish imports.

APDRA-F, a French NGO, is conducting a 5-year project in Centre and West provinces with European Union financial support of about $1 million. This NGO puts emphasis on pond construction, considering this basic asset as a key factor for successful fish farming in a context where most farmers are poor and feed the fish only on-farm inputs. Some interesting results have been achieved, as farmers have been empowered to improve pond construction

Figure 10: Layout of PNRVA hierarchy



MINADER = Ministry of Agriculture and Rural Development, MINEPIA = Ministry of Livestock, Fisheries and Animal Industries, PNRVA = National Agricultural Research and Extension Programme.

Source: Adapted from PNVRA 2006, courtesy Adolphe Munshikpu, December 2007.

in Centre Province and common carp seed production was initiated using on-farm techniques with some innovative farmers in West Province. Project activities effectively started in mid-2006, and outcomes of prior initiatives in terms of improved sustainable fish production are still awaited (APDRA-F 2007a).

Many CIGs are engaged directly in research through the FSRP. Though this approach is relatively expensive because it involves direct interaction, exchange and collaboration between farmers and researchers, results registered so far seem sustainable from the farmers' point of view. Overall, harmonization among these many initiatives is lacking. To address this, MINEPIA, the ministry in charge of aquaculture extension policy, needs to implement regular exchanges among these organizations as suggested in the Strategic Framework for Aquaculture Development (Nna Abo'o et al. 2004, Moehl et al. 2005). See Annex 2.

5. POLICY ENVIRONMENT AND INSTITUTIONAL FRAMEWORK

Many documents have been published describing macroeconomic policy evolution in Cameroon with a view to improving the current situation (DSDSR 2002, DSRP 2003).

5.1 MACRO-LEVEL POLICIES

At the end of the 1980s, an economic crisis followed a heavy drop in export revenues from basic products caused by high levels of corruption in the government. As a result, since 1990, the Cameroonian government's ability to meet basic needs for roads, health, education, water, electricity and rural development has essentially collapsed. Public agent salaries were cut by more than half, and the devaluation of the local currency made imported goods expensive. The state reduced social services and increased taxes on entrepreneurs at all levels. Implemented with strong and repressive measures on the part of the police, gendarmerie and army, these policies brought higher income to the state treasury and a certain amount of growth, but corruption remained a major constraint to complete economic recovery. In addition, to prevent social disorder over the lack of essential goods, imports are encouraged over the provision of support to the domestic industry. For example, over 100,000 t of fish has been imported annually since 2000 to meet domestic demand. At the same time, nearly all government fish demonstration stations and hatcheries are about to close because funding is insufficient and extension agents are poorly paid and equipped.

The International Monetary Fund and the World Bank were, however, sufficiently satisfied with the implementation of the structural adjustment plan to negotiate a debt-relief agreement under the HIPC initiative with Cameroon's government in early 2004. This plan converted certain debts into investments in well-identified national development projects aimed at meeting objectives for poverty reduction. One of the specific targets of the programme is alleviating malnutrition, for which aquaculture is one option, and projects with over FCFA9 billion in funding have recently been approved for implementation by MINEPIA (MINEPIA 2006) and IRAD (IRAD 2003). Many other projects benefiting aquaculture development in Cameroon were initiated by FAO, WorldFish and CIRAD.

5.2 SECTORAL POLICIES

STRATEGIC FRAMEWORK FOR AQUACULTURE DEVELOPMENT IN CAMEROON

Aquaculture in Cameroon remains underdeveloped compared with other farm activities. To help address this inadequacy, MINEPIA elaborated its Strategic Framework for the Development of Aquaculture. Facilitated by FAO and WorldFish, this framework was approved by the major stakeholders of the sector at the end of 2003 and is said to be currently implemented, an early output being the concrete and specific strategic plan itself (Nna Abo'o et al. 2004, Maloum personal communication). The framework fits within the National Rural Development Plan and the Poverty Reduction Strategy currently being implemented by the government (DSRP 2000, DSDSR 2002).

The strategic framework clearly defines the respective roles of the public and private sectors (Annex 2). Relevant key points are highlighted as follows:

1) The role of the government will be largely restricted to the provision and dissemination of information geared towards the promotion of production and market chain activities and will divest itself of any direct production activities. The private sector (including commercial and other producers, investors, NGOs, banks and development agencies) will be directly responsible for developing the sector. Under these conditions, a sharp reduction of current government infrastructure will occur, providing opportunities for the private sector. Moreover, the framework recognizes

that previous interest in aquaculture was driven largely by wrongly directed development assistance projects. Henceforth, the development of the sector should be driven by market forces. Scarce government resources can then be mobilized to focus on promoting aquaculture in zones identified as having high potential, using RETs that include senior researchers and multidisciplinary extension technicians. Producers will be encouraged to work together through fish farmers' associations to facilitate information flow among members and with the market.

2) The unavailability of high-quality fish seed has historically been a major constraint to aquaculture development. In the new strategic framework, the government will aim to provide private fingerling producers with up-to-date information on fish seed production and hatchery management. Moreover, the public service, through its own infrastructure or specialized NGOs acting for the government, will develop and maintain parental brood stocks to ensure a regular supply of certified and improved genetic material to private fingerling producers.

3) The poor quality of outreach and extension in Cameroon, as elsewhere in sub-Saharan Africa, remains a major obstacle to aquaculture development. Lessons learned from the past emphasize the effectiveness of specialized technicians' providing on-farm support and supervision and conducting on-farm participatory research (Brummett et al. 2004c). However, the cost of this approach applied nationally is prohibitively high and therefore unsustainable. By contrast, failures have repeatedly been registered with generalist extension services providing aquaculture advice. A compromise should be sought with, inter alia, the idea of the RET evoked earlier, or the establishment of technical assistance contracts with specialized NGO partners on the basis of objectively verifiable indicators. In prioritized zones of high potential (e.g., periurban areas of large cities such as Yaoundé or Douala), the government should explore the opportunity of providing high-level technical assistance to suitable and specifically identified private producers. In return for this support, these commercial producers would be required to lend support to small-scale farmers.

To ensure the success of these initiatives, a multidisciplinary committee comprised of representatives of major stakeholders will monitor and revise the strategy as necessary. For some recurrent issues, such as higher education and training, new outreach paradigms or specific regulatory aspects (e.g., sanitary fish processing, the introduction of alien species and managing pond effluent, etc.), multilateral partners may be needed to help tackle the issues regionally or sub-regionally rather than nationally, a position confirmed by NEPAD (2005).

The proposals above are developed in detail in the nine elements of the strategic framework: (1) suitable production systems; (2) the availability of and access to seed, feed and fertilizer inputs; (3) outreach; (4) research; (5) education and training; (6) marketing; (7) producer organizations; (8) regulation and control; and (9) monitoring and evaluation. For each of these elements, the roles of the government and the private sector are specified. The framework tackles some specific questions, including the future of public aquaculture stations. It is suggested that most of them be sold or leased to the private sector according to existing laws and procedures on the sale or lease of public property. One or more stations, preferably those in zones of high potential, should be maintained by the state for training, research and the genetic management of brood stock.

Although this framework was adopted 5 years ago, few steps have been taken by MINEPIA, the main implementing ministry, for various reasons. None of the state stations has so far been sold or leased with a satisfactory outcome. The Food Fish Corp., a large-scale private fish farm at CNFZV, went bankrupt after less than 2 years from mismanagement. Future investments based on better-analyzed proposals can be expected to result in better outcomes.

MINEPIA is currently renovating some of the stations and seed-production centres in the hope that they will fetch higher sale prices. However, it indeed appears difficult to sell or lease a bankrupt facility.

LAND AND WATER USE: AQUACULTURE INVESTMENT

Land tenure, water use and aquaculture businesses are clearly governed by specific legislation. According to article 3 of ordinance no. 74 (6 July 1974) on Land Tenure and State Lands, all marshy areas and natural water bodies are in the public domain and cannot be exploited by private investors. Many articles of law no. 96/12 (5 August 1996) on the Management of the Environment, and of law no. 98/005 (14 April 1998) on Water Use, mandate the protection of springs and the purification of polluted water before its discharge into nature. To invest in commercial aquaculture, managers need authorization from MINEPIA after an environmental impact study (article 131 of law no. 94/1 [20 January 1994] dealing with Forests, Wildlife and Fisheries and article 17 of the law on the Management of the Environment). For all of these regulations, the government is required to react within 60 days following a formal request. Otherwise that request shall be considered as approved pending payment of any necessary fees. No authorization is necessary for small-scale subsistence aquaculture, according to natives' right of usage recognized by article 117 of law no. 94/1 (JORC 1994). So far, because of the mostly subsistence nature of the activity, less than 2% of fish farm owners possess formal authorization to operate aquaculture businesses in Cameroon.

Few serious commercial aquaculture investments exist in Cameroon, and legislation cannot be considered a hindrance to their operation. In cases where high rates of taxation may impinge on economic viability, the opportunity exists for developing the activity under the umbrella of a CIG, according to law no. 92/006 (August 1992) regarding cooperatives and common initiative groups (Pouomogne 2006), which are less subject to direct taxation. This can constitute a temporary start-up strategy for new aqua-businesses.

5.3 AVAILABILITY OF CREDIT

Many credit firms exist in the country, but funding for aquaculture projects is rare. There is no specialized credit institution in Cameroon for aquaculture business. In 1991, Crédit Agricole du Cameroun was created to provide resources specifically for agro-business, but mismanagement bankrupted it within 6 years. Interest rates at most commercial banks are close to 20% per year. In addition, the documents demanded by bankers are generally out of reach of the average fish farmer. Micro-credit firms base loan amounts on the investor's savings, which are usually insignificant among small-scale farmers (Table 12).

To access greater funding, the mortgage of a CIG affiliated to the firm is needed, and certain symbolic traditional belongings such as ritual costumes and wild animal skins (panther, lion or python, etc.) may be kept by the banker. Funding through Mutuelle Communautaire de Croissance (MC^2) is available in many rural settlements and may be the most accessible to small-scale farmers, at least in West and Centre provinces. The MC^2 interest rate is close to 12% per year for agricultural projects.

5.4 MARKETING AND COMMODITY CHAINS

On small farms, the quantity of fish produced is usually very low compared with local demand. Nearly all fish are sold on the pond dike. Marketing trials reveal, however, that fish could be sold in urban markets at much higher prices. Fresh fish is still something of a luxury product, and its marketing chain is usually very short, with producers often selling directly to the consumers and seldom through more than one intermediary retailer (Figure 11).

By the end of the last DFID-funded project to develop integrated aquaculture-agriculture systems for small-scale farmers in the forest margins of Cameroon, farmers with good training in farming techniques could produce amounts of fish exceeding local demand. To manage this expansion, a collective marketing strategy was developed involving SEAPB, a local NGO specialized in group dynamics. SEAPB managed the purchase

Table 12: Share of agriculture projects funded by micro-financing firms in Cameroon

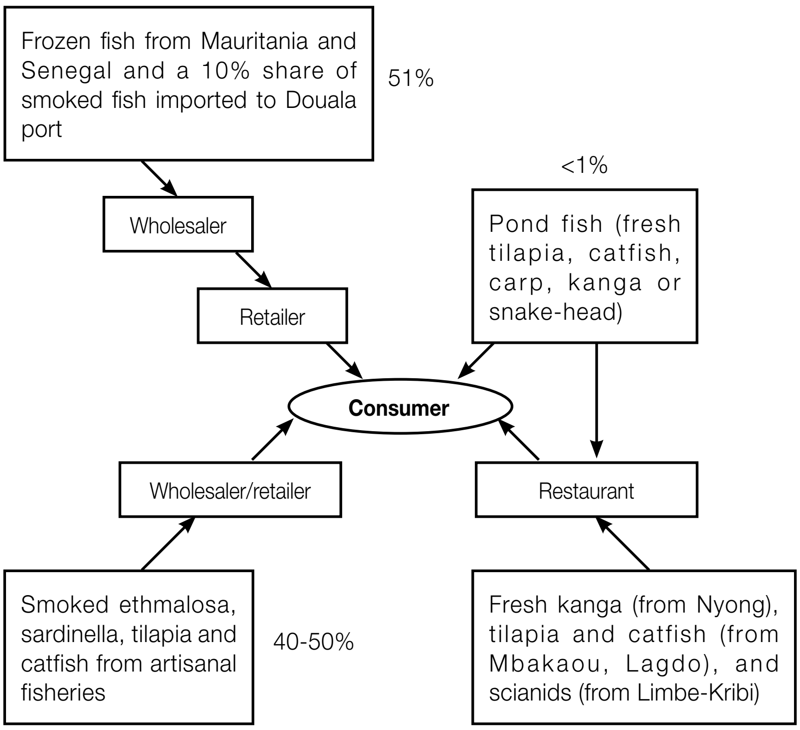
	Loan total		Share for agriculture and animal husbandry			
	Number	Amount (million FCFA*)	Number	%	Amount (million FCFA)	%
COOPEC	14,850	9,782,354	3,773	25.4	918,135	9.4
CAMCCUL	66,750	11,204,501	3,856	5.8	1,053,696	9.4
CV	4,858	317,127	1,932	39.8	121,945	38.5
MC²	3,803	2,840,093	2,496	65.6	1,125,222	39.6
CABA	623	33,611	104	16.7	5,717	17.1
Total	90,884	24,177,686	12,161	13.4	3,224,715	13.3

CABA = Caisses Villageoises de Base, CAMCCUL = Cameroon Cooperative Credit Union League,
COOPEC = Coopératives d'Epargne et de Crédit, CV = Caisses Villageoises, MC² = Mutuelle Communautaire de Croissance.

* $1 = FCFA530.

Source: DSDSR 2003.

Figure 11: Fish market chains in Cameroon



Source: Adapted from APDRA-F 2007b.

of fingerlings on credit, technical training in basic fish farming, collective harvest and joint marketing between the NGO and the 32 members of local farmers' groups. The NGO also facilitated linking fish farmers with *buyam sellams*, or women who specialize in fish retailing in the Mvog-Mbi and Mfoundi markets of Yaoundé. Through this process, fish farmers could acquire quality fish seed at a lower price and earn more from their fish harvest through collective sales. Some farmers lacking cash who benefited from buying fingerlings on credit have set up small fish production units, which have survived for the 3 years since the project ended.

When marketed, most fish, including imported frozen fish and smoked and/or dried fish from artisanal marine and freshwater capture fisheries, passes through a longer chain (Figure 11). Frozen and smoked fish are sold at lower prices than fresh fish, which is sold directly to restaurants and consumers, and prices for pond fish are significantly higher in urban areas than in rural ones (Table 13). Particularly in rural areas, demand for fish is highly elastic because of the poverty of most consumers.

Table 13: Differences in structural and price parameters between rural and periurban harvest markets in southern Cameroon (84 farms)

	Type of harvest market		
Variable	**Periurban Mean ± 1SD**	**Rural Mean ± 1SD**	**Significance level (p)*** **
Quantity marketed per harvest (kg)	89.9 ± 48.7	28.2 ± 23.5	0.013
Quantity given as gifts (kg)	55.7 ± 41.2	11.4 ± 9.3	0.046
Quantity consumed by household (kg)	50.3 ± 89.6	8.3 ± 6.8	0.302
Catfish price (FCFA*/kg)	2,583 ± 376	1,636 ± 354	< 0.001
Tilapia price (FCFA/kg)	1,833 ± 408	1,054 ± 258	< 0.001
Mean price for all species (FCFA/kg)**	1,908 ± 570	1,290 ± 386	0.005

kg = kilogram; SD = standard deviation.

* $1 = FCFA530.

** Average prices of similar grade fish in Mfoundi or Mvog-Mbi market in Yaoundé were as follows: fresh kanga, catfish or snakehead from rivers, FCFA1,000/kg; frozen mackerel and bar FCFA800-1,100/kg; smoked bonga, FCFA2,500/kg (i.e., about FCFA1,100/kg before processing).

*** Significance level determined from one-tail t test with 84-1 (83) degrees of freedom testing the null hypothesis that there is no significant difference between rural and periurban markets.

Source: WorldFish 2005, APDRA-F 2007b.

6. CONSTRAINTS AND OPPORTUNITIES OF AQUACULTURE: LESSONS LEARNT

In the present context, many guidelines from the strategic framework summarized above appear very pragmatic for future development. Aquaculture is more than 50 years old in Cameroon, but not a single self-sustaining aquaculture business is known to exist in the country. The aquaculture sector resembles others in the country: booming from its start in 1950 to independence in 1960, decline until 1970 as more pressing problems confront the new state, and erratic evolution under a variety of short-term foreign-funded development projects until 1990. With the end of the "state does all" attitude signalled by the strategic framework and the promotion of private enterprise and CIGs, the aquaculture sector may be on the verge of rebirth. In aquaculture research and extension, more participatory approaches have brought increased fish production and renewed interest among foreign donors. Most analysts feel that the prospects for progress now depend more on the socio-institutional environment than on technological constraints and that improved policies may bring sustainable changes in the sector.

Some of the key lessons learnt are as follows:

(i) In the Cameroonian context, aquaculture is more difficult to master and to make profitable than other agricultural activities, with which farmers are familiar.

(ii) For sustainability, farmers need to earn money, and aquaculture should be considered a commercial venture rather than a secondary or subsistence activity. Capital to acquire basic inputs and high-quality seed and feed are necessary to push production above the minimum critical level.

(iii) Participatory action research involving well-trained researchers and technicians working together with motivated farmers as a team has proven successful. To make the most of the scarce funding available, it should go only to demand-driven research conducted by people with a deep desire to learn and exchange knowledge with committed producers and working in areas where many such producers can be found.

(iv) Socioeconomic and institutional factors, specifically those related to access to inputs (including knowledge) and market development (roads, market infrastructure, population density and purchasing power) strongly influence aquaculture development. They require careful management and well planned interventions.

(v) Special credit schemes should be made available to support start-up aqua-businesses. The government may, in addition, provide private fingerling producers with up-to-date information on fish seed production and hatchery management. Moreover, the public service, through its own infrastructure or specialized NGOs acting for the government, should develop and maintain parental brood stocks to ensure a regular supply of certified and improved genetic material to private fingerling producers.

(vi) A national body is needed to coordinate all stakeholders involved in outreach to prevent duplication of effort and facilitate information exchange.

(vii) Regionally, Cameroon may house a research and training centre for sub-Saharan Africa. Serving the region will help rationalize expenditures, and the recently started project Sustainable Aquaculture Research Networks in Sub-Saharan Africa (Institute of Aquaculture 2007) may constitute a step toward this vision.

7. REFERENCES

Abwo D. 2003. Cameroon history. In: Jeune Afrique. Atlas de l'Afrique – Cameroon. p 72.

Anon. 1976. Fish culture activity in Cameroon. Peace Corps report, mimeo, 5 p.

APDRA-F. 2007a. Rapport d'activités, année 2006, Projet pour une pisciculture villageoise rentable dans les régions Centre et Ouest du Cameroun PVCOC (ONG-PVD/2005/095346). 41 p.

APDRA-F. 2007b. La commercialisation du poisson dans 5 zones du Cameroun — Région centre et region Ouest. Projet PVCOC. 38 p.

Balarin JD. 1985. National reviews for aquaculture development in Africa. FAO Fisheries Circular No. 770.6. Food and Agriculture Organization, Rome. 88 p.

Brummett RE. 2007. Fish seed supply case study: Cameroon. FAO regional workshop November 2007. Accra, Ghana. 13 p.

Brummett RE, Pouomogne V, Coche A. 2004c. Aquaculture extension in sub-Saharan Africa. FAO Fisheries Circular No. 1002. Food and Agriculture Organization, Rome. 55 p.

Brummett RE, Gokowsky J, Bakwowi J, Etaba AD. 2004a. Analysis of aquaculture investments in periurban Yaoundé, Cameroon. Aquaculture Economics & Management 8(5/6): 1-10.

Brummett RE, Jamu D, Jere J, Pouomogne V. 2004b. A farmer-participatory approach to aquaculture technology development and dissemination. Uganda Journal of Agricultural Sciences 9, p 530-536.

CIRAD. 2005. Rapport d'ORP sur Analyse diagnostic de l'insertion de la pisciculture dans les exploitations familiales agricoles de la Menoua (Ouest-Cameroun), juin-novembre 2004. Document de travail PCP-Uté de Dschang-IRAD-CIRAD. 54 p + annexes.

CTFT. 1972. Perfectionnement et recherches en pisciculture: Republique Centrafricaine, Congo, Gabon et Cameroun. UNDP report F1:SF/RAF/66/054. 78 p + annexes.

CTS. 2002. Barombi Kang fish station. Cameroon Trading & Services report on preliminary studies. Southwest Development Authority, Cameroon. 35 p.

DSCN. 2007. Archives courantes dont annuaire statistique du Cameroun 2005. Direction de la Statistique et de la Comptabilité Nationale, Cameroon Ministry of Economy and Finance.

DSDSR. 2002. Document de stratégie de développement du secteur rural. Document de Stratégie de Développement du Secteur Rural. Ministère de l'Agriculture et du Développement Rural, Yaoundé. 113 p.

DSRP. 2000. Document intérimaire de stratégie de réduction de la pauvreté, 2000-2003. Document de Stratégie de Réduction de la Pauvreté. Ministère du Plan et de l'Amenagement du Territoire, Yaoundé. 170 p.

FAO. 1993. Séminaire national sur la politique et la planification de la pêche au Cameroun. Exposés présentés. Palais des Congrès, Yaoundé, 16-20 septembre 1991. Food and Agriculture Organization, Rome. 244 p.

FAO. 1997. Aquaculture production statistics. FAO Fisheries Circular No. 815, Rev. 9. Food and Agriculture Organization, Rome.

FAO. 1999. Africa Regional Aquaculture Review. Proceedings of a workshop in Accra, Ghana, 22-24 September 1999. CIFA Occasional Paper No 24. Center for Inland Fisheries and Aquaculture of the Food and Agriculture Organization, Accra. 50 p.

FAO. 2006. State of world Aquaculture. FAO Fisheries Technical Paper No. 500. Food and Agriculture Organization, Rome. 134 p.

FAOSTAT. 2004. Online fish production statistics. http://faostat.fao.org Food and Agriculture Organization, Rome.

Groupement Professionnel des Acconiers. 2007. Statistiques informatisées sur les importations transitant par le port de Douala. Extraits 1995-2006.

Hogendoorn H, Wieme R. 1976. Preliminary results concerning the culture of *Clarias lazera* in Cameroon. CIFA Technical Paper No. 4 Suppl. 1. p 621-624.

IRAD. 2003. Projet de maintenance de semences de pre-base et de production de semences de base au Cameroun. Document de Projet PPTE, financé. Institute of Agricultural Research for Development. 44 p.

Institute of Aquaculture. 2007. Sustainable aquaculture research networks in sub-Saharan Africa. Grant agreement No. 213143. European Union grant 7th framework programme. Annex 1 of the grant agreement, September 2007. 57 p.

INS. 2001. Enquête Camerounaise sur les ménages ECAM2. Institut National de la Statistique du Cameroun.

Jeune Afrique. 2003. Atlas de l'Afrique – Cameroun. Les Editions Jeune Afrique. 119 p.

JORC. 1991. Journal officiel de la République du Cameroun, Loi No. 90/53 du 19 décembre 1990 portant sur la liberté d'association. Journal Officiel, 31^{e} année, Supplément No.

1, 1 Janvier 1991. Imprimerie Nationale. 65 p.

JORC. 1992. Journal officiel de la République du Cameroun, Loi No. 92/006 du 14 août 1992 relative aux sociétés coopératives et aux groupes d'initiative commune.

JORC. 1994. Journal officiel de la République du Cameroun, Loi No. 94/01 du 20 janvier 1994 portant régime des forêts, de la faune et de la Pêche. 57 p.

Kouam J. 2002. Aquaculture extension in Cameroon. In: Brummett RE, Pouomogne V, Coche A. 2004. Aquaculture extension in sub-Saharan Africa. FAO Fisheries Circular No. 1002. Food and Agriculture Organization, Rome. 55 p.

Kriesemer S, Hoffmann V. 2006. Determinants of adoption and diffusion of fishponds in Cameroon. Presentation at the mid-term workshop, 9-11 August 2006. Recommendation Domains GIS-based project. WorldFish Center, Penang, Malaysia. University of Hohenheim, Germany. 32 slides + text.

Laclavère G, Loung J-F. 1980. Atlas de la République Unie du Cameroun. Jeune Afrique, Paris. 72 p.

Lazard J, Lecomte Y, Stomal B, Weigel JY. 1990. Pisciculture en Afrique subsaharienne. Situations et projets dans des pays francophones. Propositions d'action. Ministère de la coopération et du développement, CID/DOC, Paris. 155 p.

Lemasson J, Bard J. 1964. Bilan de la pisciculture dans neuf états d'Afrique tropicale. Notes et documents sur la pêche et la pisciculture. CTFT Nogent sur Marne.

Marek M. 1975. Revision of supplementary feeding tables for pond fish. Bamidgeh 27: 57-64.

MINEPIA. 1994. Recueil des textes régissant l'élevage, les pêches et les industries animales. Contact hors série No. 1. CNFZV Cameroun/ AGCD Belgique. 292 p.

MINEPIA. 2003. Archives courantes. Direction des pêches. Cité par Ngok et al. 2005.

MINEPIA. 2006. Programme de Développement de la Pisciculture au Cameroun. Document de projet soumis pour le financement PPTE. 79 p.

Moehl J, Halwart M, Brummett R. 2005. Report of the FAO-WorldFish Center workshop on small-scale aquaculture in sub-Saharan Africa: Revisiting the aquaculture target group paradigm. Limbé, Cameroon, 23-26 March 2004. CIFA Occasional Paper. No. 25. Food and Agriculture Organization, Rome. 54 p.

Moehl J, Brummett RE, Mulonda KB, Coche A. 2006. Guiding principles for promoting aquaculture in Africa: Benchmarks for sustainable development. CIFA Occasional paper No. 28. CIFA/OP28. FAO Ghana regional office, WorldFish. 133 p.

NEPAD. 2005. Plan d'action pour le développement des pêcheries et de l'aquaculture en Afrique. Sommet NEPAD Poissons pour tous, 22-24 août 2005. Abuja, Nigeria. 33 p.

Nna Abo'o P, Kouam J, Pouomogne V, Moehl J, Halwart M, Brummett RE. 2004. A strategic framework for aquaculture development in Cameroon. African regional workshop on small-scale aquaculture. Limbe, Cameroon, 23-26 March.

Ngok E, Njamen D, Dongmo JV. 2005. Contribution économique et sociale de la pêche artisanale aux moyens d'existence durables et à la réduction de la pauvreté. FAO/PMEDP/Projet pilote No. 3. Version provisoire. 42 p.

Nguenga D, Pouomogne V. 2006. Etat actuel de la recherche aquacole et halieutique au Cameroun. Atelier de rapprochement MINEPIA-MINRESI pour le développement du secteur halieutique au Cameroun. Palais des Congrès, 5-6 août 2006. 10 p.

Oswald M, Pouomogne V. 2000. Etude de pré-faisabilté pour un développement de la pisciculture villageoise dans les régions du Centre et de l'Ouest du Cameroun. (Rapport définitif). APDRA-F/MCAC Yaoundé/MINEPIA. 96 p.

PNVRA. 2006. Décision conjointe No. 392/ MINADER – No. 0068/MINEPIA du 15 mai 2006 portant restructuration du programme National de Vulgarisation et de Recherche Agricoles. 9 p.

Pouomogne V. 2002. Monographie du CPN de Melap, Foumban, Rapport de stage optionnel. 4eme ENSA, Yaoundé. 53 p.

Pouomogne V. 2004a. Rapport de vidange d'un étang piscicole à Nkolnguem. FAO/PSSA, Province du centre Cameroun, le 25/09/04. 2 p + annex.

Pouomogne V. 2004b. Quarterly progress report. July-September 2004. WorldFish FSRP Project. 10 p.

Pouomogne V. 2004c. Rapport de vidange d'un étang piscicole à Ebogo 1. FAO/PSSA, Province du Centre, Cameroun, le 15/10/04. 2 p + annex.

Pouomogne V. 2005a. Mission FAO, Projet TCP-2903 Diversification, volet pisciculture: Situation des UDs au 31 mars 2005. 11 p.

Pouomogne V. 2005b. Contribution to NEPAD development plan for aquaculture in Africa. Preparatory workshop for Fish for All Summit, 26-30 June 2005, in Abuja. NEPAD/WorldFish Center, Cairo. 10 p.

Pouomogne V. 2006. Recensement des systèmes de régulation applicable à l'activité de pisciculture au Cameroun. Projet EVAD/CIRAD France. 26 p.

Pouomogne V. 2007a. Analysis of feeds and fertilizers for sustainable aquaculture development in Cameroon. In Hasan MR (ed.). Study and analysis of feeds and fertilizers for sustainable aquaculture development. FAO Fisheries Technical Paper No. 497. Food and Agriculture Organization, Rome.

Pouomogne V. 2007b. Review on the use of wild-caught *Clarias* catfish as seed in aquaculture: Case of Santchou agrofishers in western Cameroon. FAO technical report in press. 28 p.

Pouomogne V, Brummett RE. 2002. Fish culture in Cameroon. Small-scale commercial systems for rural poor. Global advocate Vol. 5, December 2002, p 86-87.

Pouomogne V, Brummett RE, Gatchouko M. 2003. Impacts of aquaculture development projects in western Cameroon. In press. Aquatic Resources, Culture & Development.

Pouomogne V, Mikolasek O. 2008. Construction des Innovations en Partenariat (CIP): Cas de la pisciculture dans les Exploitations Familiales Agricoles des Hautes Terres de l'Ouest et de la Plaine des Mbos. Rapport technique et financier phase 1. 40 p + annexes. Projet REPARAC.

Pouomogne V, Nana J-P, Pouomegne J-B. 1998. Principes de pisciculture appliquée en milieu tropical africain. Comment produire du poisson à coût modéré (des exemples du Cameroun). CEPID / Coopération Française Yaoundé. Livre paru aux Presses Universitaires d'Afrique. 236 p.

Pouomogne V, Oswald M. 2002. Développement de la pisciculture paysanne en zone forestière camerounaise: Exemple du Groupe des Pisciculteurs de Yemessoa (GROUPY), Lekié, Province du Centre. Contribution présentée au Salon professionnel international « Bordeaux Aquaculture2002 », Journée de réflexion sur le développement de la pisciculture paysanne en Afrique (20/09/02). 23 p.

REPARAC. 2006. Construction des innovations en partenariat (CIP): Cas de la pisciculture dans les exploitations familiales agricoles des Hautes Terres de l'Ouest et de la Plaine des Mbos. Projet de recherche soumis au Reparac. 8 p + annexes.

Satia PNB. 1991. Historique du développement de la pisciculture au Cameroun. In: FAO. 2003. Séminaire national sur la planification de la pêche au Cameroun. p 163-170.

SOGREAH. 1982. Cameroun: Etude de l'aquaculture et de la pêche continentale. Tome 2: la pisciculture d'étang, les stations de pisciculture, les centres d'alevinage. Société Grenobloise d'Etudes et d'Applications Hydrauliques, Grenoble, France. 135 p.

UNESCO. 2000. L'Atlas de l'Afrique. Jaguar éditions. 207 p.

Vivien J. 1992. Faune du Cameroun. Guide des mammifères et poissons. Edition GICAM-Coopération française. 271 p.

WorldFish. 2005. Final technical report: Development of integrated agriculture-aquaculture systems for small-scale farmers in the forest margins of Cameroon. NRE9800 605/522/003, Department for International Development, London.

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ANNEX 1: EDITED SUMMARIES OF THE ABSTRACTS OF MAJOR PAPERS AND TECHNICAL BULLETINS PUBLISHED BY THE NATIONAL AQUACULTURE RESEARCH SYSTEM OF CAMEROON

(Note: These are not the original published abstracts.)

A1.1. Brummett RE, Etaba DA, Pouomogne V. 2003. On-farm and on-station comparison of wild and domesticated Cameroonian populations of *Oreochromis niloticus.* Aquaculture 242: 157-164.

Wild populations of *Oreochromis niloticus* in the Sanaga River were compared with domesticated populations on-farm and on-station in Centre Province, Cameroon, to determine the degree to which genetic deterioration of stocks may have occurred during domestication and subsequent breeding. On-station, average weight at harvest was 284.3 ± 16.2 g for Sanaga and 178.1 ± 9.9 g for domesticated. The on-station specific growth rate was 0.0660 ± 0.0022 g/day for Sanaga and 0.0555 ± 0.0016 g/day for domesticated. On-station standing stock at harvest was 5,747.3 ± 624.4 kg/ha for Sanaga and 4,170.3 ± 233.4 kg/ha for domesticated. Differences in average weight at harvest and specific growth rate on-station are significant at $P < 0.003$. Differences in standing stock at harvest on-station are significant at $P < 0.015$. On-farm, average weight at harvest was 121.1 ± 26.5 g for Sanaga and 87.5 ± 17.2 g for domesticated. On-farm specific growth rate was 0.0442 ± 0.0057 g/day for Sanaga and 0.0358 ± 0.0047 g/day for domesticated. On-farm standing stock at harvest was 2,454.2 ± 445.6 kg/ha for Sanaga and 1,667.8 ± 352.2 kg/ha for domesticated. Differences in average weight at harvest on-farm are significant at $P < 0.05$. Differences in specific growth rate on-farm are significant at $P < 0.04$. Differences in standing stock at harvest on-farm are significant at $P < 0.015$. The Sanaga River population consistently out-performed the domesticated population. Final individual weight of domesticated fish averaged 39% less than wild fish on-station and 42% less than wild fish on-farm.

A1.2. Brummett RE, Gockowski J, Bakwowi J, Etaba AD. 2004. Analysis of aquaculture investments in periurban Yaoundé, Cameroon. Aquaculture Economics and Management 8(5/6): 1-10.

To better understand the key components of aquaculture production in periurban Africa, the farming systems and profitability of five semi-intensive fish culture investments within 35 km of the centre of Yaoundé, Cameroon, were subjected to economic analysis. The profitability of farms varied considerably. Two farmers lose money every year. Net returns to management on profitable farms ranged from a low of FCFA0.3 million to a high of FCFA3.87 million (overall weighted average = FCFA0.99 million). The payback period for the initial investment on farms that turn a profit ranges from 5 to 28 years. Only two farms can be considered solid investments. Nevertheless, the potential of aquaculture systems to be productive and profitable is apparent from the data collected. It is estimated that the five surveyed farms could increase their production from the current 7.6 t of fish to at least 44 t per annum, returning average profits of FCFA21.5 million, if basic principles of fish culture were adopted.

A1.3. Nguenga D, Teugels GG, Legendre M, Ollevier F. 2004. The influence of tropical seasonal changes on oocyte diameter, responses to hormonal induction and hatching quality in two strains of an African catfish, *Heterobranchus longifilis* (Clariidae). Aquaculture Research 35: 1349-1357.

A comparison was made between the oocyte diameter, pseudo-absolute fecundity and egg quality of two strains of an African catfish, *Heterobranchus longifilis*, maintained in outdoor ponds under a tropical highland climate in Cameroon. The results indicated that circannual endogenous rhythms for ovarian recrudescence and regression are absent in *H. longifilis*, irrespective of breeding history, age or strain. There appeared to be a possible slight adverse climate effect in the dry season on the reproductive performance of both strains. Oocyte diameter and pseudo-absolute fecundity increased with higher fish weight when data from both strains were combined, indicating that the two strains may exhibit the same reproductive performance. Viable eggs were obtained all year round after hormonal induction of spawning. It is concluded that, for propagating *H. longifilis* in tropical African countries, broodfish could be maintained in outdoor earthen fishponds with proper feeding.

A1.4. Nguenga D, Teugels GG, Legendre M, Ollevier F. 2004. The effects of storage and incubation temperature on the viability of eggs, embryos and larvae in two strains of an African catfish, *Heterobranchus longifilis* (Siluriformes, Clariidae). Aquaculture Research 35: 1358-1369.

Eggs of African catfish (*Heterobranchus longifilis*) from two strains were stored for intervals up to 8 hours under two temperature regimes: in a household refrigerator (3-5°C) and at ambient room temperature (20.5-22.0°C) in the first experiment. In another experiment, eggs were incubated from fertilization to hatching at different experimental temperatures (21, 25, 29, 32 and 35°C) to determine the effects of temperature on the kinetics of white egg appearance, hatching times and hatching quality. Gamete storage at warmer temperatures significantly prolonged viability irrespective of the strain used. For example, the hatching rate for eggs stored for 5 hours at 20.5-22.0°C was 75.2-79.3% and at 3-5°C was 6.5-9.4%. Loss of viability was most noticeable after 6 hours of storage at ambient room temperature. Post-storage viability significantly declined after 2 hours of exposure to the refrigerator temperature. No hatching of normal larvae took place after 8 hours post-storage time. Times to maximum whitening of eggs were found to depend on both strain and temperature. The times to maximum mortality of eggs were shorter in the Layo strain (LS) than in the Noun strain (NS) regardless of incubation temperature. The time to appearance of white eggs was shorter with increasing incubation temperatures. Hatching times decreased with increasing temperature, regardless of strain. After fertilization at a temperature of 29°C, hatching took place in 21-27 hours for NS and in 19-24 hours for LS. The length of the hatching period was remarkably shorter for LS than NS at any tested incubation temperature except 35°C. No hatching took place at 21°C. The highest proportion of normal larvae occurred at 25°C for NS and 29°C for LS. The hatching rate was highest at 25°C for NS and 29°C for LS. There was a significantly higher proportion of deformed larvae at 35°C regardless of the strain. Short-term storage of *H. longifilis* eggs would be beneficial to fish breeders when gamete collection, insemination and incubation take place at different sites.

A1.5. Nguenga D, Breine JJ, Teugels GG, Ollevier F. 1996. Artificial propagation of the African catfish *Heterobranchus longifilis* (Siluroidei, Clariidae): Description of a simple technique to avoid sacrificing male broodfish for the obtention of milt. Aquaculture 143: 215-217.

In clariid catfish culture, it is a common practice to sacrifice male broodfish to remove the testes during the artificial fertilization of eggs. This paper describes a technique for the routine ablation of the testes in *Heterobranchus longifilis* without killing the donor males. The advantages of this technique of "partial gonadectomy" in aquaculture hatcheries are discussed.

A1.6. Pouomogne V, Nana J-P, Pouomegne J-B, 1998. Principes de Pisciculture appliqués en milieu tropical africain. Comment produire du poisson à coût modéré (des exemples du Cameroun). CEPID/Coopération Française, Yaoundé. Edité par Presses Universitaires d'Afrique (PUA), Yaoundé. 236 p.

This handbook provides current information on semi-intensive fish farming in Cameroon. It is easy to use and aimed mainly at graduate-level readers and educated fish farmers who are willing to pay for information. The document has constituted the base for training hundreds of aquaculture technicians, specifically the subject-matter specialists of the PNVRA, through about 10 monthly technology review workshops. A technical bulletin summarizing the content of the book is presented in Table A1.11.

A1.7. Pouomogne V, Takam G, Pouemegne J-B. 1997. A preliminary evaluation of cacao husks in practical diets for juvenile Nile tilapia (*Oreochromis niloticus*). Aquaculture 156: 211-219.[4]

An experiment was conducted to assess the use of cacao husks, an agricultural waste in the tropics, as partial substitute for more expensive ingredients in juvenile tilapia diets. In this respect, triplicate groups of 100 Nile tilapia fingerlings (1.40 g) were fed each of three isonitrogenous (28% crude protein) and isocaloric (4.80 kcal/g) diets in nine 1,500-litre "fastanks" for 13 weeks. In the three diets, ground cacao husk was incorporated at 0 (diet cc0), 10 (diet cc10), and 20 (diet cc20) levels to replace maize flour, wheat bran and rice bran. Fish were fed to satiation by hand, and growth monitored with fortnightly intermediate samplings. Fish ate aggressively throughout the trial, thus showing acceptance of the three experimental diets. The specific growth rates were very similar, ranging from 2.3 (cc0) to 2.5%/day (cc20). Although feed:gain ratios ranged from 1.95 (cc20) to 2.08 (cc0) and protein efficiency ratios ranged from 1.66 (cc0) to 1.83 (cc20), no significant differences among dietary treatments were noticed. Likewise, carcass analysis revealed a slight decrease ($p<0.05$) in the protein content of the whole fish body from diets cc0 (14.2%) to diet cc20 (13.5%). The cost analysis of diets showed a considerable reduction of the production cost of 1 kg of fish while moving from diet cc0 to diet cc20 ($0.15). Based on growth performance, feed and nutrient retention efficiencies, and economic analysis, cacao husk appears to be a viable source of dietary protein for juvenile tilapia for up to 20% of the diet, according to this preliminary appraisal.

A1.8. Pouomogne V. 1994. Alimentation du tilapia *Oreochromis niloticus* en étang: Evaluation du potentiel d'utilisation de quelques sous-produits de l'industrie agro-alimentaire et modalités d'apport des aliments. (Nile tilapia feeding in earthen ponds: Evaluation of the nutritional value of some agro-industrial by-products and feeding practices.) Thèse de doctorat d'halieutique, ENSA de Rennes, France. Editée par CIRAD-EMVT, Maisons-Alfort. 138 p.[5]

One of the major constraints limiting the development of tilapia farming in sub-Saharan Africa is the lack of practical scientific data on the feeding of these fish species under semi-intensive field conditions. Experiments were conducted mainly in earthen ponds of 400 m^2 between 1990 and 1993 at the Foumban fish-culture research station in Cameroon. Triplicate batches of *Oreochromis niloticus* (10-150 g) were randomly submitted to the experimental treatments in all trials for about 12 weeks each. Trials dealing with the optimum use of by-products showed that cotton seed cake, soya oil meal, brewery draff and rice middlings could be incorporated at 30% of the diet without significantly depressing growth or nutrient-retention efficiencies. When either rice bran and brewery draff was used as a single diet, the analysis of the body composition of tilapia showed significantly ($p < 0.05$) more moisture: 76-81%, against 72-78% while using compounded diets. The best diet in terms of growth and body composition of tilapia appeared to be the one containing 30% rice bran, with brewery waste, cotton seed cake, soya oil meal and groundnut seed meal each incorporated to 17%. Another set of trials tested practical means of distributing the feed in ponds. The validity of Marek's feeding table (Marek 1975) was confirmed for the feeding rate in the gaps of fish size studied, i.e., from 5.3% of fish biomass per day for fish weighing 10-20 g, to 2.8% for those weighing 70-100 g. When food was applied in six meals, weight gain was 1.4 times better than at a frequency of three meals per day. The use of pelleted rather than powdered feed reduced the feed conversion ratio from 3.0 to 1.8 and significantly ($p < 0.05$) improved fish production (2.7 t/ha/yr, against 1.7) and the retention efficiencies of protein (36.0%, against 22.4%) and energy (19.0%, against

4 This paper had marginal impact in-country but was a major marketing tool for IRAD aquaculture, as more than 30 reprints requests were received from five continents within 3 months of publication.

5 This is a PhD thesis edited by CIRAD for wider distribution.

13.1%). Likewise, growth and retention efficiency of the supplemental feed (A) protein in tilapia was significantly improved ($p < 0.05$) by pond manuring with the equivalent of 180 kg dry matter of cow dung per day (F). The additive effect of fertilization and supplemental feeding was observed for total fish production (i.e., 2.9 t/ha/yr for A+F treatment $\simeq$ 2.2 t of treatment A + 0.8 t of treatment F). Two trials were further conducted on predation in tilapia ponds by *Hemichromis fasciatus*. Results showed that all tilapia fry weighing less than 6 g were effectively eaten by *Hemichromis* adults (40 g). The latter totally abstained from the supplemental feed, though by contrast their fry grew well when fed the tilapia feed. The analysis of the results for the site, at an altitude of 1,100 m and with a mean annual water temperature of 24°C, showed that the best growth of tilapia was registered from March to July, with a daily growth coefficient of about 2.5%/day.

A1.9. Sulem Yong S, Brummett RE, Tomedi ET, Tchoumboué J. 2007. Towards the maximum profitability of smallholder catfish nurseries: Predator defence and feeding-adapted stocking of *Clarias gariepinus*. Aquaculture 271: 371-376.

To determine how best smallholders can maximize the profitability of their catfish hatcheries, cost/benefit analyses were conducted using fences, hapas and bird nets to exclude predators, as well as using over-stocking to create a food shortage. As compared to the typical production system of fertilized, unfenced ponds, and at a stocking density of 10 two-day old fry/m^2, survival increased by 28% in fenced ponds, 34% in open hapas and 55% in bird-netted hapas. These increases were believed to arise from the exclusion of adult amphibians in fenced ponds, and of aquatic insects in open hapas, as well as of flying predators in bird-netted hapas. This implies that adult amphibians were responsible for 28% of the fry mortality observed in unfenced ponds, aquatic insects for 6% and birds for 23%. When the stocking density of predator-free closed hapas was increased from 10 to 40 fry/m^2, fry survival significantly dropped ($P < 0.002$), indicating a shortage of food/fry. Consequently, the maximum yield was only 29 out of 40 fingerlings/m^2 (though up from 10 out of 10 in the low-stocked systems), and 29 larvae/m^2 appeared to be the stocking density that could optimize the profitability of smallholder *C. gariepinus* hatcheries. Calculations based on corresponding survival rates, final average weights and size-dependent selling price showed that stocking at this optimum density could significantly improve profitability — for instance, from a loss of FCFA184 to a profit of FCFA982 per square metre — by using closed hapas. Smallholders should therefore determine and stock their nursing systems at optimum densities as well as defend the stocked fry from predators to maximize their profits.

A1.10. Sulem Yong S, Tomedi ET, Mounchili S, Tekeng S, Brummett RE. 2006. Survival of *Clarias gariepinus* fry in earthen ponds: Effects of composts and leaks. Aquaculture 260: 139-144.

To inform decisions on improving the yields of African catfish (*Clarias gariepinus*) fingerlings in earthen ponds, the hypothesis that composts and leaks were partly responsible for usually low and variable fry survivals was tested through the comparison of treatments and simple regression. The occurrence of amphibians was significantly higher ($P < 0.05$) and the survival of fry was significantly lower ($P < 0.02$) in ponds with composts than in those without. The survival of fry and fingerlings in earthen ponds negatively correlated with their night leaking rates, and regression analysis yielded the equations $y = -13.31x + 82.56$ for fry and $y = -6.97x + 95.29$ for fingerlings, where y is the survival of fry or fingerlings in a holding pond and x is the leaking rate of the pond. Reflecting how negatively the existence of composts and leaks can affect the survival of fry and fingerlings, fertilizing unfenced ponds with composts and sterilizing nursery ponds by drying were proscribed.

Keywords: earthen ponds, composts, leaking, survival of *Clarias gariepinus*

Table A1.1 A Technical Bulletin on Pond Construction, Fingerling Production and Integrated Management of Ponds
22-23 May 2003 in Mbalmayo (PNRVA Cameroon)

What to do (Activity)	Why and how to do it (Expected results and tasks)	When to do it	What with (Materials needed)	Additional remarks
1. Pond Construction				
1.1. Site Selection	Topography: Land slope should allow: 1. water supply and drainage through gravity, 2. soil movements at the lowest costs, and 3. opportunity to build large ponds. Use levelling materials and tape to estimate slope and distance.	In any season	Machete to clear site, pegs, mason's line, plumbs, theodolite (or mason's water level with attached line and graduated pegs)	Topography determines the type of pond to construct (barrage, derivation, derivated dam, etc.). Good average slope in areas of Cameroon with high potential range from 2% to 10%.
	Soil: Texture should allow easy construction of dikes and sufficient water retention. Manually test to estimate clay content (e.g., by throwing doughy earthen balls against a vertical wall; if it adheres, it is okay. Another way is to squeeze a ball of soil in your hand and see if fingerprints or imprints of finger rings remain). Clay, loam and sand content can be analyzed in a soil laboratory.	Same as above	Pickaxe, pedologic (soil) auger, pit, vertical wall, laboratory or bucket with soil solution to be analyzed	Soils that are sandy or too rich in clay are to be avoided. Samples should come from within the clay region of the textural diagram of soils. Good soils for manufacturing bricks may be suitable for pond construction.
	Water: No water, no fish farming. Water should be available all year around to ensure reasonable fish development. Estimate quantity (debit measuring) and quality (measurements of hardness with soap; transparency with Secchi disk; and pollution, nitrates, phosphorous and other factors using kits).	End of dry season (all temporary streams dry)	Chronometer and accessories for debit; chemistry kits for water quality (available at IRAD station at Foumban if needed)	Note that 5 mm of water is lost daily through evaporation in most areas of Cameroon and should be compensated for by a debit of 1/3 litre/minute/100 m^2. The existence of wild fish in the stream is a quality indicator.
1.2. Constructing new ponds or rehabilitating existing ponds	Cleaning: Cleaning the area facilitates eventual operations. Drain existing ponds before clearing.	End of rainy season	Motorized pump, machete, axes, power saw	Stumps should be rooted out as much as possible.
	Detailed topographic surveys: To determine the volume of soil to be dug out and to be filled in. Peg, level and mark out characteristic points. Levelling should be done manually using a mason's water level plus line or, preferably, an automatic level or a theodolite	Same as above	Pegs, theodolite, mason's water level with attached line and graduated pegs, etc.	Pegs with marks in zones to be filled in, and pegs attached to 'gabarits' (jigs or templates) in zones to be dug out. (Drawings in the original bulletin.)
	Terracing and compacting: To form the dish and dikes of the pond. To dig out humps (pegs with 'gabarits') and fill in holes (mark pegs) as shown by detail topographic surveys. The pond should have a water depth of about 1 m upstream and 1.5 m in the drainage zone.	Same as above	Pickaxes, spades, compacters, planks and possibly bulldozers	Wet and compact filled-in zones after every 20 cm at most. If soil is bad, form a waterproof nucleus using soil with better texture brought from elsewhere.
	Transforming a barrage into a derivated dam to improve water management for fish farming: Create a dike between its upper (shallower) part and its lower (deeper) part. Position the new dike to ease the deviation of stream into a side canal.	As possible, during dry season	Same materials as above	The topography of the site should permit this derivation to one side of the valley. The debit of the stream should be modest.

1.3. Finishing touches	Pond water supply and drainage system: Dig a trench across the upstream and downstream dikes, install pipes, and refill with ground compacting as described above. The upper end of pipes should be positioned lower than the main water supply canal bottom and the draining point within the pond dish. Draining pipe slope < 1% slope.	Following completion of all major digging and filling	PVC pipe with joining elbow, 100 mm diameter at water inlet and 125 mm diameter at drain	Use pressure-resistant PVC as possible for draining system. If pond surface > 0.5 ha, use a cement monk with a bigger draining canal. Tightly compact around buried part of the draining pipe.
	Complete draining of the pond during harvesting: Dig out small canals converging towards deepest part of the pond, just upstream of the drain.	Same as above	Levelling materials, light digging materials, line	In case of groundwater, increase the slope of pond dish above 10% (instead of usual 3% maximum).
	Dike sloping, to prevent erosion from wave action: Waves roll up a slope rather than bang against a vertical wall.	Same as above	Same as above	Dike sides must be sufficiently sloped to allow entry from the pond platform towards pond bottom without running (slope ranging from 1/3 to 2/3 according to topography and soil type).
	Anti-erosion cover: Stabilized and protected dikes are attractive. Plant grasses on the unsubmerged part of the pond dish and dikes, and arrange stones on the upstream area of pond bottom, where water first drops during pond filling.	By the end of finishing touches	Gramineae grasses, stones, fertilizers, dibber	Prefer Gramineae with stabilizing roots and leaves such as *Cynodon* sp. or *Axonopus* sp.
	Organic seal: In case of water leakage all over the pond dike and dish caused by poor soil quality, an organic seal may alleviate the problem. Spread a 20 cm, well-compacted layer of pig, cow or chicken manure all over the pond dish and inner side of the dikes. Cover with a thin layer of dried vegetation, and then with earth. Leave for a minimum of 3 weeks before filling with water.	After pond building and noticing generalized leaking	Vegetation, animal dung, spreading and ramming tools	This technique was first tested in Russia. It also contributes to fertilizing the pond. The waterproof nucleus (see above) may be necessary if the organic seal does not reduce leakage.
2. Pond water management				
2.1. Pond preparation	Liming: To disinfect the pond and eradicate most predators and eventually increase water alkalinity, apply quicklime all over the pond dish.	Before water filling	Quicklime	Applying at a rate, per 350 m^2 of water surface, from 35 kg for sandy soil up to 80 kg for a pond bottom of clay
	Compost crib: Base manuring, to make available natural feed before fish stocking. Build a frame on 1/10 of the pond surface and load with organic materials. The upper end of the pegs used to build the frame should not be too much higher than the water surface to avoid offering a perch to preying birds.	Before water filling	Sticks, frame, organic materials	Organic materials should be loaded up to the maximum water level expected in the pond. A *dacao* (Chinese for green manure) pit built outside the pond may be better. Use about 20 kg of dry matter of organic manure per 350 m^2 per day.
	Filling the pond with water: Adopt a low debit at start to prevent erosion of the pond dish. Prevent the entrance of wild fish with a screen at the water inlet. The water level should be at least 20 cm below the top of the dike.	Following liming and building compost crib	Main water supply canal and pond water supply system, screen	Lining with stones will prevent erosion where water falls into the pond. Check for leaks and then readjust the water level or drain to remedy.

2.2. Stocking	Fish stocking: To harvest good size fish, stock 0.5-3.0 Nile tilapia per square metre according to fertilizing and feeding capabilities; 1 to 3 months later, stock other species at the following tilapia:other ratio. 1:1 for African catfish or 1:10 for panther fish or snakehead as a police fish species, plus as possible 1:5-1:10 for African bonytongue (kanga) or common carp.	About a week after filling the pond	Fingerlings over 10 g in size	Secchi disk transparency should be < 25 cm. Gently transfer fingerlings from transporting bucket to the pond. Respect the stocking density below 100 g of biomass per square metre for a normal semi-intensive pond.
2..3. Routine operations	Continuous fertilization: Natural feed for fish is stimulated through fertilization. Weekly load 1 to 3, 10-litre buckets of animal manure into the compost crib, or daily dilute 1 bucket of animal manure and spread it all over pond surface (5 kg dry matter per 400 m^2) if there is no compost crib. When directly integrating with land animals, adopt 200 fowl, 80 ducks, 50 rabbits, 12 goats, 4 pigs, 1 horse or 0.75 cow per 400 m^2 of water surface.	Throughout the rearing process	Organic manure, brought or produced on-farm by land animal integrated in shelters. Secchi disk to test water transparency.	Water transparency should remain with 10 and 25 cm. Groups of fish observed gulping air at the water surface early in the morning may be a sign of oxygen deficiency; manuring should then be stopped or aerators activated if available.
	Additional feeding: Supplement feed to improve fish growth. Floating frame (100 cm^2 per fish) should be designed to habituate fish coming to a specific pond area to ingest feed. Daily distribute the equivalent of 2% for larger fish to 6% for smaller fish of estimated fish biomass, in 2-5 meals. The feed conversion rate for usual pellets ranges from 1.5 to 2.5	Same as above	Agro-industrial by-products or balanced pellets. According to fish size and species, balanced feed should contain 30-45% crude protein with 19-22 kJ/kg of energy.	Intermediate sampling may be done three months after stocking to control fish growth. Use Marek's feeding table to calculate corresponding feed amounts (Marek 1975). It is important to monitor what fish are eating by watching them rush to the feeding frame area during distribution.
	Other routine activities: Fight predators by keeping the whole pond area clean. Use scarecrows and traps to drive away birds, otters and snakes. Pay a visit to the fish farm every day to control eventual leakage and readjust the water level.	Same as above	Machete, clearing machine, fence, scarecrow	Bury the lower part of the fence, which should have sufficiently small mesh and be at least 1.5 m in height.
2.4. End of fish-breeding cycle	Harvesting: Drain the pond when marketable fish size is reached, i.e., 0.3-1.0 kg/m^2 water surface according to management level. Open the draining system and use a hand net and hauling net to catch the fish. Handle with care and respect fish welfare to earn more money from consumers. Operate in fresh weather, i.e., open the draining system in time to be able to start collecting fish before 7 a.m.	6 to 12 months after stocking and following adequate management	Draining system, hand and hauling net, bucket plus stocking tanks, handling table, scales	Have on hand a stocking receptacle for fingerlings. Emptying a 400 m^2 pond using a 125 mm diameter draining pipe takes about 5 hours. It is important to market the whole anticipated harvest before draining.
	Activities just after harvesting: Caring for the infrastructure lengthens its lifespan. This includes smoothing the pond dish bottom, dredging after 3-4 breeding cycles and sun drying.	Between harvest and next breeding cycle	Hoe, spade, smoothing and compacting tools	1-4 weeks of sun drying as possible

3. Fingerlings production				
3.1. Breeders selection	Successful artificial breeding needs mature females capable of providing ripe oocytes and sufficient milt from males. Choose females with rounded abdomen. For African catfish, 75% of oocytes expulsed through abdominal pressure should be > 1 mm in diameter. The recommended sex ratio in a semi-natural production process is 1 male:3 females for Nile tilapia, 1:1 for catfish and 3:1 for common carp	During pond harvesting	Measuring tape with mm precision, cannula to extract oocytes, magnifying glass	For African catfish, the best female breeders appear to average 400 g. For common carp, abdominal pressure results in milt flowing from mature males.
3.2. Hormone injections	Inducing ovulation is necessary when natural breeding does not occur in ponds. Hormones are injected by introducing the syringe containing the hormone in dorsal muscles and pressing until all the product is transferred into the fish body. Doses: 4,000 UI hCG per kilogram for African catfish and 1,500 for common carp; 4 mg/kg of pituitary gland for African catfish and 5 mg/kg for common carp. If these hormones are not available, 3 fresh hypophysis may be ok per female.	After breeder selection, usually by 8 p.m. of day preceding gamete expulsion	Syringe, hormones (hCG, carp pituitary gland, etc.)	In common carp, apply 1/10 initiation dose followed 12 hours later by the decisive 9/10. The female oviduct should be sewn to prevent early uncontrolled spawning.
3.3. Extraction of gametes	Collect oocytes and milt: In African catfish, carefully cut open the male, detach the two testis, and sew the opening shut. Collect oocytes by abdominal pressure till emptying the ovary (blood indicates the last oocytes batch). In common carp, collect milt through abdominal pressure.	At 26°C, about 12 hours after injecting hormones	Surgical materials, clean dish	Milt should be kept away from water before using it for fertilization. In African catfish, testis is normally regenerated in the male after 6 months. Milt is collected from the testis by incision.
3.4. Mixing of gametes	To allow fertilization, shower the oocytes with milt. Add to both 0.7% salt water and immediately mix for 30 seconds. Rinse to raise any dirt.	Just after expulsion of gametes	0.7% salt water, gametes, feather for mixing	Fertilized eggs are very sticky in common carp and should be gently stirred into fresh milk to avoid agglutination.
3.5. Incubation	For the adequate development of fertilized eggs, spread them in single layer on a fine mesh screen receiving a gentle debit of well oxygenated flowing water.	Just following fertilization	Frame with adequate mesh size, incubation container, clean flowing and oxygenated water	At 26°C, hatching occurs within 24 hours following fertilization.
3.6. Siphoning yolked larvae	Separate larvae from shells and transfer them in clean water.	Just following hatching	Mini tube, bucket, clean and oxygenated water at a temperature > 25°C	Larvae should be kept in water of adequate quality until yolk is re-absorbed. Use heat as needed to keep water temperature > 25°C.
3.7. Prefattening postlarvae in fertilized ponds	To produce high-quality fry and fingerlings, transfer the unyolked larvae to prepared and fertilized pond as described above (without compost crib) and feed with a balanced diet containing at least 40% crude protein and an adequate fatty acids profile, at a rate of 10% of biomass in many meals per day	3 to 5 days after hatching	Bucket, pond or hapa or raceways, fertilizers, supplemental feeds	Ensure before transferring common carp larvae that zooplankton in fertilized waters is dominated by rotifers. The pond absolutely should be fenced to prevent predation. Artemia may be used in intensive systems.

3.8. Harvesting of fry	Drain the pond as described above. Stocking tank should be prepared to “harden” the fry before transport over long distances. Current survival rate is close to 30%, i.e., about 6,000 fry of 5 g from almost 20,000 eggs per female African catfish brooder	3 to 5 weeks after transfer	Hand and hauling nets with fine meshes, bucket, stocking tank	For catfish, do not go beyond 4 weeks of prefattening to prevent heavy cannibalism. Further prefattening steps can be conducted to increase average size to 10-15 g.
3.9. Transportation of live fish	Fry should be transported and should reach grow-out ponds in healthy condition. Stock harvested fry in high density with no feeding for a minimum of 18 hours before transportation (the hardening process allows the fish gut to empty to better face transportation stress). A closed transportation system uses 50-litre plastic bags 1/3 filled with water and 2/3 filled with pure oxygen under pressure. These bags are protected in isotherm boxes containing ice to keep the environment cold.	Early in the morning, preferably in fresh weather	Hardening stocking tanks, plastic bag, oxygen under pressure, transporting system	A 50-litre bag can ensure transportation in close system of about 2 kg fry (average weight < 5 g) for 6 hours with no mortality.
4. Economic aspects				
An average net annual revenue amounting to FCFA231,000 per 350 m² pond (i.e., about FCFA660 per square metre) is registered in periurban farms with good market opportunities. For small-scale rural fish farming, economic benefits are related more to nutritional and social welfare than to finances.		Always ensure adequate marketing before harvesting	Fair accounting and marketing systems, market opportunities, adequate pond size and number, and improved government policy on taxes related to the sector	Fish size at harvest should meet market demand. To remain a sustainable commercial activity, good seed and feed production systems, appropriate taxes, and better policy on imported frozen fish should be established.

Continued from Table A1.1 A Technical Bulletin on Pond Construction, Fingerling Production and Integrated Management of Ponds 22-23 May 2003 in Mbalmayo (PNRVA Cameroon)

Precautions

- Pond construction: For catfish, ensure the pond dish can be completely emptied to prevent some fish hiding in pond-bottom mud, and build a fence all around the pond dike to prevent escape into a nearby stream at the start of the rainy season. For common carp, lower dike slopes to < 1/4 and reinforce by compacting to reduce damage as the fish search for natural feed.
- Pond management: For African catfish, calibrating fish sizes following intermediate sampling is essential to prevent high cannibalism in fish batches of unhomogeneous size. Common carp thrives better in the Western Highlands around Bafoussam and Bamenda in marginally fertilized ponds.
- Fingerling production: Brooders should be replaced as possible at 3-years intervals to prevent lost of growth potential from inbreeding.

Useful contacts

- The following public institutions and resource persons are available to provide more information on the subject: IRAD Aquaculture Station at Foumban, PO Box 255; Faculty of Agronomy, University of Dschang, PO Box 222. Phone contacts: 77 59 00 26 (Dr Pouomogne); 99 83 52 09 (Dr Nguenga); 96 71 19 51 (Mr Sulem); 77 97 70 26 (Dr Tomedi Eyango Minette [spouse Tabi]).
- NGOs and international organizations engaged in the promotion of fish farming in Cameroon: CIFORD, BP 1476 Bafoussam, Phone: 33 44 26 40 (Attn. Mr Tangou); CEPID Foumban, BP 139, phone: 33 48 25 05 (Attn. Mrs. A. Tourere). WorldFish Center, International Institute of Tropical Agriculture, Nkolbisson, BP 2008 Yaoundé, phone: 22 23 74 34 and 99 88 02 00 (Attn. Dr Brummett).

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ANNEX 2: ELEMENTS OF THE CAMEROON STRATEGIC FRAMEWORK AND THE ROLE OF PUBLIC AND PRIVATE SECTORS[6]

Source: Moehl et al*.* 2006, pp 56-61.

Sustainable aquaculture development relies on a number of conditions that must be met and addressed in any strategy in a flexible way. The most prominent of these are (1) suitable production systems; (2) the availability of and access to such inputs as feeds, seed, capital, etc.; (3) outreach; (4) research; (5) education and training; (6) marketing; (7) producer organizations; (8) regulation; and (9) control, monitoring and evaluation.

For each of the two types of aquaculture defined in this document (commercial and non-commercial), the following sections define the role of the public[7] and private[8] sectors in meeting each condition. Unless otherwise specified, the role discussed applies to both commercial and non-commercial aquaculture.

In light of limited human and financial resources, the government is generally shifting away, as it should, from its role as a direct investor and development promoter toward one of facilitator of an independent and commercially viable aquaculture sub-sector. The private sector is composed of two general groups of actors: direct investors, including producers and service providers, and partners, principally producer and civil society organizations.

1. SUITABLE PRODUCTION SYSTEMS

The government should

- identify general production technologies appropriate to relevant aquaculture zones,
- inform investors of these technologies, and
- concentrate its outreach activities in these zones.

The private sector should be aware of the government strategy regarding different production systems within aquaculture zones.

2. AVAILABILITY AND ACCESS TO INPUTS

a) Feeds[9]:

The government should

- stimulate domestic feed industries by reducing or removing taxes on imported feed-milling machinery and basic feed ingredients;
- make information on feed and feed materials, especially prices, regularly available to producers through all means of information transmission;
- ensure within its means feed quality through inspections and feed certification;
- promote the adoption of appropriate feed-manufacturing guidelines such as FAO's *Technical Guidelines for Good Aquaculture Feed Manufacturing Practice*; and
- encourage commercial farmers and millers to facilitate access to quality feed for the entire sub-sector.

6 Strategic elements as adopted by a National Stakeholders Seminar in December 2003.

7 Includes the ministry in charge of aquaculture, national research institute, and government extension service.

8 Includes producers, investors (in fish farming and related sectors), NGOs, commercial banks, universities and development agencies.

9 Including commercial and tradable feeds, feed materials, and other nutrient inputs.

Direct investors (feed mills) should

- produce and market necessary feedstuffs to growers;
- provide products of uniform quality at a fair price;
- find mechanisms to facilitate access to high-quality feed throughout the sub-sector;
- make proximate analyses available to clients;
- provide information on feed availability and efficacy to the public sector; and
- assist, as appropriate, outreach programmes in promoting good feeding practices and fish management, as well as monitor results.

Producer organizations should

- serve as a forum for information sharing among stakeholders,
- lobby for collective bargaining and appropriate public sector intervention, and
- link with research organizations.

b) Seed:

The government should restrict itself to

- providing regular information on sources and prices of high-quality seed to producers,
- providing guidelines on producing and ensuring high-quality seed through such measures as seed certification,
- maintaining broodstock of selected culture organisms corresponding to the identified production systems, and
- encouraging commercial farmers and hatcheries to facilitate access to quality seed for the entire sub-sector.

Direct investors (seed producers) should

- produce and distribute quality seed,
- sell products at a fair price,
- find mechanisms to facilitate access to high-quality seed throughout the sub-sector,
- assist, as appropriate, outreach programmes in promoting good management practices favouring improved yields, and
- monitor results.

Producer organizations should

- serve as a forum for sharing information among stakeholders,
- lobby for collective bargaining and appropriate public sector intervention, and
- link with research organizations.

c) Capital:

Conflicts often arise when the government provides and manages credit. Thus, in terms of investment capital for commercial aquaculture,[10] the government should restrict itself to creating an enabling environment through, for example,

10 Credit is not generally considered appropriate for non-commercial aquaculture (FAO 1999).

- providing information to lending agencies on the profitability of aquaculture,[11]
- evaluating the technical merits of investment proposals submitted to lending agencies for funding,
- advising farmers on where and how to access funding from specialized institutions, and
- interacting with these funding institutions as appropriate to negotiate preferential interest rates for aquaculture development.

The private sector should do the following:

- Commercial producers should rely on their own equity and private sector funding institutions for capital.
- Lending institutions should consider preferential interest rates for aquaculture enterprises when applicable.
- Investors requesting credit support should prepare clear and precise business plans.
- Formal lending institutions should finance viable aquaculture businesses.
- Small investors should ensure that they have appropriate skills in business and financial management before requesting external financial support.
- NGOs should work with non-commercial producers to develop financing options, collect information on other funding mechanisms and make it available to farmers, sensitize farmers to savings and solidarity funds for use in aquaculture development, examine the possibility of creating an aquaculture guarantee fund, and examine the possibility of providing temporary direct assistance to aquaculture producers' organizations.

3. OUTREACH

The government should

- provide quality technical assistance through an efficient aquaculture outreach programme;
- seek partners as necessary to meet information shortfalls that cannot be met with public resources;
- establish national and international aquaculture information networks that are accessible at local hubs;
- play a coordinating role in the outreach programme;
- emphasize participatory approaches when providing services to farmers;
- encourage group formation for the purposes of rationalizing marketing and purchase of inputs, as well as increasing outreach contact with farmers;
- encourage commercial investors to provide outreach support to smaller operators;
- facilitate the creation of discussion channels among different aquaculture stakeholders; and
- require larger investors to pay for technical assistance on a contractual basis negotiated with the institution providing assistance.

The private sector should

- assist and reinforce public sector outreach programmes, particularly with regard to outreach contributions by feed and/or seed suppliers;
- evaluate outreach efficacy and advise as to outreach needs;
- provide feedback to the public sector regarding available information sources; and

11 Relevant information from a variety of sources should be collated by research agencies for this purpose.

- pay for technical assistance if they are commercial producers and assess their opportunities to serve as information providers.

4. RESEARCH

For commercial aquaculture, the government should

- support applied and farmer-participatory research directed at small- and medium-scale commercial farmers,
- ensure that research is responsive to the needs of farmers,[12] and
- develop methods whereby farmers at the upper limit of the spectrum (i.e., large-scale, capital-intensive systems) have access to government research facilities and scientists on a contractual basis.

For non-commercial aquaculture, the government should fully fund research for systems operated by low-income farmers. The private sector should

- also fund research,
- disseminate research results as appropriate, and
- evaluate research results and offer input into research agendas.

5. EDUCATION AND TRAINING

The government should

- develop specific curricula for practical training of entry-level farm managers and aquaculture technicians;
- arrange and/or conduct — on demand at regular intervals — short courses for in-service training and human resource enhancement;
- establish a continuing training plan for its staff and assist in linking candidates with local, regional or international agencies providing training, education and/or financial assistance, including distance learning options;
- provide information on career development in aquaculture; and
- introduce longer-term professional training in aquaculture sciences into university programmes.

The private sector should

- pay for training of those technicians necessary for the development of a commercial aquaculture sector;
- facilitate training opportunities on their farms; and
- provide feedback to the public sector regarding the efficacy of training, materials and curricula and advise on training needs as necessary.

6. MARKETING

The government should

- make information on fish retail prices, conservation and treatment available to producers and consumers through, for example, newspapers, newsletters, rural radio or other media;
- protect local producers from unfair foreign competition provided that the protective measures conform with international trade conventions and agreements;

12 Researchers' merit pay increases should be linked to on-farm results rather than publication record.

- provide basic marketing infrastructure, such as roads and communication channels;
- assist producers in promoting aquaculture products to stimulate demand through agricultural fairs and other such opportunities;
- encourage commercial producers to develop market channels that can be accessed by smaller producers; and
- prepare, publish and regularly monitor guidelines on the implementation of quality standards of aquatic products to protect public health as well as improve the acceptability of aquaculture products.

Commercial producers should

- provide products of uniform quality according to market requirements and
- look for mechanisms to provide market guarantees for smaller producers (e.g., satellite production systems).

7. PRODUCER ORGANIZATIONS

The government should

- promote and facilitate the formation of producer organizations with legal status as appropriate by, for example, advertising their advantages in collective bargaining, streamlining administrative and registration processes, etc., and
- advise interested farmers and feed and seed producers on where and how to get assistance in group formation and functions.

The private sector should do the following:

- Producers should organize themselves to defend their mutual interests and facilitate access to inputs and markets, etc.
- NGOs should play a catalytic role in establishing producer organizations.
- Organizations should consider establishing a national producers' organization combining local organizations.

8. REGULATION

The government should

- establish clear and secure user rights to land and water favourable to aquaculture investment;
- avoid placing unnecessary costs on applicants' acquisition of necessary rights to land and water and the right to undertake aquaculture operations;
- regulate the movement of aquatic organisms between watersheds and the provision of discharge and outfall standards (e.g., biological oxygen demand limits or alien species to receiving water bodies, etc.);
- regulate the use of alien and genetically modified aquatic organisms;
- require commercial aquaculture farmers to acquire permits that specify their rights and obligations;
- waive such permits for non-commercial aquaculture as long as government regulatory thresholds are not exceeded;
- adopt a one-stop shop for obtaining permits and information relevant to aquaculture development;
- collect and publish reliable, up-to-date statistics;
- apply and enforce appropriate international codes to which the government subscribes (e.g., Code of Conduct for Responsible Fisheries);
- determine criteria for requiring environmental impact assessment studies;

- regulate seed production;
- regulate commercial feed production; and
- define a regulation on quality control of aquaculture products.

The private sector should

- be aware of relevant regulations,
- self regulate to ensure good farm management practices with the goal of sustainable resource use,
- self regulate to ensure that products that are safe to consume are provided to all consumers, and
- provide complete and correct data for monitoring by the public sector.

9. CONTROL, MONITORING AND EVALUATION

The government should

- control the movement of aquatic organisms between watersheds and the provision of discharge and outfall standards (e.g., biological oxygen demand limits and alien species to receiving water bodies, etc.);
- control the use of alien and genetically modified aquatic organisms;
- require commercial aquaculture operators to acquire permits that specify their rights and obligations;
- apply and enforce appropriate international codes to which the government subscribes (e.g., Code of Conduct for Responsible Fisheries);
- define a standard system for statistics and data collection and treatment;
- collect and publish reliable, up-to-date statistics;
- ensure, where necessary, that environmental impact assessments are properly conducted;
- control seed quality;
- control the quality of commercial feeds;
- enforce regulations on the quality control of aquaculture products; and
- regularly evaluate sector development.

The private sector should

- respect regulations on the movement of aquatic organisms between watersheds and the provision of discharge and outfall standards;
- respect regulations on the use of alien and genetically modified aquatic organisms;
- seek permits before establishing a commercial aquaculture farm;
- apply appropriate international codes to which the government subscribes;
- regularly provide reliable, up-to-date statistics; and
- have self-regulatory, self-control mechanisms to ensure seed quality, the quality of commercial feeds and the quality of aquaculture products.

SPECIFIC ISSUES

1. Government stations

One or more government stations should be maintained for training, research and the genetic management of fish. The criteria for maintaining a station should include, inter-alia, its economic viability and needs for genetic conservation, research and training, as well as identifying zones with high aquaculture potential. Following the existing draft government master plan for aquaculture, other economically viable government infrastructure should progressively be sold or leased long-term in their existing condition to well-chosen entities in the private sector according to existing laws and procedures on the sale or lease of public property. Unviable infrastructure, or those stations for which no buyer or lessee can be found, can be donated to such public institutions as schools, prisons or orphanages. Public sector technical services should be able to assist potential buyers or lessees in determining the economic potential of these facilities.

2. Marine and coastal aquaculture

   Mariculture and other coastal production systems are strategically no different from inland systems, and the same processes should be applied. However, it should be recalled that coastal regions comprise critical ecosystems that are highly productive though fragile, requiring careful attention to environmental considerations. Also, these areas are complex socioeconomic zones where the potential for conflict over use is high and whose economic contribution to livelihoods is highly significant. The existing body of knowledge of best practices for integrated coastal management should be applied.

3. Non-conventional aquaculture systems

   The culture of ornamental species should be considered among the multiple aquaculture systems practised in the country. Organically certified aquaculture and growing aquatic plants, etc., are other examples of non-conventional systems.

4. Unexplored culture species, introductions and genetically modified organisms

   Mainstream aquaculture species are tilapia, catfish, carp and *Heterotis* along with a few minor cichlids. The establishment of culture species so far unexplored may impose high economic costs in the development of the required seed-multiplication and distribution networks. Any promotion of new culture organisms must take these costs into consideration. Introductions of alien species need to adhere to international conventions and covenants. Controlling the genetic integrity of aquatic organisms is an important issue that is frequently addressed under the rubric of aquaculture. Reference has been made above to advised precautionary procedures, but is it noteworthy that pond management needs to be significantly enhanced before any benefits of genetically modified organisms are foreseen.

ANNEX 3: COMMON INITIATIVE GROUPS OF THE AQUACAM FISH FARMER ASSOCIATION

Common initiative groups (GICs)	Leader	Date of Inception
1. GIC Pisciculeurs Intégrés de Batié (Grands Pisciculteurs)	Bernard Youdom	1995
2. GIC Producteurs d'alevins de l'Ouest (Foreke Hatchery)	Télesphore Djoumessi	1998
3. GIC Agriculteurs Intégrés de l'Ouest	Michel Diogni	1998
4. GICAE Bandjoun	Joseph Pouma	
5. GIC NKOUMGNE Bandjoun	Emmanuel Kamga	
6. GIC des pisciculteurs de Mbô Bandjoun		
7. GIC des femmes de BASSOCCIA	Martin Kolla	
8. Groupe KOUONGNE	Pierre Neguem	
9. GICAEB	Louis Talla	
10. GIC Pisciculture KOUTSAC Baméka	Rigobert Fotsing	
11. Pisciculteur de Banéfo	Joseph Tamo	
12. Pisciculteur Baméka	Joseph Nde	
13. GIC DEUEKI	Henri Tene	
14. GIC Bafut	Daniel Tumfumchuchwi	2000
15. GIC Ngoundoup	Issah Linjoum	2000

Source: Adapted from Samuel Tangou, unpublished data.

ANNEX 4: COMMON ENGLISH AND ZOOLOGICAL NAMES OF MAJOR FISH SPECIES CULTURED AND CONSUMED IN CAMEROON

Common English name	Local name	Scientific name
Nile tilapia	tilapia	*Oreochromis niloticus*
African catfish	silure, ngouot	*Clarias gariepinus*
African catfish	silure, djounkeu	*Heterobranchus longifilis*
common carp	carp	*Cyprinus carpio*
African bonytongue	kanga	*Heterotis niloticus*
banded jewel fish	panther fish	*Hemichromis fasciatus*
snakehead	viper fish	*Parachanna obscura*
barb	gougeon	*Barbus* sp.
Bonga shad	bonga	*Ethmalosa fimbiata*
Madeiran sardinella	bifaka	*Sardinella madarensis*
mackerel	maquereau	*Scomber scombrus, Scomber japonicus*
cassava croaker	bar, bossu	*Pseudotolithus* spp
Atlantic cod	makanjou	*Gadus morhua*
shrimp	crayfish, majanga	*Peneaux* sp., *Parapeneopsis atlantica*

ANNEX 5: PRODUCTION AND CONSUMPTION OF FISH PRODUCTS IN CAMEROON IN 2001

Table A5.1: Production

	Total production (tonnes)	Average production price (FCFA1,000/tonne*)	Value (billion FCFA)
Artisanal maritime fisheries	79,236	382	30,285
Industrial fisheries (fish)	6,898	1,264	8,719
Industrial fisheries (crustaceans)	530	6,500	3,448
Inland fisheries and aquaculture	68,750	629	43,250
Total	155,414	551	85,702

* $1 = FCFA530.

Sources: Translated from Ngok et al. 2005.

Table A5.2: Export and import

	Volume (tonnes)	Average price (FCFA1,000/tonne*)	Value (billion FCFA)
Exports	95	1,556	0,148
Imports	124,513	197	24,574
Balance	–124,418		–24,426

* $1 = FCFA530.

Source: Translated from Ngok et al. 2005.

Table A5.3: Trade balance including informal exchanges

	Volume (tonnes)	Value (billion FCFA*)
Exports	15,095	9,405
Imports	157,612	42,138
Balance	–142,517	–32,733

* $1 = FCFA530.

Source: Translated from Ngok et al. 2005.

Table A5.4: Fish consumption re household survey of 2001

Items	Total consumption (tonnes)	Average price (FCFA1,000/tonne*)
Fresh fish and crustaceans	146,321	684
Smoked fish and crustaceans)	43,030	1,912

* $1 = FCFA530.

Source: INS 2001.

Table A5.5: Fishery products prices re household survey of 2001

Items*	Price (FCFA/kilogram**)
Sea fish	218
Frozen bar	1,927
Frozen mackerel	731
Freshwater fish	1,161
Smoked or dried fish	1,852
Smoked Bonga shad or Madeiran sardinella	1,701
Smoked or dried tilapia	2,003
Dried Atlantic cod (premium quality)	11,184
Smoked or dried shrimp	3,293

* See Annex 4 for scientific names.

** $1 = FCFA530.

Source: INS 2001 (office for price consumption index).

ANNEX 6: FISH HATCHERIES OPERATING IN CAMEROON AS OF NOVEMBER 2005

Table A6.1: Private sources of fish seed

Hatchery or farmer name	Location	Species	Facilities	Production in 2006-2007
Nkoa, Bruno	Nkoabang, Centre Province	African catfish	Hatchery building + 7 ponds, 9,000 m^2	
Etaba, Desiré	Nkolzoa, Centre Province	Nile tilapia	11 ponds, 1,430 m^2	10,000 Nile tilapia
Diogne, Michel	Batié, West Province	African catfish	Hatchery building + 6 ponds, 2,400 m^2	12,000 African catfish, 8,800 common carp
Noupimbong, Maurice	Bapi, West Province	African catfish, Nile tilapia	6 ponds, 700 m^2	
Ndoumou, Antoine	Nkolmesseng, Centre Province	African catfish	1 pond + 8 tanks, 2,500 m^2	
Wouanji, Jean	Bandjoun, West Province	African catfish	3 ponds, 900 m^2	
Youdom, Bernard	Batié-Nsoh, West Province	African catfish	10 ponds, 5,000 m^2	2,000 Nile tilapia
Tamo, David	Bafoussam, West Province	African catfish	6 ponds, 1,200 m^2	
Djoumessi, Télesphore	Foreke Dschang, West Province	African catfish, common carp	4 ponds, 2,000 m^2, hatchery building plus equipment	32,000 African catfish in 2002
Lindjouom, Issah	Ngoundoup, West Province	Nile tilapia	3 ponds, 1,500 m^2	28,000 Nile tilapia
Awoa, Lucien	Yemssoa, Centre Province	African catfish	Hatchery building + 5 ponds, 3,200 m^2	
Tabi, Abodo	Mbankomo, Centre Province	Nile tilapia, African catfish	Hatchery building + 19 ponds, 9,500 m^2	Over 20,000 Nile tilapia, African catfish and common carp
Yene, Joseph	Nkoabang (Lada), Centre Province	African catfish	12 ponds, 360 m^2	
Yong-Sulem, Steve	Mbankolo, Centre Province	African catfish	23 ponds, 2,100 m^2	
Oben, Benedicta	Buea, Southwest Province	African catfish	Hatchery building + 5 concrete tanks	
Ebanda, Jeanne	Mbandoum, Centre Province	Nile tilapia	17 ponds, 7,000 m^2	

Source: adapted from Brummett 2007.

Table A6.2: Public sources of fish seed

Hatchery/station name	Location	Species	Facilities	Production in 2006/2007
Melen Yaoundé	Valley between the University of Yaoundé 1 and the University Hospital Centre	Nile tilapia, African catfish, African bonytongue	Offices, hatchery, concrete tanks, 10 ponds	40,000 African catfish
Ebolowa		Nile tilapia, African catfish	Offices, hatchery, concrete tanks, 10 ponds	
Bertoua/Batouri		Nile tilapia, African catfish	Offices, hatchery, concrete tanks, 16 ponds	
Nkwen Bamenda	Nken, in the direction of Bambui	African catfish, common carp	Offices, hatchery, concrete tanks, 10 ponds	
CNFZV Foumban	10 km from Foumban to the north, on the left bank of the Nchi River	Nile tilapia, African catfish	Offices, hatchery, concrete tanks, 52 ponds	
IRAD Koupa Matapit	12 km from Foumban town to the northwest	Nile tilapia, African catfish, common carp	Offices, hatchery, concrete tanks, 20 ponds	15,000 common carp 50,000 African catfish

Source: adapted from Brummett 2007.

This document describes the historical background, practices, stakeholder profiles, production levels, economic and institutional environment, policy issues, and prospects for freshwater aquaculture in Cameroon. It is an output from a 3-year project that produced a decision-support toolkit with supporting databases and case studies to help researchers, planners and extension agents working on pond aquaculture. The purpose of the work, carried out in Cameroon and Malawi in Africa, and Bangladesh and China in Asia, was to provide tools and information to help practitioners identify places and conditions where freshwater pond aquaculture can benefit the poor, both as producers and as consumers of fish.

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